RESEARCH CENTER

FIELD

Activity Report 2019

Section Software

Algorithmics, Programming, Software and Architecture

DIGITAL HEALTH, BIOLOGY AND EARTH

NETWORKS, SYSTEMS AND SERVICES, DISTRIBUTED COMPUTING

ANTIQUE Project-Team

6. New Software and Platforms

6.1. APRON

SCIENTIFIC DESCRIPTION: The APRON library is intended to be a common interface to various underlying libraries/abstract domains and to provide additional services that can be implemented independently from the underlying library/abstract domain, as shown by the poster on the right (presented at the SAS 2007 conference. You may also look at:

FUNCTIONAL DESCRIPTION: The Apron library is dedicated to the static analysis of the numerical variables of a program by abstract interpretation. Its goal is threefold: provide ready-to-use numerical abstractions under a common API for analysis implementers, encourage the research in numerical abstract domains by providing a platform for integration and comparison of domains, and provide a teaching and demonstration tool to disseminate knowledge on abstract interpretation.

- Participants: Antoine Miné and Bertrand Jeannet
- Contact: Antoine Miné
- URL: http://apron.cri.ensmp.fr/library/

6.2. Astrée

The AstréeA Static Analyzer of Asynchronous Software

KEYWORDS: Static analysis - Static program analysis - Program verification - Software Verification - Abstraction

SCIENTIFIC DESCRIPTION: Astrée analyzes structured C programs, with complex memory usages, but without dynamic memory allocation nor recursion. This encompasses many embedded programs as found in earth transportation, nuclear energy, medical instrumentation, and aerospace applications, in particular synchronous control/command. The whole analysis process is entirely automatic.

Astrée discovers all runtime errors including:

undefined behaviors in the terms of the ANSI C99 norm of the C language (such as division by 0 or out of bounds array indexing),

any violation of the implementation-specific behavior as defined in the relevant Application Binary Interface (such as the size of integers and arithmetic overflows),

any potentially harmful or incorrect use of C violating optional user-defined programming guidelines (such as no modular arithmetic for integers, even though this might be the hardware choice),

failure of user-defined assertions.

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Astrée is a static analyzer for sequential programs based on abstract interpretation. The Astrée static analyzer aims at proving the absence of runtime errors in programs written in the C programming language.

- Participants: Antoine Miné, Jérôme Feret, Laurent Mauborgne, Patrick Cousot, Radhia Cousot and Xavier Rival
- Partners: CNRS - ENS Paris - AbsInt Angewandte Informatik GmbH
- Contact: Patrick Cousot
- URL: http://www.astree.ens.fr/

6.3. AstréeA

The AstréeA Static Analyzer of Asynchronous Software

KEYWORDS: Static analysis - Static program analysis

SCIENTIFIC DESCRIPTION: AstréeA analyzes C programs composed of a fixed set of threads that communicate through a shared memory and synchronization primitives (mutexes, FIFOs, blackboards, etc.), but without recursion nor dynamic creation of memory, threads nor synchronization objects. AstréeA assumes a real-time scheduler, where thread scheduling strictly obeys the fixed priority of threads. Our model follows the ARINC 653 OS specification used in embedded industrial aeronautic software. Additionally, AstréeA employs a weakly-consistent memory semantics to model memory accesses not protected by a mutex, in order to take into account soundly hardware and compiler-level program transformations (such as optimizations). AstréeA checks for the same run-time errors as Astrée , with the addition of data-races.

FUNCTIONAL DESCRIPTION: AstréeA is a static analyzer prototype for parallel software based on abstract interpretation. The AstréeA prototype is a fork of the Astrée static analyzer that adds support for analyzing parallel embedded C software.

- Participants: Antoine Miné, Jérôme Feret, Patrick Cousot, Radhia Cousot and Xavier Rival
- Partners: CNRS - ENS Paris - AbsInt Angewandte Informatik GmbH
- Contact: Patrick Cousot
- URL: http://www.astreea.ens.fr/

6.4. ClangML

KEYWORD: Compilation

FUNCTIONAL DESCRIPTION: ClangML is an OCaml binding with the Clang front-end of the LLVM compiler suite. Its goal is to provide an easy to use solution to parse a wide range of C programs, that can be called from static analysis tools implemented in OCaml, which allows to test them on existing programs written in C (or in other idioms derived from C) without having to redesign a front-end from scratch. ClangML features an interface to a large set of internal AST nodes of Clang , with an easy to use API. Currently, ClangML supports all C language AST nodes, as well as a large part of the C nodes related to C++ and Objective-C.

- Participants: Devin Mccoughlin, François Berenger and Pippijn Van Steenhoven
- Contact: Xavier Rival
- URL: https://github.com/Antique-team/clangml/tree/master/clang

6.5. FuncTion

SCIENTIFIC DESCRIPTION: FuncTion is based on an extension to liveness properties of the framework to analyze termination by abstract interpretation proposed by Patrick Cousot and Radhia Cousot. FuncTion infers ranking functions using piecewise-defined abstract domains. Several domains are available to partition the ranking function, including intervals, octagons, and polyhedra. Two domains are also available to represent the value of ranking functions: a domain of affine ranking functions, and a domain of ordinal-valued ranking functions (which allows handling programs with unbounded non-determinism).

FUNCTIONAL DESCRIPTION: FuncTion is a research prototype static analyzer to analyze the termination and functional liveness properties of programs. It accepts programs in a small non-deterministic imperative language. It is also parameterized by a property: either termination, or a recurrence or a guarantee property (according to the classification by Manna and Pnueli of program properties). It then performs a backward static analysis that automatically infers sufficient conditions at the beginning of the program so that all executions satisfying the conditions also satisfy the property.

- Participants: Antoine Miné and Caterina Urban
- Contact: Caterina Urban
- URL: http://www.di.ens.fr/~urban/FuncTion.html

6.6. HOO

Heap Abstraction for Open Objects

FUNCTIONAL DESCRIPTION: JSAna with HOO is a static analyzer for JavaScript programs. The primary component, HOO, which is designed to be reusable by itself, is an abstract domain for a dynamic language heap. A dynamic language heap consists of open, extensible objects linked together by pointers. Uniquely, HOO abstracts these extensible objects, where attribute/field names of objects may be unknown. Additionally, it contains features to keeping precise track of attribute name/value relationships as well as calling unknown functions through desynchronized separation.

As a library, HOO is useful for any dynamic language static analysis. It is designed to allow abstractions for values to be easily swapped out for different abstractions, allowing it to be used for a wide-range of dynamic languages outside of JavaScript.

- Participant: Arlen Cox
- Contact: Arlen Cox

6.7. MemCAD

The MemCAD static analyzer

KEYWORDS: Static analysis - Abstraction

FUNCTIONAL DESCRIPTION: MemCAD is a static analyzer that focuses on memory abstraction. It takes as input C programs, and computes invariants on the data structures manipulated by the programs. It can also verify memory safety. It comprises several memory abstract domains, including a flat representation, and two graph abstractions with summaries based on inductive definitions of data-structures, such as lists and trees and several combination operators for memory abstract domains (hierarchical abstraction, reduced product). The purpose of this construction is to offer a great flexibility in the memory abstraction, so as to either make very efficient static analyses of relatively simple programs, or still quite efficient static analyses of very involved pieces of code. The implementation consists of over 30 000 lines of ML code, and relies on the ClangML front-end. The current implementation comes with over 300 small size test cases that are used as regression tests.

- Participants: Antoine Toubhans, François Berenger, Huisong Li and Xavier Rival
- Contact: Xavier Rival
- URL: http://www.di.ens.fr/~rival/memcad.html

6.8. KAPPA

A rule-based language for modeling interaction networks

KEYWORDS: Systems Biology - Modeling - Static analysis - Simulation - Model reduction

SCIENTIFIC DESCRIPTION: OpenKappa is a collection of tools to build, debug and run models of biological pathways. It contains a compiler for the Kappa Language, a static analyzer (for debugging models), a simulator, a compression tool for causal traces, and a model reduction tool.

FUNCTIONAL DESCRIPTION: Kappa is provided with the following tools: - a compiler - a stochastic simulator - a static analyzer - a trace compression algorithm - an ODE generator.

RELEASE FUNCTIONAL DESCRIPTION: On line UI, Simulation is based on a new data-structure (see ESOP 2017), New abstract domains are available in the static analyzer (see SASB 2016), Local traces (see TCBB 2018), Reasoning on polymers (see SASB 2018).

- Participants: Jean Krivine, Jérôme Feret, Kim-Quyen Ly, Pierre Boutillier, Russ Harmer, Vincent Danos and Walter Fontana
- Partners: ENS Lyon - Université Paris-Diderot - HARVARD Medical School
- Contact: Jérôme Feret
- URL: http://www.kappalanguage.org/

6.9. QUICr

FUNCTIONAL DESCRIPTION: QUICr is an OCaml library that implements a parametric abstract domain for sets. It is constructed as a functor that accepts any numeric abstract domain that can be adapted to the interface and produces an abstract domain for sets of numbers combined with numbers. It is relational, flexible, and tunable. It serves as a basis for future exploration of set abstraction.

- Participant: Arlen Cox
- Contact: Arlen Cox

6.10. LCertify

KEYWORD: Compilation

SCIENTIFIC DESCRIPTION: The compilation certification process is performed automatically, thanks to a prover designed specifically. The automatic proof is done at a level of abstraction which has been defined so that the result of the proof of equivalence is strong enough for the goals mentioned above and so that the proof obligations can be solved by efficient algorithms.

FUNCTIONAL DESCRIPTION: Abstract interpretation, Certified compilation, Static analysis, Translation validation, Verifier. The main goal of this software project is to make it possible to certify automatically the compilation of large safety critical software, by proving that the compiled code is correct with respect to the source code: When the proof succeeds, this guarantees semantic equivalence. Furthermore, this approach should allow to meet some domain specific software qualification criteria (such as those in DO-178 regulations for avionics software), since it allows proving that successive development levels are correct with respect to each other i.e., that they implement the same specification. Last, this technique also justifies the use of source level static analyses, even when an assembly level certification would be required, since it establishes separately that the source and the compiled code are equivalent.ntees that no compiler bug did cause incorrect code to be generated.

- Participant: Xavier Rival
- Partners: CNRS - ENS Paris
- Contact: Xavier Rival
- URL: http://www.di.ens.fr/~rival/lcertify.html

6.11. Zarith

FUNCTIONAL DESCRIPTION: Zarith is a small (10K lines) OCaml library that implements arithmetic and logical operations over arbitrary-precision integers. It is based on the GNU MP library to efficiently implement arithmetic over big integers. Special care has been taken to ensure the efficiency of the library also for small integers: small integers are represented as Caml unboxed integers and use a specific C code path. Moreover, optimized assembly versions of small integer operations are provided for a few common architectures.

Zarith is currently used in the Astrée analyzer to enable the sound analysis of programs featuring 64-bit (or larger) integers. It is also used in the Frama-C analyzer platform developed at CEA LIST and Inria Saclay.

- Participants: Antoine Miné, Pascal Cuoq and Xavier Leroy
- Contact: Antoine Miné
- URL: http://forge.ocamlcore.org/projects/zarith

6.12. PYPPAI

Pyro Probabilistic Program Analyzer

KEYWORDS: Probability - Static analysis - Program verification - Abstraction

FUNCTIONAL DESCRIPTION: PYPPAI is a program analyzer to verify the correct semantic definition of probabilistic programs written in Pyro. At the moment, PYPPAI verifies consistency conditions between models and guides used in probabilistic inference programs.

PYPPAI is written in OCaml and uses the pyml Python in OCaml library. It features a numerical abstract domain based on Apron, an abstract domain to represent zones in tensors, and dedicated abstract domains to describe distributions and states in probabilistic programs.

- Contact: Xavier Rival
- URL: https://github.com/wonyeol/static-analysis-for-support-match

ARIC Project-Team

6. New Software and Platforms

6.1. FPLLL

KEYWORDS: Euclidean Lattices - Computer algebra system (CAS) - Cryptography

SCIENTIFIC DESCRIPTION: The fplll library is used or has been adapted to be integrated within several mathematical computation systems such as Magma, Sage, and PariGP. It is also used for cryptanalytic purposes, to test the resistance of cryptographic primitives.

FUNCTIONAL DESCRIPTION: fplll contains implementations of several lattice algorithms. The implementation relies on floating-point orthogonalization, and LLL is central to the code, hence the name.

It includes implementations of floating-point LLL reduction algorithms, offering different speed/guarantees ratios. It contains a 'wrapper' choosing the estimated best sequence of variants in order to provide a guaranteed output as fast as possible. In the case of the wrapper, the succession of variants is oblivious to the user.

It includes an implementation of the BKZ reduction algorithm, including the BKZ-2.0 improvements (extreme enumeration pruning, pre-processing of blocks, early termination). Additionally, Slide reduction and self dual BKZ are supported.

It also includes a floating-point implementation of the Kannan-Fincke-Pohst algorithm that finds a shortest non-zero lattice vector. For the same task, the GaussSieve algorithm is also available in fplll. Finally, it contains a variant of the enumeration algorithm that computes a lattice vector closest to a given vector belonging to the real span of the lattice.

- Author: Damien Stehlé
- Contact: Damien Stehlé
- URL: https://github.com/fplll/fplll

6.2. Gfun

generating functions package

KEYWORD: Symbolic computation

FUNCTIONAL DESCRIPTION: Gfun is a Maple package for the manipulation of linear recurrence or differential equations. It provides tools for guessing a sequence or a series from its first terms, for manipulating rigorously solutions of linear differential or recurrence equations, using the equation as a data-structure.

- Contact: Bruno Salvy
- URL: http://perso.ens-lyon.fr/bruno.salvy/software/the-gfun-package/

6.3. GNU-MPFR

KEYWORDS: Multiple-Precision - Floating-point - Correct Rounding

FUNCTIONAL DESCRIPTION: GNU MPFR is an efficient arbitrary-precision floating-point library with well-defined semantics (copying the good ideas from the IEEE 754 standard), in particular correct rounding in 5 rounding modes. It provides about 80 mathematical functions, in addition to utility functions (assignments, conversions...). Special data (Not a Number, infinities, signed zeros) are handled like in the IEEE 754 standard. GNU MPFR is based on the mpn and mpz layers of the GMP library.

- Participants: Guillaume Hanrot, Paul Zimmermann, Philippe Théveny and Vincent Lefèvre
- Contact: Vincent Lefèvre
- Publications: Correctly Rounded Arbitrary-Precision Floating-Point Summation - Optimized Binary64 and Binary128 Arithmetic with GNU MPFR - Évaluation rapide de fonctions hypergéométriques - Arbitrary Precision Error Analysis for computing $\zeta(s)$ with the Cohen-Olivier algorithm: Complete description of the real case and preliminary report on the general case - MPFR: A Multiple-Precision Binary Floating-Point Library with Correct Rounding. - The Generic Multiple-Precision Floating-Point Addition With Exact Rounding (as in the MPFR Library)
- URL: https://www.mpfr.org/

6.4. Sipe

KEYWORDS: Floating-point - Correct Rounding

FUNCTIONAL DESCRIPTION: Sipe is a mini-library in the form of a C header file, to perform radix-2 floating-point computations in very low precisions with correct rounding, either to nearest or toward zero. The goal of such a tool is to do proofs of algorithms/properties or computations of tight error bounds in these precisions by exhaustive tests, in order to try to generalize them to higher precisions. The currently supported operations are addition, subtraction, multiplication (possibly with the error term), fused multiply-add/subtract (FMA/FMS), and miscellaneous comparisons and conversions. Sipe provides two implementations of these operations, with the same API and the same behavior: one based on integer arithmetic, and a new one based on floating-point arithmetic.

- Participant: Vincent Lefèvre
- Contact: Vincent Lefèvre
- Publications: SIPE: Small Integer Plus Exponent - Sipe: a Mini-Library for Very Low Precision Computations with Correct Rounding
- URL: https://www.vinc17.net/research/sipe/

6.5. LinBox

KEYWORD: Exact linear algebra

FUNCTIONAL DESCRIPTION: LinBox is an open-source C++ template library for exact, high-performance linear algebra computations. It is considered as the reference library for numerous computations (such as linear system solving, rank, characteristic polynomial, Smith normal forms,...) over finite fields and integers with dense, sparse, and structured matrices.

- Participants: Clément Pernet and Thierry Gautier
- Contact: Clément Pernet
- URL: http://linalg.org/

6.6. HPLLL

KEYWORDS: Euclidean Lattices - Computer algebra system (CAS)

FUNCTIONAL DESCRIPTION: Software library for linear algebra and Euclidean lattice problems

- Contact: Gilles Villard
- URL: http://perso.ens-lyon.fr/gilles.villard/hplll/

AROMATH Project-Team (section vide)

CAIRN Project-Team

5. New Software and Platforms

5.1. Gecos

Generic Compiler Suite

KEYWORDS: Source-to-source compiler - Model-driven software engineering - Retargetable compilation

SCIENTIFIC DESCRIPTION: The Gecos (Generic Compiler Suite) project is a source-to-source compiler infrastructure developed in the Cairn group since 2004. It was designed to enable fast prototyping of program analysis and transformation for hardware synthesis and retargetable compilation domains.

Gecos is Java based and takes advantage of modern model driven software engineering practices. It uses the Eclipse Modeling Framework (EMF) as an underlying infrastructure and takes benefits of its features to make it easily extensible. Gecos is open-source and is hosted on the Inria gforge.

The Gecos infrastructure is still under very active development, and serves as a backbone infrastructure to projects of the group. Part of the framework is jointly developed with Colorado State University and between 2012 and 2015 it was used in the context of the FP7 ALMA European project. The Gecos infrastructure is currently used by the EMMTRIX start-up, a spin-off from the ALMA project which aims at commercializing the results of the project, and in the context of the H2020 ARGO European project.

FUNCTIONAL DESCRIPTION: GeCoS provides a programme transformation toolbox facilitating parallelisation of applications for heterogeneous multiprocessor embedded platforms. In addition to targeting programmable processors, GeCoS can regenerate optimised code for High Level Synthesis tools.

- Participants: Tomofumi Yuki, Thomas Lefeuvre, Imèn Fassi, Mickael Dardaillon, Ali Hassan El Moussawi and Steven Derrien
- Partner: Université de Rennes 1
- Contact: Steven Derrien
- URL: http://gecos.gforge.inria.fr

5.2. ID-Fix

Infrastructure for the Design of Fixed-point systems

KEYWORDS: Energy efficiency - Dynamic range evaluation - Accuracy optimization - Fixed-point arithmetic - Analytic Evaluation - Embedded systems - Code optimisation

SCIENTIFIC DESCRIPTION: The different techniques proposed by the team for fixed-point conversion are implemented in the ID.Fix infrastructure. The application is described with a C code using floating-point data types and different pragmas, used to specify parameters (dynamic, input/output word-length, delay operations) for the fixed-point conversion. This tool determines and optimizes the fixed-point specification and then, generates a C code using fixed-point data types (ac_fixed) from Mentor Graphics. The infrastructure is made of two main modules corresponding to the fixed-point conversion (ID.Fix-Conv) and the accuracy evaluation (ID.Fix-Eval).

FUNCTIONAL DESCRIPTION: ID.Fix focuses on computational precision accuracy and can provide an optimized specification using fixed-point arithmetic from a C source code with floating-point data types. Fixed point arithmetic is very widely used in embedded systems as it provides better performance and is much more energy-efficient. ID.Fix constructs an analytic accuracy model of the program, which means it can explore more solutions and thereby produce a much more efficient code.

- Participant: Olivier Sentieys
- Partner: Université de Rennes 1
- Contact: Olivier Sentieys
- URL: http://idfix.gforge.inria.fr

5.3. SmartSense

KEYWORDS: Wireless Sensor Networks - Smart building - Non-Intrusive Appliance Load Monitoring

FUNCTIONAL DESCRIPTION: To measure energy consumption by equipment in a building, NILM techniques (Non-Intrusive Appliance Load Monitoring) are based on observation of overall variations in electrical voltage. This avoids having to deploy watt-meters on every device and thus reduces the cost. SmartSense goes a step further to improve on these techniques by combining sensors (light, temperature, electromagnetic wave, vibration and sound sensors, etc.) to provide additional information on the activity of equipment and people. Low-cost sensors can be energy-autonomous too.

- Contact: Olivier Sentieys

5.4. Platforms

5.4.1. Zyggie: a Wireless Body Sensor Network Platform

KEYWORDS: Health - Biomechanics - Wireless body sensor networks - Low power - Gesture recognition - Hardware platform - Software platform - Localization

SCIENTIFIC DESCRIPTION: Zyggie is a hardware and software wireless body sensor network platform. Each sensor node, attached to different parts of the human body, contains inertial sensors (IMU) (accelerometer, gyrometer, compass and barometer), an embedded processor and a low-power radio module to communicate data to a coordinator node connected to a computer, tablet or smartphone. One of the system's key innovations is that it collects data from sensors as well as on distances estimated from the power of the radio signal received to make the 3D location of the nodes more precise and thus prevent IMU sensor drift and power consumption overhead. Zyggie can be used to determine posture or gestures and mainly has applications in sport, healthcare and the multimedia industry.

FUNCTIONAL DESCRIPTION: The Zyggie sensor platform was developed to create an autonomous Wireless Body Sensor Network (WBSN) with the capabilities of monitoring body movements. The Zyggie platform is part of the BoWI project funded by CominLabs. Zyggie is composed of a processor, a radio transceiver and different sensors including an Inertial Measurement Unit (IMU) with 3-axis accelerometer, gyrometer, and magnetometer. Zyggie is used for evaluating data fusion algorithms, low power computing algorithms, wireless protocols, and body channel characterization in the BoWI project.

The Zyggie V2 prototype (see Figure 2) includes the following features: a 32-bit micro-controller to manage a custom MAC layer and process quaternions based on IMU measures, and an UWB radio from DecaWave to measure distances between nodes with Time of Flight (ToF).

- Participants: Arnaud Carer and Olivier Sentieys
- Partners: Lab-STICC, Université de Rennes 1
- Contact: Olivier Sentieys
- URL: https://bowi.cominlabs.u-bretagneloire.fr/zyggie-wbsn-platform

5.4.2. E-methodHW: an automatic tool for the evaluation of polynomial and rational function approximations

KEYWORDS: function approximation, FPGA hardware implementation generator

SCIENTIFIC DESCRIPTION: E-methodHW is an open source C/C++ prototype tool written to exemplify what kind of numerical function approximations can be developed using a digit recurrence evaluation scheme for polynomials and rational functions.

Figure 2. CAIRN*'s Zyggie platform for WBSN*

FUNCTIONAL DESCRIPTION: E-methodHW provides a complete design flow from choice of mathematical function operator up to optimised VHDL code that can be readily deployed on an FPGA. The use of the E-method allows the user great flexibility if targeting high throughput applications.

- Participants: Silviu-Ioan Filip, Matei Istoan
- Partners: Université de Rennes 1, Imperial College London
- Contact: Silviu-Ioan Filip
- URL: https://github.com/sfilip/emethod

5.4.3. Firopt: a tool for the simultaneous design of digital FIR filters along with the dedicated hardware model

KEYWORDS: FIR filter design, multiplierless hardware implementation generator

SCIENTIFIC DESCRIPTION: the firopt tool is an open source C++ prototype that produces Finite Impulse Response (FIR) filters that have minimal cost in terms of digital adders needed to implement them. This project aims at fusing the filter design problem from a frequency domain specification with the design of the dedicated hardware architecture. The optimality of the results is ensured by solving appropriate mixed integer linear programming (MILP) models developed for the project. It produces results that are generally more efficient than those of other methods found in the literature or from commercial tools (such as MATLAB).

- Participants: Silviu-Ioan Filip, Martin Kumm, Anastasia Volkova
- Partners: Université de Rennes 1, Université de Nantes, Fulda University of Applied Sciences
- Contact: Silviu-Ioan Filip
- URL: https://gitlab.com/filteropt/firopt

5.4.4. Hybrid-DBT

KEYWORDS: Dynamic Binary Translation, hardware acceleration, VLIW processor, RISC-V

SCIENTIFIC DESCRIPTION: Hybrid-DBT is a hardware/software Dynamic Binary Translation (DBT) framework capable of translating RISC-V binaries into VLIW binaries. Since the DBT overhead has to be as small as possible, our implementation takes advantage of hardware acceleration for performance critical stages (binary translation, dependency analysis and instruction scheduling) of the flow. Thanks to hardware acceleration, our implementation is two orders of magnitude faster than a pure software implementation and enable an overall performance improvements by 23% on average, compared to a native RISC-V execution.

- Participants: Simon Rokicki, Steven Derrien
- Partners: Université de Rennes 1
- URL: https://github.com/srokicki/HybridDBT

5.4.5. *Comet*

KEYWORDS: Processor core, RISC-V instruction-set architecture

SCIENTIFIC DESCRIPTION: Comet is a RISC-V pipelined processor with data/instruction caches, fully developed using High-Level Synthesis. The behavior of the core is defined in a small C code which is then fed into a HLS tool to generate the RTL representation. Thanks to this design flow, the C description can be used as a fast and cycle-accurate simulator, which behaves exactly like the final hardware. Moreover, modifications in the core can be done easily at the C level.

- Participants: Simon Rokicki, Steven Derrien, Olivier Sentieys, Davide Pala, Joseph Paturel
- Partners: Université de Rennes 1
- URL: https://gitlab.inria.fr/srokicki/Comet

5.4.6. *TypEx*

KEYWORDS: Embedded systems, Fixed-point arithmetic, Floating-point, Low power consumption, Energy efficiency, FPGA, ASIC, Accuracy optimization, Automatic floating-point to fixed-point conversion

SCIENTIFIC DESCRIPTION: TypEx is a tool designed to automatically determine custom number representations and word-lengths (i.e., bit-width) for FPGAs and ASIC designs at the C source level. The main goal of TypEx is to explore the design space spanned by possible number formats in the context of High-Level Synthesis. TypEx takes a C code written using floating-point datatypes specifying the application to be explored. The tool also takes as inputs a cost model as well as some user constraints and generates a C code where the floating-point datatypes are replaced by the wordlengths found after exploration. The best set of word-lengths is the one found by the tool that respects the given accuracy constraint and that minimizes a parametrized cost function. Figure 3 presents an overview of the TypEx design flow.

- Participants: Olivier Sentieys, Tomofumi Yuki, Van-Phu Ha
- Partners: Université de Rennes 1
- URL: https://gitlab.inria.fr/gecos/gecos-float2fix

Application
Description

C Code (float)+pragmas

Cost
model

**Type
Exploration**

**Fixed-Point
Floating-Point**

MSE
PSNR
SSIM

Accuracy
constraint

GeCoS
Generic Compiler Suite

C++ Code
Customized Arithmetic
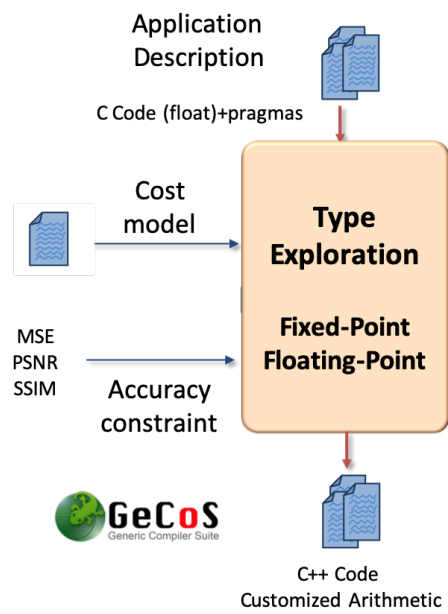
Figure 3. TypEx: a tool for type exploration and automatic floating-point to fixed-point conversion

CAMBIUM Project-Team

5. New Software and Platforms

5.1. OCaml

KEYWORDS: Functional programming - Static typing - Compilation

FUNCTIONAL DESCRIPTION: The OCaml language is a functional programming language that combines safety with expressiveness through the use of a precise and flexible type system with automatic type inference. The OCaml system is a comprehensive implementation of this language, featuring two compilers (a bytecode compiler, for fast prototyping and interactive use, and a native-code compiler producing efficient machine code for x86, ARM, PowerPC and System Z), a debugger, a documentation generator, a compilation manager, a package manager, and many libraries contributed by the user community.

- Participants: Damien Doligez, Xavier Leroy, Fabrice Le Fessant, Luc Maranget, Gabriel Scherer, Alain Frisch, Jacques Garrigue, Marc Shinwell, Jeremy Yallop and Leo White
- Contact: Damien Doligez
- URL: https://ocaml.org/

5.2. Compcert

The CompCert formally-verified C compiler

KEYWORDS: Compilers - Formal methods - Deductive program verification - C - Coq

FUNCTIONAL DESCRIPTION: CompCert is a compiler for the C programming language. Its intended use is the compilation of life-critical and mission-critical software written in C and meeting high levels of assurance. It accepts most of the ISO C 99 language, with some exceptions and a few extensions. It produces machine code for the ARM, PowerPC, RISC-V, and x86 architectures. What sets CompCert C apart from any other production compiler, is that it is formally verified to be exempt from miscompilation issues, using machine-assisted mathematical proofs (the Coq proof assistant). In other words, the executable code it produces is proved to behave exactly as specified by the semantics of the source C program. This level of confidence in the correctness of the compilation process is unprecedented and contributes to meeting the highest levels of software assurance. In particular, using the CompCert C compiler is a natural complement to applying formal verification techniques (static analysis, program proof, model checking) at the source code level: the correctness proof of CompCert C guarantees that all safety properties verified on the source code automatically hold as well for the generated executable.

RELEASE FUNCTIONAL DESCRIPTION: Novelties include a formally-verified type checker for CompCert C, a more careful modeling of pointer comparisons against the null pointer, algorithmic improvements in the handling of deeply nested struct and union types, much better ABI compatibility for passing composite values, support for GCC-style extended inline asm, and more complete generation of DWARF debugging information (contributed by AbsInt).

- Participants: Xavier Leroy, Sandrine Blazy, Jacques-Henri Jourdan, Sylvie Boldo and Guillaume Melquiond
- Partner: AbsInt Angewandte Informatik GmbH
- Contact: Xavier Leroy
- URL: http://compcert.inria.fr/

5.3. Diy

Do It Yourself

KEYWORD: Parallelism

FUNCTIONAL DESCRIPTION: The diy suite provides a set of tools for testing shared memory models: the litmus tool for running tests on hardware, various generators for producing tests from concise specifications, and herd, a memory model simulator. Tests are small programs written in x86, Power or ARM assembler that can thus be generated from concise specification, run on hardware, or simulated on top of memory models. Test results can be handled and compared using additional tools.

- Participants: Jade Alglave and Luc Maranget
- Partner: University College London UK
- Contact: Luc Maranget
- URL: http://diy.inria.fr/

5.4. Menhir

KEYWORDS: Compilation - Context-free grammars - Parsing

FUNCTIONAL DESCRIPTION: Menhir is a LR(1) parser generator for the OCaml programming language. That is, Menhir compiles LR(1) grammar specifications down to OCaml code. Menhir was designed and implemented by François Pottier and Yann Régis-Gianas.

- Contact: François Pottier
- Publications: A Simple, Possibly Correct LR Parser for C11 - Reachability and Error Diagnosis in LR(1) Parsers

5.5. CFML

Interactive program verification using characteristic formulae

KEYWORDS: Coq - Software Verification - Deductive program verification - Separation Logic

FUNCTIONAL DESCRIPTION: The CFML tool supports the verification of OCaml programs through interactive Coq proofs. CFML proofs establish the full functional correctness of the code with respect to a specification. They may also be used to formally establish bounds on the asymptotic complexity of the code. The tool is made of two parts: on the one hand, a characteristic formula generator implemented as an OCaml program that parses OCaml code and produces Coq formulae, and, on the other hand, a Coq library that provides notations and tactics for manipulating characteristic formulae interactively in Coq.

- Participants: Arthur Charguéraud, Armaël Guéneau and François Pottier
- Contact: Arthur Charguéraud
- URL: http://www.chargueraud.org/softs/cfml/

5.6. TLAPS

TLA+ proof system

KEYWORD: Proof assistant

SCIENTIFIC DESCRIPTION: TLAPS is a platform for developing and mechanically verifying proofs about TLA+ specifications. The TLA+ proof language is hierarchical and explicit, allowing a user to decompose the overall proof into proof steps that can be checked independently. TLAPS consists of a proof manager that interprets the proof language and generates a collection of proof obligations that are sent to backend verifiers. The current backends include the tableau-based prover Zenon for first-order logic, Isabelle/TLA+, an encoding of TLA+ set theory as an object logic in the logical framework Isabelle, an SMT backend designed for use with any SMT-lib compatible solver, and an interface to a decision procedure for propositional temporal logic.

FUNCTIONAL DESCRIPTION: TLAPS is a proof assistant for the TLA+ specification language.

NEWS OF THE YEAR: Work in 2019 focused on providing support for reasoning about TLA+'s ENABLED and action composition constructs. We also prepared a minor release, fixing some issues and switching to Z3 as the default SMT back-end solver.

- Participants: Damien Doligez, Stephan Merz and Ioannis Filippidis
- Contact: Stephan Merz
- URL: https://tla.msr-inria.inria.fr/tlaps/content/Home.html

5.7. ZENON

KEYWORD: Automated theorem proving

FUNCTIONAL DESCRIPTION: Zenon is an automatic theorem prover based on the tableaux method. Given a first-order statement as input, it outputs a fully formal proof in the form of a Coq proof script. It has special rules for efficient handling of equality and arbitrary transitive relations. Although still in the prototype stage, it already gives satisfying results on standard automatic-proving benchmarks.

Zenon is designed to be easy to interface with front-end tools (for example integration in an interactive proof assistant), and also to be retargeted to output scripts for different frameworks (for example, Isabelle and Dedukti).

- Author: Damien Doligez
- Contact: Damien Doligez
- URL: http://zenon-prover.org/

5.8. hevea

hevea is a fast latex to html translator.

KEYWORDS: LaTeX - Web

FUNCTIONAL DESCRIPTION: HEVEA is a LATEX to html translator. The input language is a fairly complete subset of LATEX 2 (old LATEX style is also accepted) and the output language is html that is (hopefully) correct with respect to version 5. HEVEA understands LATEX macro definitions. Simple user style files are understood with little or no modifications. Furthermore, HEVEA customisation is done by writing LATEX code.

HEVEA is written in Objective Caml, as many lexers. It is quite fast and flexible. Using HEVEA it is possible to translate large documents such as manuals, books, etc. very quickly. All documents are translated as one single html file. Then, the output file can be cut into smaller files, using the companion program HACHA. HEVEA can also be instructed to output plain text or info files.

Information on HEVEA is available at http://hevea.inria.fr/.

- Author: Luc Maranget
- Contact: Luc Maranget
- URL: http://hevea.inria.fr/

CAMUS Project-Team

6. New Software and Platforms

6.1. CLooG

Code Generator in the Polyhedral Model

KEYWORDS: Polyhedral compilation - Optimizing compiler - Code generator

FUNCTIONAL DESCRIPTION: CLooG is a free software and library to generate code (or an abstract syntax tree of a code) for scanning Z-polyhedra. That is, it finds a code (e.g. in C, FORTRAN...) that reaches each integral point of one or more parameterized polyhedra. CLooG has been originally written to solve the code generation problem for optimizing compilers based on the polyhedral model. Nevertheless it is used now in various area e.g. to build control automata for high-level synthesis or to find the best polynomial approximation of a function. CLooG may help in any situation where scanning polyhedra matters. While the user has full control on generated code quality, CLooG is designed to avoid control overhead and to produce a very effective code. CLooG is widely used (including by GCC and LLVM compilers), disseminated (it is installed by default by the main Linux distributions) and considered as the state of the art in polyhedral code generation.

RELEASE FUNCTIONAL DESCRIPTION: It mostly solves building and offers a better OpenScop support.

- Participant: Cédric Bastoul
- Contact: Cédric Bastoul
- URL: http://www.cloog.org

6.2. OpenScop

A Specification and a Library for Data Exchange in Polyhedral Compilation Tools

KEYWORDS: Polyhedral compilation - Optimizing compiler

FUNCTIONAL DESCRIPTION: OpenScop is an open specification that defines a file format and a set of data structures to represent a static control part (SCoP for short), i.e., a program part that can be represented in the polyhedral model. The goal of OpenScop is to provide a common interface to the different polyhedral compilation tools in order to simplify their interaction. To help the tool developers to adopt this specification, OpenScop comes with an example library (under 3-clause BSD license) that provides an implementation of the most important functionalities necessary to work with OpenScop.

- Participant: Cédric Bastoul
- Contact: Cédric Bastoul
- URL: http://icps.u-strasbg.fr/people/bastoul/public_html/development/openscop/

6.3. ORWL

Ordered Read-Write Lock

KEYWORDS: Task scheduling - Deadlock detection

FUNCTIONAL DESCRIPTION: ORWL is a reference implementation of the Ordered Read-Write Lock tools. The macro definitions and tools for programming in C99 that have been implemented for ORWL have been separated out into a toolbox called P99.

- Participants: Jens Gustedt, Mariem Saied and Stéphane Vialle
- Contact: Jens Gustedt
- Publications: Iterative Computations with Ordered Read-Write Locks - Automatic, Abstracted and Portable Topology-Aware Thread Placement - Resource-Centered Distributed Processing of Large Histopathology Images - Automatic Code Generation for Iterative Multi-dimensional Stencil Computations

6.4. musl

KEYWORDS: Standards - Library

SCIENTIFIC DESCRIPTION: musl provides consistent quality and implementation behavior from tiny embedded systems to full-fledged servers. Minimal machine-specific code means less chance of breakage on minority architectures and better success with "write once run everywhere" C development.

musl's efficiency is unparalleled in Linux libc implementations. Designed from the ground up for static linking, musl carefully avoids pulling in large amounts of code or data that the application will not use. Dynamic linking is also efficient, by integrating the entire standard library implementation, including threads, math, and even the dynamic linker itself into a single shared object, most of the startup time and memory overhead of dynamic linking have been eliminated.

FUNCTIONAL DESCRIPTION: We participate in the development of musl, a re-implementation of the C library as it is described by the C and POSIX standards. It is lightweight, fast, simple, free, and strives to be correct in the sense of standards-conformance and safety. Musl is production quality code that is mainly used in the area of embedded devices. It gains more market share also in other areas, e.g. there are now Linux distributions that are based on musl instead of Gnu LibC.

- Participant: Jens Gustedt
- Contact: Jens Gustedt
- URL: http://www.musl-libc.org/

6.5. Modular C

KEYWORDS: Programming language - Modularity

FUNCTIONAL DESCRIPTION: The change to the C language is minimal since we only add one feature, composed identifiers, to the core language. Our modules can import other modules as long as the import relation remains acyclic and a module can refer to its own identifiers and those of the imported modules through freely chosen abbreviations. Other than traditional C include, our import directive ensures complete encapsulation between modules. The abbreviation scheme allows to seamlessly replace an imported module by another one with an equivalent interface. In addition to the export of symbols, we provide parameterized code injection through the import of "snippets". This implements a mechanism that allows for code reuse, similar to X macros or templates. Additional features of our proposal are a simple dynamic module initialization scheme, a structured approach to the C library and a migration path for existing software projects.

- Author: Jens Gustedt
- Contact: Jens Gustedt
- Publications: Modular C - Arbogast: Higher order automatic differentiation for special functions with Modular C - Futex based locks for C11's generic atomics
- URL: http://cmod.gforge.inria.fr/

6.6. arbogast

KEYWORD: Automatic differentiation

SCIENTIFIC DESCRIPTION: This high-level toolbox for the calculus with Taylor polynomials is named after L.F.A. Arbogast (1759-1803), a French mathematician from Strasbourg (Alsace), for his pioneering work in derivation calculus. Its modular structure ensures unmatched efficiency for computing higher order Taylor polynomials. In particular it permits compilers to apply sophisticated vector parallelization to the derivation of nearly unmodified application code.

FUNCTIONAL DESCRIPTION: Arbogast is based on a well-defined extension of the C programming language, Modular C, and places itself between tools that proceed by operator overloading on one side and by rewriting, on the other. The approach is best described as contextualization of C code because it permits the programmer to place his code in different contexts – usual math or AD – to reinterpret it as a usual C function or as a differential operator. Because of the type generic features of modern C, all specializations can be delegated to the compiler.

- Author: Jens Gustedt
- Contact: Jens Gustedt
- Publications: Arbogast: Higher order automatic differentiation for special functions with Modular C - Arbogast – Origine d'un outil de dérivation automatique
- URL: https://gforge.inria.fr/projects/arbo

6.7. CFML

Interactive program verification using characteristic formulae

KEYWORDS: Coq - Software Verification - Deductive program verification - Separation Logic

FUNCTIONAL DESCRIPTION: The CFML tool supports the verification of OCaml programs through interactive Coq proofs. CFML proofs establish the full functional correctness of the code with respect to a specification. They may also be used to formally establish bounds on the asymptotic complexity of the code. The tool is made of two parts: on the one hand, a characteristic formula generator implemented as an OCaml program that parses OCaml code and produces Coq formulae, and, on the other hand, a Coq library that provides notations and tactics for manipulating characteristic formulae interactively in Coq.

- Participants: Arthur Charguéraud, Armaël Guéneau and François Pottier
- Contact: Arthur Charguéraud
- URL: http://www.chargueraud.org/softs/cfml/

6.8. SPETABARU

SPEculative TAsk-BAsed RUntime system

KEYWORDS: HPC - Parallel computing - Task-based algorithm

FUNCTIONAL DESCRIPTION: SPETABARU is a task-based runtime system for multi-core architectures that includes speculative execution models. It is a pure C++11 product without external dependency. It uses advanced meta-programming and allows for an easy customization of the scheduler. It is also capable to generate execution traces in SVG to better understand the behavior of the applications.

- Contact: Bérenger Bramas
- URL: https://gitlab.inria.fr/bramas/spetabaru

6.9. APAC

KEYWORDS: Source-to-source compiler - Automatic parallelization - Parallelisation - Parallel programming

SCIENTIFIC DESCRIPTION: APAC is a compiler for automatic parallelization that transforms C++ source code to make it parallel by inserting tasks. It uses the tasks+dependencies paradigm and relies on OpenMP or SPETABARU as runtime system. Internally, it is based on Clang-LLVM.

FUNCTIONAL DESCRIPTION: Automatic task-based parallelization compiler

- Participants: Bérenger Bramas, Stéphane Genaud and Garip Kusoglu
- Contact: Bérenger Bramas
- URL: https://gitlab.inria.fr/bramas/apac

6.10. Dagpar

KEYWORDS: Graph algorithmics - Clustering - Partitioning

SCIENTIFIC DESCRIPTION: This library is a clustering algorithm to create macro-tasks in a DAG of tasks. It extends a clustering/partitioning strategy proposed by Rossignon et al. to speed up the parallel execution of a task-based application. In this package, we provide two additional heuristics to this algorithm, which have been validated on a large graph set. The objective of clustering the nodes of task graphs is to increase the granularity of the tasks and thus obtain faster execution by mitigating the overhead from the management of the dependencies. An important asset of this approach is that working at the graph level allows us to create a generic method independent of the application and of what is done at the user level, but also independent of the task-based runtime system that could be used underneath.

FUNCTIONAL DESCRIPTION: Acyclic Dag Partitioning.

- Participants: Bérenger Bramas and Alain Ketterlin
- Contact: Bérenger Bramas
- URL: https://gitlab.inria.fr/bramas/dagpar

6.11. LetItBench

Lenient to Errors, Transformations, Irregularities and Turbulence Benchmarks

KEYWORDS: Approximate computing - Benchmarking

FUNCTIONAL DESCRIPTION: LetItBench is a benchmark set to help evaluating works on approximate compilation techniques. We propose a set of meaningful applications with an iterative kernel, that is not too complex for automatic analysis and can be analyzed by polyhedral tools. The benchmark set called LetItBench (Lenient to Errors, Transformations, Irregularities and Turbulence Benchmarks) is composed of standalone applications written in C, and a benchmark runner based on CMake. The benchmark set includes fluid simulation, FDTD, heat equations, game of life or K-means clustering. It spans various kind of applications that are resilient to approximation.

- Contact: Cédric Bastoul
- URL: https://github.com/Syllo/LetItBench

6.12. ACR

Adaptive Code Refinement

KEYWORDS: Approximate computing - Optimizing compiler

FUNCTIONAL DESCRIPTION: ACR is to approximate programming what OpenMP is to parallel programming. It is an API including a set of language extensions to provide the compiler with pertinent information about how to approximate a code block, a high-level compiler to automatically generate the approximated code, and a runtime library to exploit the approximation information at runtime according to the dataset properties. ACR is designed to provide approximate computing to non experts. The programmer may write a trivial code without approximation, provide approximation information thanks to pragmas, and let the compiler generate an optimized code based on approximation.

- Contact: Cédric Bastoul
- URL: https://github.com/Syllo/acr

6.13. APOLLO

Automatic speculative POLyhedral Loop Optimizer

KEYWORD: Automatic parallelization

FUNCTIONAL DESCRIPTION: APOLLO is dedicated to automatic, dynamic and speculative parallelization of loop nests that cannot be handled efficiently at compile-time. It is composed of a static part consisting of specific passes in the LLVM compiler suite, plus a modified Clang frontend, and a dynamic part consisting of a runtime system. It can apply on-the-fly any kind of polyhedral transformations, including tiling, and can handle nonlinear loops, as while-loops referencing memory through pointers and indirections.

- Participants: Aravind Sukumaran-Rajam, Juan Manuel Martinez Caamaño, Manuel Selva and Philippe Clauss
- Contact: Philippe Clauss
- URL: http://apollo.gforge.inria.fr

<p style="text-align:center;color:red;font-weight:bold;">CARAMBA Project-Team</p>

6. New Software and Platforms

6.1. Belenios

Belenios - Verifiable online voting system

KEYWORD: E-voting

FUNCTIONAL DESCRIPTION: Belenios is an open-source online voting system that provides confidentiality and verifiability. End-to-end verifiability relies on the fact that the ballot box is public (voters can check that their ballots have been received) and on the fact that the tally is publicly verifiable (anyone can recount the votes). Confidentiality relies on the encryption of the votes and the distribution of the decryption key.

Belenios builds upon Helios, a voting protocol used in several elections. The main design enhancement of Belenios vs. Helios is that the ballot box can no longer add (fake) ballots, due to the use of credentials. Moreover, Belenios includes a practical threshold decryption system that allows splitting the decryption key among several authorities.

NEWS OF THE YEAR: Since 2015, it has been used by CNRS for remote election among its councils (more than 30 elections every year) and since 2016, it has been used by Inria to elect representatives in the "comités de centre" of each Inria center. In 2018, it has been used to organize about 250 elections (not counting test elections). Belenios is typically used for elections in universities as well as in associations. This goes from laboratory councils (e.g. Irisa, Cran), scientific societies (e.g. SMAI) to various associations (e.g. FFBS - Fédération Française de Baseball et Softball, or SRFA - Société du Rat Francophone et de ses Amateurs).

In 2019, a threshold encryption mode has been added that makes the system more robust to the case where (say) one trustee among three loses her part of the decryption key.

- Participants: Pierrick Gaudry, Stéphane Glondu and Véronique Cortier
- Partners: CNRS - Inria
- Contact: Stéphane Glondu
- URL: http://www.belenios.org/

6.2. CADO-NFS

Crible Algébrique: Distribution, Optimisation - Number Field Sieve

KEYWORDS: Cryptography - Number theory

FUNCTIONAL DESCRIPTION: CADO-NFS is a complete implementation in C/C++ of the Number Field Sieve (NFS) algorithm for factoring integers and computing discrete logarithms in finite fields. It consists in various programs corresponding to all the phases of the algorithm, and a general script that runs them, possibly in parallel over a network of computers.

NEWS OF THE YEAR: The main program for relation collection now supports composite "special-q". The memory footprint of the central step of linear algebra was reduced. Parallelism of many of the Cado-NFS programs was improved considerably (sieving, relation filtering, as well as the central step of linear algebra).

- Participants: Pierrick Gaudry, Emmanuel Thomé and Paul Zimmermann
- Contact: Emmanuel Thomé
- URL: http://cado-nfs.gforge.inria.fr/

6.3. Platforms

6.3.1. *Platform: computational resources*

Since 2018, the CARAMBA team has been using in particular a computer cluster called `grvingt`, acquired in 2018. This equipment was funded by the CPER «CyberEntreprises» (French Ministry of Research, Région Grand Est, Inria, CNRS) and comprises a 64-node, 2,048-core cluster. This cluster is installed in the Inria facility. Other slightly older hardware (a medium-size cluster called `grcinq` from 2013, funded by ANR, and a special machine funded by the aforementioned CPER grant) is also installed in the same location, to form a coherent platform with about 3,000 cpu cores, 100 TB of storage, and specific machines for RAM-demanding computations. As a whole, this platform provides an excellent support for the computational part of the work done in CARAMBA. This platform is also embedded in the larger Grid'5000/Silecs platform (and accessible as a normal resource within this platform). Technical administration is done by the Grid'5000 staff.

This equipment has played a key role in the record factorization of RSA-240 as well as the computation of discrete logarithms modulo a 240-digit prime, completed in the end of 2019.

CASCADE Project-Team (section vide)

CASH Project-Team

5. New Software and Platforms

5.1. DCC

DPN C Compiler

KEYWORDS: Polyhedral compilation - Automatic parallelization - High-level synthesis

FUNCTIONAL DESCRIPTION: Dcc (Data-aware process network C compiler) analyzes a sequential regular program written in C and generates an equivalent architecture of parallel computer as a communicating process network (Data-aware Process Network, DPN). Internal communications (channels) and external communications (external memory) are automatically handled while fitting optimally the characteristics of the global memory (latency and throughput). The parallelism can be tuned. Dcc has been registered at the APP ("Agence de protection des programmes") and transferred to the XtremLogic start-up under an Inria license.

- Participants: Alexandru Plesco and Christophe Alias
- Contact: Christophe Alias

5.2. PoCo

Polyhedral Compilation Library

KEYWORDS: Polyhedral compilation - Automatic parallelization

FUNCTIONAL DESCRIPTION: PoCo (Polyhedral Compilation Library) is a compilation framework allowing to develop parallelizing compilers for regular programs. PoCo features many state-of-the-art polyhedral program analysis and a symbolic calculator on execution traces (represented as convex polyhedra). PoCo has been registered at the APP ("agence de protection des programmes") and transferred to the XtremLogic start-up under an Inria licence.

- Participant: Christophe Alias
- Contact: Christophe Alias

5.3. MPPcodegen

Source-to-source loop tiling based on MPP

KEYWORDS: Source-to-source compiler - Polyhedral compilation

FUNCTIONAL DESCRIPTION: MPPcodegen applies a monoparametric tiling to a C program enriched with pragmas specifying the tiling and the scheduling function. The tiling can be generated by any convex polyhedron and translation functions, it is not necessarily a partition. The result is a C program depending on a scaling factor (the parameter). MPPcodegen relies on the MPP mathematical library to tile the iteration sets.

- Partner: Colorado State University
- Contact: Christophe Alias
- URL: http://foobar.ens-lyon.fr/mppcodegen/

<p style="text-align:center">**CELTIQUE Project-Team**</p>

3. New Software and Platforms

3.1. CompcertSSA

KEYWORDS: Optimizing compiler - Formal methods - Proof assistant - SSA

FUNCTIONAL DESCRIPTION: CompcertSSA is built on top of the Compcert verified C compiler, by adding a middle-end based on the SSA form (Static Single Assignment) : conversion to SSA, SSA-based optimizations, and destruction of SSA.

- Participants: Sandrine Blazy, Delphine Demange, Yon Fernandez de Retana, David Pichardie and Leo Stefanesco
- Contact: Delphine Demange
- Publications: Mechanizing conventional SSA for a verified destruction with coalescing - Validating Dominator Trees for a Fast, Verified Dominance Test - A Formally Verified SSA-based Middle-end : Static Single Assignment meets CompCert - Formal Verification of an SSA-based Middle-end for CompCert - Verifying Fast and Sparse SSA-based Optimizations in Coq.
- URL: http://compcertssa.gforge.inria.fr/

3.2. Jacal

JAvaCard AnaLyseur

KEYWORDS: JavaCard - Certification - Static program analysis - AFSCM

FUNCTIONAL DESCRIPTION: Jacal is a JAvaCard AnaLyseur developed on top of the SAWJA platform. This proprietary software verifies automatically that Javacard programs conform with the security guidelines issued by the AFSCM (Association Française du Sans Contact Mobile). Jacal is based on the theory of abstract interpretation and combines several object-oriented and numeric analyses to automatically infer sophisticated invariants about the program behaviour. The result of the analysis is thereafter harvest to check that it is sufficient to ensure the desired security properties.

- Participants: David Pichardie, Delphine Demange, Frédéric Besson and Thomas Jensen
- Contact: Thomas Jensen

3.3. Javalib

KEYWORDS: Library - Java - Ocaml

FUNCTIONAL DESCRIPTION: Javalib is an efficient library to parse Java .class files into OCaml data structures, thus enabling the OCaml programmer to extract information from class files, to manipulate and to generate valid .class files.

- Participants: David Pichardie, Frédéric Besson, Laurent Guillo, Laurent Hubert, Nicolas Barré, Pierre Vittet and Tiphaine Turpin
- Contact: David Pichardie
- URL: http://sawja.inria.fr/

3.4. JSCert

Certified JavaScript

FUNCTIONAL DESCRIPTION: The JSCert project aims to really understand JavaScript. JSCert itself is a mechanised specification of JavaScript, written in the Coq proof assistant, which closely follows the ECMAScript 5 English standard. JSRef is a reference interpreter for JavaScript in OCaml , which has been proved correct with respect to JSCert and tested with the Test 262 test suite.

- Participants: Alan Schmitt and Martin Bodin
- Partner: Imperial College London
- Contact: Alan Schmitt
- URL: http://jscert.org/

3.5. SAWJA

Static Analysis Workshop for Java

KEYWORDS: Security - Software - Code review - Smart card

SCIENTIFIC DESCRIPTION: Sawja is a library written in OCaml, relying on Javalib to provide a high level representation of Java bytecode programs. It name comes from Static Analysis Workshop for JAva. Whereas Javalib is dedicated to isolated classes, Sawja handles bytecode programs with their class hierarchy and with control flow algorithms.

Moreover, Sawja provides some stackless intermediate representations of code, called JBir and A3Bir. The transformation algorithm, common to these representations, has been formalized and proved to be semantics-preserving.

See also the web page http://sawja.inria.fr/ .

Version: 1.5

Programming language: Ocaml

FUNCTIONAL DESCRIPTION: Sawja is a toolbox for developing static analysis of Java code in bytecode format. Sawja provides advanced algorithms for reconstructing high-level programme representations. The SawjaCard tool dedicated to JavaCard is based on the Sawja infrastructure and automatically validates the security guidelines issued by AFSCM (http://www.afscm.org/). SawjaCard can automate the code audit process and automatic verification of functional properties.

- Participants: David Pichardie, Frédéric Besson and Laurent Guillo
- Partners: CNRS - ENS Cachan
- Contact: David Pichardie
- URL: http://sawja.inria.fr/

3.6. Timbuk

KEYWORDS: Automated deduction - Ocaml - Program verification - Tree Automata - Term Rewriting Systems

FUNCTIONAL DESCRIPTION: Timbuk is a tool designed to compute or over-approximate sets of terms reachable by a given term rewriting system. The libray also provides an OCaml toplevel with all usual functions on Bottom-up Nondeterministic Tree Automata.

- Participant: Thomas Genet
- Contact: Thomas Genet
- URL: http://people.irisa.fr/Thomas.Genet/timbuk/index.html

3.7. jsexplain

JSExplain

KEYWORDS: JavaScript - Compilation - Standards - Debug - Interpreter

FUNCTIONAL DESCRIPTION: JSExplain is a reference interpreter for JavaScript that closely follows the specification and that produces execution traces. These traces may be interactively investigated in a browser, with an interface that displays not only the code and the state of the interpreter, but also the code and the state of the interpreted program. Conditional breakpoints may be expressed with respect to both the interpreter and the interpreted program. In that respect, JSExplain is a double-debugger for the specification of JavaScript.

- Partner: Imperial College London
- Contact: Alan Schmitt
- Publication: JSExplain: A Double Debugger for JavaScript
- URL: https://gitlab.inria.fr/star-explain/jsexplain

CIDRE Project-Team

5. New Software and Platforms

5.1. Blare

To detect intrusion using information flows

KEYWORDS: Cybersecurity - Intrusion Detection Systems (IDS) - Data Leakage Protection

SCIENTIFIC DESCRIPTION: Blare implements our approach of illegal information flow detection for a single node (Android and Linux kernel, JVM) and a set of nodes (monitoring of flows between linux machines).

FUNCTIONAL DESCRIPTION: Blare IDS is a set of tools that implements our approach to illegal information flow detection for a single node and a set of nodes.

NEWS OF THE YEAR: During this year, Laurent Georget has modified the implementation of Blare in order to correctly monitor the kernel system calls with LSM hooks. He add also ported this new version of Blare to the Lollipop Android emulator.

- Partner: CentraleSupélec
- Contact: Frédéric Tronel
- Publications: Information Flow Tracking for Linux Handling Concurrent System Calls and Shared Memory - Verifying the Reliability of Operating System-Level Information Flow Control Systems in Linux - Monitoring both OS and program level information flows to detect intrusions against network servers - Experimenting a Policy-Based HIDS Based on an Information Flow Control Model - Introducing reference flow control for intrusion detection at the OS level - Blare Tools: A Policy-Based Intrusion Detection System Automatically Set by the Security Policy - Diagnosing intrusions in Android operating system using system flow graph - Intrusion detection in distributed systems, an approach based on taint marking - BSPL: A Language to Specify and Compose Fine-grained Information Flow Policies - Information Flow Policies vs Malware - A taint marking approach to confidentiality violation detection - Designing information flow policies for Android's operating system - Information Flow Control for Intrusion Detection derived from MAC Policy - Flow based interpretation of access control: Detection of illegal information flows - A taint marking approach to confidentiality violation detection
- URL: http://www.blare-ids.org

5.2. GroddDroid

KEYWORDS: Android - Detection - Malware

SCIENTIFIC DESCRIPTION: GroddDroid automates the dynamic analysis of a malware. When a piece of suspicious code is detected, groddDroid interacts with the user interface and eventually forces the execution of the identified code. Using Blare (Information Flow Monitor), GroddDroid monitors how an execution contaminates the operating system. The output of GroddDroid can be visualized in an web browser. GroddDroid is used by the Kharon software.

FUNCTIONAL DESCRIPTION: GroddDroid 1 - locates suspicious code in Android application 2 - computes execution paths towards suspicious code 3 - forces executions of suspicious code 4 - automate the execution of a malware or a regular Android application

NEWS OF THE YEAR: In 2017, GroddDroid has integrated the work of Mourad Leslous, who have implemented GFinder. GPFinder improves the computation of control flow paths by taking into account the Android framework. The end of the year has been used to clean the code and to improves the graphical interface.

- Authors: Mourad Leslous, Adrien Abraham, Pierre Graux, Jean François Lalande, Valérie Viet Triem Tong and Pierre Wilke
- Partners: CentraleSupélec - Insa Centre Val-de-Loire
- Contact: Valérie Viet Triem Tong
- Publications: Kharon dataset: Android malware under a microscope - GroddDroid: a Gorilla for Triggering Malicious Behaviors - GPFinder: Tracking the Invisible in Android Malware - Information flows at OS level unmask sophisticated Android malware
- URL: http://kharon.gforge.inria.fr/grodddroid.html

5.3. HardBlare

KEYWORDS: Intrusion Detection Systems (IDS) - FPGA - Static analysis

FUNCTIONAL DESCRIPTION: HardBlare is a hardware/software framework to implement hardware DIFC on Xilinx Zynq Platform. HardBlare consists of three components : 1) the VHDL code of the coprocessor, 2) a modified LLVM compiler to compute the static analysis, and 3) a dedicated Linux kernel. This last component is a specific version of the Blare monitor.

- Partners: CentraleSupélec - Lab-STICC
- Contact: Guillaume Hiet
- Publications: ARMHEx: A hardware extension for DIFT on ARM-based SoCs - ARMHEx: a framework for efficient DIFT in real-world SoCs - ARMHEx: embedded security through hardware-enhanced information flow tracking - HardBlare: a Hardware-Assisted Approach for Dynamic Information Flow Tracking - A portable approach for SoC-based Dynamic Information Flow Tracking implementations - Towards a hardware-assisted information flow tracking ecosystem for ARM processors - HardBlare: an efficient hardware-assisted DIFC for non-modified embedded processors

5.4. GroddViewer

KEYWORDS: Android - Detection - Malware

FUNCTIONAL DESCRIPTION: To visualise data from GroddDroid

- Authors: Jean-François Lalande, Valérie Viet Triem Tong, Sébastien Campion, Mathieu Simon and Pierre Wilke
- Contact: Valérie Viet Triem Tong

5.5. Survivor

KEYWORDS: Intrusion Response - Intrusion Recovery - Survivability - Resiliency - Linux - Checkpoint/Restore - Threat Mitigation

FUNCTIONAL DESCRIPTION: Survivor is a set of low-level components to design a Linux-based operating system able to withstand ongoing intrusions and to allow business continuity despite the presence of an active adversary. Survivor provides an Intrusion Response System (IRS) with the low-level components and interfaces needed to orchestrate a per-service checkpoint, recovery, and mitigation actions. It recovers infected services (i.e., their processes and their associated files) to a previous safe state and it protects their state by applying a set of mitigations (e.g., privilege restrictions and resource quotas) aimed at withstanding further reinfections.

- Participants: Ronny Chevalier, Guillaume Hiet, David Plaquin and Chris Dalton
- Partners: CentraleSupélec - HP Labs
- Contact: Ronny Chevalier

5.6. PyMaO

Python Malware Orchestrator

KEYWORDS: Android - Malware

FUNCTIONAL DESCRIPTION: PyMaO chains several analyses that are part of an experiment. An analysis is most of the time, a call to an external tool that returns a result, for example apktool, grep, Androguard, Apkid. An experiment is a collection of analyses that are run one by one, chained, if some conditions hold. For example, if the unpacking of an application with Apktool succeeds, then you can grep the code for searching a string.

PyMaO has a nice old-fashion graphical interface (ncurses).

RELEASE FUNCTIONAL DESCRIPTION: Initial release corresponding to the demo presented at MASCOTS 2019.

NEWS OF THE YEAR: A demo has been presented at the MASCOTS 2019 conference: https://hal-centralesupelec.archives-ouvertes.fr/hal-02305473

- Authors: Jean-François Lalande, Pierre Graux and Tomas Javier Concepcion Miranda
- Contact: Jean-François Lalande
- URL: https://gitlab.inria.fr/cidre-public/pymao

5.7. OATs'inside

KEYWORDS: Android - Malware - Reverse engineering - Code analysis

FUNCTIONAL DESCRIPTION: OATs'inside is a Android reverse engineering tool that handles all native obfuscation techniques. This tool uses a hybrid approach based on dynamic monitoring and trace-based symbolic execution to output control flow graphs (CFGs) for each method of the analyzed application. These CFGs spare users the need to dive into low-level instructions, which are difficult to reverse engineer.

- Participants: Pierre Graux, Jean-François Lalande, Valérie Viet Triem Tong and Pierre Wilke
- Contact: Pierre Graux

COMETE Project-Team

6. New Software and Platforms

6.1. libqif - A Quantitative Information Flow C++ Toolkit Library

KEYWORDS: Information leakage - Privacy - C++ - Linear optimization

FUNCTIONAL DESCRIPTION: The goal of libqif is to provide an efficient C++ toolkit implementing a variety of techniques and algorithms from the area of quantitative information flow and differential privacy. We plan to implement all techniques produced by Comète in recent years, as well as several ones produced outside the group, giving the ability to privacy researchers to reproduce our results and compare different techniques in a uniform and efficient framework.

Some of these techniques were previously implemented in an ad-hoc fashion, in small, incompatible with each-other, non-maintained and usually inefficient tools, used only for the purposes of a single paper and then abandoned. We aim at reimplementing those – as well as adding several new ones not previously implemented – in a structured, efficient and maintainable manner, providing a tool of great value for future research. Of particular interest is the ability to easily re-run evaluations, experiments and case-studies from all our papers, which will be of great value for comparing new research results in the future.

The library's development continued in 2018 with several new added features. 82 new commits were pushed to the project's git repository during this year. The new functionality was directly applied to the exeperimental results of several publications of the team (QEST'18, Entropy'18, POST'18, CSF'18).

- Contact: Konstantinos Chatzikokolakis
- URL: https://github.com/chatziko/libqif

6.2. F-BLEAU

KEYWORDS: Information leakage - Machine learning - Privacy

FUNCTIONAL DESCRIPTION: F-BLEAU is a tool for estimating the leakage of a system about its secrets in a black-box manner (i.e., by only looking at examples of secret inputs and respective outputs). It considers a generic system as a black-box, taking secret inputs and returning outputs accordingly, and it measures how much the outputs "leak" about the inputs.

F-BLEAU is based on the equivalence between estimating the error of a Machine Learning model of a specific class and the estimation of information leakage.

This code was also used for the experiments of a paper under submission, on the following evaluations: Gowalla, e-passport, and side channel attack to finite field exponentiation.

RELEASE FUNCTIONAL DESCRIPTION: First F-BLEAU release. Supports frequentist and k-NN estimates with several parameters, and it allows stopping according to delta-convergence criteria.

- Contact: Konstantinos Chatzikokolakis
- URL: https://github.com/gchers/fbleau

6.3. Location Guard

KEYWORDS: Privacy - Geolocation - Browser Extensions

SCIENTIFIC DESCRIPTION: The purpose of Location Guard is to implement obfuscation techniques for achieving location privacy, in a an easy and intuitive way that makes them available to the general public. Various modern applications, running either on smartphones or on the web, allow third parties to obtain the user's location. A smartphone application can obtain this information from the operating system using a system call, while web application obtain it from the browser using a JavaScript call.

FUNCTIONAL DESCRIPTION: Websites can ask the browser for your location (via JavaScript). When they do so, the browser first asks your permission, and if you accept, it detects your location (typically by transmitting a list of available wifi access points to a geolocation provider such as Google Location Services, or via GPS if available) and gives it to the website.

Location Guard is a browser extension that intercepts this procedure. The permission dialog appears as usual, and you can still choose to deny. If you give permission, then Location Guard obtains your location and adds "random noise" to it, creating a fake location. Only the fake location is then given to the website.

Location Guard is by now a stable tool with a large user base. No new features were added in 2018, however the tool is still actively maintained, and several issues have beed fixed during this year (new geocoder API, manual installation method for Opera users, etc).

- Participants: Catuscia Palamidessi, Konstantinos Chatzikokolakis, Marco Stronati, Miguel Andrés and Nicolas Bordenabe
- Contact: Konstantinos Chatzikokolakis
- URL: https://github.com/chatziko/location-guard

6.4. dspacenet

Distributed-Spaces Network.

KEYWORDS: Social networks - Distributed programming

FUNCTIONAL DESCRIPTION: DSpaceNet is a tool for social networking based on multi-agent spatial and timed concurrent constraint language.

I - The fundamental structure of DSPaceNet is that of *space*: A space may contain

(1) spatial-mobile-reactive tcc programs, and (2) other spaces.

Furthermore, (3) each space belongs to a given agent. Thus, a space of an agent j within the space of agent i means that agent i allows agent j to use a computation sub-space within its space.

II - The fundamental operation of DSPaceNet is that of *program posting*: In each time unit, agents can post spatial-mobile-reactive tcc programs in the spaces they are allowed to do so (ordinary message posting corresponds to the posting of tell processes). Thus, an agent can for example post a watchdog tcc process to react to messages in their space, e.g. whenever (*happy b*frank*) do tell("thank you!"). More complex mobile programs are also allowed (see below).

The language of programs is a spatial mobile extension of tcc programs:

$P, Q... := tell(c) | when\ c\ do\ P || next\ P | P || Q | unless\ c\ next\ P | [P]_i | \uparrow_i P | rec\ X.P$

Computation of timed processes proceeds as in tcc. The spatial construct $[P]_i$ runs P in the space of agent i and the mobile process $\uparrow_i P$, extrudes P from the space of i. By combining space and mobility, arbitrary processes can be moved from one a space into another. For example, one could send a trojan watchdog to another space for spying for a given message and report back to one's space.

III- Constraint systems can be used to specify advance text message deduction, arithmetic deductions, scheduling, etc.

IV - Epistemic Interpretation of spaces can be used to derive whether they are users with conflicting/inconsistent information, or whether a group of agents may be able to deduce certain message.

V - The scheduling of agent requests for program posts, privacy settings, friendship lists are handled by an external interface. For example, one could use type systems to check whether a program complies with privacy settings (for example checking that the a program does not move other program into a space it is not allowed into).

- Partner: Pontificia Universidad Javeriana Cali
- Contact: Frank Valencia
- URL: http://www.dspacenet.com

<p align="center" style="color:red">**CONVECS Project-Team**</p>

6. New Software and Platforms

6.1. CADP

Construction and Analysis of Distributed Processes

KEYWORDS: Formal methods - Verification

FUNCTIONAL DESCRIPTION: CADP (*Construction and Analysis of Distributed Processes* – formerly known as *CAESAR/ALDEBARAN Development Package*) [5] is a toolbox for protocols and distributed systems engineering.

In this toolbox, we develop and maintain the following tools:

- CAESAR.ADT [34] is a compiler that translates LOTOS abstract data types into C types and C functions. The translation involves pattern-matching compiling techniques and automatic recognition of usual types (integers, enumerations, tuples, etc.), which are implemented optimally.

- CAESAR [40], [39] is a compiler that translates LOTOS processes into either C code (for rapid prototyping and testing purposes) or finite graphs (for verification purposes). The translation is done using several intermediate steps, among which the construction of a Petri net extended with typed variables, data handling features, and atomic transitions.

- OPEN/CAESAR [35] is a generic software environment for developing tools that explore graphs on the fly (for instance, simulation, verification, and test generation tools). Such tools can be developed independently of any particular high level language. In this respect, OPEN/CAESAR plays a central role in CADP by connecting language-oriented tools with model-oriented tools. OPEN/CAESAR consists of a set of 16 code libraries with their programming interfaces, such as:

  – CAESAR_GRAPH, which provides the programming interface for graph exploration,

  – CAESAR_HASH, which contains several hash functions,

  – CAESAR_SOLVE, which resolves Boolean equation systems on the fly,

  – CAESAR_STACK, which implements stacks for depth-first search exploration, and

  – CAESAR_TABLE, which handles tables of states, transitions, labels, etc.

A number of on-the-fly analysis tools have been developed within the OPEN/CAESAR environment, among which:

  – BISIMULATOR, which checks bisimulation equivalences and preorders,

  – CUNCTATOR, which performs steady-state simulation of continuous-time Markov chains,

  – DETERMINATOR, which eliminates stochastic nondeterminism in normal, probabilistic, or stochastic systems,

  – DISTRIBUTOR, which generates the graph of reachable states using several machines,

  – EVALUATOR, which evaluates MCL formulas,

  – EXECUTOR, which performs random execution,

  – EXHIBITOR, which searches for execution sequences matching a given regular expression,

  – GENERATOR, which constructs the graph of reachable states,

  – PROJECTOR, which computes abstractions of communicating systems,

- REDUCTOR, which constructs and minimizes the graph of reachable states modulo various equivalence relations,
- SIMULATOR, XSIMULATOR, and OCIS, which enable interactive simulation, and
- TERMINATOR, which searches for deadlock states.

- BCG (*Binary Coded Graphs*) is both a file format for storing very large graphs on disk (using efficient compression techniques) and a software environment for handling this format. BCG also plays a key role in CADP as many tools rely on this format for their inputs/outputs. The BCG environment consists of various libraries with their programming interfaces, and of several tools, such as:
  - BCG_CMP, which compares two graphs,
  - BCG_DRAW, which builds a two-dimensional view of a graph,
  - BCG_EDIT, which allows the graph layout produced by BCG_DRAW to be modified interactively,
  - BCG_GRAPH, which generates various forms of practically useful graphs,
  - BCG_INFO, which displays various statistical information about a graph,
  - BCG_IO, which performs conversions between BCG and many other graph formats,
  - BCG_LABELS, which hides and/or renames (using regular expressions) the transition labels of a graph,
  - BCG_MIN, which minimizes a graph modulo strong or branching equivalences (and can also deal with probabilistic and stochastic systems),
  - BCG_STEADY, which performs steady-state numerical analysis of (extended) continuous-time Markov chains,
  - BCG_TRANSIENT, which performs transient numerical analysis of (extended) continuous-time Markov chains, and
  - XTL (*eXecutable Temporal Language*), which is a high level, functional language for programming exploration algorithms on BCG graphs. XTL provides primitives to handle states, transitions, labels, *successor* and *predecessor* functions, etc.

    For instance, one can define recursive functions on sets of states, which allow evaluation and diagnostic generation fixed point algorithms for usual temporal logics (such as HML [43], CTL [32], ACTL [33], etc.) to be defined in XTL.

- PBG (*Partitioned BCG Graph*) is a file format implementing the theoretical concept of *Partitioned LTS* [38] and providing a unified access to a graph partitioned in fragments distributed over a set of remote machines, possibly located in different countries. The PBG format is supported by several tools, such as:
  - PBG_CP, PBG_MV, and PBG_RM, which facilitate standard operations (copying, moving, and removing) on PBG files, maintaining consistency during these operations,
  - PBG_MERGE (formerly known as BCG_MERGE), which transforms a distributed graph into a monolithic one represented in BCG format,
  - PBG_INFO, which displays various statistical information about a distributed graph.

- The connection between explicit models (such as BCG graphs) and implicit models (explored on the fly) is ensured by OPEN/CAESAR-compliant compilers, e.g.:
  - BCG_OPEN, for models represented as BCG graphs,
  - CAESAR.OPEN, for models expressed as LOTOS descriptions,
  - EXP.OPEN, for models expressed as communicating automata,
  - FSP.OPEN, for models expressed as FSP [45] descriptions,
  - LNT.OPEN, for models expressed as LNT descriptions, and
  - SEQ.OPEN, for models represented as sets of execution traces.

The CADP toolbox also includes TGV (*Test Generation based on Verification*), which has been developed by the VERIMAG laboratory (Grenoble) and Inria Rennes – Bretagne-Atlantique.

The CADP tools are well-integrated and can be accessed easily using either the EUCALYPTUS graphical interface or the SVL [36] scripting language. Both EUCALYPTUS and SVL provide users with an easy and uniform access to the CADP tools by performing file format conversions automatically whenever needed and by supplying appropriate command-line options as the tools are invoked.

- Participants: Hubert Garavel, Frédéric Lang, Radu Mateescu and Wendelin Serwe
- Contact: Hubert Garavel
- URL: http://cadp.inria.fr/

6.2. TRAIAN

KEYWORDS: Compilation - LOTOS NT

FUNCTIONAL DESCRIPTION: TRAIAN is a compiler for translating LOTOS NT descriptions into C programs, which will be used for simulation, rapid prototyping, verification, and testing.

The current version of TRAIAN, which handles LOTOS NT types and functions only, has useful applications in compiler construction [37], being used in all recent compilers developed by CONVECS.

- Participants: Hubert Garavel, Frédéric Lang and Wendelin Serwe
- Contact: Hubert Garavel
- URL: http://convecs.inria.fr/software/traian/

CORSE Project-Team

5. New Software and Platforms

5.1. Verde

KEYWORDS: Debug - Verification

FUNCTIONAL DESCRIPTION: Interactive Debugging with a traditional debugger can be tedious. One has to manually run a program step by step and set breakpoints to track a bug.

i-RV is an approach to bug fixing that aims to help developpers during their Interactive Debbugging sessions using Runtime Verification.

Verde is the reference implementation of i-RV.

- Participants: Kevin Pouget, Ylies Falcone, Raphael Jakse and Jean-François Méhaut
- Contact: Raphael Jakse
- Publication: Interactive Runtime Verification - When Interactive Debugging meets Runtime Verification
- URL: https://gitlab.inria.fr/monitoring/verde

5.2. Mickey

KEYWORDS: Dynamic Analysis - Performance analysis - Profiling - Polyhedral compilation

FUNCTIONAL DESCRIPTION: Mickey is a set of tools for profiling based performance debugging for compiled binaries. It uses a dynamic binary translator to instrument arbitrary programs as they are being run to reconstruct the control flow and track data dependencies. This information is then fed to a polyhedral optimizer that proposes structured transformations for the original code.

Mickey can handle both inter- and intra-procedural control and data flow in a unified way, thus enabling inter-procedural structured transformations. It is based on QEMU to allow for portability, both in terms of targeted CPU architectures, but also in terms of programming environment and the use of third-party libraries for which no source code is available.

- Partner: STMicroelectronics
- Contact: Fabrice Rastello
- Publications: hal-02060796v1 - hal-01967828v2

5.3. GUS

KEYWORDS: CPU - Microarchitecture simulation - Performance analysis - Dynamic Analysis

FUNCTIONAL DESCRIPTION: GUS' goal is to detect performance bottlenecks at the very low level on monothread applications by the use of sensitivity analysis. It is coded as a QEMU plug-in in order to collect runtime information that are later treated by the generic CPU model.

- Contact: Nicolas Derumigny
- URL: https://gitlab.inria.fr/nderumig/gus

5.4. Pipedream

KEYWORDS: Performance analysis - CPU - Reverse engineering

SCIENTIFIC DESCRIPTION: Pipedream reverse engineers the following performance characteristics: - Instruction latency – The number of cycles an instruction requires to execute. - Peak micro-op retirement rate – How many fused micro-ops the CPU can retire per cycle. - Micro-fusion – The number of fused micro-ops an instruction decomposes into. - Micro-op decomposition and micro-op port usage – The list of unfused micro-ops every instruction decomposes into and the list of execution ports every one of these micro-ops can execute on.

The first step of the reverse engineering process consists of generating a number of microbenchmarks. Pipedream then runs these benchmark, measuring their performance using hardware counters. The latency, throughput, and micro-fusion of different instructions can then be read directly from these measurements.

The process of finding port mappings, i.e. micro-op decompositions and micro-op port usage, however, is more involved. For this purpose, we have defined a variation of the maximum flow problem which we call the "instruction flow problem". We have developed a linear program (LP) formulation of the instruction flow problem which can be used to calculate the peak IPC and micro-operations per cycle (MPC) a benchmark kernel can theoretically achieve with a given port mapping. The actual port mapping of the underlying hardware is then determined by finding the mapping for which the throughput predicted by instruction flow best matches the actual measured IPC and MPC.

FUNCTIONAL DESCRIPTION: Pipedream is a tool for measuring specific performance characteristics of CPUs It is used to build the performance model of another tool called Gus (https://gitlab.inria.fr/nderumig/gus). Pipedream finds measured performance characteristics such as the throughput and latency of instructions by running a large set of automatically generated microbenchmarks. The tool can also find port mappings, a model of part of the CPU instruction scheduler, by analysing performance measurements of specially crafted microkernels using a LP solver. We have used it to produce a port mapping for the Intel Skylake CPU architecture. Pipedream is able to find the port mappings for some instructions for which existing approaches fall back to manual analysis.

- Contact: Nicolas Derumigny
- URL: https://gitlab.inria.fr/fgruber/pipedream

5.5. Platforms

5.5.1. *Grid'5000*

Grid'5000 [0] is a large-scale and versatile testbed for experiment-driven research in all areas of computer science, with a focus on parallel and distributed computing including Cloud, HPC and Big Data. It provides access to a large amount of resources: 14828 cores, 829 compute-nodes grouped in homogeneous clusters located in 8 sites in France connected through a dedicated network (Renater), and featuring various technologies (GPU, SSD, NVMe, 10G and 25G Ethernet, Infiniband, Omni-Path) and advanced monitoring and measurement features for traces collection of networking and power consumption, providing a deep understanding of experiments. It is highly reconfigurable and controllable. Researchers can experiment with a fully customized software stack thanks to bare-metal deployment features, and can isolate their experiment at the networking layer advanced monitoring and measurement features for traces collection of networking and power consumption, providing a deep understanding of experiments designed to support Open Science and reproducible research, with full traceability of infrastructure and software changes on the testbed. Frédéric Desprez is director of the GRID5000 GIS.

5.5.2. *SILECS/SLICES*

Frédéric Desprez is co-PI with Serge Fdida (Université Sorbonne) of the SILECS [0] infrastructure (IR ministère) which goal is to provide an experimental platform for experimental computer Science (Internet of things, clouds, HPC, big data, IA, wireless technologies, ...). This new infrastructure is based on two existing infrastructures, Grid'5000 and FIT. A European infrastructure (SLICES) is also currently designed with other european partners (Spain, Cyprus, Greece, Netherland, Switzerland, Poland, ...).

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[0]https://www.grid5000.fr/
[0]https://www.silecs.net/

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DATASHAPE Project-Team

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4. New Software and Platforms

4.1. GUDHI

Geometric Understanding in Higher Dimensions

KEYWORDS: Computational geometry - Topology

SCIENTIFIC DESCRIPTION: The current release of the GUDHI library includes: – Data structures to represent, construct and manipulate simplicial and cubical complexes. – Algorithms to compute simplicial complexes from point cloud data. – Algorithms to compute persistent homology and multi-field persistent homology. – Simplification methods via implicit representations.

FUNCTIONAL DESCRIPTION: The GUDHI open source library will provide the central data structures and algorithms that underly applications in geometry understanding in higher dimensions. It is intended to both help the development of new algorithmic solutions inside and outside the project, and to facilitate the transfer of results in applied fields.

NEWS OF THE YEAR: - Cover complex - Representation of persistence diagrams - Cech complex - weighted periodic 3d alpha-complex - sparse Rips complex - debian / docker / conda-forge packages

- Participants: Clément Maria, François Godi, David Salinas, Jean-Daniel Boissonnat, Marc Glisse, Mariette Yvinec, Pawel Dlotko, Siargey Kachanovich, Vincent Rouvreau, Mathieu Carrière and Bertrand Michel
- Contact: Jean-Daniel Boissonnat
- URL: https://gudhi.inria.fr/

4.2. CGAL module: interval arithmetics

KEYWORD: Arithmetic

FUNCTIONAL DESCRIPTION: This package of CGAL (Computational Geometry Algorithms Library http://www.cgal.org) provides an efficient number type for intervals of double and the corresponding arithmetic operations. It is used in the evaluation of geometric predicates for a first quick computation, which either provides the result with guarantees, or rarely answers that more precision is needed.

RELEASE FUNCTIONAL DESCRIPTION: Partial rewrite to take advantage of SIMD instructions on recent x86 processors.

- Contact: Marc Glisse
- URL: https://www.cgal.org/

4.3. CGAL module: interface to Boost.Multiprecision

KEYWORD: Arithmetic

FUNCTIONAL DESCRIPTION: This package of CGAL (Computational Geometry Algorithms Library http://www.cgal.org) makes it possible to use some number types from Boost.Multiprecision in CGAL.

- Author: Marc Glisse
- Contact: Marc Glisse
- URL: https://www.cgal.org/

4.4. Module CGAL: New dD Geometry Kernel

KEYWORD: Computational geometry

FUNCTIONAL DESCRIPTION: This package of CGAL (Computational Geometry Algorithms Library http://www.cgal.org) provides the basic geometric types (point, vector, etc) and operations (orientation test, etc) used by geometric algorithms in arbitrary dimension. It uses filters for efficient exact predicates.

RELEASE FUNCTIONAL DESCRIPTION: New kernel with lazy exact constructions.

- Author: Marc Glisse
- Contact: Marc Glisse
- URL: http://www.cgal.org/

<p style="text-align:center;color:red;">DATASPHERE Team</p>

5. New Software and Platforms

5.1. DNS data analysis

Data analytics tools for DNS data analysis were developed in a cooperation with ICT, Chinese Academy of Sciences in the frame of the thesis of Jingxiu SU.

5.1.1. BGP Monitoring platform

An observatory of global BGP connectivity has been developed that is used to monitor and detect in real time BGP level attacks. In addition, a set of tools were developed to analyse the structure of information propagation over social networks.

5.1.2. Atlas of Data

A platform to visualize data flows over the planet is under construction. It can be accessed online at https://theatlasofdata.earth/.

5.1.3. Observatory of foreign influence on social media

This observatory is monitoring on twitter and facebook the evolution of foreign influence. It is based on a twitter collection platform that is using an extensive database of foreign actors to detect and monitor foreign interference.

DEDUCTEAM Project-Team

5. New Software and Platforms

5.1. Autotheo

KEYWORD: Automated deduction

SCIENTIFIC DESCRIPTION: Transformation of axiomatic theories into rewriting systems that can be used by iProverModulo.

FUNCTIONAL DESCRIPTION: Autotheo is a tool that transforms axiomatic theories into polarized rewriting systems, thus making them usable in iProverModulo. It supports several strategies to orient the axioms, some of them being proved to be complete, in the sense that ordered polarized resolution modulo the resulting systems is refutationally complete, some others being merely heuristics. In practice, Autotheo takes a TPTP input file and produces an input file for iProverModulo.

NEWS OF THE YEAR: Maintenance.

- Participant: Guillaume Burel
- Partner: ENSIIE
- Contact: Guillaume Burel
- Publication: Consistency Implies Cut Admissibility
- URL: http://www.ensiie.fr/~guillaume.burel/blackandwhite_autotheo.html.en

5.2. CoLoR

Coq Library on Rewriting and termination

KEYWORDS: Coq - Formalisation

FUNCTIONAL DESCRIPTION: CoLoR is a Coq library on rewriting theory and termination. It provides many definitions and theorems on various mathematical structures (quasi-ordered sets, relations, ordered semi-rings, etc.), data structures (lists, vectors, matrices, polynomials, finite graphs), term structures (strings, first-order terms, lambda-terms, etc.), transformation techniques (dependency pairs, semantic labeling, etc.) and (non-)termination criteria (polynomial and matrix interpretations, recursive path ordering, computability closure, etc.).

- Authors: Frédéric Blanqui and Sébastien Hinderer
- Contact: Frédéric Blanqui
- Publications: CoLoR: a Coq library on well-founded rewrite relations and its application to the automated verification of termination certificates - Automated Verification of Termination Certificates - CoLoR: a Coq library on rewriting and termination
- URL: http://color.inria.fr/

5.3. Coqine

Coq In dEdukti

KEYWORDS: Higher-order logic - Formal methods - Proof

FUNCTIONAL DESCRIPTION: CoqInE is a plugin for the Coq software translating Coq proofs into Dedukti terms. It provides a Dedukti signature file faithfully encoding the underlying theory of Coq (or a sufficiently large subset of it). Current development is mostly focused on implementing support for Coq universe polymorphism. The generated ouput is meant to be type-checkable using the latest version of Dedukti.

- Contact: Guillaume Burel
- URL: http://www.ensiie.fr/~guillaume.burel/blackandwhite_coqInE.html.en

5.4. Dedukti

KEYWORD: Logical Framework

FUNCTIONAL DESCRIPTION: Dedukti is a proof-checker for the LambdaPi-calculus modulo. As it can be parametrized by an arbitrary set of rewrite rules, defining an equivalence relation, this calculus can express many different theories. Dedukti has been created for this purpose: to allow the interoperability of different theories.

Dedukti's core is based on the standard algorithm for type-checking semi-full pure type systems and implements a state-of-the-art reduction machine inspired from Matita's and modified to deal with rewrite rules.

Dedukti's input language features term declarations and definitions (opaque or not) and rewrite rule definitions. A basic module system allows the user to organize his project in different files and compile them separately.

Dedukti features matching modulo beta for a large class of patterns called Miller's patterns, allowing for more rewriting rules to be implemented in Dedukti.

NEWS OF THE YEAR: There has been a new release 2.6 in 2018. This release provides a better control on module loading, and a better log of rewrite steps.

- Participants: François Thiré, Gaspard Ferey, Guillaume Genestier and Rodolphe Lepigre
- Contact: François Thiré
- Publications: Dedukti:un vérificateur de preuves universel - Rewriting Modulo β in the $\lambda\,\Pi$-Calculus Modulo - Expressing theories in the $\lambda\Pi$-calculus modulo theory and in the Dedukti system
- URL: https://deducteam.github.io/

5.5. Holide

KEYWORD: Proof

FUNCTIONAL DESCRIPTION: Holide translates HOL proofs to Dedukti[OT] proofs, using the OpenTheory standard (common to HOL Light and HOL4). Dedukti[OT] being the encoding of OpenTheory in Dedukti.

- Contact: Guillaume Burel
- URL: http://deducteam.gforge.inria.fr/holide/

5.6. HOT

Higher-Order Termination

FUNCTIONAL DESCRIPTION: HOT is an automated termination prover for higher-order rewriting, based on the notion of computability closure.

- Contact: Frédéric Blanqui
- URL: http://rewriting.gforge.inria.fr/hot.html

5.7. iProver Modulo

KEYWORDS: Automated deduction - Automated theorem proving

SCIENTIFIC DESCRIPTION: Integration of ordered polarized resolution modulo theory into the prover iProver.

FUNCTIONAL DESCRIPTION: iProver Modulo is an extension of the automated theorem prover iProver originally developed by Konstantin Korovin at the University of Manchester. It implements ordered polarized resolution modulo theory, a refinement of the resolution method based on deduction modulo theory. It takes as input a proposition in predicate logic and a clausal rewriting system defining the theory in which the formula has to be proved. Normalization with respect to the term rewriting rules is performed very efficiently through translation into OCaml code, compilation and dynamic linking. Experiments have shown that ordered polarized resolution modulo dramatically improves proof search compared to using raw axioms.

NEWS OF THE YEAR: Maintenance of Dedukti output

- Participant: Guillaume Burel
- Partner: ENSIIE
- Contact: Guillaume Burel
- Publications: A Shallow Embedding of Resolution and Superposition Proofs into the ??-Calculus Modulo - Experimenting with deduction modulo
- URL: https://github.com/gburel/iProverModulo

5.8. mSAT

KEYWORD: Propositional logic

FUNCTIONAL DESCRIPTION: mSAT is a modular, proof-producing, SAT and SMT core based on Alt-Ergo Zero, written in OCaml. The solver accepts user-defined terms, formulas and theory, making it a good tool for experimenting. This tool produces resolution proofs as trees in which the leaves are user-defined proof of lemmas.

- Contact: Guillaume Bury
- Publication: mSAT:An OCaml SAT Solver
- URL: https://github.com/Gbury/mSAT

5.9. Rainbow

Termination certificate verifier

KEYWORDS: Demonstration - Code generation - Verification

FUNCTIONAL DESCRIPTION: Rainbow is a set of tools for automatically verifying the correctness of termination certificates expressed in the CPF format used in the annual international competition of termination tools. It contains: a tool xsd2coq for generating Coq data types for representing XML files valid with respect to some XML Schema, a tool xsd2ml for generating OCaml data types and functions for parsing XML files valid with respect to some XML Schema, a tool for translating a CPF file into a Coq script, and a standalone Coq certified tool for verifying the correctness of a CPF file.

- Author: Frédéric Blanqui
- Contact: Frédéric Blanqui
- Publications: Automated verification of termination certificates - Automated verification of termination certificates
- URL: http://color.inria.fr/rainbow.html

5.10. Krajono

KEYWORD: Proof

FUNCTIONAL DESCRIPTION: Krajono translates Matita proofs into Dedukti[CiC] (encoding of CiC in Dedukti) terms.

- Contact: François Thiré

5.11. archsat

KEYWORDS: Automated theorem proving - First-order logic - Propositional logic

FUNCTIONAL DESCRIPTION: Archsat is an automated theorem prover aimed at studying the integration of first-order theorem prover technologies, such as rewriting, into SMT solvers.

- Contact: Guillaume Bury
- URL: https://gforge.inria.fr/projects/archsat

5.12. lrat2dk

KEYWORDS: Automated theorem proving - Proof

FUNCTIONAL DESCRIPTION: Take as input a SAT proof trace in LRAT format, which can be obtained from the de facto standard format DRAT using drat-trim. Output a proof checkable by Dedukti, in a shallow encoding of propositional logic.

- Participant: Guillaume Burel
- Partner: ENSIIE
- Contact: Guillaume Burel
- URL: https://github.com/gburel/lrat2dk

5.13. ekstrakto

KEYWORDS: TPTP - TSTP - Proof assistant - Dedukti

FUNCTIONAL DESCRIPTION: Extracting TPTP problems from a TSTP trace. Proof reconstruction in Dedukti from TSTP trace.

- Contact: Mohamed Yacine El Haddad
- URL: https://github.com/elhaddadyacine/ekstrakto

5.14. SizeChangeTool

KEYWORDS: Rewriting systems - Proof assistant - Termination

FUNCTIONAL DESCRIPTION: A termination-checker for higher-order rewriting with dependent types. Took part in the Termination Competition 2018 (http://termination-portal.org/wiki/Termination_Competition_2018) in the "Higher-Order Rewriting (union Beta)" category.

- Partner: Mines ParisTech
- Contact: Guillaume Genestier
- URL: https://github.com/Deducteam/SizeChangeTool

5.15. Logipedia

KEYWORDS: Formal methods - Web Services - Logical Framework

FUNCTIONAL DESCRIPTION: Logipedia is composed of two distinct parts: 1) A back-end that translates proofs expressed in a theory encoded in Dedukti to other systems such as Coq, Lean or HOL 2) A front-end that prints these proofs in a "nice way" via a website. Using the website, the user can search for a definition or a theorem then, download the whole proof into the wanted system.

Currently, the available systems are: Coq, Matita, Lean, PVS and OpenTheory. The proofs comes from a logic called STTForall.

In the long run, more systems and more logic should be added.

RELEASE FUNCTIONAL DESCRIPTION: This is the beta version of Logipedia. It implements the functionalities mentioned above.

- Contact: François Thiré
- URL: http://www.logipedia.science

GALLINETTE Project-Team

5. New Software and Platforms

5.1. Coq

The Coq Proof Assistant

KEYWORDS: Proof - Certification - Formalisation

SCIENTIFIC DESCRIPTION: Coq is an interactive proof assistant based on the Calculus of (Co-)Inductive Constructions, extended with universe polymorphism. This type theory features inductive and co-inductive families, an impredicative sort and a hierarchy of predicative universes, making it a very expressive logic. The calculus allows to formalize both general mathematics and computer programs, ranging from theories of finite structures to abstract algebra and categories to programming language metatheory and compiler verification. Coq is organised as a (relatively small) kernel including efficient conversion tests on which are built a set of higher-level layers: a powerful proof engine and unification algorithm, various tactics/decision procedures, a transactional document model and, at the very top an IDE.

FUNCTIONAL DESCRIPTION: Coq provides both a dependently-typed functional programming language and a logical formalism, which, altogether, support the formalisation of mathematical theories and the specification and certification of properties of programs. Coq also provides a large and extensible set of automatic or semi-automatic proof methods. Coq's programs are extractable to OCaml, Haskell, Scheme, ...

RELEASE FUNCTIONAL DESCRIPTION: Coq version 8.10 contains two major new features: support for a native fixed-precision integer type and a new sort SProp of strict propositions. It is also the result of refinements and stabilization of previous features, deprecations or removals of deprecated features, cleanups of the internals of the system and API, and many documentation improvements. This release includes many user-visible changes, including deprecations that are documented in the next subsection, and new features that are documented in the reference manual.

Version 8.10 is the fifth release of Coq developed on a time-based development cycle. Its development spanned 6 months from the release of Coq 8.9. Vincent Laporte is the release manager and maintainer of this release. This release is the result of 2500 commits and 650 PRs merged, closing 150+ issues.

See the Zenodo citation for more information on this release: https://zenodo.org/record/3476303#.Xe54f5NKjOQ

NEWS OF THE YEAR: Coq 8.10.0 contains:

- some quality-of-life bug fixes, - a critical bug fix related to template polymorphism, - native 63-bit machine integers, - a new sort of definitionally proof-irrelevant propositions: SProp, - private universes for opaque polymorphic constants, - string notations and numeral notations, - a new simplex-based proof engine for the tactics lia, nia, lra and nra, - new introduction patterns for SSReflect, - a tactic to rewrite under binders: under, - easy input of non-ASCII symbols in CoqIDE, which now uses GTK3.

All details can be found in the user manual.

- Participants: Yves Bertot, Frédéric Besson, Maxime Denes, Emilio Jesús Gallego Arias, Gaëtan Gilbert, Jason Gross, Hugo Herbelin, Assia Mahboubi, Érik Martin-Dorel, Guillaume Melquiond, Pierre-Marie Pédrot, Michael Soegtrop, Matthieu Sozeau, Enrico Tassi, Laurent Théry, Théo Zimmermann, Theo Winterhalter, Vincent Laporte, Arthur Charguéraud, Cyril Cohen, Christian Doczkal and Chantal Keller
- Partners: CNRS - Université Paris-Sud - ENS Lyon - Université Paris-Diderot
- Contact: Matthieu Sozeau
- URL: http://coq.inria.fr/

5.2. Math-Components

Mathematical Components library

KEYWORD: Proof assistant

FUNCTIONAL DESCRIPTION: The Mathematical Components library is a set of Coq libraries that cover the prerequiste for the mechanization of the proof of the Odd Order Theorem.

RELEASE FUNCTIONAL DESCRIPTION: The library includes 16 more theory files, covering in particular field and Galois theory, advanced character theory, and a construction of algebraic numbers.

- Participants: Alexey Solovyev, Andrea Asperti, Assia Mahboubi, Cyril Cohen, Enrico Tassi, François Garillot, Georges Gonthier, Ioana Pasca, Jeremy Avigad, Laurence Rideau, Laurent Théry, Russell O'Connor, Sidi Ould Biha, Stéphane Le Roux and Yves Bertot
- Contact: Assia Mahboubi
- URL: http://math-comp.github.io/math-comp/

5.3. Ssreflect

FUNCTIONAL DESCRIPTION: Ssreflect is a tactic language extension to the Coq system, developed by the Mathematical Components team.

- Participants: Assia Mahboubi, Cyril Cohen, Enrico Tassi, Georges Gonthier, Laurence Rideau, Laurent Théry and Yves Bertot
- Contact: Yves Bertot
- URL: http://math-comp.github.io/math-comp/

5.4. Ltac2

KEYWORDS: Coq - Proof assistant

FUNCTIONAL DESCRIPTION: A replacement for Ltac, the tactic language of Coq.

- Contact: Pierre-Marie Pédrot

GAMBLE Project-Team

6. New Software and Platforms

6.1. CGAL Package : 2D periodic hyperbolic triangulations

KEYWORDS: Geometry - Delaunay triangulation - Hyperbolic space

FUNCTIONAL DESCRIPTION: This module implements the computation of Delaunay triangulations of the Bolza surface.

NEWS OF THE YEAR: Integration into CGAL 4.14

- Authors: Iordan Iordanov and Monique Teillaud
- Contact: Monique Teillaud
- Publication: Implementing Delaunay Triangulations of the Bolza Surface
- URL: https://doc.cgal.org/latest/Manual/packages.html#PkgPeriodic4HyperbolicTriangulation2

6.2. CGAL Package : 2D hyperbolic triangulations

KEYWORDS: Geometry - Delaunay triangulation - Hyperbolic space

FUNCTIONAL DESCRIPTION: This package implements the construction of Delaunay triangulations in the Poincaré disk model.

NEWS OF THE YEAR: Integration into CGAL 4.14

- Participants: Mikhail Bogdanov, Olivier Devillers, Iordan Iordanov and Monique Teillaud
- Contact: Monique Teillaud
- Publication: Hyperbolic Delaunay Complexes and Voronoi Diagrams Made Practical
- URL: https://doc.cgal.org/latest/Manual/packages.html#PkgHyperbolicTriangulation2

6.3. clenshaw

KEYWORDS: Numerical solver - Visualization - Polynomial equations

FUNCTIONAL DESCRIPTION: Clenshaw is a mixed C and python library that provides computation and plotting functions for the solutions of polynomial equations in the Taylor or the Chebyshev basis. The library is optimized for machine double precision and for numerically well-conditioned polynomials. In particular, it can find the roots of polynomials with random coefficients of degree one million.

- Contact: Guillaume Moroz
- URL: https://gitlab.inria.fr/gmoro/clenshaw

6.4. voxelize

KEYWORDS: Visualization - Curve plotting - Implicit surface - Polynomial equations

FUNCTIONAL DESCRIPTION: Voxelize is a C++ software to visualize the solutions of polynomial equations and inequalities. The software is optimized for high degree curves and surfaces. Internally, polynomials and sets of boxes are stored in the Compressed Sparse Fiber format. The output is either a mesh or a union of boxes written in the standard 3D file format ply.

RELEASE FUNCTIONAL DESCRIPTION: This is the first published version.

- Contact: Guillaume Moroz
- URL: https://gitlab.inria.fr/gmoro/voxelize

<p style="text-align:center; color:red;">**GRACE Project-Team**</p>

5. New Software and Platforms

5.1. ACTIS

Algorithmic Coding Theory in Sage

FUNCTIONAL DESCRIPTION: The aim of this project is to vastly improve the state of the error correcting library in Sage. The existing library does not present a good and usable API, and the provided algorithms are very basic, irrelevant, and outdated. We thus have two directions for improvement: renewing the APIs to make them actually usable by researchers, and incorporating efficient programs for decoding, like J. Nielsen's CodingLib, which contains many new algorithms.

- Partner: Technical University Denmark
- Contact: Daniel Augot

5.2. DECODING

KEYWORD: Algebraic decoding

FUNCTIONAL DESCRIPTION: Decoding is a standalone C library. Its primary goal is to implement Guruswami–Sudan list decoding-related algorithms, as efficiently as possible. Its secondary goal is to give an efficient tool for the implementation of decoding algorithms (not necessarily list decoding algorithms) and their benchmarking.

- Participant: Guillaume Quintin
- Contact: Daniel Augot

5.3. Fast Compact Diffie-Hellman

KEYWORD: Cryptography

FUNCTIONAL DESCRIPTION: A competitive, high-speed, open implementation of the Diffie–Hellman protocol, targeting the 128-bit security level on Intel platforms. This download contains Magma files that demonstrate how to compute scalar multiplications on the x-line of an elliptic curve using endomorphisms. This accompanies the EuroCrypt 2014 paper by Costello, Hisil and Smith, the full version of which can be found here: http://eprint.iacr.org/2013/692. The corresponding SUPERCOP-compatible crypto_dh application can be downloaded from http://hhisil.yasar.edu.tr/files/hisil20140318compact.tar.gz.

- Participant: Ben Smith
- Contact: Ben Smith
- URL: http://research.microsoft.com/en-us/downloads/ef32422a-af38-4c83-a033-a7aafbc1db55/

5.4. CADO-NFS

Crible Algébrique: Distribution, Optimisation - Number Field Sieve

KEYWORDS: Cryptography - Number theory

FUNCTIONAL DESCRIPTION: CADO-NFS is a complete implementation in C/C++ of the Number Field Sieve (NFS) algorithm for factoring integers and computing discrete logarithms in finite fields. It consists in various programs corresponding to all the phases of the algorithm, and a general script that runs them, possibly in parallel over a network of computers.

NEWS OF THE YEAR: The main program for relation collection now supports composite "special-q". The memory footprint of the central step of linear algebra was reduced. Parallelism of many of the Cado-NFS programs was improved considerably (sieving, relation filtering, as well as the central step of linear algebra).

- Participants: Pierrick Gaudry, Emmanuel Thomé and Paul Zimmermann
- Contact: Emmanuel Thomé
- URL: http://cado-nfs.gforge.inria.fr/

<p align="center" style="color:red">HYCOMES Project-Team</p>

5. New Software and Platforms

5.1. Demodocos

Demodocos (Examples to Generic Scenario Models Generator)

KEYWORDS: Surgical process modelling - Net synthesis - Process mining

SCIENTIFIC DESCRIPTION: Demodocos is used to construct a Test and Flip net (Petri net variant) from a collection of instances of a given procedure. The tool takes as input either standard XES log files (a standard XML file format for process mining tools) or a specific XML file format for surgical applications. The result is a Test and Flip net and its marking graph. The tool can also build a #SEVEN scenario for integration into a virtual reality environment. The scenario obtained corresponds to the generalization of the input instances, namely the instances synthesis enriched with new behaviors respecting the relations of causality, conflicts and competition observed.

Demodocos is a synthesis tool implementing a linear algebraic polynomial time algorithm. Computations are done in the Z/2Z ring. Test and Flip nets extend Elementary Net Systems by allowing test to zero, test to one and flip arcs. The effect of flip arcs is to complement the marking of the place. While the net synthesis problem has been proved to be NP hard for Elementary Net Systems, thanks to flip arcs, the synthesis of Test and Flip nets can be done in polynomial time. Test and flip nets have the required expressivity to give concise and accurate representations of surgical processes (models of types of surgical operations). Test and Flip nets can express causality and conflict relations. The tool takes as input either standard XES log files (a standard XML file format for process mining tools) or a specific XML file format for surgical applications. The output is a Test and Flip net, solution of the following synthesis problem: Given a finite input language (log file), compute a net, which language is the least language in the class of Test and Flip net languages, containing the input language.

FUNCTIONAL DESCRIPTION: The tool Demodocos allows to build a generic model for a given procedure from some examples of instances of this procedure. The generated model can take the form of a graph, a Test 'n Flip net or a SEVEN scenario (intended for integration into a virtual reality environment).

The classic use of the tool is to apply the summary operation to a set of files describing instances of the target procedure. Several file formats are supported, including the standard XES format for log events. As output, several files are generated. These files represent the generic procedure in different forms, responding to varied uses.

This application is of limited interest in the case of an isolated use, out of context and without a specific objective when using the model generated. It was developed as part of a research project focusing in particular on surgical procedures, and requiring the generation of a generic model for integration into a virtual reality training environment. It is also quite possible to apply the same method in another context.

- Participants: Aurélien Lamercerie and Benoît Caillaud
- Contact: Benoît Caillaud
- Publication: Surgical Process Mining with Test and Flip Net Synthesis

5.2. MICA

Model Interface Compositional Analysis Library

KEYWORDS: Modal interfaces - Contract-based desing

SCIENTIFIC DESCRIPTION: In Mica, systems and interfaces are represented by extension. However, a careful design of the state and event heap enables the definition, composition and analysis of reasonably large systems and interfaces. The heap stores states and events in a hash table and ensures structural equality (there is no duplication). Therefore complex data-structures for states and events induce a very low overhead, as checking equality is done in constant time.

Thanks to the Inter module and the mica interactive environment, users can define complex systems and interfaces using Ocaml syntax. It is even possible to define parameterized components as Ocaml functions.

FUNCTIONAL DESCRIPTION: Mica is an Ocaml library implementing the Modal Interface algebra. The purpose of Modal Interfaces is to provide a formal support to contract based design methods in the field of system engineering. Modal Interfaces enable compositional reasoning methods on I/O reactive systems.

- Participant: Benoît Caillaud
- Contact: Benoît Caillaud
- URL: http://www.irisa.fr/s4/tools/mica/

5.3. IsamDAE

Implicit Structural Analysis of Multimode DAE systems

KEYWORDS: Structural analysis - Differential algebraic equations - Multimode - Scheduling

SCIENTIFIC DESCRIPTION: Modeling languages and tools based on Differential Algebraic Equations (DAE) bring several specific issues that do not exist with modeling languages based on Ordinary Differential Equations. The main problem is the determination of the differentiation index and latent equations. Prior to generating simulation code and calling solvers, the compilation of a model requires a structural analysis step, which reduces the differentiation index to a level acceptable by numerical solvers.

The Modelica language, among others, allows hybrid models with multiple modes, mode-dependent dynamics and state-dependent mode switching. These Multimode DAE (mDAE) systems are much harder to deal with. The main difficulties are (i) the combinatorial explosion of the number of modes, and (ii) the correct handling of mode switchings.

The aim of the software is on the first issue, namely: How can one perform a structural analysis of an mDAE in all possible modes, without enumerating these modes? A structural analysis algorithm for mDAE systems has been designed and implemented, based on an implicit representation of the varying structure of an mDAE. It generalizes J. Pryce's Sigma-method to the multimode case and uses Binary Decision Diagrams (BDD) to represent the mode-dependent structure of an mDAE. The algorithm determines, as a function of the mode, the set of latent equations, the leading variables and the state vector. This is then used to compute a mode-dependent block-triangular decomposition of the system, that can be used to generate simulation code with a mode-dependent scheduling of the blocks of equations.

FUNCTIONAL DESCRIPTION: IsamDAE (Implicit Structural Analysis of Multimode DAE systems) is a software library for testing new structural analysis algorithms for multimode DAE systems, based on an implicit representation of incidence graphs, matchings between equations and variables, and block decompositions. The input of the software is a variable dimension multimode DAE system consisting in a set of guarded equations and guarded variable declarations. It computes a mode-dependent structural index-reduction of the multimode system and produces a mode-dependent graph for the scheduling of blocks of equations. Evaluation functions make it possible to return the lists of leading equations and leading variables, as well as the actual scheduling of blocks, in a specified mode.

IsamDAE is coded in OCaml, and uses the following packages: * MLBDD by Arlen Cox, * Menhir by François Pottier and Yann Régis-Gianas, * Pprint by François Pottier, * XML-Light by Nicolas Cannasse and Jacques Garrigue.

RELEASE FUNCTIONAL DESCRIPTION: Version 0.2: * MEL: ad hoc language for the declaration of variable dimension multi-mode DAE systems * automatic parsing, model checking and model allocation * XML output for the list of evaluation blocks (parameters, equations, unknowns to be computed) * new algorithms for the mode-dependent scheduling and the evaluation of the scheduling in a given mode

NEWS OF THE YEAR: It has been possible to perform the structural analysis of systems with more than 750 equations and 10 to the power 23 modes, therefore demonstrating the scalability of the method.

- Authors: Benoît Caillaud and Mathias Malandain
- Contact: Benoît Caillaud

Kairos Project-Team

6. New Software and Platforms

6.1. VerCors

VERification of models for distributed communicating COmponants, with safety and Security

KEYWORDS: Software Verification - Specification language - Model Checking

FUNCTIONAL DESCRIPTION: The VerCors tools include front-ends for specifying the architecture and behaviour of components in the form of UML diagrams. We translate these high-level specifications, into behavioural models in various formats, and we also transform these models using abstractions. In a final step, abstract models are translated into the input format for various verification toolsets. Currently we mainly use the various analysis modules of the CADP toolset.

RELEASE FUNCTIONAL DESCRIPTION: It includes integrated graphical editors for GCM component architecture descriptions, UML classes, interfaces, and state-machines. The user diagrams can be checked using the recently published validation rules from, then the corresponding GCM components can be executed using an automatic generation of the application ADL, and skeletons of Java files.

The experimental version (2019) also includes algorithms for computing the symbolic semantics of Open Systems, using symbolic methods based on the Z3 SMT engine.

NEWS OF THE YEAR: The experimental version (2019) also includes: - algorithms for computing the symbolic semantics of Open Systems, using symbolic methods based on the Z3 SMT engine. - a stand alone textual editor for (open) pNet systems, that generates API code to construct their internal representation in the platform.

- Participants: Antonio Cansado, Bartlomiej Szejna, Eric Madelaine, Ludovic Henrio, Marcela Rivera, Nassim Jibai, Oleksandra Kulankhina, Siqi Li, Xudong Qin and Zechen Hou
- Partner: East China Normal University Shanghai (ECNU)
- Contact: Eric Madelaine
- URL: https://team.inria.fr/scale/software/vercors/

6.2. TimeSquare

KEYWORDS: Profil MARTE - Embedded systems - UML - IDM

SCIENTIFIC DESCRIPTION: TimeSquare offers six main functionalities:

* graphical and/or textual interactive specification of logical clocks and relative constraints between them,

* definition and handling of user-defined clock constraint libraries,

* automated simulation of concurrent behavior traces respecting such constraints, using a Boolean solver for consistent trace extraction,

* call-back mechanisms for the traceability of results (animation of models, display and interaction with waveform representations, generation of sequence diagrams...).

* compilation to pure java code to enable embedding in non eclipse applications or to be integrated as a time and concurrency solver within an existing tool.

* a generation of the whole state space of a specification (if finite of course) in order to enable model checking of temporal properties on it

FUNCTIONAL DESCRIPTION: TimeSquare is a software environment for the modeling and analysis of timing constraints in embedded systems. It relies specifically on the Time Model of the Marte UML profile, and more accurately on the associated Clock Constraint Specification Language (CCSL) for the expression of timing constraints.

- Participants: Benoît Ferrero, Charles André, Frédéric Mallet, Julien DeAntoni and Nicolas Chleq
- Contact: Julien DeAntoni
- URL: http://timesquare.inria.fr

6.3. GEMOC Studio

KEYWORDS: DSL - Language workbench - Model debugging

SCIENTIFIC DESCRIPTION: The language workbench put together the following tools seamlessly integrated to the Eclipse Modeling Framework (EMF):

- Melange, a tool-supported meta-language to modularly define executable modeling languages with execution functions and data, and to extend (EMF-based) existing modeling languages.
- MoCCML, a tool-supported meta-language dedicated to the specification of a Model of Concurrency and Communication (MoCC) and its mapping to a specific abstract syntax and associated execution functions of a modeling language.
- GEL, a tool-supported meta-language dedicated to the specification of the protocol between the execution functions and the MoCC to support the feedback of the data as well as the callback of other expected execution functions.
- BCOoL, a tool-supported meta-language dedicated to the specification of language coordination patterns to automatically coordinates the execution of, possibly heterogeneous, models.
- Sirius Animator, an extension to the model editor designer Sirius to create graphical animators for executable modeling languages.

FUNCTIONAL DESCRIPTION: The GEMOC Studio is an eclipse package that contains components supporting the GEMOC methodology for building and composing executable Domain-Specific Modeling Languages (DSMLs). It includes the two workbenches: The GEMOC Language Workbench: intended to be used by language designers (aka domain experts), it allows to build and compose new executable DSMLs. The GEMOC Modeling Workbench: intended to be used by domain designersto create, execute and coordinate models conforming to executable DSMLs. The different concerns of a DSML, as defined with the tools of the language workbench, are automatically deployed into the modeling workbench. They parametrize a generic execution framework that provide various generic services such as graphical animation, debugging tools, trace and event managers, timeline, etc.

- Participants: Didier Vojtisek, Dorian Leroy, Erwan Bousse, Fabien Coulon and Julien DeAntoni
- Partners: IRIT - ENSTA - I3S - OBEO - Thales TRT
- Contact: Benoît Combemale
- URL: http://gemoc.org/studio.html

6.4. BCOol

BCOoL

KEYWORDS: DSL - Language workbench - Behavior modeling - Model debugging - Model animation

FUNCTIONAL DESCRIPTION: BCOoL is a tool-supported meta-language dedicated to the specification of language coordination patterns to automatically coordinates the execution of, possibly heterogeneous, models.

- Participants: Julien DeAntoni, Matias Vara Larsen, Benoît Combemale and Didier Vojtisek
- Contact: Julien DeAntoni
- URL: http://www.gemoc.org

6.5. myMed

A geo-localised Framework for building Publish-Subscribe applications in a fixed and mobile environment

KEYWORDS: Framework - Peer-to-peer. - NoSQL - Mobile application - Social network - Publish-subscribe - Iot - Peer-to-peer

SCIENTIFIC DESCRIPTION: myMed : an ad-hoc framework to design, develop, host, and execute Publish-Subscribe based fully distributed applications running in a static or mobile network. Application examples can be found in Online Social Networks or in Resource Discovery for the IoT. In a nutshell myMed is composed by:

• A myMed Software Development Kit (SDK) to develop fixed and mobile web applications, but also to build native applications on Smartphones equipped with Android or iOS. Every module can be freely used without interfering with other applications, in a true Lego fashion.

• A myMed cloud to execute the mobile applications: the cloud is composed of a backbone of 50PCs, distributed through the "AlpMed" EuroRegion and following some precise network criteria (4G, optical Fiber, ..). The operating system running on those PC is a customised and partitioned version of Ubuntu to allow to use the PC as a myMed server as well as a ordinary desktops. As in Peer-to-Peer technology, we do not require that all machines belonging to the backbone are constantly running.

• A myMed backbone, based on a well-tested noSQL database, Cassandra, which can accommodate any number of users without any code changes. Machines can be classically concentrated on a data-center or – more interestingly – fully decentralized (modulo a decent internet connection). Failures of one or many machines do not affect the running of the system, thanks to replication of the data on several servers. A little collection of proof of concept applications to validate, experiment, and testing the development kit and the execution cloud have been implemented.

FUNCTIONAL DESCRIPTION: myMed is an experimental framework for implementing, hosting and deploying, on the top of a built-in cloud platform, many applications using intensively the Publish-Subscribe (PUB/SUB) paradigm, like e.g. Open Social Networks or Resource Discovery in a distributed data-base. Those applications could take advantage of sharing common software modules, hardware resources, making inter-communication and inter-interaction simpler and improving rapid development and deployement.

- Participants: Luigi Liquori, Claudio Casetti, Mariangiola Dezani and Mino Anglano
- Partners: Politecnico di Torino - Université de Nice Sophia Antipolis (UNS) - Università di Torino - Università del Piemonte Orientale
- Contact: Luigi Liquori
- URL: http://www.mymed.fr

6.6. JMaxGraph

KEYWORDS: Java - HPC - Graph algorithmics

FUNCTIONAL DESCRIPTION: JMaxGraph is a collection of techniques for the computation of large graphs on one single computer. The motivation for such a centralized computing platform originates in the constantly increasing efficiency of computers which now come with hundred gigabytes of RAM, tens of cores and fast drives. JMaxGraph implements a compact adjacency-table for the representation of the graph in memory. This data structure is designed to 1) be fed page by page, à-la GraphChi, 2) enable fast iteration, avoiding memory jumps as much as possible in order to benefit from hardware caches, 3) be tackled in parallel by multiple-threads. Also, JMaxGraph comes with a flexible and resilient batch-oriented middleware, which is suited to executing long computations on shared clusters. The first use-case of JMaxGraph allowed F. Giroire, T. Trolliet and S. Pérennes to count K2,2s, and various types of directed triangles in the Twitter graph of users (23G arcs, 400M vertices). The computation campaign took 4 days, using up to 400 cores in the NEF Inria cluster.

- Contact: Luc Hogie
- URL: http://www.i3s.unice.fr/~hogie/software/?name=jmaxgraph

6.7. Lopht

Logical to Physical Time Compiler

KEYWORDS: Real time - Compilation

SCIENTIFIC DESCRIPTION: The Lopht (Logical to Physical Time Compiler) has been designed as an implementation of the AAA methodology. Like SynDEx, Lopht relies on off-line allocation and scheduling techniques to allow real-time implementation of dataflow synchronous specifications onto multiprocessor systems. But there are several originality points: a stronger focus on efficiency, which results in the use of a compilation-like approach, a focus on novel target architectures (many-core chips and time-triggered embedded systems), and the possibility to handle multiple, complex non-functional requirements covering real-time (release dates and deadlines possibly different from period, major time frame, end-to-end flow constraints), ARINC 653 partitioning, the possibility to preempt or not each task, and finally SynDEx-like allocation.

FUNCTIONAL DESCRIPTION: Compilation of high-level embedded systems specifications into executable code for IMA/ARINC 653 avionics platforms. It ensures the functional and non-functional correctness of the generated code.

- Participants: Dumitru Potop-Butucaru, Manel Djemal, Thomas Carle and Zhen Zhang
- Contact: Dumitru Potop-Butucaru

6.8. LoPhT-manycore

Logical to Physical Time compiler for many cores

KEYWORDS: Real time - Compilation - Task scheduling - Automatic parallelization

SCIENTIFIC DESCRIPTION: Lopht is a system-level compiler for embedded systems, whose objective is to fully automate the implementation process for certain classes of embedded systems. Like in a classical compiler (e.g. gcc), its input is formed of two objects. The first is a program providing a platform-indepedent description of the functionality to implement and of the non-functional requirements it must satisfy (e.g. real-time, partitioning). This is provided under the form of a data-flow synchronous program annotated with non-functional requirements. The second is a description of the implementation platform, defining the topology of the platform, the capacity of its elements, and possibly platform-dependent requirements (e.g. allocation).

From these inputs, Lopht produces all the C code and configuration information needed to allow compilation and execution on the physical target platform. Implementations are correct by construction Resulting implementations are functionally correct and satisfy the non-functional requirements. Lopht-manycore is a version of Lopht targeting shared-memory many-core architectures.

The algorithmic core of Lopht-manycore is formed of timing analysis, allocation, scheduling, and code generation heuristics which rely on four fundamental choices. 1) A static (off-line) real-time scheduling approach where allocation and scheduling are represented using time tables (also known as scheduling or reservation tables). 2) Scalability, attained through the use of low-complexity heuristics for all synthesis and associated analysis steps. 3) Efficiency (of generated implementations) is attained through the use of precise representations of both functionality and the platform, which allow for fine-grain allocation of resources such as CPU, memory, and communication devices such as network-on-chip multiplexers. 4) Full automation, including that of the timing analysis phase.

The last point is characteristic to Lopht-manycore. Existing methods for schedulability analysis and real-time software synthesis assume the existence of a high-level timing characterization that hides much of the hardware complexity. For instance, a common hypothesis is that synchronization and interference costs are accounted for in the duration of computations. However, the high-level timing characterization is seldom (if ever) soundly derived from the properties of the platform and the program. In practice, large margins (e.g. 100%) with little formal justification are added to computation durations to account for hidden hardware complexity. Lopht-manycore overcomes this limitation. Starting from the worst-case execution time (WCET) estimations of

computation operations and from a precise and safe timing model of the platform, it maintains a precise timing accounting throughout the mapping process. To do this, timing accounting must take into account all details of allocation, scheduling, and code generation, which in turn must satisfy specific hypotheses.

FUNCTIONAL DESCRIPTION: Accepted input languages for functional specifications include dialects of Lustre such as Heptagon and Scade v4. To ensure the respect of real-time requirements, Lopht-manycore pilots the use of the worst-case execution time (WCET) analysis tool (ait from AbsInt). By doing this, and by using a precise timing model for the platform, Lopht-manycore eliminates the need to adjust the WCET values through the addition of margins to the WCET values that are usually both large and without formal safety guarantees. The output of Lopht-manycore is formed of all the multi-threaded C code and configuration information needed to allow compilation, linking/loading, and real-time execution on the target platform.

NEWS OF THE YEAR: In the framework of the ITEA3 ASSUME project we have extended the Lopht-manycore to allow multiple cores to access the same memory bank at the same time. To do this, the timing accounting of Lopht has been extended to take into account memory access interferences during the allocation and scheduling process. Lopht now also pilots the aiT static WCET analysis tool from AbsInt by generating the analysis scripts, thus ensuring the consistency between the hypotheses made by Lopht and the way timing analysis is performed by aiT. As a result, we are now able to synthesize code for the computing clusters of the Kalray MPPA256 platform. Lopht-manycore is evaluated on avionics case studies in the perspective of increasing its technology readiness level for this application class.

- Participants: Dumitru Potop-Butucaru and Keryan Didier
- Contact: Dumitru Potop-Butucaru

KOPERNIC Team

6. New Software and Platforms

6.1. SynDEx

KEYWORDS: Distributed - Optimization - Real time - Embedded systems - Scheduling analyses

SCIENTIFIC DESCRIPTION: SynDEx is a system level CAD software implementing the AAA methodology for rapid prototyping and for optimizing distributed real-time embedded applications. It is developed in OCaML.

Architectures are represented as graphical block diagrams composed of programmable (processors) and non-programmable (ASIC, FPGA) computing components, interconnected by communication media (shared memories, links and busses for message passing). In order to deal with heterogeneous architectures it may feature several components of the same kind but with different characteristics.

Two types of non-functional properties can be specified for each task of the algorithm graph. First, a period that does not depend on the hardware architecture. Second, real-time features that depend on the different types of hardware components, ranging amongst execution and data transfer time, memory, etc.. Requirements are generally constraints on deadline equal to period, latency between any pair of tasks in the algorithm graph, dependence between tasks, etc.

Exploration of alternative allocations of the algorithm onto the architecture may be performed manually and/or automatically. The latter is achieved by performing real-time multiprocessor schedulability analyses and optimization heuristics based on the minimization of temporal or resource criteria. For example while satisfying deadline and latency constraints they can minimize the total execution time (makespan) of the application onto the given architecture, as well as the amount of memory. The results of each exploration is visualized as timing diagrams simulating the distributed real-time implementation.

Finally, real-time distributed embedded code can be automatically generated for dedicated distributed real-time executives, possibly calling services of resident real-time operating systems such as Linux/RTAI or Osek for instance. These executives are deadlock-free, based on off-line scheduling policies. Dedicated executives induce minimal overhead, and are built from processor-dependent executive kernels. To this date, executives kernels are provided for: TMS320C40, PIC18F2680, i80386, MC68332, MPC555, i80C196 and Unix/Linux workstations. Executive kernels for other processors can be achieved at reasonable cost following these examples as patterns.

FUNCTIONAL DESCRIPTION: Software for optimising the implementation of embedded distributed real-time applications and generating efficient and correct by construction code

NEWS OF THE YEAR: We improved the distribution and scheduling heuristics to take into account the needs of co-simulation.

- Participant: Yves Sorel
- Contact: Yves Sorel
- URL: http://www.syndex.org

6.2. EVT Kopernic

KEYWORDS: Embedded systems - Worst Case Execution Time - Real-time application - Statistics

SCIENTIFIC DESCRIPTION: The EVT-Kopernic tool is an implementation of the Extreme Value Theory (EVT) for the problem of the statistical estimation of worst-case bounds for the execution time of a program on a processor. Our implementation uses the two versions of EVT - GEV and GPD - to propose two independent methods of estimation. Their results are compared and only results that are sufficiently close allow to validate an estimation. Our tool is proved predictable by its unique choice of block (GEV) and threshold (GPD) while proposant reproducible estimations.

FUNCTIONAL DESCRIPTION: EVT-Kopernic is tool proposing a statistical estimation for bounds on worst-case execution time of a program on a processor. The estimator takes into account dependences between execution times by learning from the history of execution, while dealing also with cases of small variability of the execution times.

NEWS OF THE YEAR: Any statistical estimator should come with an representative measurement protocole based on the processus of composition, proved correct. We propose the first such principle of composition while using a Bayesien modeling taking into account iteratively different measurement models. The composition model has been described in a patent submitted this year with a scientific publication under preparation.

- Participants: Adriana Gogonel and Liliana Cucu
- Contact: Adriana Gogonel
- URL: http://inria-rscript.serveftp.com/

<p align="center" style="color:red">**LFANT Project-Team**</p>

5. New Software and Platforms

5.1. APIP

Another Pairing Implementation in PARI

KEYWORDS: Cryptography - Computational number theory

SCIENTIFIC DESCRIPTION: Apip , Another Pairing Implementation in PARI, is a library for computing standard and optimised variants of most cryptographic pairings.

The following pairings are available: Weil, Tate, ate and twisted ate, optimised versions (à la Vercauteren–Hess) of ate and twisted ate for selected curve families.

The following methods to compute the Miller part are implemented: standard Miller double-and-add method, standard Miller using a non-adjacent form, Boxall et al. version, Boxall et al. version using a non-adjacent form.

The final exponentiation part can be computed using one of the following variants: naive exponentiation, interleaved method, Avanzi–Mihailescu's method, Kato et al.'s method, Scott et al.'s method.

Part of the library has been included into Pari/Gp proper.

FUNCTIONAL DESCRIPTION: APIP is a library for computing standard and optimised variants of most cryptographic pairings.

- Participant: Jérôme Milan
- Contact: Andreas Enge
- URL: http://www.lix.polytechnique.fr/~milanj/apip/apip.xhtml

5.2. AVIsogenies

Abelian Varieties and Isogenies

KEYWORDS: Computational number theory - Cryptography

FUNCTIONAL DESCRIPTION: AVIsogenies is a Magma package for working with abelian varieties, with a particular emphasis on explicit isogeny computation.

Its prominent feature is the computation of (l,l)-isogenies between Jacobian varieties of genus-two hyperelliptic curves over finite fields of characteristic coprime to l, practical runs have used values of l in the hundreds.

It can also be used to compute endomorphism rings of abelian surfaces, and find complete addition laws on them.

- Participants: Damien Robert, Gaëtan Bisson and Romain Cosset
- Contact: Damien Robert
- URL: http://avisogenies.gforge.inria.fr/

5.3. CM

KEYWORD: Arithmetic

FUNCTIONAL DESCRIPTION: The Cm software implements the construction of ring class fields of imaginary quadratic number fields and of elliptic curves with complex multiplication via floating point approximations. It consists of libraries that can be called from within a C program and of executable command line applications.

RELEASE FUNCTIONAL DESCRIPTION: Features - Precisions beyond 300000 bits are now supported by an addition chain of variable length for the -function. Dependencies - The minimal version number of Mpfr has been increased to 3.0.0, that of Mpc to 1.0.0 and that of Pari to 2.7.0.

- Participant: Andreas Enge
- Contact: Andreas Enge
- URL: http://www.multiprecision.org/cm/home.html

5.4. CMH

Computation of Igusa Class Polynomials

KEYWORDS: Mathematics - Cryptography - Number theory

FUNCTIONAL DESCRIPTION: Cmh computes Igusa class polynomials, parameterising two-dimensional abelian varieties (or, equivalently, Jacobians of hyperelliptic curves of genus 2) with given complex multiplication.

- Participants: Andreas Enge, Emmanuel Thomé and Regis Dupont
- Contact: Emmanuel Thomé
- URL: http://cmh.gforge.inria.fr

5.5. CUBIC

KEYWORD: Number theory

FUNCTIONAL DESCRIPTION: Cubic is a stand-alone program that prints out generating equations for cubic fields of either signature and bounded discriminant. It depends on the Pari library. The algorithm has quasi-linear time complexity in the size of the output.

- Participant: Karim Belabas
- Contact: Karim Belabas
- URL: http://www.math.u-bordeaux.fr/~belabas/research/software/cubic-1.2.tgz

5.6. Euclid

KEYWORD: Number theory

FUNCTIONAL DESCRIPTION: Euclid is a program to compute the Euclidean minimum of a number field. It is the practical implementation of the algorithm described in [38] . Some corresponding tables built with the algorithm are also available. Euclid is a stand-alone program depending on the PARI library.

- Participants: Jean-Paul Cerri and Pierre Lezowski
- Contact: Jean-Paul Cerri
- URL: http://www.math.u-bordeaux1.fr/~plezowsk/euclid/index.php

5.7. KleinianGroups

KEYWORDS: Computational geometry - Computational number theory

FUNCTIONAL DESCRIPTION: KleinianGroups is a Magma package that computes fundamental domains of arithmetic Kleinian groups.

- Participant: Aurel Page
- Contact: Aurel Page
- URL: http://www.normalesup.org/~page/Recherche/Logiciels/logiciels-en.html

5.8. GNU MPC

KEYWORD: Arithmetic

FUNCTIONAL DESCRIPTION: Mpc is a C library for the arithmetic of complex numbers with arbitrarily high precision and correct rounding of the result. It is built upon and follows the same principles as Mpfr. The library is written by Andreas Enge, Philippe Théveny and Paul Zimmermann.

RELEASE FUNCTIONAL DESCRIPTION: Fixed `mpc_pow`, see http://lists.gforge.inria.fr/pipermail/mpc-discuss/2014-October/001315.html - #18257: Switched to libtool 2.4.5.

- Participants: Andreas Enge, Mickaël Gastineau, Paul Zimmermann and Philippe Théveny
- Contact: Andreas Enge
- URL: http://www.multiprecision.org/

5.9. MPFRCX

KEYWORD: Arithmetic

FUNCTIONAL DESCRIPTION: Mpfrcx is a library for the arithmetic of univariate polynomials over arbitrary precision real (Mpfr) or complex (Mpc) numbers, without control on the rounding. For the time being, only the few functions needed to implement the floating point approach to complex multiplication are implemented. On the other hand, these comprise asymptotically fast multiplication routines such as Toom-Cook and the FFT.

RELEASE FUNCTIONAL DESCRIPTION: - new function `product_and_hecke` - improved memory consumption for unbalanced FFT multiplications

- Participant: Andreas Enge
- Contact: Andreas Enge
- URL: http://www.multiprecision.org/mpfrcx/home.html

5.10. PARI/GP

KEYWORD: Computational number theory

FUNCTIONAL DESCRIPTION: Pari/Gp is a widely used computer algebra system designed for fast computations in number theory (factorisation, algebraic number theory, elliptic curves, modular forms ...), but it also contains a large number of other useful functions to compute with mathematical entities such as matrices, polynomials, power series, algebraic numbers, etc., and many transcendental functions.

- Participants: Andreas Enge, Hamish Ivey-Law, Henri Cohen and Karim Belabas
- Partner: CNRS
- Contact: Karim Belabas
- URL: http://pari.math.u-bordeaux.fr/

5.11. Platforms

5.11.1. SageMath

Following the article [19], Xavier Caruso and Thibaut Verron proposed an implementation of Tate algebras and ideals in Tate algebras (including an implementation of Buchberger algorithm) for SageMath; their implementation is now part of the standard distribution.

Xavier Caruso implemented a new unified framework for dealing with ring extensions and field extensions in SageMath. This code will be integrated soon in the standard distribution.

5.11.2. ARB

Fredrik Johansson released a new version, 2.17, of ARB.

MEXICO Project-Team

6. New Software and Platforms

6.1. COSMOS

KEYWORD: Model Checker

FUNCTIONAL DESCRIPTION: COSMOS is a statistical model checker for the Hybrid Automata Stochastic Logic (HASL). HASL employs Linear Hybrid Automata (LHA), a generalization of Deterministic Timed Automata (DTA), to describe accepting execution paths of a Discrete Event Stochastic Process (DESP), a class of stochastic models which includes, but is not limited to, Markov chains. As a result HASL verification turns out to be a unifying framework where sophisticated temporal reasoning is naturally blended with elaborate reward-based analysis. COSMOS takes as input a DESP (described in terms of a Generalized Stochastic Petri Net), an LHA and an expression Z representing the quantity to be estimated. It returns a confidence interval estimation of Z, recently, it has been equipped with functionalities for rare event analysis.

It is easy to generate and use a C code for discrete Simulink models (using only discrete blocks, which are sampled at fixed intervals) using MathWorks tools. However, it limits the expressivity of the models. In order to use more diverse Simulink models and control the flow of a multi-model simulation (with Discrete Event Stochastic Processes) we developed a Simulink Simulation Engine embedded into Cosmos.

COSMOS is written in C++

- Participants: Benoît Barbot, Hilal Djafri, Marie Duflot-Kremer, Paolo Ballarini and Serge Haddad
- Contact: Benoît Barbot
- URL: http://www.lsv.ens-cachan.fr/~barbot/cosmos/

6.2. CosyVerif

FUNCTIONAL DESCRIPTION: CosyVerif is a platform dedicated to the formal specification and verification of dynamic systems. It allows to specify systems using several formalisms (such as automata and Petri nets), and to run verification tools on these models.

- Participants: Alban Linard, Fabrice Kordon, Laure Petrucci and Serge Haddad
- Partners: LIP6 - LSV - LIPN (Laboratoire d'Informatique de l'Université Paris Nord)
- Contact: Serge Haddad
- URL: http://www.cosyverif.org/

6.3. Mole

FUNCTIONAL DESCRIPTION: Mole computes, given a safe Petri net, a finite prefix of its unfolding. It is designed to be compatible with other tools, such as PEP and the Model-Checking Kit, which are using the resulting unfolding for reachability checking and other analyses. The tool Mole arose out of earlier work on Petri nets.

- Participant: Stefan Schwoon
- Contact: Stefan Schwoon
- URL: http://www.lsv.ens-cachan.fr/~schwoon/tools/mole/

<p align="center">**MOCQUA Team**</p>

6. New Software and Platforms

6.1. FiatLux

KEYWORDS: Cellular automaton - Multi-agent - Distributed systems

SCIENTIFIC DESCRIPTION: FiatLux is a discrete dynamical systems simulator that allows the user to experiment with various models and to perturb them. It includes 1D and 2D cellular automata, moving agents, interacting particle systems, etc. Its main feature is to allow users to change the type of updating, for example from a deterministic parallel updating to an asynchronous random updating. FiatLux has a Graphical User Interface and can also be launched in a batch mode for the experiments that require statistics.

FUNCTIONAL DESCRIPTION: FiatLux is a cellular automata simulator in Java specially designed for the study of the robustness of the models. Its main distinctive features is to allow to perturb the updating of the system (synchrony rate) and to perturb the topology of the grid.

- Participants: Nazim Fatès and Olivier Boure
- Partners: ENS Lyon - Université de Lorraine
- Contact: Nazim Fatès
- URL: http://fiatlux.loria.fr/

6.2. ComplexityParser

KEYWORDS: Complexity - Static typing - Parsing

FUNCTIONAL DESCRIPTION: ComplexityParser is a static complexity analyzer of Java programs written in Java (approximatively 5000 lines of code). The program consists in a type inference and checking program based on the data tiering principle. It allows the program to certify that the typed program has a polynomial time complexity.

- Participants: Olivier Zeyen, Emmanuel Hainry, Romain Péchoux and Emmanuel Jeandel
- Contact: Emmanuel Hainry

OURAGAN Project-Team

6. New Software and Platforms

6.1. ISOTOP

Topology and geometry of planar algebraic curves

KEYWORDS: Topology - Curve plotting - Geometric computing

FUNCTIONAL DESCRIPTION: Isotop is a Maple software for computing the topology of an algebraic plane curve, that is, for computing an arrangement of polylines isotopic to the input curve. This problem is a necessary key step for computing arrangements of algebraic curves and has also applications for curve plotting. This software has been developed since 2007 in collaboration with F. Rouillier from Inria Paris - Rocquencourt.

- Participants: Luis Penaranda, Marc Pouget and Sylvain Lazard
- Contact: Marc Pouget
- Publications: Rational Univariate Representations of Bivariate Systems and Applications - Separating Linear Forms for Bivariate Systems - On The Topology of Planar Algebraic Curves - New bivariate system solver and topology of algebraic curves - Improved algorithm for computing separating linear forms for bivariate systems - Solving bivariate systems using Rational Univariate Representations - On the topology of planar algebraic curves - On the topology of real algebraic plane curves - Bivariate triangular decompositions in the presence of asymptotes - Separating linear forms and Rational Univariate Representations of bivariate systems
- URL: https://isotop.gamble.loria.fr/

6.2. RS

FUNCTIONAL DESCRIPTION: Real Roots isolation for algebraic systems with rational coefficients with a finite number of Complex Roots

- Participant: Fabrice Rouillier
- Contact: Fabrice Rouillier
- URL: https://team.inria.fr/ouragan/software/

6.3. A NewDsc

A New Descartes

KEYWORD: Scientific computing

FUNCTIONAL DESCRIPTION: Computations of the real roots of univariate polynomials with rational coefficients.

- Authors: Fabrice Rouillier, Alexander Kobel and Michael Sagraloff
- Partner: Max Planck Institute for Software Systems
- Contact: Fabrice Rouillier
- URL: https://anewdsc.mpi-inf.mpg.de

6.4. SIROPA

KEYWORDS: Robotics - Kinematics

FUNCTIONAL DESCRIPTION: Library of functions for certified computations of the properties of articulated mechanisms, particularly the study of their singularities

- Authors: Damien Chablat, Fabrice Rouillier, Guillaume Moroz and Philippe Wenger
- Partner: LS2N
- Contact: Guillaume Moroz
- URL: http://siropa.gforge.inria.fr/

6.5. MPFI

KEYWORD: Arithmetic

FUNCTIONAL DESCRIPTION: MPFI is a C library based on MPFR and GMP for multi precision floating point arithmetic.

- Contact: Fabrice Rouillier
- URL: http://mpfi.gforge.inria.fr

PACAP Project-Team

6. New Software and Platforms

6.1. ATMI

KEYWORDS: Analytic model - Chip design - Temperature

SCIENTIFIC DESCRIPTION: Research on temperature-aware computer architecture requires a chip temperature model. General purpose models based on classical numerical methods like finite differences or finite elements are not appropriate for such research, because they are generally too slow for modeling the time-varying thermal behavior of a processing chip.

ATMI (Analytical model of Temperature in MIcroprocessors) is an ad hoc temperature model for studying thermal behaviors over a time scale ranging from microseconds to several minutes. ATMI is based on an explicit solution to the heat equation and on the principle of superposition. ATMI can model any power density map that can be described as a superposition of rectangle sources, which is appropriate for modeling the microarchitectural units of a microprocessor.

FUNCTIONAL DESCRIPTION: ATMI is a library for modelling steady-state and time-varying temperature in microprocessors. ATMI uses a simplified representation of microprocessor packaging.

- Participant: Pierre Michaud
- Contact: Pierre Michaud
- URL: https://team.inria.fr/pacap/software/atmi/

6.2. HEPTANE

KEYWORDS: IPET - WCET - Performance - Real time - Static analysis - Worst Case Execution Time

SCIENTIFIC DESCRIPTION: WCET estimation

The aim of Heptane is to produce upper bounds of the execution times of applications. It is targeted at applications with hard real-time requirements (automotive, railway, aerospace domains). Heptane computes WCETs using static analysis at the binary code level. It includes static analyses of microarchitectural elements such as caches and cache hierarchies.

FUNCTIONAL DESCRIPTION: In a hard real-time system, it is essential to comply with timing constraints, and Worst Case Execution Time (WCET) in particular. Timing analysis is performed at two levels: analysis of the WCET for each task in isolation taking account of the hardware architecture, and schedulability analysis of all the tasks in the system. Heptane is a static WCET analyser designed to address the first issue.

- Participants: Benjamin Lesage, Loïc Besnard, Damien Hardy, François Joulaud, Isabelle Puaut and Thomas Piquet
- Partner: Université de Rennes 1
- Contact: Isabelle Puaut
- URL: https://team.inria.fr/pacap/software/heptane/

6.3. tiptop

KEYWORDS: Instructions - Cycles - Cache - CPU - Performance - HPC - Branch predictor

SCIENTIFIC DESCRIPTION: Tiptop is a new simple and flexible user-level tool that collects hardware counter data on Linux platforms (version 2.6.31+) and displays them in a way simple to the Linux "top" utility. The goal is to make the collection of performance and bottleneck data as simple as possible, including simple installation and usage. No privilege is required, any user can run tiptop.

Tiptop is written in C. It can take advantage of libncurses when available for pseudo-graphic display. Installation is only a matter of compiling the source code. No patching of the Linux kernel is needed, and no special-purpose module needs to be loaded.

Current version is 2.3.1, released October 2017. Tiptop has been integrated in major Linux distributions, such as Fedora, Debian, Ubuntu, CentOS.

FUNCTIONAL DESCRIPTION: Today's microprocessors have become extremely complex. To better understand the multitude of internal events, manufacturers have integrated many monitoring counters. Tiptop can be used to collect and display the values from these performance counters very easily. Tiptop may be of interest to anyone who wants to optimise the performance of their HPC applications.

- Participant: Erven Rohou
- Contact: Erven Rohou
- URL: http://tiptop.gforge.inria.fr

6.4. PADRONE

KEYWORDS: Legacy code - Optimization - Performance analysis - Dynamic Optimization

FUNCTIONAL DESCRIPTION: Padrone is new platform for dynamic binary analysis and optimization. It provides an API to help clients design and develop analysis and optimization tools for binary executables. Padrone attaches to running applications, only needing the executable binary in memory. No source code or debug information is needed. No application restart is needed either. This is especially interesting for legacy or commercial applications, but also in the context of cloud deployment, where actual hardware is unknown, and other applications competing for hardware resources can vary. The profiling overhead is minimum.

- Participants: Emmanuel Riou and Erven Rohou
- Contact: Erven Rohou
- URL: https://team.inria.fr/pacap/software/padrone

6.5. If-memo

KEYWORD: Performance

SCIENTIFIC DESCRIPTION: We propose a linker based technique for enabling software memorizing of any dynamically linked pure function by function interception and we illustrate our framework using a set of computationally expensive pure functions - the transcendental functions.

FUNCTIONAL DESCRIPTION: If-memo is a linker-based technique for enabling software memorizing of any dynamically linked pure function by function interception. Typically, this framework is useful to intercept the computationally expensive pure functions - the transcendental functions from the math library. Our technique does not need the availability of source code and thus can even be applied to commercial applications as well as applications with legacy codes. As far as users are concerned, enabling memoization is as simple as setting an environment variable. Our framework does not make any specific assumptions about the underlying architecture or compiler too-chains, and can work with a variety of current architectures.

- Participants: Arjun Suresh and Erven Rohou
- Contact: Erven Rohou
- URL: https://team.inria.fr/pacap/software/if-memo/

6.6. Simty

KEYWORDS: GPU - Softcore - FPGA - SIMT - Multi-threading - RISC-V

FUNCTIONAL DESCRIPTION: Simty is a massively multi-threaded processor core that dynamically assembles SIMD instructions from scalar multi-thread code. It runs the RISC-V (RV32-I) instruction set. Unlike existing SIMD or SIMT processors like GPUs, Simty takes binaries compiled for general-purpose processors without any instruction set extension or compiler changes. Simty is described in synthesizable VHDL.

- Author: Caroline Collange
- Contact: Caroline Collange
- URL: https://gforge.inria.fr/projects/simty

6.7. Barra

KEYWORDS: GPU - GPGPU - Tesla ISA - Debug - Computer architecture - Performance - Profiling - Simulator - HPC - CUDA

SCIENTIFIC DESCRIPTION: Research on throughput-oriented architectures demands accurate and representative models of GPU architectures in order to be able to evaluate new architectural ideas, explore design spaces and characterize applications. The Barra project is a simulator of the NVIDIA Tesla GPU architecture.

Barra builds upon knowledge acquired through micro-benchmarking, in order to provide a baseline model representative of industry practice. The simulator provides detailed statistics to identify optimization opportunities and is fully customizable to experiment ideas of architectural modifications. Barra incorporates both a functional model and a cycle-level performance model.

FUNCTIONAL DESCRIPTION: Barra is a Graphics Processing Unit (GPU) architecture simulator. It simulates NVIDIA CUDA programs at the assembly language level. Barra is a tool for research on computer architecture, and can also be used to debug, profile and optimize CUDA programs at the lowest level.

RELEASE FUNCTIONAL DESCRIPTION: Version 0.5.10 introduces: Timing model, Tesla-like architecture model, Fermi-like architecture model, New per-PC control-flow divergence management, Support for Simultaneous branch and warp interweaving, Support for Affine vector cache.

- Participants: Alexandre Kouyoumdjian, David Defour, Fabrice Mouhartem and Caroline Collange
- Partners: ENS Lyon - UPVD
- Contact: Caroline Collange
- URL: http://barra.gforge.inria.fr/

6.8. Memoization

KEYWORDS: Optimization - Pure function - Memoization

FUNCTIONAL DESCRIPTION: Memoization is a technique used at runtime that consists in caching results of pure functions and retrieving them instead of computing them when the arguments repeat. It can be applied to C and C++ programs. To be memoized, the interface of a pure function (or a method) must verify the following properties: (1) the function/method has at most four arguments of same type T, (2) the function/method returns a data of type T, (3) T is either 'double', 'float', or 'int'.

The memoization operation of a function/method is controlled by several parameters: the size of the internal table (number of entries), the replacement policy to be used in case of index conflict (whether the value of the table must be replaced or not), an approximation threshold that allows to not distinguish very close values). It is also possible to initialize the table with the content of a file, and to save the content of the table to a file at the end of the execution (the data may be used as input for a future execution).

- Participants: Loïc Besnard, Imane Lasri and Erven Rohou
- Contact: Loïc Besnard

6.9. FiPlib

KEYWORDS: Compilation - Approximate computing - Fixed-point representation

FUNCTIONAL DESCRIPTION: FiPlib is a C++ library that provides type definition and conversion operations for computations in fixed-point representation. Basic arithmetic as well as logical operations are transparently supported thanks to operator overloading. FiPlib also provides optimized implementations of the transcendental math functions of libm. For convenient integration, FiPlib is released as C++ header files only. Optionally, FiPlib can detect overflows and compute errors compared to floating point representation.

- Participants: Pierre Le Meur, Imane Lasri and Erven Rohou
- Contact: Erven Rohou

6.10. sigmask

KEYWORDS: Compilation - Side-channel - Masking - Security - Embedded systems

SCIENTIFIC DESCRIPTION: Sigmask is a compiler plugin based on the LLVM infrastructure that automatically protects secret information in programs, such as encryption keys, against side-channel attacks. The programmer annotates their source code to highlight variables containing sensitive data. The compiler automatically analyzes the program and computes all memory locations potentially derived from the secret. It then applies a masking scheme to avoid information leakage. Sigmask provides several schemes: OSDM (Orthogonal Direct Sum Masking), IP (Inner Product) Masking, and simple random bit masking. The programmer may also provide their own masking scheme through a well-defined API.

FUNCTIONAL DESCRIPTION: Sigmask is a compiler plugin based on the LLVM infrastructure that automatically protects secret information in programs, such as encryption keys, against side-channel attacks. The programmer annotates their source code to highlight variables containing sensitive data. The compiler automatically analyzes the program and computes all memory locations potentially derived from the secret. It then applies a masking scheme to avoid information leakage. Sigmask provides several schemes: ODSM (Orthogonal Direct Sum Masking), IP (Inner Product) Masking, and simple random bit masking. The programmer may also provide their own masking scheme through a well-defined API.

- Participants: Nicolas Kiss, Damien Hardy and Erven Rohou
- Contact: Erven Rohou

PARKAS Project-Team

5. New Software and Platforms

5.1. Cmmtest

FUNCTIONAL DESCRIPTION: Cmmtest is a tool for hunting concurrency compiler bugs. The Cmmtest tool performs random testing of C and C++ compilers against the C11/C++11 memory model. A test case is any well-defined, sequential C program, for each test case, cmmtest:

compiles the program using the compiler and compiler optimisations that are being tested,

runs the compiled program in an instrumented execution environment that logs all memory accesses to global variables and synchronisations,

compares the recorded trace with a reference trace for the same program, checking if the recorded trace can be obtained from the reference trace by valid eliminations, reorderings and introductions.

Cmmtest identified several mistaken write introductions and other unexpected behaviours in the latest release of the gcc compiler. These have been promptly fixed by the gcc developers.

- Participants: Anirudh Kumar, Francesco Zappa Nardelli, Pankaj More, Pankaj Pawan, Pankaj Prateek Kewalramani and Robin Morisset
- Contact: Francesco Zappa Nardelli
- URL: http://www.di.ens.fr/~zappa/projects/cmmtest/

5.2. GCC

KEYWORDS: Compilation - Polyhedral compilation

FUNCTIONAL DESCRIPTION: The GNU Compiler Collection includes front ends for C, C++, Objective-C, Fortran, Java, Ada, and Go, as well as libraries for these languages (libstdc++, libgcj,...). GCC was originally written as the compiler for the GNU operating system. The GNU system was developed to be 100% free software, free in the sense that it respects the user's freedom.

- Participants: Albert Cohen, Feng Li, Nhat Minh Le, Riyadh Baghdadi and Tobias Grosser
- Contact: Albert Cohen
- URL: http://gcc.gnu.org/

5.3. Heptagon

KEYWORDS: Compilers - Synchronous Language - Controller synthesis

FUNCTIONAL DESCRIPTION: Heptagon is an experimental language for the implementation of embedded real-time reactive systems. It is developed inside the Synchronics large-scale initiative, in collaboration with Inria Rhones-Alpes. It is essentially a subset of Lucid Synchrone, without type inference, type polymorphism and higher-order. It is thus a Lustre-like language extended with hierchical automata in a form very close to SCADE 6. The intention for making this new language and compiler is to develop new aggressive optimization techniques for sequential C code and compilation methods for generating parallel code for different platforms. This explains much of the simplifications we have made in order to ease the development of compilation techniques.

The current version of the compiler includes the following features: - Inclusion of discrete controller synthesis within the compilation: the language is equipped with a behavioral contract mechanisms, where assumptions can be described, as well as an "enforce" property part. The semantics of this latter is that the property should be enforced by controlling the behaviour of the node equipped with the contract. This property will be enforced by an automatically built controller, which will act on free controllable variables given by the programmer. This extension has been named BZR in previous works. - Expression and compilation of array values with modular memory optimization. The language allows the expression and operations on arrays (access, modification, iterators). With the use of location annotations, the programmer can avoid unnecessary array copies.

- Participants: Adrien Guatto, Brice Gelineau, Cédric Pasteur, Eric Rutten, Gwenaël Delaval, Léonard Gérard and Marc Pouzet
- Partners: UGA - ENS Paris - Inria - LIG
- Contact: Gwenaël Delaval
- URL: http://heptagon.gforge.inria.fr

5.4. isl

FUNCTIONAL DESCRIPTION: isl is a library for manipulating sets and relations of integer points bounded by linear constraints. Supported operations on sets include intersection, union, set difference, emptiness check, convex hull, (integer) affine hull, integer projection, transitive closure (and over-approximation), computing the lexicographic minimum using parametric integer programming. It includes an ILP solver based on generalized basis reduction, and a new polyhedral code generator. isl also supports affine transformations for polyhedral compilation, and increasingly abstract representations to model source and intermediate code in a polyhedral framework.

- Participants: Albert Cohen, Sven Verdoolaege and Tobias Grosser
- Contact: Sven Verdoolaege
- URL: http://freshmeat.net/projects/isl

5.5. Lem

lightweight executable mathematics

FUNCTIONAL DESCRIPTION: Lem is a lightweight tool for writing, managing, and publishing large scale semantic definitions. It is also intended as an intermediate language for generating definitions from domain-specific tools, and for porting definitions between interactive theorem proving systems (such as Coq, HOL4, and Isabelle). As such it is a complementary tool to Ott. Lem resembles a pure subset of Objective Caml, supporting typical functional programming constructs, including top-level parametric polymorphism, datatypes, records, higher-order functions, and pattern matching. It also supports common logical mechanisms including list and set comprehensions, universal and existential quantifiers, and inductively defined relations. From this, Lem generates OCaml, HOL4, Coq, and Isabelle code.

- Participants: Francesco Zappa Nardelli, Peter Sewell and Scott Owens
- Contact: Francesco Zappa Nardelli
- URL: http://www.cl.cam.ac.uk/~pes20/lem/

5.6. Lucid Synchrone

FUNCTIONAL DESCRIPTION: Lucid Synchrone is a language for the implementation of reactive systems. It is based on the synchronous model of time as provided by Lustre combined with features from ML languages. It provides powerful extensions such as type and clock inference, type-based causality and initialization analysis and allows to arbitrarily mix data-flow systems and hierarchical automata or flows and valued signals.

RELEASE FUNCTIONAL DESCRIPTION: The language is still used for teaching and in our research but we do not develop it anymore. Nonetheless, we have integrated several features from Lucid Synchrone in new research prototypes described below. The Heptagon language and compiler are a direct descendent of it. The new language Zélus for hybrid systems modeling borrows many features originaly introduced in Lucid Synchrone.

- Contact: Marc Pouzet
- URL: http://www.di.ens.fr/~pouzet/lucid-synchrone/

5.7. Lucy-n

Lucy-n: an n-synchronous data-flow programming language

FUNCTIONAL DESCRIPTION: Lucy-n is a language to program in the n-synchronous model. The language is similar to Lustre with a buffer construct. The Lucy-n compiler ensures that programs can be executed in bounded memory and automatically computes buffer sizes. Hence this language allows to program Kahn networks, the compiler being able to statically compute bounds for all FIFOs in the program.

- Participants: Adrien Guatto, Albert Cohen, Louis Mandel and Marc Pouzet
- Contact: Albert Cohen
- URL: https://www.lri.fr/~mandel/lucy-n/

5.8. Ott

FUNCTIONAL DESCRIPTION: Ott is a tool for writing definitions of programming languages and calculi. It takes as input a definition of a language syntax and semantics, in a concise and readable ASCII notation that is close to what one would write in informal mathematics. It generates output:

a LaTeX source file that defines commands to build a typeset version of the definition,

a Coq version of the definition,

an Isabelle version of the definition, and

a HOL version of the definition.

Additionally, it can be run as a filter, taking a LaTeX/Coq/Isabelle/HOL source file with embedded (symbolic) terms of the defined language, parsing them and replacing them by typeset terms.

The main goal of the Ott tool is to support work on large programming language definitions, where the scale makes it hard to keep a definition internally consistent, and to keep a tight correspondence between a definition and implementations. We also wish to ease rapid prototyping work with smaller calculi, and to make it easier to exchange definitions and definition fragments between groups. The theorem-prover backends should enable a smooth transition between use of informal and formal mathematics.

- Participants: Francesco Zappa Nardelli, Peter Sewell and Scott Owens
- Contact: Francesco Zappa Nardelli
- URL: http://www.cl.cam.ac.uk/~pes20/ott/

5.9. PPCG

FUNCTIONAL DESCRIPTION: PPCG is our source-to-source research tool for automatic parallelization in the polyhedral model. It serves as a test bed for many compilation algorithms and heuristics published by our group, and is currently the best automatic parallelizer for CUDA and OpenCL (on the Polybench suite).

- Participants: Albert Cohen, Riyadh Baghdadi, Sven Verdoolaege and Tobias Grosser
- Contact: Sven Verdoolaege
- URL: http://freshmeat.net/projects/ppcg

5.10. ReactiveML

FUNCTIONAL DESCRIPTION: ReactiveML is a programming language dedicated to the implementation of interactive systems as found in graphical user interfaces, video games or simulation problems. ReactiveML is based on the synchronous reactive model due to Boussinot, embedded in an ML language (OCaml).

The Synchronous reactive model provides synchronous parallel composition and dynamic features like the dynamic creation of processes. In ReactiveML, the reactive model is integrated at the language level (not as a library) which leads to a safer and a more natural programming paradigm.

- Participants: Cédric Pasteur, Guillaume Baudart and Louis Mandel
- Contact: Guillaume Baudart

5.11. SundialsML

Sundials/ML

KEYWORDS: Simulation - Mathematics - Numerical simulations

SCIENTIFIC DESCRIPTION: Sundials/ML is a comprehensive OCaml interface to the Sundials suite of numerical solvers (CVODE, CVODES, IDA, IDAS, KINSOL). Its structure mostly follows that of the Sundials library, both for ease of reading the existing documentation and for adapting existing source code, but several changes have been made for programming convenience and to increase safety, namely:

solver sessions are mostly configured via algebraic data types rather than multiple function calls,

errors are signalled by exceptions not return codes (also from user-supplied callback routines),

user data is shared between callback routines via closures (partial applications of functions),

vectors are checked for compatibility (using a combination of static and dynamic checks), and

explicit free commands are not necessary since OCaml is a garbage-collected language.

FUNCTIONAL DESCRIPTION: Sundials/ML is a comprehensive OCaml interface to the Sundials suite of numerical solvers (CVODE, CVODES, IDA, IDAS, KINSOL, ARKODE).

RELEASE FUNCTIONAL DESCRIPTION: Adds support for v3.1.x of the Sundials Suite of numerical solvers.

Notably this release adds support for the new generic matrix and linear solver interfaces. The OCaml interface changes but the library is backward compatible with Sundials 2.7.0.

OCaml 4.02.3 or greater is now required and optionally OCamlMPI 1.03.

* New Sundials.Matrix and Sundials.LinearSolver modules. * Better treatment of integer type used for matrix indexing. * Refactor Dls and Sls modules into Sundials.Matrix. * Add confidence intervals to performance graph. * Miscellaneous improvements to configure script. * Potential incompatibility: changes to some label names: comm_fn -> comm, iter_type -> iter. * Untangle the ARKODE mass-solver interface from the Jacobian interface.

- Participants: Jun Inoue, Marc Pouzet and Timothy Bourke
- Partner: UPMC
- Contact: Marc Pouzet
- URL: http://inria-parkas.github.io/sundialsml/

5.12. Zelus

SCIENTIFIC DESCRIPTION: The Zélus implementation has two main parts: a compiler that transforms Zélus programs into OCaml programs and a runtime library that orchestrates compiled programs and numeric solvers. The runtime can use the Sundials numeric solver, or custom implementations of well-known algorithms for numerically approximating continuous dynamics.

FUNCTIONAL DESCRIPTION: Zélus is a new programming language for hybrid system modeling. It is based on a synchronous language but extends it with Ordinary Differential Equations (ODEs) to model continuous-time behaviors. It allows for combining arbitrarily data-flow equations, hierarchical automata and ODEs. The language keeps all the fundamental features of synchronous languages: the compiler statically ensure the absence of deadlocks and critical races, it is able to generate statically scheduled code running in bounded time and space and a type-system is used to distinguish discrete and logical-time signals from continuous-time ones. The ability to combines those features with ODEs made the language usable both for programming discrete controllers and their physical environment.

- Participants: Marc Pouzet and Timothy Bourke
- Contact: Marc Pouzet

5.13. Telamon

KEYWORDS: Compilation - Monte-Carlo methods - Constraint Programming - GPU - Dense linear algebra

FUNCTIONAL DESCRIPTION: Telamon is a framework for the optimization of computational kernels for GPUs through efficient search in a well-behaved optimization space in which optimization decisions commute and satisfaction of constraints restricting legal optimizations.

- Contact: Ulysse Beaugnon
- URL: https://github.com/ulysseB/telamon/

5.14. Vélus

Verified Lustre Compiler

KEYWORDS: Synchronous Language - Compilation - Software Verification - Coq - Ocaml

FUNCTIONAL DESCRIPTION: Vélus is a prototype compiler from a subset of Lustre to assembly code. It is written in a mix of Coq and OCaml and incorporates the CompCert verified C compiler. The compiler includes formal specifications of the semantics and type systems of Lustre, as well as the semantics of intermediate languages, and a proof of correctness that relates the high-level dataflow model to the values produced by iterating the generated assembly code.

RELEASE FUNCTIONAL DESCRIPTION: First source-code release. Treatment of primitive reset construct. Clocks allowed for node arguments.

- Contact: Timothy Bourke
- URL: https://velus.inria.fr

5.15. Tensor Comprehensions

KEYWORDS: Machine learning - Matrix calculation - Polyhedral compilation - GPU - CUDA

FUNCTIONAL DESCRIPTION: Tensor Comprehensions (TC) is a notation based on generalized Einstein notation for computing on multi-dimensional arrays. TC greatly simplifies ML framework implementations by providing a concise and powerful syntax which can be efficiently translated to high-performance computation kernels, automatically.

RELEASE FUNCTIONAL DESCRIPTION: Integration of the loop tactics matching framework for identifying linear algebra operations and optimizing them.

- Partner: Eindhoven University of Technology
- Contact: Albert Cohen

5.16. Aftermath

KEYWORDS: Performance analysis - Runtime system - Parallel programming - High-performance calculation - Execution trace

FUNCTIONAL DESCRIPTION: Aftermath is a toolkit for building custom graphical tools for trace-based performance analysis of parallel programs, run-time systems and compilers.

- Partner: The University of Manchester
- Contact: Andi Drebes

5.17. MPPcodegen

Source-to-source loop tiling based on MPP

KEYWORDS: Source-to-source compiler - Polyhedral compilation

FUNCTIONAL DESCRIPTION: MPPcodegen applies a monoparametric tiling to a C program enriched with pragmas specifying the tiling and the scheduling function. The tiling can be generated by any convex polyhedron and translation functions, it is not necessarily a partition. The result is a C program depending on a scaling factor (the parameter). MPPcodegen relies on the MPP mathematical library to tile the iteration sets.

- Partner: Colorado State University
- Contact: Christophe Alias
- URL: http://foobar.ens-lyon.fr/mppcodegen/

5.18. MPP

MonoParametric Partitionning transformation

KEYWORDS: Compilation - Polyhedral compilation

FUNCTIONAL DESCRIPTION: This library applies a monoparametric partitioning transformation to polyhedra and affine functions. This transformation is a subset of the parametric sized tiling transformation, specialized for the case where shapes depend only on a single parameter. Unlike in the general case, the resulting sets and functions remain in the polyhedral model.

- Contact: Guillaume Iooss
- URL: https://github.com/guillaumeiooss/MPP

5.19. Obelisk

KEYWORDS: LaTeX - HTML - Ocaml

FUNCTIONAL DESCRIPTION: Obelisk is a simple tool which produces pretty-printed output from a Menhir parser file (.mly).

It is inspired from yacc2latex and it is also written in OCaml, but it is aimed at supporting features from Menhir instead of only those of ocamlyacc.

- Contact: Lelio Brun
- URL: https://github.com/Lelio-Brun/Obelisk

<p align="center" style="color:red">PARSIFAL Project-Team</p>

6. New Software and Platforms

6.1. Abella

FUNCTIONAL DESCRIPTION: Abella is an interactive theorem prover for reasoning about computations given as relational specifications. Abella is particuarly well suited for reasoning about binding constructs.

- Participants: Dale Miller, Gopalan Nadathur, Kaustuv Chaudhuri, Mary Southern, Matteo Cimini, Olivier Savary-Bélanger and Yuting Wang
- Partner: Department of Computer Science and Engineering, University of Minnesota
- Contact: Kaustuv Chaudhuri
- URL: http://abella-prover.org/

6.2. Bedwyr

Bedwyr - A proof search approach to model checking

KEYWORD: Model Checker

FUNCTIONAL DESCRIPTION: Bedwyr is a generalization of logic programming that allows model checking directly on syntactic expressions that possibly contain bindings. This system, written in OCaml, is a direct implementation of two recent advances in the theory of proof search.

It is possible to capture both finite success and finite failure in a sequent calculus. Proof search in such a proof system can capture both may and must behavior in operational semantics. Higher-order abstract syntax is directly supported using term-level lambda-binders, the nabla quantifier, higher-order pattern unification, and explicit substitutions. These features allow reasoning directly on expressions containing bound variables.

The distributed system comes with several example applications, including the finite pi-calculus (operational semantics, bisimulation, trace analyses, and modal logics), the spi-calculus (operational semantics), value-passing CCS, the lambda-calculus, winning strategies for games, and various other model checking problems.

- Participants: Dale Miller, Quentin Heath and Roberto Blanco Martinez
- Contact: Dale Miller
- URL: http://slimmer.gforge.inria.fr/bedwyr/

6.3. Checkers

Checkers - A proof verifier

KEYWORDS: Proof - Certification - Verification

FUNCTIONAL DESCRIPTION: Checkers is a tool in Lambda-prolog for the certification of proofs. Checkers consists of a kernel which is based on LKF and is based on the notion of ProofCert.

- Participants: Giselle Machado Nogueira Reis, Marco Volpe and Tomer Libal
- Contact: Tomer Libal
- URL: https://github.com/proofcert/checkers

6.4. Psyche

Proof-Search factorY for Collaborative HEuristics

KEYWORD: Automated theorem proving

FUNCTIONAL DESCRIPTION: Psyche is a modular platform for automated or interactive theorem proving, programmed in OCaml and built on an architecture (similar to LCF) where a trusted kernel interacts with plugins. The kernel offers an API of proof-search primitives, and plugins are programmed on top of the API to implement search strategies. This architecture is set up for pure logical reasoning as well as for theory-specific reasoning, for various theories.

RELEASE FUNCTIONAL DESCRIPTION: It is now equipped with the machinery to handle quantifiers and quantifier-handling techniques. Concretely, it uses meta-variables to delay the instantiation of existential variables, and constraints on meta-variables are propagated through the various branches of the search-space, in a way that allows local backtracking. The kernel, of about 800 l.o.c., is purely functional.

- Participants: Assia Mahboubi, Jean-Marc Notin and Stéphane Graham-Lengrand
- Contact: Stéphane Graham-Lengrand
- URL: http://www.csl.sri.com/users/sgl/

6.5. Maetning

FUNCTIONAL DESCRIPTION: Mætning is an automated theorem prover for intuitionistic predicate logic that is designed to disprove non-theorems.

- Contact: Kaustuv Chaudhuri
- URL: https://github.com/chaudhuri/maetning/

6.6. OCaml

KEYWORDS: Functional programming - Static typing - Compilation

FUNCTIONAL DESCRIPTION: The OCaml language is a functional programming language that combines safety with expressiveness through the use of a precise and flexible type system with automatic type inference. The OCaml system is a comprehensive implementation of this language, featuring two compilers (a bytecode compiler, for fast prototyping and interactive use, and a native-code compiler producing efficient machine code for x86, ARM, PowerPC and System Z), a debugger, a documentation generator, a compilation manager, a package manager, and many libraries contributed by the user community.

- Participants: Damien Doligez, Xavier Leroy, Fabrice Le Fessant, Luc Maranget, Gabriel Scherer, Alain Frisch, Jacques Garrigue, Marc Shinwell, Jeremy Yallop and Leo White
- Contact: Damien Doligez
- URL: https://ocaml.org/

<p align="center">**PESTO Project-Team**</p>

6. New Software and Platforms

6.1. Akiss

AKISS - Active Knowledge in Security Protocols

KEYWORDS: Security - Verification

FUNCTIONAL DESCRIPTION: AKISS (Active Knowledge in Security Protocols) is a tool for verifying indistinguishability properties in cryptographic protocols, modelled as trace equivalence in a process calculus. Indistinguishability is used to model a variety of properties including anonymity properties, strong versions of confidentiality and resistance against offline guessing attacks, etc. AKISS implements a procedure to verify equivalence properties for a bounded number of sessions based on a fully abstract modelling of the traces of a bounded number of sessions of the protocols into first-order Horn clauses and a dedicated resolution procedure. The procedure can handle a large set of cryptographic primitives, namely those that can be modeled by an optimally reducing convergent rewrite system, as well as the exclusive or (xor) operator.

- Contact: Steve Kremer
- URL: https://github.com/akiss

6.2. Belenios

Belenios - Verifiable online voting system

KEYWORD: E-voting

FUNCTIONAL DESCRIPTION: Belenios is an open-source online voting system that provides confidentiality and verifiability. End-to-end verifiability relies on the fact that the ballot box is public (voters can check that their ballots have been received) and on the fact that the tally is publicly verifiable (anyone can recount the votes). Confidentiality relies on the encryption of the votes and the distribution of the decryption key.

Belenios builds upon Helios, a voting protocol used in several elections. The main design enhancement of Belenios vs. Helios is that the ballot box can no longer add (fake) ballots, due to the use of credentials. Moreover, Belenios includes a practical threshold decryption system that allows splitting the decryption key among several authorities.

NEWS OF THE YEAR: Since 2015, it has been used by CNRS for remote election among its councils (more than 30 elections every year) and since 2016, it has been used by Inria to elect representatives in the "comités de centre" of each Inria center. In 2018, it has been used to organize about 250 elections (not counting test elections). Belenios is typically used for elections in universities as well as in associations. This goes from laboratory councils (e.g. Irisa, Cran), scientific societies (e.g. SMAI) to various associations (e.g. FFBS - Fédération Française de Baseball et Softball, or SRFA - Société du Rat Francophone et de ses Amateurs).

In 2019, a threshold encryption mode has been added that makes the system more robust to the case where (say) one trustee among three loses her part of the decryption key.

- Participants: Pierrick Gaudry, Stéphane Glondu and Véronique Cortier
- Partners: CNRS - Inria
- Contact: Stéphane Glondu
- URL: http://www.belenios.org/

6.3. Deepsec

DEEPSEC - DEciding Equivalence Properties in SECurity protocols

KEYWORDS: Security - Verification

FUNCTIONAL DESCRIPTION: DEEPSEC (DEciding Equivalence Properties in SECurity protocols) is a tool for verifying indistinguishability properties in cryptographic protocols, modelled as trace equivalence in a process calculus. Indistinguishability is used to model a variety of properties including anonymity properties, strong versions of confidentiality and resistance against offline guessing attacks, etc. DEEPSEC implements a decision procedure to verify trace equivalence for a bounded number of sessions and cryptographic primitives modeled by a subterm convergent destructor rewrite system. The procedure is based on constraint solving techniques. The tool also implements state-of-the-art partial order reductions and allows to distribute the computation on multiple cores and multiple machines.

NEWS OF THE YEAR: In 2019, to improve efficiency for non-determinate processes, we developed new optimisation techniques. This is achieved through a new, stronger equivalence for which partial-order reductions are sound even for non-determinate processes, as well as new symmetry reductions. We demonstrated that these techniques provide a significant (several orders of magnitude) speed-up in practice, thus increasing the size of the protocols that can be analysed fully automatically. Even though the new equivalence is stronger, it is nevertheless coarse enough to avoid false attacks on most practical examples.

- Participants: Steve Kremer, Itsaka Rakotonirina and Vincent Cheval
- Contact: Vincent Cheval
- Publications: Exploiting Symmetries When Proving Equivalence Properties for Security Protocols - Exploiting symmetries when proving equivalence properties for security protocols (Technical report) - DEEPSEC: Deciding Equivalence Properties in Security Protocols Theory and Practice - DEEPSEC: Deciding Equivalence Properties in Security Protocols - Theory and Practice - The DEEPSEC prover
- URL: https://deepsec-prover.github.io/

6.4. Tamarin

TAMARIN prover

KEYWORDS: Security - Verification

FUNCTIONAL DESCRIPTION: The TAMARIN prover is a security protocol verification tool that supports both falsification and unbounded verification of security protocols specified as multiset rewriting systems with respect to (temporal) first-order properties and a message theory that models Diffie-Hellman exponentiation, bilinear pairing, multisets, and exclusive-or (XOR), combined with a user-defined convergent rewriting theory. Its main advantages are its ability to handle stateful protocols and its interactive proof mode. Moreover, it has been extended to verify equivalence properties. The tool is developed jointly by the PESTO team, the Institute of Information Security at ETH Zurich, and the University of Oxford. In a joint effort, the partners wrote and published a user manual in 2016, available from the Tamarin website.

- Contact: Jannik Dreier
- URL: http://tamarin-prover.github.io/

6.5. SAPIC

SAPIC: Stateful Applied Pi Calculus

KEYWORDS: Security - Verification

FUNCTIONAL DESCRIPTION: SAPIC is a plugin of the TAMARIN tool that translates protocols from a high-level protocol description language akin to the applied pi-calculus into multiset rewrite rules, that can then be analysed by the TAMARIN prover. TAMARIN has also been extended with dedicated heuristics that exploit the form of translated rules and favor termination.

SAPIC offers support for the analysis of protocols that include states, for example Hardware Security Tokens communicating with a possibly malicious user, or protocols that rely on databases. It also allows us to verify liveness properties and a notion of location and reporting used for modelling trusted execution environments. It has been successfully applied to several case studies including the Yubikey authentication protocol, and extensions of the PKCS#11 standard. SAPIC also includes support for verifying liveness properties, which are for instance important in fair exchange and contract signing protocols, as well as support for constructions useful when modelling isolated execution environments.

- Contact: Steve Kremer
- URL: http://sapic.gforge.inria.fr/

6.6. TypeEquiv

A type checker for privacy properties

KEYWORDS: Security - Cryptographic protocol - Privacy

FUNCTIONAL DESCRIPTION: TypeEquiv provides a (sound) type system for proving equivalence of protocols (to analyse privacy properties such as vote privacy, anonymity, unlinkability), for both a bounded or an unbounded number of sessions and for the standard cryptographic primitives. TypeEquiv takes as input the specification of a pair of security protocols, written in a dialect of the applied-pi calculus, together with some type annotations. It checks whether the two protocols are in equivalence or not. The tool provides a significant speed-up compared with tools that decide equivalence of security protocols for a bounded number of sessions.

- Partner: Technische Universität Wien
- Contact: Véronique Cortier

PI.R2 Project-Team

5. New Software and Platforms

5.1. Coq

The Coq Proof Assistant

KEYWORDS: Proof - Certification - Formalisation

SCIENTIFIC DESCRIPTION: Coq is an interactive proof assistant based on the Calculus of (Co-)Inductive Constructions, extended with universe polymorphism. This type theory features inductive and co-inductive families, an impredicative sort and a hierarchy of predicative universes, making it a very expressive logic. The calculus allows to formalize both general mathematics and computer programs, ranging from theories of finite structures to abstract algebra and categories to programming language metatheory and compiler verification. Coq is organised as a (relatively small) kernel including efficient conversion tests on which are built a set of higher-level layers: a powerful proof engine and unification algorithm, various tactics/decision procedures, a transactional document model and, at the very top an IDE.

FUNCTIONAL DESCRIPTION: Coq provides both a dependently-typed functional programming language and a logical formalism, which, altogether, support the formalisation of mathematical theories and the specification and certification of properties of programs. Coq also provides a large and extensible set of automatic or semi-automatic proof methods. Coq's programs are extractable to OCaml, Haskell, Scheme, ...

RELEASE FUNCTIONAL DESCRIPTION: Coq version 8.10 contains two major new features: support for a native fixed-precision integer type and a new sort SProp of strict propositions. It is also the result of refinements and stabilization of previous features, deprecations or removals of deprecated features, cleanups of the internals of the system and API, and many documentation improvements. This release includes many user-visible changes, including deprecations that are documented in the next subsection, and new features that are documented in the reference manual.

Version 8.10 is the fifth release of Coq developed on a time-based development cycle. Its development spanned 6 months from the release of Coq 8.9. Vincent Laporte is the release manager and maintainer of this release. This release is the result of 2500 commits and 650 PRs merged, closing 150+ issues.

See the Zenodo citation for more information on this release: https://zenodo.org/record/3476303#.Xe54f5NKjOQ

NEWS OF THE YEAR: Coq 8.10.0 contains:

- some quality-of-life bug fixes, - a critical bug fix related to template polymorphism, - native 63-bit machine integers, - a new sort of definitionally proof-irrelevant propositions: SProp, - private universes for opaque polymorphic constants, - string notations and numeral notations, - a new simplex-based proof engine for the tactics lia, nia, lra and nra, - new introduction patterns for SSReflect, - a tactic to rewrite under binders: under, - easy input of non-ASCII symbols in CoqIDE, which now uses GTK3.

All details can be found in the user manual.

- Participants: Yves Bertot, Frédéric Besson, Maxime Denes, Emilio Jesús Gallego Arias, Gaëtan Gilbert, Jason Gross, Hugo Herbelin, Assia Mahboubi, Érik Martin-Dorel, Guillaume Melquiond, Pierre-Marie Pédrot, Michael Soegtrop, Matthieu Sozeau, Enrico Tassi, Laurent Théry, Théo Zimmermann, Theo Winterhalter, Vincent Laporte, Arthur Charguéraud, Cyril Cohen, Christian Doczkal and Chantal Keller
- Partners: CNRS - Université Paris-Sud - ENS Lyon - Université Paris-Diderot
- Contact: Matthieu Sozeau
- URL: http://coq.inria.fr/

5.2. Equations

KEYWORDS: Coq - Dependent Pattern-Matching - Proof assistant - Functional programming

SCIENTIFIC DESCRIPTION: Equations is a tool designed to help with the definition of programs in the setting of dependent type theory, as implemented in the Coq proof assistant. Equations provides a syntax for defining programs by dependent pattern-matching and well-founded recursion and compiles them down to the core type theory of Coq, using the primitive eliminators for inductive types, accessibility and equality. In addition to the definitions of programs, it also automatically derives useful reasoning principles in the form of propositional equations describing the functions, and an elimination principle for calls to this function. It realizes this using a purely definitional translation of high-level definitions to core terms, without changing the core calculus in any way, or using axioms.

FUNCTIONAL DESCRIPTION: Equations is a function definition plugin for Coq (supporting Coq 8.8 to 8.10, with special support for the Coq-HoTT library), that allows the definition of functions by dependent pattern-matching and well-founded, mutual or nested structural recursion and compiles them into core terms. It automatically derives the clauses equations, the graph of the function and its associated elimination principle.

Equations is based on a simplification engine for the dependent equalities appearing in dependent eliminations that is also usable as a separate tactic, providing an axiom-free variant of dependent destruction. The main features of Equations include:

Dependent pattern-matching in the style of Agda/Epigram, with inaccessible patterns, with and where clauses. The use of the K axiom or a proof of K is configurable, and it is able to solve unification problems without resorting to the K rule if not necessary.

Support for well-founded and mutual recursion using measure/well-foundedness annotations, even on indexed inductive types, using an automatic derivation of the subterm relation for inductive families.

Support for mutual and nested structural recursion using with and where auxilliary definitions, allowing to factor multiple uses of the same nested fixpoint definition. It proves the expected elimination principles for mutual and nested definitions.

Automatic generation of the defining equations as rewrite rules for every definition.

Automatic generation of the unfolding lemma for well-founded definitions (requiring only functional extensionality).

Automatic derivation of the graph of the function and its elimination principle. In case the automation fails to prove these principles, the user is asked to provide a proof.

A new dependent elimination tactic based on the same splitting tree compilation scheme that can advantageously replace dependent destruction and sometimes inversion as well. The as clause of dependent elimination allows to specify exactly the patterns and naming of new variables needed for an elimination.

A set of Derive commands for automatic derivation of constructions from an inductive type: its signature, no-confusion property, well-founded subterm relation and decidable equality proof, if applicable.

RELEASE FUNCTIONAL DESCRIPTION: This version of Equations is based on an improved simplification engine for the dependent equalities appearing during dependent eliminations that is also usable as a separate dependent elimination tactic, providing an axiom-free variant of dependent destruction and a more powerful form of inversion. See http://mattam82.github.io/Coq-Equations/equations/2019/01/28/1.2beta.html and the following release notes for more information.

NEWS OF THE YEAR: Equations 1.2 was first released in may this year, after 3 years of development. It provides a refined simplification engine based on the work published at ICFP'19 (see the "Equations Reloaded" paper for details). The system has been improved to also work in the setting of Homotopy Type Theory and provides a more expressive source language and robust dependent elimination tactics.

- Participants: Matthieu Sozeau and Cyprien Mangin
- Contact: Matthieu Sozeau

- Publications: Equations reloaded - Equations for Hereditary Substitution in Leivant's Predicative System F: A Case Study - Equations: A Dependent Pattern-Matching Compiler
- URL: http://mattam82.github.io/Coq-Equations/

5.3. Rewr

Rewriting methods in algebra

KEYWORDS: Computer algebra system (CAS) - Rewriting systems - Algebra

FUNCTIONAL DESCRIPTION: Rewr is a prototype of computer algebra system, using rewriting methods to compute resolutions and homotopical invariants of monoids. The library implements various classical constructions of rewriting theory (such as completion), improved by experimental features coming from Garside theory, and allows homotopical algebra computations based on Squier theory. Specific functionalities have been developed for usual classes of monoids, such as Artin monoids and plactic monoids.

NEWS OF THE YEAR: Rewr has been extended with the experimental KGB completion algorithm, based on Knuth-Bendix completion procedure improved by techniques coming from Garside theory.

- Participants: Yves Guiraud and Samuel Mimram
- Contact: Yves Guiraud
- Publications: Higher-dimensional categories with finite derivation type - Higher-dimensional normalisation strategies for acyclicity - Coherent presentations of Artin monoids - A Homotopical Completion Procedure with Applications to Coherence of Monoids - Polygraphs of finite derivation type - Quadratic normalisation in monoids
- URL: http://www.lix.polytechnique.fr/Labo/Samuel.Mimram/rewr

5.4. Catex

KEYWORDS: LaTeX - String diagram - Algebra

FUNCTIONAL DESCRIPTION: Catex is a Latex package and an external tool to typeset string diagrams easily from their algebraic expression. Catex works similarly to Bibtex.

NEWS OF THE YEAR: It is now possible to add labels to objects and morphisms

- Participant: Yves Guiraud
- Contact: Yves Guiraud
- URL: https://www.irif.fr/~guiraud/catex/catex.zip

5.5. Cox

KEYWORDS: Computer algebra system (CAS) - Rewriting systems - Algebra

FUNCTIONAL DESCRIPTION: Cox is a Python library for the computation of coherent presentations of Artin monoids, with experimental features to compute the lower dimensions of the Salvetti complex.

- Participant: Yves Guiraud
- Contact: Yves Guiraud
- Publications: Coherent presentations of Artin monoids - A Homotopical Completion Procedure with Applications to Coherence of Monoids
- URL: https://www.irif.fr/~guiraud/cox/cox.zip

5.6. jsCoq

KEYWORDS: Coq - Program verification - Interactive - Formal concept analysis - Proof assistant - Ocaml - Education - JavaScript

FUNCTIONAL DESCRIPTION: jsCoq is an Online Integrated Development Environment for the Coq proof assistant and runs in your browser! It aims to enable new UI/interaction possibilities and to improve the accessibility of the Coq platform itself.

RELEASE FUNCTIONAL DESCRIPTION: - Coq 8.10 support - Much improved interaction and general experience - Open / Save dialogs - AST and full serialization of Coq's datatypes - NPM packaging - Timeout support

- Participant: Emilio Jesus Gallego Arias
- Partners: Mines ParisTech - Technion, Israel Institute of Technology
- Contact: Emilio Jesus Gallego Arias
- Publication: jsCoq: Towards Hybrid Theorem Proving Interfaces
- URL: https://github.com/ejgallego/jscoq

5.7. coq-serapi

KEYWORDS: Interaction - Coq - Ocaml - Data centric - User Interfaces - GUI (Graphical User Interface) - Toolkit

FUNCTIONAL DESCRIPTION: SerAPI is a library for machine-to-machine interaction with the Coq proof assistant, with particular emphasis on applications in IDEs, code analysis tools, and machine learning. SerAPI provides automatic serialization of Coq's internal OCaml datatypes from/to JSON or S-expressions (sexps).

RELEASE FUNCTIONAL DESCRIPTION: - Support Coq 8.10 - Serialization of extensive AST - Serialization of kernel structures - Support for kernel traces [dumping and replay] - Tokenization of Coq documents - Serialization to JSON - Improved protocol and printing - Bug fixes

- Participant: Karl Palmskog
- Partner: KTH Royal Institute of Technology
- Contact: Emilio Jesus Gallego Arias
- Publication: SerAPI: Machine-Friendly, Data-Centric Serialization for COQ : Technical Report
- URL: https://github.com/ejgallego/coq-serapi

<p style="text-align:center;color:red;">**POLSYS Project-Team**</p>

5. New Software and Platforms

5.1. Epsilon

FUNCTIONAL DESCRIPTION: Epsilon is a library of functions implemented in Maple and Java for polynomial elimination and decomposition with (geometric) applications.

- Contact: Dongming Wang
- URL: http://wang.cc4cm.org/epsilon/index.html

5.2. FGb

KEYWORDS: Gröbner bases - Nonlinear system - Computer algebra

FUNCTIONAL DESCRIPTION: FGb is a powerful software for computing Gröbner bases. It includes the new generation of algorihms for computing Gröbner bases polynomial systems (mainly the F4, F5 and FGLM algorithms). It is implemented in C/C++ (approximately 250000 lines), standalone servers are available on demand. Since 2006, FGb is dynamically linked with Maple software (version 11 and higher) and is part of the official distribution of this software.

- Participant: Jean Charles Faugere
- Contact: Jean-Charles Faugère
- URL: http://www-polsys.lip6.fr/~jcf/FGb/index.html

5.3. FGb Light

FUNCTIONAL DESCRIPTION: Gröbner basis computation modulo p (p is a prime integer of 16 bits).

- Participant: Jean-Charles Faugère
- Contact: Jean-Charles Faugère
- URL: http://www-polsys.lip6.fr/~jcf/FGb/index.html

5.4. GBLA

FUNCTIONAL DESCRIPTION: GBLA is an open source C library for linear algebra specialized for eliminating matrices generated during Gröbner basis computations in algorithms like F4 or F5.

- Contact: Jean-Charles Faugère
- URL: http://www-polsys.lip6.fr/~jcf/GBLA/index.html

5.5. HFEBoost

FUNCTIONAL DESCRIPTION: Public-key cryptography system enabling an authentification of dematerialized data.

- Authors: Jean-Charles Faugère and Ludovic Perret
- Partner: UPMC
- Contact: Jean-Charles Faugère
- URL: http://www-polsys.lip6.fr/Links/hfeboost.html

5.6. RAGlib

Real Algebraic Geometry library

FUNCTIONAL DESCRIPTION: RAGLib is a powerful library, written in Maple, dedicated to solving over the reals polynomial systems. It is based on the FGb library for computing Grobner bases. It provides functionalities for deciding the emptiness and/or computing sample points to real solution sets of polynomial systems of equations and inequalities. This library provides implementations of the state-of-the-art algorithms with the currently best known asymptotic complexity for those problems.

- Contact: Mohab Safey El Din
- URL: http://www-polsys.lip6.fr/~safey/RAGLib/

5.7. RealCertify

KEYWORDS: Polynomial or analytical systems - Univariate polynomial - Real solving

FUNCTIONAL DESCRIPTION: The package RealCertify aims at providing a full suite of hybrid algorithms for computing certificates of non-negativity based on numerical software for solving linear matrix inequalities. The module univsos handles the univariate case and the module multivsos is designed for the multivariate case.

- Contact: Mohab Safey El Din
- URL: https://gricad-gitlab.univ-grenoble-alpes.fr/magronv/RealCertify

5.8. SLV

KEYWORDS: Univariate polynomial - Real solving

FUNCTIONAL DESCRIPTION: SLV is a software package in C that provides routines for isolating (and subsequently refine) the real roots of univariate polynomials with integer or rational coefficients based on subdivision algorithms and on the continued fraction expansion of real numbers. Special attention is given so that the package can handle polynomials that have degree several thousands and size of coefficients hundrends of Megabytes. Currently the code consists of approx. 5000 lines.

- Contact: Elias Tsigaridas
- URL: https://who.paris.inria.fr/Elias.Tsigaridas/soft.html

5.9. SPECTRA

Semidefinite Programming solved Exactly with Computational Tools of Real Algebra

KEYWORD: Linear Matrix Inequalities

FUNCTIONAL DESCRIPTION: SPECTRA is a Maple library devoted to solving exactly Semi-Definite Programs. It can handle rank constraints on the solution. It is based on the FGb library for computing Gröbner bases and provides either certified numerical approximations of the solutions or exact representations thereof.

- Contact: Mohab Safey El Din
- URL: http://homepages.laas.fr/henrion/software/spectra/

PRIVATICS Project-Team

5. New Software and Platforms

5.1. FECFRAME

FEC Framework following RFC 6363 specifications (https://datatracker.ietf.org/doc/rfc6363/)

KEYWORDS: Error Correction Code - Content delivery protocol - Robust transmission

FUNCTIONAL DESCRIPTION: This sofware implements the FECFRAME IETF standard (RFC 6363) co-authored by V. Roca, and is compliant with 3GPP specifications for mobile terminals. It enables the simultaneous transmission of multimedia flows to one or several destinations, while being robust to packet erasures that happen on wireless networks (e.g., 4G or Wifi). This software relies on the OpenFEC library (the open-source http://openfec.org version or the commercial version) that provides the erasure correction codes (or FEC) and thereby offer robustness in front of packet erasures.

- Participant: Vincent Roca
- Contact: Vincent Roca

5.2. Wombat

Wi-Fi tracking system for testing and demonstrational purpose

KEYWORDS: Wi-Fi - Privacy - Multimodal tracking of human activity - Wireless network

FUNCTIONAL DESCRIPTION: Wombat is a fully functional Wi-Fi tracking platform supporting three main features: collection, storage/processing, query/output. These three features are implemented through a distributed infrastructure composed of:

Sensor nodes: small devices with wireless monitoring capabilities. They collect information sent on wireless channels and forward it to the server. Central server: the central entity of the system. It receives data sent by sensor nodes and then stores it in an internal data structure. It is also in charge of answering queries related to the stored data.

To ensure communication between the sensor nodes and the server, the Wombat system relies on a wired network (Ethernet). In addition, Wombat can be enriched with a user interface and an opt-out node:

User interface: a device in charge of displaying detailed information about one or several tracked devices (see figure below). The device to display can be specified manually by its MAC address or through proximity detection. Opt-out node: an element in charge of implementing an opt-out mechanism for users refusing to be tracked by the system.

The system is made to work on a dedicated network (the server includes a DHCP server). Nodes can be switched off at any time (they function in read-only mode to be crash-proof).

- Partner: Insa de Lyon
- Contact: Mathieu Cunche
- URL: https://github.com/Perdu/wombat

5.3. Cookie glasses

KEYWORDS: GDPR - Cookie - Consent

SCIENTIFIC DESCRIPTION: In the paper Do Cookie Banners Respect my Choice? Measuring Legal Compliance of Banners from IAB Europe's Transparency and Consent Framework, we show that Consent Management Providers (CMPs) of IAB Europe's Transparency & Consent Framework (TCF) do not always respect user's choice. This extension allows users to verify that their consent is stored appropriately by themselves.

This extension for Firefox and Chrome queries CMPs of IAB Europe's TCF in the same position as a third-party advertiser, making it possible to see consent set by CMPs in real time. In other words, you can see whether consent registered by cookie banners is actually the consent you gave. Will only work with cookie banners of IAB Europe's TCF.

We also added a functionality to manually decode a so-called "consent string" of the framework.

- Participants: Célestin Matte and Nataliia Bielova
- Contact: Alain Prette

5.4. BELL

Browser fingerprinting via Extensions and Login-Leaks

KEYWORDS: Browser Extensions - Security and Privacy in Web Services - Social Networks Security and Privacy

FUNCTIONAL DESCRIPTION: Recent studies show that users can be tracked based on their web browser properties. This software is designed to conduct an experiment on such kinds of user tracking. In this experiment, we demonstrate that a Web user can also be tracked by

- her browser extensions (such as AdBlock, Pinterest, or Ghostery), and

- the websites she has logged in (such as Facebook, Gmail, or Twitter).

In the experiment, we collect user's browser fingerprint, together with the browser extensions installed and a list of websites she has logged in. We only collect anonymous data during the experiment (more details in our Privacy Policy [0]), we will securely store the data on an Inria server, use it only for research purposes and not share it with anyone outside of Inria.

- Contact: Gabor Gulyas
- URL: https://extensions.inrialpes.fr/

5.5. SWIF-codec

An open-source sliding window FEC codec

KEYWORD: Error Correction Code

FUNCTIONAL DESCRIPTION: This development is done in the context of the "Coding for Efficient Network Communications" IRTF Research Group (NWCRG, [https://datatracker.ietf.org/rg/nwcrg]) and IETF hackathon.

This work has strong relationships with the Generic API I-D [https://datatracker.ietf.org/doc/draft-roca-nwcrg-generic-fec-api/] and RFC 8681 on RLC codes [https://www.rfc-editor.org/rfc/rfc8681] as examples of sliding window codes.

- Authors: Vincent Roca, Cédric Adjih, Oumaima Attia and François Michel
- Contact: Vincent Roca
- URL: https://github.com/irtf-nwcrg/swif-codec

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[0]https://extensions.inrialpes.fr/privacy.php

<h1 style="text-align: center; color: red;">PROSECCO Project-Team</h1>

6. New Software and Platforms

6.1. Cryptosense Analyzer

SCIENTIFIC DESCRIPTION: Cryptosense Analyzer (formerly known as Tookan) is a security analysis tool for cryptographic devices such as smartcards, security tokens and Hardware Security Modules that support the most widely-used industry standard interface, RSA PKCS#11. Each device implements PKCS#11 in a slightly different way since the standard is quite open, but finding a subset of the standard that results in a secure device, i.e. one where cryptographic keys cannot be revealed in clear, is actually rather tricky. Cryptosense Analyzer analyses a device by first reverse engineering the exact implementation of PKCS#11 in use, then building a logical model of this implementation for a model checker, calling a model checker to search for attacks, and in the case where an attack is found, executing it directly on the device. It has been used to find at least a dozen previously unknown flaws in commercially available devices.

FUNCTIONAL DESCRIPTION: Cryptosense Analyzer (formerly known as Tookan) is a security analysis tool for cryptographic devices such as smartcards,

- Participants: Graham Steel and Romain Bardou
- Contact: Graham Steel
- URL: https://cryptosense.com/

6.2. CryptoVerif

Cryptographic protocol verifier in the computational model

KEYWORDS: Security - Verification - Cryptographic protocol

FUNCTIONAL DESCRIPTION: CryptoVerif is an automatic protocol prover sound in the computational model. In this model, messages are bitstrings and the adversary is a polynomial-time probabilistic Turing machine. CryptoVerif can prove secrecy and correspondences, which include in particular authentication. It provides a generic mechanism for specifying the security assumptions on cryptographic primitives, which can handle in particular symmetric encryption, message authentication codes, public-key encryption, signatures, hash functions, and Diffie-Hellman key agreements. It also provides an explicit formula that gives the probability of breaking the protocol as a function of the probability of breaking each primitives, this is the exact security framework.

NEWS OF THE YEAR: We implemented the following features in CryptoVerif:

1) We added to the library of cryptographic primitives several variants of the PRF-ODH (pseudo-random function oracle Diffie-Hellman) assumption, pre-image resistant and second-preimage resistant hash functions, IND-CPA encryption with a nonce, IND-CPA and INT-CTXT encryption with a nonce, encryption schemes that satisfy IND$-CPA instead of IND-CPA.

2) To facilitate modular proofs, we allow querying indistinguishability properties with exactly the same syntax as the one used to specify indistinguishability assumptions on primitives.

3) To simplify declarations of assumptions on primitives, replications (which model any number of copies of processes or oracles) can be omitted at the root of indistinguishability assumptions. CryptoVerif adds them internally, thus inferring the assumption for N independent copies from the assumption for one copy. For instance, it infers the assumption for encryption with N keys from the assumption for encryption with a single key.

4) When we delay random number generations, we allow the user to specify expressions for which it is not necessary to generate the random value, so that the generation of the moved random value can be delayed further. In particular, we used this extension to prove that the OAEP scheme is IND-CCA2 assuming the underlying permutation is partial-domain one-way (a famous cryptographic result).

5) CryptoVerif can now remove parts of the code cannot be executed in case the adversary wins the game, by replacing them with event "AdversaryLoses". That is specially helpful in order to deal with complex cases of key compromise, e.g. for forward secrecy, by proving authentication by ignoring the compromise, showing that authentication is preserved in case the key is compromised (because the adversary never wins against the considered authentication property in case of compromise), and using the authentication to prove secrecy even in case of compromise. For instance, that allows us to show that the PSK-DHE handshake of TLS 1.3 preserves forward secrecy in case of compromise of the PSK.

6) After a cryptographic transformation, CryptoVerif expands terms into processes, which leads to duplicating code until the end of the protocol for each test that is expanded. The cryptographic transformation and the expansion were initially considered as a single transformation. There are now considered as separate transformations, so that other transformations can be performed in between, in particular to cut some branches of the code and reduce the code duplication.

These changes are included in CryptoVerif version 2.02 available at https://cryptoverif.inria.fr.

- Participants: Bruno Blanchet and David Cadé
- Contact: Bruno Blanchet
- Publications: Composition Theorems for CryptoVerif and Application to TLS 1.3 - Composition Theorems for CryptoVerif and Application to TLS 1.3 - A Mechanised Cryptographic Proof of the WireGuard Virtual Private Network Protocol - A Mechanised Cryptographic Proof of the WireGuard Virtual Private Network Protocol - Proved Implementations of Cryptographic Protocols in the Computational Model - Proved Generation of Implementations from Computationally Secure Protocol Specifications - Verified Models and Reference Implementations for the TLS 1.3 Standard Candidate - Verified Models and Reference Implementations for the TLS 1.3 Standard Candidate - Symbolic and Computational Mechanized Verification of the ARINC823 Avionic Protocols - Automated Verification for Secure Messaging Protocols and Their Implementations: A Symbolic and Computational Approach
- URL: http://cryptoverif.inria.fr/

6.3. F*

FStar

KEYWORDS: Programming language - Software Verification

FUNCTIONAL DESCRIPTION: F* is a new higher order, effectful programming language (like ML) designed with program verification in mind. Its type system is based on a core that resembles System Fw (hence the name), but is extended with dependent types, refined monadic effects, refinement types, and higher kinds. Together, these features allow expressing precise and compact specifications for programs, including functional correctness properties. The F* type-checker aims to prove that programs meet their specifications using an automated theorem prover (usually Z3) behind the scenes to discharge proof obligations. Programs written in F* can be translated to OCaml, F#, or JavaScript for execution.

- Participants: Antoine Delignat-Lavaud, Catalin Hritcu, Cedric Fournet, Chantal Keller, Karthikeyan Bhargavan and Pierre-Yves Strub
- Contact: Catalin Hritcu
- URL: https://www.fstar-lang.org/

6.4. miTLS

KEYWORDS: Cryptographic protocol - Software Verification

FUNCTIONAL DESCRIPTION: miTLS is a verified reference implementation of the TLS protocol. Our code fully supports its wire formats, ciphersuites, sessions and connections, re-handshakes and resumptions, alerts and errors, and data fragmentation, as prescribed in the RFCs, it interoperates with mainstream web browsers and servers. At the same time, our code is carefully structured to enable its modular, automated verification, from its main API down to computational assumptions on its cryptographic algorithms.

- Participants: Alfredo Pironti, Antoine Delignat-Lavaud, Cedric Fournet, Jean-Karim Zinzindohoué, Karthikeyan Bhargavan, Pierre-Yves Strub and Santiago Zanella
- Contact: Karthikeyan Bhargavan
- URL: https://github.com/mitls/mitls-fstar

6.5. ProVerif

KEYWORDS: Security - Verification - Cryptographic protocol

FUNCTIONAL DESCRIPTION: ProVerif is an automatic security protocol verifier in the symbolic model (so called Dolev-Yao model). In this model, cryptographic primitives are considered as black boxes. This protocol verifier is based on an abstract representation of the protocol by Horn clauses. Its main features are:

It can verify various security properties (secrecy, authentication, process equivalences).

It can handle many different cryptographic primitives, specified as rewrite rules or as equations.

It can handle an unbounded number of sessions of the protocol (even in parallel) and an unbounded message space.

NEWS OF THE YEAR: Vincent Cheval and Bruno Blanchet worked on several extensions of ProVerif: 1) support for integer counters, with incrementation and inequality tests, 2) lemmas and axioms to give intermediate results to ProVerif, which it exploits to help proving subsequent queries, by deriving additional information in the Horn clauses that it uses to perform the proofs, 3) proofs by induction on the length of the trace, by giving as lemma the property to prove, but obviously for strictly shorter traces. Detailed soundness proofs for these extensions are in progress. These features are not released yet.

- Participants: Bruno Blanchet, Marc Sylvestre and Vincent Cheval
- Contact: Bruno Blanchet
- Publications: Automated reasoning for equivalences in the applied pi calculus with barriers - Automated Reasoning for Equivalences in the Applied Pi Calculus with Barriers - Automated reasoning for equivalences in the applied pi calculus with barriers - Modeling and Verifying Security Protocols with the Applied Pi Calculus and ProVerif - Automatic Verification of Security Protocols in the Symbolic Model: The Verifier ProVerif - Verified Models and Reference Implementations for the TLS 1.3 Standard Candidate - Verified Models and Reference Implementations for the TLS 1.3 Standard Candidate - Automated Verification for Secure Messaging Protocols and Their Implementations: A Symbolic and Computational Approach - Symbolic and Computational Mechanized Verification of the ARINC823 Avionic Protocols - Symbolic and Computational Mechanized Verification of the ARINC823 Avionic Protocols
- URL: http://proverif.inria.fr/

6.6. HACL*

High Assurance Cryptography Library

KEYWORDS: Cryptography - Software Verification

FUNCTIONAL DESCRIPTION: HACL* is a formally verified cryptographic library in F*, developed by the Prosecco team at Inria Paris in collaboration with Microsoft Research, as part of Project Everest.

HACL stands for High-Assurance Cryptographic Library and its design is inspired by discussions at the HACS series of workshops. The goal of this library is to develop verified C reference implementations for popular cryptographic primitives and to verify them for memory safety, functional correctness, and secret independence.

- Contact: Karthikeyan Bhargavan
- URL: https://github.com/mitls/hacl-star

<h1 style="text-align:center; color:red">SECRET Project-Team</h1>

6. New Software and Platforms

6.1. CFS

FUNCTIONAL DESCRIPTION: Reference implementation of parallel CFS (reinforced version of the digital signature scheme CFS). Two variants are proposed, one with a « bit-packing » finite field arithmetic and an evolution with a « bit-slicing » finite-field arithmetic (collaboration with Peter Schwabe). For 80 bits of security the running time for producing one signature with the « bit-packing » variant is slightly above one second. This is high but was still the fastest so far. The evolution with the « bit-slicing » arithmetic produces the same signature in about 100 milliseconds.

- Participants: Grégory Landais and Nicolas Sendrier
- Contact: Nicolas Sendrier
- URL: https://gforge.inria.fr/projects/cfs-signature/

6.2. Collision Decoding

KEYWORDS: Algorithm - Binary linear code

FUNCTIONAL DESCRIPTION: Collision Decoding implements two variants of information set decoding : Stern-Dumer, and MMT. To our knowledge it is the best full-fledged open-source implementation of generic decoding of binary linear codes. It is the best generic attack against code-based cryptography.

- Participants: Grégory Landais and Nicolas Sendrier
- Contact: Nicolas Sendrier
- URL: https://gforge.inria.fr/projects/collision-dec/

6.3. ISDF

FUNCTIONAL DESCRIPTION: Implementation of the Stern-Dumer decoding algorithm, and of a variant of the algorithm due to May, Meurer and Thomae.

- Participants: Grégory Landais and Nicolas Sendrier
- Contact: Anne Canteaut
- URL: https://gforge.inria.fr/projects/collision-dec/

SPADES Project-Team

5. New Software and Platforms

5.1. pyCPA_TWCA

Analysis tool for weakly-hard real-time systems

KEYWORDS: Real time - Scheduling analyses

FUNCTIONAL DESCRIPTION: pyCPA_TWCA is a pyCPA plugin for Typical Worst-Case Analysis. pyCPA is an open-source Python implementation of Compositional Performance Analysis developed at TU Braunschweig, which allows in particular response-time analysis. pyCPA_TWCA is an extension of that tool that is co-developed by Sophie Quinton and Zain Hammadeh at TU Braunschweig. It allows in particular the computation of weakly-hard guarantees for real-time tasks, i.e. number of deadline misses out of a sequence of executions. So far, pyCPA_TWCA is restricted to uniprocessor systems of independent tasks. pyCPA_TWCA can handle the following scheduling policies: Fixed Priority Preemptive, Fixed Priority Non-Preemptive, Weighted Round-Robin, Earliest Deadline First.

- Contact: Sophie Quinton

5.2. CertiCAN

Certifier of CAN bus analysis results

KEYWORDS: Certification - CAN bus - Real time - Static analysis

FUNCTIONAL DESCRIPTION: CertiCAN is a tool, produced using the Coq proof assistant, allowing the formal certification of the correctness of CAN bus analysis results. Result certification is a process that is lightweight and flexible compared to tool certification, which makes it a practical choice for industrial purposes. The analysis underlying CertiCAN, which is based on a combined use of two well-known CAN analysis techniques, is computationally efficient. Experiments demonstrate that CertiCAN is able to certify the results of RTaW-Pegase, an industrial CAN analysis tool, even for large systems. Furthermore, CertiCAN can certify the results of any other RTA tool for the same analysis and system model (periodic tasks with offsets in transactions).

- Contact: Xiaojie Guo

SPECFUN Project-Team

5. New Software and Platforms

5.1. DynaMoW

Dynamic Mathematics on the Web

FUNCTIONAL DESCRIPTION: Programming tool for controlling the generation of mathematical websites that embed dynamical mathematical contents generated by computer-algebra calculations. Implemented in OCaml.

- Participants: Alexis Darrasse, Frédéric Chyzak and Maxence Guesdon
- Contact: Frédéric Chyzak
- URL: http://ddmf.msr-inria.inria.fr/DynaMoW/

5.2. ECS

Encyclopedia of Combinatorial Structures

FUNCTIONAL DESCRIPTION: On-line mathematical encyclopedia with an emphasis on sequences that arise in the context of decomposable combinatorial structures, with the possibility to search by the first terms in the sequence, keyword, generating function, or closed form.

- Participants: Alexis Darrasse, Frédéric Chyzak, Maxence Guesdon and Stéphanie Petit
- Contact: Frédéric Chyzak
- URL: http://ecs.inria.fr/

5.3. DDMF

Dynamic Dictionary of Mathematical Functions

FUNCTIONAL DESCRIPTION: Web site consisting of interactive tables of mathematical formulas on elementary and special functions. The formulas are automatically generated by OCaml and computer-algebra routines. Users can ask for more terms of the expansions, more digits of the numerical values, proofs of some of the formulas, etc.

- Participants: Alexandre Benoit, Alexis Darrasse, Bruno Salvy, Christoph Koutschan, Frédéric Chyzak, Marc Mezzarobba, Maxence Guesdon, Stefan Gerhold and Thomas Gregoire
- Contact: Frédéric Chyzak
- URL: http://ddmf.msr-inria.inria.fr/1.9.1/ddmf

5.4. Mgfun

multivariate generating functions package

FUNCTIONAL DESCRIPTION: The Mgfun Project is a collection of packages for the computer algebra system Maple, and is intended for the symbolic manipulation of a large class of special functions and combinatorial sequences (in one or several variables and indices) that appear in many branches of mathematics, mathematical physics, and engineering sciences. Members of the class satisfy a crucial finiteness property which makes the class amenable to computer algebra methods and enjoy numerous algorithmic closure properties, including algorithmic closures under integration and summation.

- Contact: Frédéric Chyzak
- URL: http://specfun.inria.fr/chyzak/mgfun.html

5.5. Ssreflect

KEYWORD: Proof assistant

SCIENTIFIC DESCRIPTION: Ssreflect is tactic language that helps writing concise and uniform tactic based proof scripts for the Coq system. It was designed during the proofs of the 4 Color Theorem and the Feit-Thompson theorem.

FUNCTIONAL DESCRIPTION: Ssreflect is a tactic language extension to the Coq system, developed by the Mathematical Components team.

NEWS OF THE YEAR: In 2019, we extended the intro pattern functionality of SSreflect and added support for working under binders using the "under" tactical.

- Participants: Assia Mahboubi, Cyril Cohen, Enrico Tassi, Georges Gonthier, Laurence Rideau, Laurent Théry and Yves Bertot
- Contact: Yves Bertot
- URL: http://math-comp.github.io/math-comp/

5.6. Math-Components

Mathematical Components library

KEYWORD: Proof assistant

FUNCTIONAL DESCRIPTION: The Mathematical Components library is a set of Coq libraries that cover the prerequiste for the mechanization of the proof of the Odd Order Theorem.

RELEASE FUNCTIONAL DESCRIPTION: This releases is compatible with Coq 8.9 and Coq 8.10 it adds many theorems for finite function, prime numbers, sequences, finite types, bigo operations, natural numbers, cycles in graphs.

- Participants: Alexey Solovyev, Andrea Asperti, Assia Mahboubi, Cyril Cohen, Enrico Tassi, François Garillot, Georges Gonthier, Ioana Pasca, Jeremy Avigad, Laurence Rideau, Laurent Théry, Russell O'Connor, Sidi Ould Biha, Stéphane Le Roux and Yves Bertot
- Contact: Assia Mahboubi
- URL: http://math-comp.github.io/math-comp/

STAMP Project-Team

5. New Software and Platforms

5.1. Coq

The Coq Proof Assistant

KEYWORDS: Proof - Certification - Formalisation

SCIENTIFIC DESCRIPTION: Coq is an interactive proof assistant based on the Calculus of (Co-)Inductive Constructions, extended with universe polymorphism. This type theory features inductive and co-inductive families, an impredicative sort and a hierarchy of predicative universes, making it a very expressive logic. The calculus allows to formalize both general mathematics and computer programs, ranging from theories of finite structures to abstract algebra and categories to programming language metatheory and compiler verification. Coq is organised as a (relatively small) kernel including efficient conversion tests on which are built a set of higher-level layers: a powerful proof engine and unification algorithm, various tactics/decision procedures, a transactional document model and, at the very top an IDE.

FUNCTIONAL DESCRIPTION: Coq provides both a dependently-typed functional programming language and a logical formalism, which, altogether, support the formalisation of mathematical theories and the specification and certification of properties of programs. Coq also provides a large and extensible set of automatic or semi-automatic proof methods. Coq's programs are extractible to OCaml, Haskell, Scheme, ...

RELEASE FUNCTIONAL DESCRIPTION: Coq version 8.10 contains two major new features: support for a native fixed-precision integer type and a new sort SProp of strict propositions. It is also the result of refinements and stabilization of previous features, deprecations or removals of deprecated features, cleanups of the internals of the system and API, and many documentation improvements. This release includes many user-visible changes, including deprecations that are documented in the next subsection, and new features that are documented in the reference manual.

Version 8.10 is the fifth release of Coq developed on a time-based development cycle. Its development spanned 6 months from the release of Coq 8.9. Vincent Laporte is the release manager and maintainer of this release. This release is the result of 2500 commits and 650 PRs merged, closing 150+ issues.

See the Zenodo citation for more information on this release: https://zenodo.org/record/3476303#.Xe54f5NKjOQ

NEWS OF THE YEAR: Coq 8.10.0 contains:

- some quality-of-life bug fixes,

- a critical bug fix related to template polymorphism,

- native 63-bit machine integers,

- a new sort of definitionally proof-irrelevant propositions: SProp,

- private universes for opaque polymorphic constants,

- string notations and numeral notations,

- a new simplex-based proof engine for the tactics lia, nia, lra and nra,

- new introduction patterns for SSReflect,

- a tactic to rewrite under binders: under,

- easy input of non-ASCII symbols in CoqIDE, which now uses GTK3.

All details can be found in the user manual.

- Participants: Yves Bertot, Frédéric Besson, Maxime Denes, Emilio Jesús Gallego Arias, Gaëtan Gilbert, Jason Gross, Hugo Herbelin, Assia Mahboubi, Érik Martin-Dorel, Guillaume Melquiond, Pierre-Marie Pédrot, Michael Soegtrop, Matthieu Sozeau, Enrico Tassi, Laurent Théry, Théo Zimmermann, Theo Winterhalter, Vincent Laporte, Arthur Charguéraud, Cyril Cohen, Christian Doczkal and Chantal Keller
- Partners: CNRS - Université Paris-Sud - ENS Lyon - Université Paris-Diderot
- Contact: Matthieu Sozeau
- URL: http://coq.inria.fr/

5.2. Math-Components

Mathematical Components library

KEYWORD: Proof assistant

FUNCTIONAL DESCRIPTION: The Mathematical Components library is a set of Coq libraries that cover the prerequiste for the mechanization of the proof of the Odd Order Theorem.

RELEASE FUNCTIONAL DESCRIPTION: This releases is compatible with Coq 8.9 and Coq 8.10 it adds many theorems for finite function, prime numbers, sequences, finite types, bigo operations, natural numbers, cycles in graphs.

- Participants: Alexey Solovyev, Andrea Asperti, Assia Mahboubi, Cyril Cohen, Enrico Tassi, François Garillot, Georges Gonthier, Ioana Pasca, Jeremy Avigad, Laurence Rideau, Laurent Théry, Russell O'Connor, Sidi Ould Biha, Stéphane Le Roux and Yves Bertot
- Contact: Assia Mahboubi
- URL: http://math-comp.github.io/math-comp/

5.3. Semantics

KEYWORDS: Semantic - Programming language - Coq

FUNCTIONAL DESCRIPTION: A didactical Coq development to introduce various semantics styles. Shows how to derive an interpreter, a verifier, or a program analyser from formal descriptions, and how to prove their consistency.

This is a library for the Coq system, where the description of a toy programming language is presented. The value of this library is that it can be re-used in classrooms to teach programming language semantics or the Coq system. The topics covered include introductory notions to domain theory, pre and post-conditions, abstract interpretation, and the proofs of consistency between all these point of views on the same programming language. Standalone tools for the object programming language can be derived from this development.

- Participants: Christine Paulin and Yves Bertot
- Contact: Yves Bertot
- URL: http://www-sop.inria.fr/members/Yves.Bertot/proofs/semantics_survey.tgz

5.4. Easycrypt

KEYWORDS: Proof assistant - Cryptography

FUNCTIONAL DESCRIPTION: EasyCrypt is a toolset for reasoning about relational properties of probabilistic computations with adversarial code. Its main application is the construction and verification of game-based cryptographic proofs. EasyCrypt can also be used for reasoning about differential privacy.

- Participants: Benjamin Grégoire, Gilles Barthe and Pierre-Yves Strub
- Contact: Gilles Barthe
- URL: https://www.easycrypt.info/trac/

5.5. ELPI

Embeddable Lambda Prolog Interpreter

KEYWORDS: Constraint Programming - Programming language - Higher-order logic

SCIENTIFIC DESCRIPTION: The programming language has the following features

- Native support for variable binding and substitution, via an Higher Order Abstract Syntax (HOAS) embedding of the object language. The programmer needs not to care about De Bruijn indexes.

- Native support for hypothetical context. When moving under a binder one can attach to the bound variable extra information that is collected when the variable gets out of scope. For example when writing a typechecker the programmer needs not to care about managing the typing context.

- Native support for higher order unification variables, again via HOAS. Unification variables of the metalanguage (lambdaProlog) can be reused to represent the unification variables of the object language. The programmer does not need to care about the unification-variable assignment map and cannot assign to a unification variable a term containing variables out of scope, or build a circular assignment.

- Native support for syntactic constraints and their meta-level handling rules. The generative semantics of Prolog can be disabled by turning a goal into a syntactic constraint (suspended goal). A syntactic constraint is resumed as soon as relevant variables gets assigned. Syntactic constraints can be manipulated by constraint handling rules (CHR).

- Native support for backtracking. To ease implementation of search.

- The constraint store is extensible. The host application can declare non-syntactic constraints and use custom constraint solvers to check their consistency.

- Clauses are graftable. The user is free to extend an existing program by inserting/removing clauses, both at runtime (using implication) and at "compilation" time by accumulating files.

Most of these feature come with lambdaProlog. Constraints and propagation rules are novel in ELPI.

FUNCTIONAL DESCRIPTION: ELPI implements a variant of lambdaProlog enriched with Constraint Handling Rules, a programming language well suited to manipulate syntax trees with binders and unification variables.

ELPI is a research project aimed at providing a programming platform for the so called elaborator component of an interactive theorem prover.

ELPI is designed to be embedded into larger applications written in OCaml as an extension language. It comes with an API to drive the interpreter and with an FFI for defining built-in predicates and data types, as well as quotations and similar goodies that come in handy to adapt the language to the host application.

RELEASE FUNCTIONAL DESCRIPTION: improvement to the parser (parsing negative numbers) improvement to the foreign function interface (accepting ternary comparison, instead of equality) adds ternary comparisons to the standard library provides a builtin comparison cmp_term provides a builtin to check whether a term is ground

NEWS OF THE YEAR: There were 7 releases in 2019. Work done mostly in these areas:

- consolidation (documentation, bug fixes, test suits)

- API and FFI (making it easier to export host applications to ELPI)

- standard library

- Participant: Claudio Sacerdoti Coen

- Contact: Enrico Tassi

- Publications: ELPI: fast, Embeddable, λProlog Interpreter - Implementing Type Theory in Higher Order Constraint Logic Programming - Deriving proved equality tests in Coq-elpi: Stronger induction principles for containers in Coq

- URL: https://github.com/lpcic/elpi/

5.6. Coq-elpi

KEYWORDS: Metaprogramming - Extension

SCIENTIFIC DESCRIPTION: Coq-elpi provides a Coq plugin that embeds ELPI. It also provides a way to embed Coq's terms into lambdaProlog using the Higher-Order Abstract Syntax approach (HOAS) and a way to read terms back. In addition to that it exports to ELPI a set of Coq's primitives, e.g. printing a message, accessing the environment of theorems and data types, defining a new constant and so on. For convenience it also provides a quotation and anti-quotation for Coq's syntax in lambdaProlog. E.g. {{nat}} is expanded to the type name of natural numbers, or {{A -> B}} to the representation of a product by unfolding the -> notation. Finally it provides a way to define new vernacular commands and new tactics.

FUNCTIONAL DESCRIPTION: Coq plugin embedding ELPI

RELEASE FUNCTIONAL DESCRIPTION: Minor relase for extra API for global reference data types

NEWS OF THE YEAR: Releases 1.0, 1.1, and 1.2 were made in 2019, they constitute the first public release with tutorials and examples.

Work done in 2019 is mostly in these areas:

- expose a complete set of API to script Coq's vernacular language

- take advantage or recent ELPI API and FFI to convert back and forth terms containing existential variables (Evars)

- Contact: Enrico Tassi
- Publications: Deriving proved equality tests in Coq-elpi: Stronger induction principles for containers in Coq - Elpi: an extension language for Coq (Metaprogramming Coq in the Elpi λProlog dialect)

5.7. AutoGnP

KEYWORDS: Formal methods - Security - Cryptography

FUNCTIONAL DESCRIPTION: autoGnP is an automated tool for analyzing the security of padding-based public-key encryption schemes (i.e. schemes built from trapdoor permutations and hash functions). This years we extended the tool to be able to deal with schemes based on cyclic groups and bilinear maps.

- Participants: Benjamin Grégoire, Gilles Barthe and Pierre-Yves Strub
- Contact: Gilles Barthe
- URL: https://github.com/ZooCrypt/AutoGnP

5.8. MaskComp

KEYWORD: Masking

FUNCTIONAL DESCRIPTION: MaskComp is a compiler generating masked implémentation protected against side channel attack based on differential power analysis. It take a unmasked program in a syntaxe close to C and generate a new C protected program. We did not claim that the generate C program will be secure after compilation (C compiler can break protection), but it provide a good support for generating masked implementation.

- Contact: Benjamin Grégoire
- URL: https://sites.google.com/site/maskingcompiler/home

5.9. Jasmin

Jasmin compiler and analyser

KEYWORDS: Cryptography - Static analysis - Compilers

FUNCTIONAL DESCRIPTION: Analysing the execution time of a cryptographic code can be a way to discover the secret protected by this code. To avoid this pitfall, Jasmin proposes a high-level language and an analyzer for this language that makes it possible to predict when the execution of this code will happen in constant time and thus does not unveil the secret (for instance, the cryptographic key). Once the Jasmin code is valid with respect to the analyzer, the compiler produces assembly code that still preserves this property of constant time.

- Contact: Benjamin Grégoire

5.10. MaskVerif

KEYWORDS: Masking - Hardware and Software Platform

FUNCTIONAL DESCRIPTION: MaskVerif is a tool to verify the security of implementations protected against side channel attacks, in particular differential power analysis. It allows to check different security notions in the probing model: - Probing security - Non Interference - Strong Non Interference. The tool is able to analyse software implementations and hardware implementations (written in Verilog). It can prove the different security notions in presence of glitch or transition.

- Contact: Benjamin Grégoire
- URL: https://sites.google.com/view/maskverif/home

5.11. CoqEAL

The Coq Effective Algebra Library

KEYWORD: Proof assistant

FUNCTIONAL DESCRIPTION: This library contains formal developments in algebra and optimized algorithms on mathcomp data structures and a framework to ease change of data representation during a proof.

RELEASE FUNCTIONAL DESCRIPTION: First release

- Contact: Cyril Cohen

5.12. math-comp-analysis

Mathematical Components Analysis

KEYWORD: Proof assistant

FUNCTIONAL DESCRIPTION: This library adds definitions and theorems for real numbers and their mathematical structures

RELEASE FUNCTIONAL DESCRIPTION: Compatible with mathcomp 1.8.0, 1.9.0, and 1.10.0

NEWS OF THE YEAR: In 2019, there were 3 releases.

- Partners: Ecole Polytechnique - AIST Tsukuba
- Contact: Cyril Cohen
- Publication: Formalization Techniques for Asymptotic Reasoning in Classical Analysis
- URL: https://github.com/math-comp/analysis

5.13. math-comp-finmap

Finite maps and ordered types library

KEYWORD: Proof assistant

FUNCTIONAL DESCRIPTION: Support for reasoning about finite maps and ordered types

RELEASE FUNCTIONAL DESCRIPTION: This release is solely an update of order.v and set.v in order to integrate the changes in math-comp/math-comp#270

- Contact: Cyril Cohen

5.14. math-comp-real-closed

Real Closed Fields

KEYWORD: Proof assistant

FUNCTIONAL DESCRIPTION: Theorems for real closed fields

RELEASE FUNCTIONAL DESCRIPTION: First release

- Contact: Cyril Cohen
- URL: https://github.com/math-comp/real-closed

SUMO Project-Team

6. New Software and Platforms

6.1. Active Workspaces

KEYWORDS: Active workspace - Collaborative systems - Artifact centric workflow system

SCIENTIFIC DESCRIPTION: Tool for computer supported cooperative work where a user's workspace is given by an active structured repository containing the pending tasks together with information needed to perform the tasks. Communication between active workspaces is asynchronous using message passing. The tool is based on the model of guarded attribute grammars.

- Authors: Éric Badouel and Robert Nsaibirni
- Contact: Éric Badouel
- URL: http://people.rennes.inria.fr/Eric.Badouel/Research/ActiveWorkspaces.html

6.2. SIMSTORS

Simulator for stochastic regulated systems

KEYWORDS: Simulation - Public transport - Stochastic models - Distributed systems

FUNCTIONAL DESCRIPTION: SIMSTORS is a software for the simulation of stochastic concurrent timed systems. The heart of the software is a variant of stochastic and timed Petri nets, whose execution is controlled by a regulation policy (a controller), or a predetermined theoretical schedule. The role of the regulation policy is to control the system to realize objectives or a schedule when it exists with the best possible precision. SIMSTORS is well adapted to represent systems with randomness, parallelism, tasks scheduling, and resources. From 2015 to 2018, it was used for the P22 collaboration with Asltom Transport, to model metro traffic and evaluate performance of regulation solutions. It is now (2019) at the heart of a collaboration on multi-modal networks with Alstom transport Madrid. This software allows for step by step simulation, but also for efficient performance analysis of systems such as production cells or train systems. The initial implementation was released in 2015, and the software is protected by the APP.

Since then, SIMSTORS has been extended along two main axes: on one hand, SIMSTORS models were extended to handle situations where shared resources can be occupied by more than one object (this is of paramount importance to represent conveyors, roads occupied by cars, or train tracks with smoothed scheduling allowing shared sections among trains) with priorities, constraint on their ordering and individual characteristics. This allows for instance to model vehicles with different speeds on a road, while handling safety distance constraints. On the other hand, SIMSTORS models were extended to allow control of stochastic nets based on decision rules that follow optimization schemes. In 2019, it was extended to include planning-based regulation techniques during a collaboration with Roma 3 University.

RELEASE FUNCTIONAL DESCRIPTION: modeling of continuous vehicles movements

- Participants: Abd El Karim Kecir and Loïc Hélouët
- Contact: Loïc Hélouët
- URL: http://www.irisa.fr/sumo/Software/SIMSTORS/

<center>**TAMIS Project-Team**</center>

5. New Software and Platforms

5.1. MASSE

Modular Automated Syntactic Signature Extraction

KEYWORDS: Malware - Syntactic analysis

FUNCTIONAL DESCRIPTION: The Modular Automated Syntactic Signature Extraction (MASSE) architecture is a new integrated open source client-server architecture for syntactic malware detection and analysis based on the YARA, developed with Teclib'. MASSE includes highly effective automated syntactic malware detection rule generation for the clients based on a server-side modular malware detection system. Multiple techniques are used to make MASSE effective at detecting malware while keeping it from disrupting users and hindering reverse-engineering of its malware analysis by malware creators. MASSE integrates YARA in a distributed system able to detect malware on endpoint systems using YARA, analyze malware with multiple analysis techniques, automatically generate syntactic malware detection rules, and deploy the new rules to the endpoints. The MASSE architecture is freely available to companies and institutions as a complete, modular, self-maintained antivirus solution. Using MASSE, a security department can immediately update the rule database of the whole company, stopping an infection on its tracks and preventing future ones.

- Participants: Bruno Lebon, Olivier Zendra, Alexander Zhdanov and Fabrizio Biondi
- Contact: Bruno Lebon

5.2. IoTMLT

IoT Modeling Language and tool

KEYWORDS: Internet of things - Modeling language - Cyber attack

SCIENTIFIC DESCRIPTION: We propose a framework to analyze security in IoT systems consisting of a formal languages for modeling IoT systems and of attack trees for modeling the possible attacks on the system. In our approach a malicious entity is present in the system, called the Attacker. The other IoT entities can inadvertently help the Attacker, by leaking their sensitive data. Equipped with the acquired knowledge the Attacker can then communicate with the IoT entities undetected. The attack tree provided with the model acts as a monitor: It observes the interactions the Attacker has with the system and detects when an attack is successful.

An IoT system is then analyzed using statistical model checking (SMC). The first method we use is Monte Carlo, which consists of sampling the executions of an IoT system and computing the probability of a successful attack based on the number of executions for which the attack was successful. However, the evaluation may be difficult if a successful attack is rare. We therefore propose a second SMC method, developed for rare events, called importance splitting. Both methods are proposed by Plasma, the SMC tool we use.

FUNCTIONAL DESCRIPTION: The IoT modeling language is a formal language and tool for specifying and enforcing security in IoT systems.

- Participants: Delphine Beaulaton, Ioana-Domnina Cristescu and Najah Ben Said
- Partner: Vérimag
- Contact: Delphine Beaulaton
- URL: http://iot-modeling.gforge.inria.fr

5.3. SimFI

Tool for Simulation Fault injection

KEYWORDS: Fault injection - Fault-tolerance

FUNCTIONAL DESCRIPTION: Fault injections are used to test the robust and security of systems. We have developed SimFI, a tool that can be used to simulate fault injection attacks against binary files. SimFI is lightweight utility designed to be integrated into larger environments as part of robustness testing and fault injection vulnerability detection.

- Contact: Nisrine Jafri
- URL: https://github.com/nisrine/Fault-Injection-Tool

5.4. AHMA

Automatic Malware Hardware Analysis

KEYWORDS: Side-channel - Deep learning - Malware

FUNCTIONAL DESCRIPTION: This framework is composed of several parts, each one of them taking in charge the generation and the processing of the data at different levels. Drivers have been developed to automatically control the different oscilloscopes we are working with (picoscope 6407 et infiniium keysight). We use signal processing tools on the raw data to feed a deep neural network which is in charge of classifying the observed malwares. We are using two different approaches to manage the infection of the system. The first one is to reinitialize it each time we make a measurement to ensure its integrity. We have proposed a method allowing to speed the procedure up a lot. Besides, we developed several malwares, to make our experiments in a controlled environment, to avoid the necessity of cleaning the system up after each measurement.

- Contact: Annelie Heuser

5.5. SABR

Semantic-driven Analysis of BinaRies

KEYWORDS: Malware - Semantic - Binary analysis - Unsupervised graph clustering SCDG - Machine learning

FUNCTIONAL DESCRIPTION: Toolchain for binary analysis based on different techniques for capturing binaries' semantics and performing machine learning-assisted analysis. The primary use is malware analysis for malware detection and classification, either based on supervised and unsupervised learning.

This toolchain includes modules of the former BMA toolchain, specifically the SCDG extraction.

Our approach is based on artificial intelligence. We use concolic analysis to extract behavioral signatures from binaries in a form of system call dependency graphs (SCDGs). Our software can do both supervised and unsupervised learning. The former learns the distinctive features of different malware families on a large training set in order to classify the new binaries as malware or cleanware according to their behavioural signatures. In the unsupervised learning the binaries are clustered according to their graph similarity. The toolchain is orchestrated by an experiment manager that allows to easily setup, launch and view results of all modules of the toolchain.

- Contact: Olivier Zendra

5.6. ORQAL

ORQchestration of ALgorithms

KEYWORDS: Docker - Orchestration

FUNCTIONAL DESCRIPTION: ORQAL is a simple batch scheduler for docker cluster which can be used to remotely and without overhead in scientific experiment.

- Contact: Olivier Zendra

5.7. Side-channel deep learning evaluation platform

KEYWORDS: Deep learning - Evaluation

FUNCTIONAL DESCRIPTION: Our platform is based on several software. The first software permits to train a deep neural network and evaluate it for side-channel analysis, we evaluate our neural network with guessing entropy metrics. The second software is used for programming and communicating with the target devices, but we also develop a software to communicate with the equipment and made some measurement for side-channel analysis. The last software is used to make some attack and analysis of side-channel (e.g. made Correlation Power Analysis)

- Contact: Annelie Heuser

5.8. E-PAC

Evolving-PAcker Classifier

KEYWORDS: Packer classification - Incremental learning - Clustering - Malware - Obfuscation

FUNCTIONAL DESCRIPTION: E-PAC is an Evolving packer classifier that identifies the class of the packer used in a batch of packed binaries given in input. The software has the ability to identify both known packer classes and new unseen packer classes. After each update, the evolving classifier self-updates itself with the predicted packer classes.

The software is based on a semi-supervised machine learning system composed of an offline phase and an online phase. In the offline phase, a set of features is extracted from a collection of packed binaries provided with their ground truth labels, then a density-based clustering algorithm (DBSCAN) is used to group similar packers together with respect to a distance measure. In this step, the similarity threshold is tuned in order to form the clusters that fit the best with the the set of labels provided.

In the online phase, the software reproduces the same operations of features extraction and distances calculation with the incoming packed samples, then uses a customized version of the incremental clustering algorithm DBSCAN in order to classify them, either in knowns packer classes or fom new packer classes, or provisoirely leave them unclassified (notion of noise with DBSCAN).

The clusters formed after each update serve as a baseline for the application to self-evolve.

- Contact: Lamine Noureddine

<div align="center">**TEA Project-Team**</div>

6. New Software and Platforms

6.1. ADFG

Affine data-flow graphs schedule synthesizer

KEYWORDS: Code generation - Scheduling - Static program analysis

FUNCTIONAL DESCRIPTION: ADFG is a synthesis tool of real-time system scheduling parameters: ADFG computes task periods and buffer sizes of systems resulting in a trade-off between throughput maximization and buffer size minimization. ADFG synthesizes systems modeled by ultimately cyclo-static dataflow (UCSDF) graphs, an extension of the standard CSDF model.

Knowing the WCET (Worst Case Execute Time) of the actors and their exchanges on the channels, ADFG tries to synthezise the scheduler of the application. ADFG offers several scheduling policies and can detect unschedulable systems. It ensures that the real scheduling does not cause overflows or underflows and tries to maximize the throughput (the processors utilization) while minimizing the storage space needed between the actors (i.e. the buffer sizes).

Abstract affine scheduling is first applied on the dataflow graph, that consists only of periodic actors, to compute timeless scheduling constraints (e.g. relation between the speeds of two actors) and buffering parameters. Then, symbolic schedulability policies analysis (i.e., synthesis of timing and scheduling parameters of actors) is applied to produce the scheduller for the actors.

ADFG, initially defined to synthesize real-time schedulers for SCJ/L1 applications, may be used for scheduling analysis of AADL programs.

- Authors: Thierry Gautier, Jean-Pierre Talpin, Adnan Bouakaz, Alexandre Honorat and Loïc Besnard
- Contact: Loïc Besnard

6.2. POLYCHRONY

KEYWORDS: Code generation - AADL - Proof - Optimization - Multi-clock - GALS - Architecture - Cosimulation - Real time - Synchronous Language

FUNCTIONAL DESCRIPTION: Polychrony is an Open Source development environment for critical/embedded systems. It is based on Signal, a real-time polychronous data-flow language. It provides a unified model-driven environment to perform design exploration by using top-down and bottom-up design methodologies formally supported by design model transformations from specification to implementation and from synchrony to asynchrony. It can be included in heterogeneous design systems with various input formalisms and output languages. The Polychrony tool-set provides a formal framework to: validate a design at different levels, by the way of formal verification and/or simulation, refine descriptions in a top-down approach, abstract properties needed for black-box composition, compose heterogeneous components (bottom-up with COTS), generate executable code for various architectures. The Polychrony tool-set contains three main components and an experimental interface to GNU Compiler Collection (GCC):

* The Signal toolbox, a batch compiler for the Signal language, and a structured API that provides a set of program transformations. Itcan be installed without other components and is distributed under GPL V2 license.

* The Signal GUI, a Graphical User Interface to the Signal toolbox (editor + interactive access to compiling functionalities). It can be used either as a specific tool or as a graphical view under Eclipse. It has been transformed and restructured, in order to get a more up-to-date interface allowing multi-window manipulation of programs. It is distributed under GPL V2 license.

* The POP Eclipse platform, a front-end to the Signal toolbox in the Eclipse environment. It is distributed under EPL license.

- Participants: Loïc Besnard, Paul Le Guernic and Thierry Gautier
- Partners: CNRS - Inria
- Contact: Loïc Besnard
- URL: https://www.polarsys.org/projects/polarsys.pop

6.3. Polychrony AADL2SIGNAL

KEYWORDS: Real-time application - Polychrone - Synchronous model - Polarsys - Polychrony - Signal - AADL - Eclipse - Meta model

FUNCTIONAL DESCRIPTION: This polychronous MoC has been used previously as semantic model for systems described in the core AADL standard. The core AADL is extended with annexes, such as the Behavior Annex, which allows to specify more precisely architectural behaviors. The translation from AADL specifications into the polychronous model should take into account these behavior specifications, which are based on description of automata.

For that purpose, the AADL state transition systems are translated as Signal automata (a slight extension of the Signal language has been defined to support the model of polychronous automata).

Once the AADL model of a system transformed into a Signal program, one can analyze the program using the Polychrony framework in order to check if timing, scheduling and logical requirements over the whole system are met.

We have implemented the translation and experimented it using a concrete case study, which is the AADL modeling of an Adaptive Cruise Control (ACC) system, a highly safety-critical system embedded in recent cars.

- Participants: Huafeng Yu, Loïc Besnard, Paul Le Guernic, Thierry Gautier and Yue Ma
- Partner: CNRS
- Contact: Loïc Besnard
- URL: http://www.inria.fr/equipes/tea

6.4. POP

Polychrony on Polarsys

KEYWORDS: Synchronous model - Model-driven engineering

FUNCTIONAL DESCRIPTION: The Eclipse project POP is a model-driven engineering front-end to our open-source toolset Polychrony. a major achievement of the ESPRESSO (and now TEA) project-team. The Eclipse project POP is a model-driven engineering front-end to our open-source toolset Polychrony. It was finalised in the frame of project OPEES, as a case study: by passing the POLARSYS qualification kit as a computer aided simulation and verification tool. This qualification was implemented by CS Toulouse in conformance with relevant generic (platform independent) qualification documents. Polychrony is now distributed by the Eclipse project POP on the platform of the POLARSYS industrial working group. Team TEA aims at continuing its dissemination to academic partners, as to its principles and features, and industrial partners, as to the services it can offer.

Project POP is composed of the Polychrony tool set, under GPL license, and its Eclipse framework, under EPL license. SSME (Syntactic Signal-Meta under Eclipse), is the meta-model of the Signal language implemented with Eclipse/Ecore. It describes all syntactic elements specified in Signal Reference Manual[0]: all Signal operators (e.g. arithmetic, clock synchronization), model (e.g. process frame, module), and construction (e.g. iteration, type declaration). The meta-model primarily aims at making the language and services of the Polychrony environment available to inter-operation and composition with other components (e.g. AADL, Simulink, GeneAuto, P) within an Eclipse-based development tool-chain. Polychrony now comprises the capability to directly import and export Ecore models instead of textual Signal programs, in order to facilitate interaction between components within such a tool-chain. The download site for project POP has opened in 2015 at https://www.polarsys.org/projects/polarsys.pop. It should be noted that the Eclipse Foundation does not host code under GPL license. So, the Signal toolbox useful to compile Signal code from Eclipse is hosted on our web server.

- Participants: Jean-Pierre Talpin, Loïc Besnard, Paul Le Guernic and Thierry Gautier

- Contact: Loïc Besnard

- URL: https://www.polarsys.org/projects/polarsys.pop

6.5. Sigali

FUNCTIONAL DESCRIPTION: Sigali is a model-checking tool that operates on ILTS (Implicit Labeled Transition Systems, an equational representation of an automaton), an intermediate model for discrete event systems. It offers functionalities for verification of reactive systems and discrete controller synthesis. The techniques used consist in manipulating the system of equations instead of the set of solutions, which avoids the enumeration of the state space. Each set of states is uniquely characterized by a predicate and the operations on sets can be equivalently performed on the associated predicates. Therefore, a wide spectrum of properties, such as liveness, invariance, reachability and attractivity, can be checked. Algorithms for the computation of predicates on states are also available. Sigali is connected with the Polychrony environment (Tea project-team) as well as the Matou environment (VERIMAG), thus allowing the modeling of reactive systems by means of Signal Specification or Mode Automata and the visualization of the synthesized controller by an interactive simulation of the controlled system.

- Contact: Hervé Marchand

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SIGNAL V4-Inria version: Reference Manual. Besnard, L., Gautier, T. and Le Guernic, P. http://www.irisa.fr/espresso/Polychrony, 2010

TOCCATA Project-Team

6. New Software and Platforms

6.1. Alt-Ergo

Automated theorem prover for software verification

KEYWORDS: Software Verification - Automated theorem proving

FUNCTIONAL DESCRIPTION: Alt-Ergo is an automatic solver of formulas based on SMT technology. It is especially designed to prove mathematical formulas generated by program verification tools, such as Frama-C for C programs, or SPARK for Ada code. Initially developed in Toccata research team, Alt-Ergo's distribution and support are provided by OCamlPro since September 2013.

RELEASE FUNCTIONAL DESCRIPTION: the "SAT solving" part can now be delegated to an external plugin, new experimental SAT solver based on mini-SAT, provided as a plugin. This solver is, in general, more efficient on ground problems, heuristics simplification in the default SAT solver and in the matching (instantiation) module, re-implementation of internal literals representation, improvement of theories combination architecture, rewriting some parts of the formulas module, bugfixes in records and numbers modules, new option "-no-Ematching" to perform matching without equality reasoning (i.e. without considering "equivalence classes"). This option is very useful for benchmarks coming from Atelier-B, two new experimental options: "-save-used-context" and "-replay-used-context". When the goal is proved valid, the first option allows to save the names of useful axioms into a ".used" file. The second one is used to replay the proof using only the axioms listed in the corresponding ".used" file. Note that the replay may fail because of the absence of necessary ground terms generated by useless axioms (that are not included in .used file) during the initial run.

- Participants: Alain Mebsout, Évelyne Contejean, Mohamed Iguernelala, Stéphane Lescuyer and Sylvain Conchon
- Partner: OCamlPro
- Contact: Sylvain Conchon
- URL: http://alt-ergo.lri.fr

6.2. CoqInterval

Interval package for Coq

KEYWORDS: Interval arithmetic - Coq

FUNCTIONAL DESCRIPTION: CoqInterval is a library for the proof assistant Coq.

It provides several tactics for proving theorems on enclosures of real-valued expressions. The proofs are performed by an interval kernel which relies on a computable formalization of floating-point arithmetic in Coq.

The Marelle team developed a formalization of rigorous polynomial approximation using Taylor models in Coq. In 2014, this library has been included in CoqInterval.

- Participants: Assia Mahboubi, Érik Martin-Dorel, Guillaume Melquiond, Jean-Michel Muller, Laurence Rideau, Laurent Théry, Micaela Mayero, Mioara Joldes, Nicolas Brisebarre and Thomas Sibut-Pinote
- Contact: Guillaume Melquiond
- Publications: Proving bounds on real-valued functions with computations - Floating-point arithmetic in the Coq system - Proving Tight Bounds on Univariate Expressions with Elementary Functions in Coq - Formally Verified Approximations of Definite Integrals - Formally Verified Approximations of Definite Integrals
- URL: http://coq-interval.gforge.inria.fr/

6.3. Coquelicot

The Coquelicot library for real analysis in Coq

KEYWORDS: Coq - Real analysis

FUNCTIONAL DESCRIPTION: Coquelicot is library aimed for supporting real analysis in the Coq proof assistant. It is designed with three principles in mind. The first is the user-friendliness, achieved by implementing methods of automation, but also by avoiding dependent types in order to ease the stating and readability of theorems. This latter part was achieved by defining total function for basic operators, such as limits or integrals. The second principle is the comprehensiveness of the library. By experimenting on several applications, we ensured that the available theorems are enough to cover most cases. We also wanted to be able to extend our library towards more generic settings, such as complex analysis or Euclidean spaces. The third principle is for the Coquelicot library to be a conservative extension of the Coq standard library, so that it can be easily combined with existing developments based on the standard library.

- Participants: Catherine Lelay, Guillaume Melquiond and Sylvie Boldo
- Contact: Sylvie Boldo
- URL: http://coquelicot.saclay.inria.fr/

6.4. Cubicle

The Cubicle model checker modulo theories

KEYWORDS: Model Checking - Software Verification

FUNCTIONAL DESCRIPTION: Cubicle is an open source model checker for verifying safety properties of array-based systems, which corresponds to a syntactically restricted class of parametrized transition systems with states represented as arrays indexed by an arbitrary number of processes. Cache coherence protocols and mutual exclusion algorithms are typical examples of such systems.

- Participants: Alain Mebsout and Sylvain Conchon
- Contact: Sylvain Conchon
- URL: http://cubicle.lri.fr/

6.5. Flocq

The Flocq library for formalizing floating-point arithmetic in Coq

KEYWORDS: Floating-point - Arithmetic code - Coq

FUNCTIONAL DESCRIPTION: The Flocq library for the Coq proof assistant is a comprehensive formalization of floating-point arithmetic: core definitions, axiomatic and computational rounding operations, high-level properties. It provides a framework for developers to formally verify numerical applications.

Flocq is currently used by the CompCert verified compiler to support floating-point computations.

- Participants: Guillaume Melquiond, Pierre Roux and Sylvie Boldo
- Contact: Sylvie Boldo
- Publications: Flocq: A Unified Library for Proving Floating-point Algorithms in Coq - A Formally-Verified C Compiler Supporting Floating-Point Arithmetic - Verified Compilation of Floating-Point Computations - Innocuous Double Rounding of Basic Arithmetic Operations - Formal Proofs of Rounding Error Bounds : With application to an automatic positive definiteness check - Computer Arithmetic and Formal Proofs : Verifying Floating-point Algorithms with the Coq System
- URL: http://flocq.gforge.inria.fr/

6.6. Gappa

The Gappa tool for automated proofs of arithmetic properties

KEYWORDS: Floating-point - Arithmetic code - Software Verification - Constraint solving

FUNCTIONAL DESCRIPTION: Gappa is a tool intended to help formally verifying numerical programs dealing with floating-point or fixed-point arithmetic. It has been used to write robust floating-point filters for CGAL and it is used to verify elementary functions in CRlibm. While Gappa is intended to be used directly, it can also act as a backend prover for the Why3 software verification plateform or as an automatic tactic for the Coq proof assistant.

- Participant: Guillaume Melquiond
- Contact: Guillaume Melquiond
- Publications: Generating formally certified bounds on values and round-off errors - Formal certification of arithmetic filters for geometric predicates - Assisted verification of elementary functions - From interval arithmetic to program verification - Formally Certified Floating-Point Filters For Homogeneous Geometric Predicates - Combining Coq and Gappa for Certifying Floating-Point Programs - Handbook of Floating-Point Arithmetic - Certifying the floating-point implementation of an elementary function using Gappa - Automations for verifying floating-point algorithms - Automating the verification of floating-point algorithms - Computer Arithmetic and Formal Proofs : Verifying Floating-point Algorithms with the Coq System
- URL: http://gappa.gforge.inria.fr/

6.7. Why3

The Why3 environment for deductive verification

KEYWORDS: Formal methods - Trusted software - Software Verification - Deductive program verification

FUNCTIONAL DESCRIPTION: Why3 is an environment for deductive program verification. It provides a rich language for specification and programming, called WhyML, and relies on external theorem provers, both automated and interactive, to discharge verification conditions. Why3 comes with a standard library of logical theories (integer and real arithmetic, Boolean operations, sets and maps, etc.) and basic programming data structures (arrays, queues, hash tables, etc.). A user can write WhyML programs directly and get correct-by-construction OCaml programs through an automated extraction mechanism. WhyML is also used as an intermediate language for the verification of C, Java, or Ada programs.

- Participants: Andriy Paskevych, Claude Marché, François Bobot, Guillaume Melquiond, Jean-Christophe Filliâtre, Levs Gondelmans and Martin Clochard
- Partners: CNRS - Université Paris-Sud
- Contact: Claude Marché
- URL: http://why3.lri.fr/

6.8. Coq

The Coq Proof Assistant

KEYWORDS: Proof - Certification - Formalisation

SCIENTIFIC DESCRIPTION: Coq is an interactive proof assistant based on the Calculus of (Co-)Inductive Constructions, extended with universe polymorphism. This type theory features inductive and co-inductive families, an impredicative sort and a hierarchy of predicative universes, making it a very expressive logic. The calculus allows to formalize both general mathematics and computer programs, ranging from theories of finite structures to abstract algebra and categories to programming language metatheory and compiler verification. Coq is organised as a (relatively small) kernel including efficient conversion tests on which are built a set of higher-level layers: a powerful proof engine and unification algorithm, various tactics/decision procedures, a transactional document model and, at the very top an IDE.

FUNCTIONAL DESCRIPTION: Coq provides both a dependently-typed functional programming language and a logical formalism, which, altogether, support the formalisation of mathematical theories and the specification and certification of properties of programs. Coq also provides a large and extensible set of automatic or semi-automatic proof methods. Coq's programs are extractable to OCaml, Haskell, Scheme, ...

RELEASE FUNCTIONAL DESCRIPTION: Coq version 8.10 contains two major new features: support for a native fixed-precision integer type and a new sort SProp of strict propositions. It is also the result of refinements and stabilization of previous features, deprecations or removals of deprecated features, cleanups of the internals of the system and API, and many documentation improvements. This release includes many user-visible changes, including deprecations that are documented in the next subsection, and new features that are documented in the reference manual.

Version 8.10 is the fifth release of Coq developed on a time-based development cycle. Its development spanned 6 months from the release of Coq 8.9. Vincent Laporte is the release manager and maintainer of this release. This release is the result of 2500 commits and 650 PRs merged, closing 150+ issues.

See the Zenodo citation for more information on this release: https://zenodo.org/record/3476303#.Xe54f5NKjOQ

NEWS OF THE YEAR: Coq 8.10.0 contains:

- some quality-of-life bug fixes, - a critical bug fix related to template polymorphism, - native 63-bit machine integers, - a new sort of definitionally proof-irrelevant propositions: SProp, - private universes for opaque polymorphic constants, - string notations and numeral notations, - a new simplex-based proof engine for the tactics lia, nia, lra and nra, - new introduction patterns for SSReflect, - a tactic to rewrite under binders: under, - easy input of non-ASCII symbols in CoqIDE, which now uses GTK3.

All details can be found in the user manual.

- Participants: Yves Bertot, Frédéric Besson, Maxime Denes, Emilio Jesús Gallego Arias, Gaëtan Gilbert, Jason Gross, Hugo Herbelin, Assia Mahboubi, Érik Martin-Dorel, Guillaume Melquiond, Pierre-Marie Pédrot, Michael Soegtrop, Matthieu Sozeau, Enrico Tassi, Laurent Théry, Théo Zimmermann, Theo Winterhalter, Vincent Laporte, Arthur Charguéraud, Cyril Cohen, Christian Doczkal and Chantal Keller
- Partners: CNRS - Université Paris-Sud - ENS Lyon - Université Paris-Diderot
- Contact: Matthieu Sozeau
- URL: http://coq.inria.fr/

VERIDIS Project-Team

6. New Software and Platforms

6.1. Redlog

Reduce Logic System

KEYWORDS: Computer algebra system (CAS) - First-order logic - Constraint solving

SCIENTIFIC DESCRIPTION: Redlog is an integral part of the interactive computer algebra system Reduce. It supplements Reduce's comprehensive collection of powerful methods from symbolic computation by supplying more than 100 functions on first-order formulas.

Redlog generally works with interpreted first-order logic in contrast to free first-order logic. Each first-order formula in Redlog must exclusively contain atoms from one particular Redlog-supported theory, which corresponds to a choice of admissible functions and relations with fixed semantics. Redlog-supported theories include Nonlinear Real Arithmetic (Real Closed Fields), Presburger Arithmetic, Parametric QSAT, and many more.

NEWS OF THE YEAR: Parts of the Redlog code are 25 years old now. Version 1 of the underlying computer algebra system Reduce has been published even 50 years ago. In 2018 we therefore started to go for major revisions and improvements of Redlog's software architecture, which are still under way.

Redlog, as well as the underlying Reduce, depends on a quite minimalistic Lisp 1 dialect called Standard Lisp. Today, there are two independent implementations of Standard Lisp left, which are supported only on the basis of private commitment of essentially one individual per Lisp. With the large code base of Redlog plus the necessary algebraic algorithms from Reduce, a migration to a different language or computer algebra system is not feasible. We are therefore experimenting with the realization of a Standard Lisp on the basis of ANSI Common Lisp.

Scientifically we are currently improving on Parametric Gaussian Elimination in Reduce/Redlog, which has various applications in our bilateral interdisciplinary ANR/DFG project SYMBIONT (Symbolic Methods for Biological Networks), e.g., classification of real singularities of systems of implicit ordinary differential equations.

- Participant: Thomas Sturm
- Contact: Thomas Sturm
- URL: http://www.redlog.eu/

6.2. SPASS

KEYWORD: First-order logic

SCIENTIFIC DESCRIPTION: The classic SPASS is an automated theorem prover based on superposition that handles first-order logic with equality and several extensions for particular classes of theories. With version SPASS 3.9 we have stopped the development of the classic prover and have started the bottom-up development of SPASS 4.0 that will actually be a workbench of automated reasoning tools. Furthermore, we use SPASS 3.9 as a test bed for the development of new calculi.

SPASS 3.9 has been used as the basis for SPASS-AR, a new approximation refinement theorem proving approach.

FUNCTIONAL DESCRIPTION: SPASS is an automated theorem prover based on superposition that handles first-order logic with equality and several extensions for particular classes of theories.

- Contact: Christoph Weidenbach
- URL: http://www.spass-prover.org/

6.3. SPASS-SATT

KEYWORDS: Automated deduction - Decision

SCIENTIFIC DESCRIPTION: SPASS -SATT is an SMT solver for the theories of linear integer arithmetic, linear rational arithmetic and mixed linear arithmetic. It features new tests for the satisfiability of unbounded systems, as well as new algorithms for the detection of integer solutions.

We further investigated the use of redundancy elimination in SAT solving and underlying implementation techniques. Our aim is a new approach to SAT solving that needs fewer conflicts (on average) *and* is faster than the current state-of-the art solvers. Furthermore, we have developed a new calculus and first prototypical implementation of a SAT solver with mixed OR/XOR clauses.

FUNCTIONAL DESCRIPTION: SPASS-SATT is an SMT solver for linear integer arithmetic, mixed linear arithmetic and rational linear arithmetic.

NEWS OF THE YEAR: SPASS-SATT participated in the SMT competition 2019 in the quantifier free integer and rational linear arithmetic categories. It scored first on rational linear arithmetic and second on integer linear arithmetic. (The winner of the latter category was a portfolio solver that includes SPASS-SATT.) The main improvements are due to an advanced translation to clause normal form, a close interaction between the theory and the SAT solvers, and a new transformation turning unbounded integer problems into bounded integer problems.

- Participants: Martin Bromberger, Mathias Fleury and Christoph Weidenbach
- Contact: Martin Bromberger
- URL: https://www.mpi-inf.mpg.de/departments/automation-of-logic/software/spass-workbench/spass-satt/

6.4. veriT

KEYWORDS: Automated deduction - Formula solving - Verification

SCIENTIFIC DESCRIPTION: veriT comprises a SAT solver, a decision procedure for uninterpreted symbols based on congruence closure, a simplex-based decision procedure for linear arithmetic, and instantiation-based quantifier handling.

FUNCTIONAL DESCRIPTION: VeriT is an open, trustable and efficient SMT (Satisfiability Modulo Theories) solver, featuring efficient decision procedure for uninterpreted symbols and linear arithmetic, and quantifier reasoning.

NEWS OF THE YEAR: Efforts in 2019 have been focused on quantifier handling, higher logic, and proof production.

The veriT solver participated in the SMT competition SMT-COMP 2019 with good results. In particular, it took the bronze medal in the QF_UF division, solving as many problems as the two leading solvers but taking somewhat more time.

We target applications where validation of formulas is crucial, such as the validation of TLA$^+$ and B specifications, and work together with the developers of the respective verification platforms to make veriT even more useful in practice. The solver is available as a plugin for the *Rodin* platform, and it is integrated within *Atelier B*.

veriT is also a prototype platform for ideas developed within the Matryoshka project, aiming at greater availability of automated reasoning for proof assistants.

- Participants: Haniel Barbosa, Daniel El Ouraoui, Pascal Fontaine and Hans-JÖrg Schurr
- Partner: Université de Lorraine
- Contact: Pascal Fontaine
- URL: http://www.veriT-solver.org

6.5. SPIKE

KEYWORDS: Proof - Automated deduction - Automated theorem proving - Term Rewriting Systems - Formal methods

SCIENTIFIC DESCRIPTION: SPIKE, an automatic induction-based theorem prover built to reason on conditional theories with equality, is one of the few formal tools able to perform automatically mutual and lazy induction. Designed in the 1990s, it has been successfully used in many non-trivial applications and served as a prototype for different proof experiments and extensions.

FUNCTIONAL DESCRIPTION: Automated induction-based theorem prover

RELEASE FUNCTIONAL DESCRIPTION: Proof certification with Coq, cyclic induction, decision procedures

- Participant: Sorin Stratulat
- Contact: Sorin Stratulat
- URL: https://github.com/sorinica/spike-prover/wiki

6.6. TLAPS

TLA+ proof system

KEYWORD: Proof assistant

SCIENTIFIC DESCRIPTION: TLAPS is a platform for developing and mechanically verifying proofs about TLA+ specifications. The TLA+ proof language is hierarchical and explicit, allowing a user to decompose the overall proof into proof steps that can be checked independently. TLAPS consists of a proof manager that interprets the proof language and generates a collection of proof obligations that are sent to backend verifiers. The current backends include the tableau-based prover Zenon for first-order logic, Isabelle/TLA+, an encoding of TLA+ set theory as an object logic in the logical framework Isabelle, an SMT backend designed for use with any SMT-lib compatible solver, and an interface to a decision procedure for propositional temporal logic.

FUNCTIONAL DESCRIPTION: TLAPS is a proof assistant for the TLA+ specification language.

NEWS OF THE YEAR: Work in 2019 focused on providing support for reasoning about TLA+'s ENABLED and action composition constructs. We also prepared a minor release, fixing some issues and switching to Z3 as the default SMT back-end solver.

- Participants: Damien Doligez, Stephan Merz and Ioannis Filippidis
- Contact: Stephan Merz
- URL: https://tla.msr-inria.inria.fr/tlaps/content/Home.html

6.7. Apalache

Abstraction-based Parameterized TLA+ Checker

KEYWORD: Model Checker

SCIENTIFIC DESCRIPTION: Apalache is a symbolic model checker that works under the following assumptions:

(1) As in TLC, all specification parameters are fixed and finite, e.g., the system is initialized integers, finite sets, and functions of finite domains and co-domains. (2) As in TLC, all data structures evaluated during an execution are finite, e.g., a system specification cannot operate on the set of all integers. (3) Only finite executions up to a given bound are analysed.

Apalache translates bounded executions of a TLA+ specifications into a set of quantifier-free SMT constraints. By querying the SMT solver, the model checker either finds a counterexample to an invariant, or proves that there is no counterexample up to given computation length.

FUNCTIONAL DESCRIPTION: The first version implements a symbolic bounded model checker for TLA$^+$ that runs under the same assumptions as the explicit-state model checker TLC. It checks whether a TLA$^+$ specification satisfies an invariant candidate by checking satisfiability of an SMT formula that encodes: (1) an execution of bounded length, and (2) preservation of the invariant candidate in every state of the execution. Our tool is still in the experimental phase, due to a number of challenges posed by the semantics of TLA$^+$ to SMT solvers.

NEWS OF THE YEAR: In 2019, we have simplified the set of rewriting rules, which are used in the translation from TLA+ to SMT. We have shown that the rules are sound, that is, that the translator produces a set of SMT constraints that are equisatisfiable to the given TLA+ formula. We have conducted the experiments on 10 TLA+ specifications of distributed algorithms. When running bounded model checking, Apalache outperforms TLC in some cases. When checking inductive invariants, Apalache runs significantly faster than TLC. These results were reported at ACM OOPSLA 2019.

- Partner: Technische Universität Wien
- Contact: Igor Konnov
- Publications: hal-01899719v1 - hal-01871131v1 - hal-02280888v1
- URL: https://forsyte.at/research/apalache/

6.8. IMITATOR

KEYWORDS: Verification - Parametric model - Parameter synthesis - Model Checking - Model Checker - Timed automata

FUNCTIONAL DESCRIPTION: IMITATOR is a software tool for parametric verification and robustness analysis of real-time systems with parameters. It relies on the formalism of networks of parametric timed automata, augmented with integer variables and stopwatches.

- Participants: Etienne Andre and Jaime Eduardo Arias Almeida
- Partner: Loria
- Contact: Etienne Andre
- Publications: The Inverse Method - Formalizing Time4sys using parametric timed automata - Minimal-Time Synthesis for Parametric Timed Automata - A benchmark library for parametric timed model checking
- URL: https://www.imitator.fr/

6.9. ByMC

Byzantine Model Checker

KEYWORDS: Model Checker - Distributed computing - Verification

SCIENTIFIC DESCRIPTION: In recent work, we have introduced a series of techniques for automatic verification of threshold-guarded distributed algorithms that have the following features: (1) up to t of n processes may exhibit crash or Byzantine failures, (2) the correct processes count messages and progress when they receive sufficiently many messages, e.g., at least $t + 1$, (3) the number n of processes in the system is a parameter, as well as t, (4) and the parameters are restricted by a resilience condition, e.g., $n > 3t$.

ByMC supports a parallel mode, which allows one to run verification experiments in an MPI cluster such as Grid5000 and Vienna Scientific Cluster.

FUNCTIONAL DESCRIPTION: ByMC implements several techniques for the parameterized verification of threshold-guarded distributed algorithms such as reliable broadcast, one-step Byzantine consensus, non-blocking atomic commit, condition-based consensus, and randomized consensus. The tool accepts two kinds of inputs: (i) threshold automata (the framework of our verification techniques) and (ii) Parametric Promela (which is similar to the way in which the distributed algorithms are presented in the distributed computing literature). Internally, the tool analyzes representative executions by querying an SMT solver. Apart from verification, ByMC also implements a technique for the automatic synthesis of threshold guards.

The tool can run on a single computer as well as in an MPI cluster, e.g., Grid5000 or Vienna Scientific Cluster.

NEWS OF THE YEAR: In 2019, we have shown how to apply ByMC to randomized fault-tolerant consensus algorithms such as randomized consensus by Ben-Or and RS-BOSCO. This result was presented at CONCUR 2019.

- Partner: Technische Universität Wien
- Contact: Igor Konnov
- Publications: ByMC: Byzantine Model Checker - Reachability in Parameterized Systems: All Flavors of Threshold Automata - Model Checking of Fault-Tolerant Distributed Algorithms: from Classics towards Contemporary - Verification of Randomized Distributed Algorithms under Round-Rigid Adversaries
- URL: https://forsyte.at/software/bymc/

ACUMES Project-Team

5. New Software and Platforms

5.1. MGDA

Multiple Gradient Descent Algorithm

KEYWORDS: Descent direction - Multiple gradients - Multi-objective differentiable optimization - Prioritized multi-objective optimization

SCIENTIFIC DESCRIPTION: The software relies upon a basic MGDA tool which permits to calculate a descent direction common to an arbitrary set of cost functions whose gradients at a computational point are provided by the user, as long as a solution exists, that is, with the exclusion of a Pareto-stationarity situation.

More specifically, the basic software computes a vector d whose scalar product with each of the given gradients (or directional derivative) is positive. When the gradients are linearly independent, the algorithm is direct following a Gram-Schmidt orthogonalization. Otherwise, a sub-family of the gradients is identified according to a hierarchical criterion as a basis of the spanned subspace associated with a cone that contains almost all the gradient directions. Then, one solves a quadratic programming problem formulated in this basis.

This basic tool admits the following extensions: - constrained multi-objective optimization - prioritized multi-objective optimization - stochastic multi-objective optimization.

FUNCTIONAL DESCRIPTION: Chapter 1: Basic MGDA tool Software to compute a descent direction common to an arbitrary set of cost functions whose gradients are provided in situations other than Pareto stationarity.

Chapter 2: Directions for solving a constrained problem Guidelines and examples are provided according the Inria research report 9007 for solving constrained problems by a quasi-Riemannian approach and the basic MGDA tool.

Chapter 3: Tool for prioritized optimization Software permitting to solve a multi-objective optimization problem in which the cost functions are defined by two subsets: - a primary subset of cost functions subject to constraints for which a Pareto optimal point is provided by the user (after using the previous tool or any other multiobjective method, possibly an evolutionary algorithm) - a secondary subset of cost functions to be reduced while maintaining quasi Pareto optimality of the first set. Procedures defining the cost and constraint functions, and a small set of numerical parameters are uploaded to the platform by an external user. The site returns an archive containing datafiles of results including graphics automatically generated.

Chapter 4: Stochastic MGDA Information and bibliographic references about SMGDA, an extension of MGDA applicable to certain stochastic formulations.

Concerning Chapter 1, the utilization of the platform can be made via two modes : – the interactive mode, through a web interface that facilitates the data exchange between the user and an Inria dedicated machine, – the iterative mode, in which the user downloads the object library to be included in a personal optimization software. Concerning Chapters 2 and 3, the utilizer specifies cost and constraint functions by providing procedures compatible with Fortran 90. Chapter 3 does not require the specification of gradients, but only the functions themselves that are approximated by the software by quadratic meta-models.

- Participant: Jean-Antoine Désidéri
- Contact: Jean-Antoine Désidéri
- Publications: Revision of the Multiple-Gradient Descent Algorithm (MGDA) by Hierarchical Orthogonalization - Parametric optimization of pulsating jets in unsteady flow by Multiple-Gradient Descent Algorithm (MGDA) - A quasi-Riemannian approach to constrained optimization - Platform for prioritized multi-objective optimization by metamodel-assisted Nash games - Direct and adaptive approaches to multi-objective optimization
- URL: http://mgda.inria.fr

5.2. Igloo

Iso-Geometric anaLysis using discOntinuOus galerkin methods

KEYWORDS: Numerical simulations - Isogeometric analysis

SCIENTIFIC DESCRIPTION: Igloo contains numerical methods to solve partial differential equations of hyperbolic type, or convection-dominant type, using an isogeometric formulation (NURBS bases) with a discontinuous Galerkin method.

FUNCTIONAL DESCRIPTION: Igloo is composed of a set of C++ libraries and applications, which allow to simulate time-dependent physical phenomena using natively CAD-based geometry descriptions.

- Author: Régis Duvigneau
- Contact: Régis Duvigneau

5.3. BuildingSmart

BuildingSmart interactive visualization

KEYWORDS: Physical simulation - 3D rendering - 3D interaction

SCIENTIFIC DESCRIPTION: The aim of the BuildingSmart project is to develop a software environment for the simulation and interactive visualisation for the design of buildings (structural safety, thermal confort).

FUNCTIONAL DESCRIPTION: The main task of the project is to study and develop solutions dedicated to interactive visualisation of building performances (heat, structural) in relation to the Building Information Modeling BIM framework, using Occulus Rift immersion.

NEWS OF THE YEAR: Demo movies are available from Youtube (see web site)

- Participants: Régis Duvigneau, Jean-Luc Szpyrka, David Rey, Clement Welsch and Abderrahmane Habbal
- Contact: Abderrahmane Habbal
- URL: http://youtu.be/MW_gIF8hUdk

<p style="text-align:center; color:red;">BONUS Project-Team</p>

6. New Software and Platforms

6.1. Platforms

6.1.1. Grid'5000 testbed: extension with storage and 10G network at Lille

Participants: Nouredine Melab [contact person], Dimitri Delabroye, Thierry Peltier [external collaborator], Lucas Nussbaum [external collaborator].

Keywords: Experimental testbed, large-scale computing, high-performance computing, GPU computing, cloud computing, big data

Functional description: Grid'5000 is a project intiated in 2003 by the French government to promote scientific research on large scale distributed systems. The project is later supported by different research organizations including Inria, CNRS, the french universities, Renater which provides the wide-area network etc. The overall objective of Grid'5000 was to build by 2007 a nation-wide experimental testbed composed of at least 5000 processing units and distributed over several sites in France. From a scientific point of view, the aim was to promote scientific research on large-scale distributed systems.

Grid'5000 was installed at the center of IT resources including supercomputing resources of Université de Lille 1 and opened to users in 2005. Since March 2017, the Grid'5000 site has moved to the premises on Inria Lille within the context of the phase 1 of the CPER data program (see Section 9.1) with a completely new hardware equipement. As a scientific leader of the testbed for the Lille's site, N. Melab has been strongly involved in the extension (phase 2 of CPER data) of the platform with mainly two storage serveurs 200TB and a 10G Internet connexion to the testbed. Grid'5000 at Lille is used by more than 150 users including 100 external ones. The testbed is used for research as well as for teaching allowing a high scientific production (publications, PhD theses etc.) and over 30 master students to get started with parallel and distributed programming.

URL: https://www.grid5000.fr/mediawiki/index.php/Grid5000:Home

CAGE Project-Team

5. New Software and Platforms

5.1. BOCOP

Boite à Outils pour le Contrôle OPtimal

KEYWORDS: Dynamic Optimization - Identification - Biology - Numerical optimization - Energy management - Transportation

FUNCTIONAL DESCRIPTION: Bocop is an open-source toolbox for solving optimal control problems, with collaborations with industrial and academic partners. Optimal control (optimization of dynamical systems governed by differential equations) has numerous applications in transportation, energy, process optimization, energy and biology. Bocop includes a module for parameter identification and a graphical interface, and runs under Linux / Windows / Mac.

RELEASE FUNCTIONAL DESCRIPTION: Handling of delay systems Alternate automatic differentiation tool: CppAD Update for CMake and MinGW (windows version)

- Participants: Benjamin Heymann, Virgile Andréani, Jinyan Liu, Joseph Frédéric Bonnans and Pierre Martinon
- Contact: Pierre Martinon
- URL: http://bocop.org

5.2. Bocop HJB

KEYWORDS: Optimal control - Stochastic optimization - Global optimization

FUNCTIONAL DESCRIPTION: Toolbox for stochastic or deterministic optimal control, dynamic programming / HJB approach.

RELEASE FUNCTIONAL DESCRIPTION: User interface State jumps for switched systems Explicit handling of final conditions Computation of state probability density (fiste step to mean field games)

- Participants: Benjamin Heymann, Jinyan Liu, Joseph Frédéric Bonnans and Pierre Martinon
- Contact: Joseph Frédéric Bonnans
- URL: http://bocop.org

CAGIRE Project-Team

6. New Software and Platforms

6.1. AeroSol

KEYWORD: Finite element modelling

FUNCTIONAL DESCRIPTION: The AeroSol software is a high order finite element library written in C++. The code has been designed so as to allow for efficient computations, with continuous and discontinuous finite elements methods on hybrid and possibly curvilinear meshes. The work of the team CARDAMOM (previously Bacchus) is focused on continuous finite elements methods, while the team Cagire is focused on discontinuous Galerkin methods. However, everything is done for sharing the largest part of code we can. More precisely, classes concerning IO, finite elements, quadrature, geometry, time iteration, linear solver, models and interface with PaMPA are used by both of the teams. This modularity is achieved by mean of template abstraction for keeping good performances. The distribution of the unknowns is made with the software PaMPA , developed within the team TADAAM (and previously in Bacchus) and the team Castor.

NEWS OF THE YEAR: In 2019, the following points were addressed in AeroSol

*Update, documentation, and wiki for the test case

*exact solution of Riemann problem and exact Godunov solver

*Development of Droplet model, and of a Baer and Nunziato diphasic model.

*Beginning of implementation of eddy viscosity models (k-epsilon, Spalart-Almarras) turbulence models.

*Add the possibility of mesh dependent data (for example, a flow computed by AeroSol with the Euler system) for being used as input for another model (e.g. advection of droplets within this flow). This feature is used also for wall distance for turbulent models.

*Penalization problems, with single core mesh adaptation was merged in the master branch.

*Improvements of PETSc usage: possibility of solving linear problems that are not of size nvar, usage of MUMPS LU solver through PETSc.

*Interfacing with SLEPc for solving eigenvalues and eigenvectors problems.

*High order visualization based on GMSH.

*Beginning of interfacing with PARMMG for parallel mesh adaptation.

*Clean of warning, error messages, etc...

- Participants: Benjamin Lux, Damien Genet, Mario Ricchiuto, Vincent Perrier, Héloïse Beaugendre, Subodh Madhav Joshi, Christopher Poette, Marco Lorini, Jonathan Jung and Enrique Gutierrez Alvarez
- Partner: BRGM
- Contact: Vincent Perrier

<h1 style="text-align:center; color:red">CARDAMOM Project-Team</h1>

6. New Software and Platforms

6.1. AeroSol

KEYWORD: Finite element modelling

FUNCTIONAL DESCRIPTION: The AeroSol software is a high order finite element library written in C++. The code has been designed so as to allow for efficient computations, with continuous and discontinuous finite elements methods on hybrid and possibly curvilinear meshes. The work of the team CARDAMOM (previously Bacchus) is focused on continuous finite elements methods, while the team Cagire is focused on discontinuous Galerkin methods. However, everything is done for sharing the largest part of code we can. More precisely, classes concerning IO, finite elements, quadrature, geometry, time iteration, linear solver, models and interface with PaMPA are used by both of the teams. This modularity is achieved by mean of template abstraction for keeping good performances. The distribution of the unknowns is made with the software PaMPA , developed within the team TADAAM (and previously in Bacchus) and the team Castor.

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*Interfacing with SLEPc for solving eigenvalues and eigenvectors problems.

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- Participants: Benjamin Lux, Damien Genet, Mario Ricchiuto, Vincent Perrier, Héloïse Beaugendre, Subodh Madhav Joshi, Christopher Poette, Marco Lorini, Jonathan Jung and Enrique Gutierrez Alvarez
- Partner: BRGM
- Contact: Vincent Perrier
- URL: https://team.inria.fr/cardamom/aerosol/

6.2. Mmg

Mmg Plateform

KEYWORDS: Mesh adaptation - Anisotropic - Mesh generation - Mesh - Isovalue discretization

SCIENTIFIC DESCRIPTION: The Mmg plateform gathers open source software for two-dimensional, surface and volume remeshing. The platform software perform local mesh modifications. The mesh is iteratively modified until the user prescriptions satisfaction.

The 3 softwares can be used by command line or using the library version (C, C++ and Fortran API) : - Mmg2d performs mesh generation and isotropic and anisotropic mesh adaptation. - Mmgs allows isotropic and anisotropic mesh adaptation for 3D surface meshes. - Mmg3d is a new version af the MMG3D4 software. It remesh both the volume and surface mesh of a tetrahedral mesh. It performs isotropic and anisotropic mesh adaptation and isovalue discretization of a level-set function.

The platform software allow to control the boundaries approximation: The "ideal" geometry is reconstruct from the piecewise linear mesh using cubic Bezier triangular partches. The surface mesh is modified to respect a maximal Hausdorff distance between the ideal geometry and the mesh.

Inside the volume, the software perform local mesh modifications (such as edge swap, pattern split, isotropic and anisotropic Delaunay insertion...).

FUNCTIONAL DESCRIPTION: The Mmg plateform gathers open source software for two-dimensional, surface and volume remeshing. It provides three applications : 1) mmg2d: generation of a triangular mesh , adaptation and optimization of a triangular mesh 2) mmgs: adaptation and optimization of a surface triangulation representing a piecewise linear approximation of an underlying surface geometry 3) mmg3d: adaptation and optimization of a tetrahedral mesh and isovalue discretization

The platform software perform local mesh modifications. The mesh is iteratively modified until the user prescription satisfaction.

NEWS OF THE YEAR: Release 5.3.0 improves: - the mmg3d algorithm for mesh adaptation (better convergency and edge lengths closest to 1) - the software behaviour in case of failure (warnings/error messages are printed only 1 time and there is no more exits in the code) - the mmg2d software that now uses the same structure than mmgs and mmg3d

It adds: - the -hsiz option for mmg2d/s/3d (that allows to generate a uniform mesh of size) - the -nosurf option for mmg2d (that allows to not modify the mesh boundaries) - the -opnbdy option for mmg3d (that allow to preserve an open boundary inside a volume mesh) - the possibility to provide meshes containing prisms to mmg3d (the prisms entities are preserved while the tetra ones are modified)

- Participants: Algiane Froehly, Charles Dapogny, Pascal Frey and Luca Cirrottola
- Partners: Université de Bordeaux - CNRS - IPB - UPMC
- Contact: Algiane Froehly
- URL: http://www.mmgtools.org

6.3. MMG3D

Mmg3d

KEYWORDS: Mesh - Anisotropic - Mesh adaptation

SCIENTIFIC DESCRIPTION: Mmg3d is an open source software for tetrahedral remeshing. It performs local mesh modifications. The mesh is iteratively modified until the user prescriptions satisfaction.

Mmg3d can be used by command line or using the library version (C, C++ and Fortran API) : - It is a new version af the MMG3D4 software. It remesh both the volume and surface mesh of a tetrahedral mesh. It performs isotropic and anisotropic mesh adaptation and isovalue discretization of a level-set function.

Mmg3d allows to control the boundaries approximation: The "ideal" geometry is reconstruct from the piecewise linear mesh using cubic Bezier triangular partches. The surface mesh is modified to respect a maximal Hausdorff distance between the ideal geometry and the mesh.

Inside the volume, the software perform local mesh modifications (such as edge swap, pattern split, isotropic and anisotropic Delaunay insertion...).

FUNCTIONAL DESCRIPTION: Mmg3d is one of the software of the Mmg platform. Is is dedicated to the modification of 3D volume meshes. It perform the adaptation and the optimization of a tetrahedral mesh and allow to discretize an isovalue.

Mmg3d perform local mesh modifications. The mesh is iteratively modified until the user prescription satisfaction.

- Participants: Algiane Froehly, Charles Dapogny, Pascal Frey and Luca Cirrottola
- Partners: Université de Bordeaux - CNRS - IPB - UPMC
- Contact: Algiane Froehly
- URL: http://www.mmgtools.org

6.4. SH-COMP

KEYWORDS: Finite element modelling - Multi-physics simulation - Chemistry - Incompressible flows - 2D

FUNCTIONAL DESCRIPTION: Numerical modelling of the healing process in ceramic matrix composites

- Participants: Gérard Vignoles, Gregory Perrot, Guillaume Couegnat, Mario Ricchiuto and Giulia Bellezza
- Partner: LCTS (UMR 5801)
- Contact: Mario Ricchiuto

6.5. SLOWS

Shallow-water fLOWS

KEYWORDS: Simulation - Free surface flows - Unstructured meshes

SCIENTIFIC DESCRIPTION: Three different approaches are available, based on conditionally depth-positivity preserving implicit schemes, or on conditionally depth-positivity preserving genuinely explicit discretizations, or on an unconditionally depth-positivity preserving space-time approach. Newton and frozen Newton loops are used to solve the implicit nonlinear equations. The linear algebraic systems arising in the discretization are solved with the MUMPS library. This year implicit and explicit (extrapolated) multistep higher order time integration methods have been implemented, and a mesh adaptation technique based on simple mesh deformation has been also included.

FUNCTIONAL DESCRIPTION: SLOWS is a C-platform allowing the simulation of free surface shallow water flows with friction. It can be used to simulate near shore hydrodynamics, wave transformations processes, etc.

- Participants: Maria Kazolea and Mario Ricchiuto
- Contact: Mario Ricchiuto
- URL: https://team.inria.fr/cardamom/slows-shallow-water-flows/

6.6. TUCWave

KEYWORD: Physical simulation

SCIENTIFIC DESCRIPTION: A novel work that advances a step ahead the methodology of the solution of dispersive models. TUCWave uses a high-order well-balanced unstructured finite volume (FV) scheme on triangular meshes for modeling weakly nonlinear and weakly dispersive water waves over varying bathymetries, as described by the 2D depth-integrated extended Boussinesq equations of Nwogu (1993), rewritten in conservation law form. The FV scheme numerically solves the conservative form of the equations following the median dual node-centered approach, for both the advective and dispersive part of the equations. The code developed follows an efficient edge based structured technique. For the advective fluxes, the scheme utilizes an approximate Riemann solver along with a well-balanced topography source term up-winding. Higher order accuracy in space and time is achieved through a MUSCL-type reconstruction technique and through a strong stability preserving explicit Runge-Kutta time stepping. Special attention is given to the accurate numerical treatment of moving wet/dry fronts and boundary conditions. Furthermore, the model is applied to several examples of wave propagation over variable topographies and the computed solutions are compared to experimental data.

FUNCTIONAL DESCRIPTION: Fortran Planform which accounts for the study of near shore processes

- Participants: Argiris Delis, Ioannis Nikolos and Maria Kazolea
- Partner: Technical University of Crete
- Contact: Maria Kazolea

6.7. Fmg

KEYWORD: Mesh adaptation

FUNCTIONAL DESCRIPTION: FMG is a library deforming an input/reference simplicial mesh w.r.t. a given smoothness error monitor (function gradient or Hessian), metric field, or given mesh size distribution. Displacements are computed by solving an elliptic Laplacian type equation with a continuous finite element method. The library returns an adapted mesh with a corresponding projected solution, obtained by either a second order projection, or by an ALE finite element remap. The addiction of a new mass conservative approach developed ad-hoc for shallow water flows is under way.

NEWS OF THE YEAR: - Development of the Elasticity model to compute the nodes displacement. - Development of a new model to compute the nodes displacement. This mixed model takes the advantages of the Laplacian model and the Elasticity model: a refined mesh where the solution varies a lot and a smooth gradation of the edges size elsewhere. - Extension in three dimension

- Participants: Leo Nouveau, Luca Arpaia, Mario Ricchiuto and Luca Cirrottola
- Contact: Algiane Froehly

6.8. ParMmg

KEYWORDS: 3D - Mesh adaptation - Anisotropic - Isotropic - Isovalue discretization - Distributed Applications - MPI communication

FUNCTIONAL DESCRIPTION: The ParMmg software build parallel (MPI based) mesh adaptation capabilities on top of the sequential open-source remesher Mmg, iteratively called over sub-meshes of the initial mesh.

ParMmg is available: - through command line , - in library mode using the dedicated API.

RELEASE FUNCTIONAL DESCRIPTION: The version 1.2 of ParMmg provide 3D volume mesh adaptation with constrained surface.

It adds to the previous release: - Mesh repartitioning through parallel interface displacement , - Support for Scotch renumeration.

- Participants: Algiane Froehly and Luca Cirrottola
- Partners: FUI Icarus - ExaQUte
- Contact: Algiane Froehly
- URL: https://mmgtools.org

CELESTE Project-Team

5. New Software and Platforms

5.1. BlockCluster

Block Clustering

KEYWORDS: Statistic analysis - Clustering package

SCIENTIFIC DESCRIPTION: Simultaneous clustering of rows and columns, usually designated by biclustering, co-clustering or block clustering, is an important technique in two way data analysis. It consists of estimating a mixture model which takes into account the block clustering problem on both the individual and variables sets. The blockcluster package provides a bridge between the C++ core library and the R statistical computing environment. This package allows to co-cluster binary, contingency, continuous and categorical data-sets. It also provides utility functions to visualize the results. This package may be useful for various applications in fields of Data mining, Information retrieval, Biology, computer vision and many more.

FUNCTIONAL DESCRIPTION: BlockCluster is an R package for co-clustering of binary, contingency and continuous data based on mixture models.

RELEASE FUNCTIONAL DESCRIPTION: Initialization strategy enhanced

- Participants: Christophe Biernacki, Gilles Celeux, Parmeet Bhatia, Serge Iovleff, Vincent Brault and Vincent Kubicki
- Partner: Université de Technologie de Compiègne
- Contact: Serge Iovleff
- URL: http://cran.r-project.org/web/packages/blockcluster/index.html

5.2. MASSICCC

Massive Clustering with Cloud Computing

KEYWORDS: Statistic analysis - Big data - Machine learning - Web Application

SCIENTIFIC DESCRIPTION: The web application let users use several software packages developed by Inria directly in a web browser. Mixmod is a classification library for continuous and categorical data. MixtComp allows for missing data and a larger choice of data types. BlockCluster is a library for co-clustering of data. When using the web application, the user can first upload a data set, then configure a job using one of the libraries mentioned and start the execution of the job on a cluster. The results are then displayed directly in the browser allowing for rapid understanding and interactive visualisation.

FUNCTIONAL DESCRIPTION: The MASSICCC web application offers a simple and dynamic interface for analysing heterogeneous data with a web browser. Various software packages for statistical analysis are available (Mixmod, MixtComp, BlockCluster) which allow for supervised and supervised classification of large data sets.

- Contact: Christophe Biernacki
- URL: https://massiccc.lille.inria.fr

5.3. Mixmod

Many-purpose software for data mining and statistical learning

KEYWORDS: Data mining - Classification - Mixed data - Data modeling - Big data

FUNCTIONAL DESCRIPTION: Mixmod is a free toolbox for data mining and statistical learning designed for large and highdimensional data sets. Mixmod provides reliable estimation algorithms and relevant model selection criteria.

It has been successfully applied to marketing, credit scoring, epidemiology, genomics and reliability among other domains. Its particularity is to propose a model-based approach leading to a lot of methods for classification and clustering.

Mixmod allows to assess the stability of the results with simple and thorough scores. It provides an easy-to-use graphical user interface (mixmodGUI) and functions for the R (Rmixmod) and Matlab (mixmodForMatlab) environments.

- Participants: Benjamin Auder, Christophe Biernacki, Florent Langrognet, Gérard Govaert, Gilles Celeux, Remi Lebret and Serge Iovleff
- Partners: CNRS - Université Lille 1 - LIFL - Laboratoire Paul Painlevé - HEUDIASYC - LMB
- Contact: Gilles Celeux
- URL: http://www.mixmod.org

COMMANDS Project-Team

6. New Software and Platforms

6.1. BOCOP

Boite à Outils pour le Contrôle OPtimal

KEYWORDS: Dynamic Optimization - Identification - Biology - Numerical optimization - Energy management - Transportation

FUNCTIONAL DESCRIPTION: Bocop is an open-source toolbox for solving optimal control problems, with collaborations with industrial and academic partners. Optimal control (optimization of dynamical systems governed by differential equations) has numerous applications in transportation, energy, process optimization, energy and biology. Bocop includes a module for parameter identification and a graphical interface, and runs under Linux / Windows / Mac.

RELEASE FUNCTIONAL DESCRIPTION: Handling of delay systems Alternate automatic differentiation tool: CppAD Update for CMake and MinGW (windows version)

- Participants: Benjamin Heymann, Virgile Andréani, Jinyan Liu, Joseph Frédéric Bonnans and Pierre Martinon
- Contact: Pierre Martinon
- URL: http://bocop.org

6.2. Bocop HJB

KEYWORDS: Optimal control - Stochastic optimization - Global optimization

FUNCTIONAL DESCRIPTION: Toolbox for stochastic or deterministic optimal control, dynamic programming / HJB approach.

RELEASE FUNCTIONAL DESCRIPTION: User interface State jumps for switched systems Explicit handling of final conditions Computation of state probability density (fiste step to mean field games)

- Participants: Benjamin Heymann, Jinyan Liu, Joseph Frédéric Bonnans and Pierre Martinon
- Contact: Joseph Frédéric Bonnans
- URL: http://bocop.org

6.3. Bocop Avion

KEYWORDS: Optimization - Aeronautics

FUNCTIONAL DESCRIPTION: Optimize the climb speeds and associated fuel consumption for the flight planning of civil airplanes.

NEWS OF THE YEAR: Improved atmosphere model 2D interpolations for temperature and wind data

- Participants: Gregorutti Baptiste, Cindie Andrieu, Anamaria Lupu, Joseph Frédéric Bonnans, Karim Tekkal, Pierre Jouniaux and Pierre Martinon
- Partner: Safety Line
- Contact: Pierre Martinon
- URL: http://www.safety-line.fr

6.4. Bocop HJB Avion

KEYWORDS: Optimization - Aeronautics

FUNCTIONAL DESCRIPTION: Optimize the climb and cruising trajectory of flight by a HJB approach.

NEWS OF THE YEAR: First demonstrator for cruise flight deployed at Safety Line

- Participants: Pierre Martinon, Joseph Frédéric Bonnans, Jinyan Liu, Gregorutti Baptiste and Anamaria Lupu
- Partner: Safety Line
- Contact: Pierre Martinon
- URL: http://www.safety-line.fr

CQFD Project-Team

5. New Software and Platforms

5.1. biips

Bayesian Inference with Interacting Particle Systems

KEYWORD: Bayesian estimation

FUNCTIONAL DESCRIPTION: Biips is a software platform for automatic Bayesian inference with interacting particle systems. Biips allows users to define their statistical model in the probabilistic programming BUGS language, as well as to add custom functions or samplers within this language. Then it runs sequential Monte Carlo based algorithms (particle filters, particle independent Metropolis-Hastings, particle marginal Metropolis-Hastings) in a black-box manner so that to approximate the posterior distribution of interest as well as the marginal likelihood. The software is developed in C++ with interfaces with the softwares R, Matlab and Octave.

- Participants: Adrien Todeschini, François Caron, Pierre Del Moral and Pierrick Legrand
- Contact: Adrien Todeschini
- URL: http://biips.gforge.inria.fr

5.2. PCAmixdata

KEYWORD: Statistic analysis

FUNCTIONAL DESCRIPTION: Mixed data type arise when observations are described by a mixture of numerical and categorical variables. The R package PCAmixdata extends standard multivariate analysis methods to incorporate this type of data. The key techniques included in the package are PCAmix (PCA of a mixture of numerical and categorical variables), PCArot (rotation in PCAmix) and MFAmix (multiple factor analysis with mixed data within a dataset). The MFAmix procedure handles a mixture of numerical and categorical variables within a group - something which was not possible in the standard MFA procedure. We also included techniques to project new observations onto the principal components of the three methods in the new version of the package.

- Contact: Marie Chavent
- URL: https://cran.r-project.org/web/packages/PCAmixdata/index.html

5.3. QuantifQuantile

KEYWORD: Regression

FUNCTIONAL DESCRIPTION: QuantifQuantile is an R package that allows to perform quantization-based quantile regression. The different functions of the package allow the user to construct an optimal grid of N quantizers and to estimate conditional quantiles. This estimation requires a data driven selection of the size N of the grid that is implemented in the functions. Illustration of the selection of N is available, and graphical output of the resulting estimated curves or surfaces (depending on the dimension of the covariate) is directly provided via the plot function.

- Contact: Jérôme Saracco
- URL: https://cran.r-project.org/web/packages/QuantifQuantile/index.html

DEFI Project-Team (section vide)

DISCO Project-Team (section vide)

ECUADOR Project-Team

5. New Software and Platforms

5.1. AIRONUM

KEYWORDS: Computational Fluid Dynamics - Turbulence

FUNCTIONAL DESCRIPTION: Aironum is an experimental software that solves the unsteady compressible Navier-Stokes equations with k-epsilon, LES-VMS and hybrid turbulence modelling on parallel platforms, using MPI. The mesh model is unstructured tetrahedrization, with possible mesh motion.

- Participant: Alain Dervieux
- Contact: Alain Dervieux
- URL: http://www-sop.inria.fr/tropics/aironum

5.2. TAPENADE

KEYWORDS: Static analysis - Optimization - Compilation - Gradients

SCIENTIFIC DESCRIPTION: Tapenade implements the results of our research about models and static analyses for AD. Tapenade can be downloaded and installed on most architectures. Alternatively, it can be used as a web server. Higher-order derivatives can be obtained through repeated application.

Tapenade performs sophisticated data-flow analysis, flow-sensitive and context-sensitive, on the complete source program to produce an efficient differentiated code. Analyses include Type-Checking, Read-Write analysis, and Pointer analysis. AD-specific analyses include the so-called Activity analysis, Adjoint Liveness analysis, and TBR analysis.

FUNCTIONAL DESCRIPTION: Tapenade is an Algorithmic Differentiation tool that transforms an original program into a new program that computes derivatives of the original program. Algorithmic Differentiation produces analytical derivatives, that are exact up to machine precision. Adjoint-mode AD can compute gradients at a cost which is independent from the number of input variables. Tapenade accepts source programs written in Fortran77, Fortran90, or C. It provides differentiation in the following modes: tangent, vector tangent, adjoint, and vector adjoint.

NEWS OF THE YEAR: - Continued development of multi-language capacity: AD of codes mixing Fortran and C - Continued front-end for C++ (using Clang-LLVM) - Preliminary work, including refactoring, in view of future Open-Source distribution

- Participants: Laurent Hascoët and Valérie Pascual
- Contact: Laurent Hascoët
- URL: http://www-sop.inria.fr/tropics/tapenade.html

ELAN Project-Team

6. New Software and Platforms

6.1. Argus-distribution

KEYWORDS: Frictional contact - Cloth dynamics - Mesh adaptation

SCIENTIFIC DESCRIPTION: The Argus-distribution software exactly replicates all the results published in the SIGGRAPH 2018 paper entitled "An Implicit Frictional Contact Solver for Adaptive Cloth Simulation", by Li et al. This paper presents the first method able to account for cloth contact with exact Coulomb friction, treating both cloth self-contacts and contacts occurring between the cloth and an underlying character. The key contribution is to observe that for a nodal system like cloth, the frictional contact problem may be formulated based on velocities as primary variables, without having to compute the costly Delassus operator. Then, by reversing the roles classically played by the velocities and the contact impulses, conical complementarity solvers of the literature can be adapted to solve for compatible velocities at nodes. To handle the full complexity of cloth dynamics scenarios, this base algorithm has been extended in two ways: first, towards the accurate treatment of frictional contact at any location of the cloth, through an adaptive node refinement strategy, second, towards the handling of multiple constraints at each node, through the duplication of constrained nodes and the adding of pin constraints between duplicata. This method allows to handle the complex cloth-cloth and cloth-body interactions in full-size garments with an unprecedented level of realism compared to former methods, while maintaining reasonable computational timings.allows to simulate cloth dynamics subject to frictional contact.

FUNCTIONAL DESCRIPTION: Adaptive cloth simulation in the presence of frictional contact. Reference software for the paper "An Implicit Frictional Contact Solver for Adaptive Cloth Simulation", Li et al. 2018, ACM Transactions on Graphics (SIGGRAPH'18). The Argus-distribution code was awarded in 2019 the [Graphics Replicability stamp](http://www.replicabilitystamp.org/), which acknowledges its reproducibility.

- Participants: Jie Li, Gilles Daviet, Rahul Narain, Florence Bertails, Matthew Overby, George Brown and Laurence Boissieux
- Partners: Department of Computer Science and Engineering, University of Minnesota - IIT Delhi
- Contact: Florence Bertails
- Publication: An Implicit Frictional Contact Solver for Adaptive Cloth Simulation
- URL: http://www-users.cselabs.umn.edu/~lixx4611/contact_friction.html

6.2. Feel++

KEYWORDS: High order finite elements - Discontinuous Galerkin - High-Performance Computing

FUNCTIONAL DESCRIPTION: Feel++ is a high-performance C++ library for the resolution of general variational formulations, including continuous and discontinuous Galerkin methods, finite element or spectral element methods, reduced basis formulations, etc. It features a high-level domain specific embedded language (DSEL) for Galerkin methods, space dimension-agnostic computation kernels and seamless and automatic parallelism. It also includes applicative toolboxes to solve physics problems in fluid mechanics, solid mechanics, thermal conduction, and the corresponding multi-physics coupling.

- Partners: Université de Strasbourg - UGA - Inria
- Contact: Thibaut Metivet
- URL: http://www.feelpp.org

FACTAS Project-Team (section vide)

GAMMA Project-Team

3. New Software and Platforms

3.1. Metrix

Metrix: Error Estimates and Mesh Control for Anisotropic Mesh Adaptation

KEYWORDS: Meshing - Metric - Metric fields

FUNCTIONAL DESCRIPTION: Metrix is a software that provides by various ways metric to govern the mesh generation. Generally, these metrics are constructed from error estimates (a priori or a posteriori) applied to the numerical solution. Metrix computes metric fields from scalar solutions by means of several error estimates: interpolation error, iso-lines error estimate, interface error estimate and goal oriented error estimate. It also contains several modules that handle meshes and metrics. For instance, it extracts the metric associated with a given mesh and it performs some metric operations such as: metric gradation and metric intersection.

- Participants: Adrien Loseille and Frédéric Alauzet
- Contact: Frédéric Alauzet
- URL: https://www.rocq.inria.fr/gamma/Frederic.Alauzet/code_eng.html

<p style="color:red; text-align:center; font-weight:bold">GEOSTAT Project-Team</p>

6. New Software and Platforms

6.1. Fluex

KEYWORDS: Signal - Signal processing

SCIENTIFIC DESCRIPTION: Fluex is a package consisting of the Microcanonical Multiscale Formalism for 1D, 2D 3D and 3D+t general signals.

FUNCTIONAL DESCRIPTION: Fluex is a C++ library developed under Gforge. Fluex is a library in nonlinear signal processing. Fluex is able to analyze turbulent and natural complex signals, Fluex is able to determine low level features in these signals that cannot be determined using standard linear techniques.

- Participants: Hussein Yahia and Rémi Paties
- Contact: Hussein Yahia
- URL: http://fluex.gforge.inria.fr/

6.2. FluidExponents

KEYWORDS: Signal processing - Wavelets - Fractal - Spectral method - Complexity

FUNCTIONAL DESCRIPTION: FluidExponents is a signal processing software dedicated to the analysis of complex signals displaying multiscale properties. It analyzes complex natural signals by use of nonlinear methods. It implements the multifractal formalism and allows various kinds of signal decomposition and reconstruction. One key aspect of the software lies in its ability to evaluate key concepts such as the degree of impredictability around a point in a signal, and provides different kinds of applications. The software can be used for times series or multidimensional signals.

- Participants: Antonio Turiel and Hussein Yahia
- Contact: Hussein Yahia
- URL: svn+ssh://fluidexponents@scm.gforge.inria.fr/svn/fluidexponents/FluidExponents

6.3. classifemo

KEYWORDS: Classification - Audio

FUNCTIONAL DESCRIPTION: Classifies vocal audio signals. Classifemo extracts characteristics from vocal audio signals. These characteristics are extracted from signals of different type: initially these were emotion databases, but it can also process signals recorded from patients with motor speech disorders. The software can train usual classifiers (SVM, random forests, etc) on these databases as well as classify new signals.

- Participants: Khalid Daoudi and Nicolas Brodu
- Contact: Khalid Daoudi
- URL: https://allgo.inria.fr/app/emotionclassifierprototype

6.4. superres

Super-Resolution of multi-spectral and multi-resolution images

KEYWORD: Multiscale

SCIENTIFIC DESCRIPTION: This resolution enhancement method is designed for multispectral and multiresolution images, such as these provided by the Sentinel-2 satellites (but not only). Starting from the highest resolution bands, band-dependent information (reflectance) is separated from information that is common to all bands (geometry of scene elements). This model is then applied to unmix low-resolution bands, preserving their reflectance, while propagating band-independent information to preserve the sub-pixel details.

FUNCTIONAL DESCRIPTION: This super-resolution software for multi-spectral images consists of: - A core C++ library, which can be used directly - A Python module interface to this library - A Java JNI interface to the library - An end-user Python script for super-resolving Sentinel-2 images - An end-user plugin for the widely used SNAP software of the ESA.

- Participant: Nicolas Brodu
- Contact: Nicolas Brodu
- URL: http://nicolas.brodu.net/recherche/superres/index.html

6.5. EdgeReconstruct

Edge Reconstruction With UPM Manifold

KEYWORDS: 2D - Fractal - Signal processing

FUNCTIONAL DESCRIPTION: EdgeReconstruct is a software that reconstructs a complex signal from the computation of most unpredictible points in the framework of the Microcanonical Multifractal Formalism. The quality of the reconstruction is also evaluated. The software is a companion of a paper published in 2013: https://hal.inria.fr/hal-00924137.

- Contact: Suman Kumar Maji
- URL: https://geostat.bordeaux.inria.fr/index.php/downloads.html

6.6. ProximalDenoising

KEYWORDS: 2D - Image filter - Filtering - Minimizing overall energy - Noise - Signal processing - Image reconstruction - Image processing

SCIENTIFIC DESCRIPTION: Image filtering is contemplated in the form of a sparse minimization problem in a non-convex setting. Given an input image I, one seeks to compute a denoised output image u such that u is close to I in the L2 norm. To do so, a minimization term is added which favors sparse gradients for output image u. Imposing sparse gradients lead to a non-convex minimization term: for instance a pseudo-norm Lp with $0 < p < 1$ or a Cauchy or Welsh function. Half-quadratic algorithm is used by adding a new variable in the minimization functionnal which leads to two sub-problems, the first sub-problem is non-convex and solved by use of proximal operators. The second sub-problem can be written in variational form, and is best solved in Fourier space: it takes the form of a deconvolution operator whose kernel can be approximated by a finite sum of separable filters. This solution method produces excellent computation times even on big images.

FUNCTIONAL DESCRIPTION: Use of proximal and non quadratic minimization. GPU implementation.

RELEASE FUNCTIONAL DESCRIPTION: This software implements H. Badri PhD thesis results.

- Authors: Marie Martin, Chiheb Sakka, Hussein Yahia, Nicolas Brodu, Gabriel Augusto Zebadua Garcia and Khalid Daoudi
- Partner: Innovative Imaging Solutions I2S
- Contact: Hussein Yahia
- URL: https://gitlab.inria.fr/marmarti/i2s_geostat_C

6.7. Amuencha

Musical analyzer and singing training

KEYWORDS: Audio - Real-time rendering

SCIENTIFIC DESCRIPTION: The typical audio analyzer uses Fast Fourier Transforms (FFT) in order to find the frequency content. The problem with this approach is that notes follow the logarithm of the frequencies... while the FFT is linear in frequency. This results in a loss of precision. Even worse, the window function used for localizing the frequencies in time is often non-optimal, which increases this precision loss. Generally, nearby frequencies « bleed on » the one being analyed. Amuencha does not uses FFT. I first create a bank of filters, each centered on one frequency to analyze. These filters are complex exponentials convoluted with a Kaiser window, which support is set according to the frequency to analyze. Once these filters are applied to the signal, I use a time-frequency reassignement technique in order to exploit the complex phase of the signal. This method combines the information from nearby filters, but with a different phase, in order to restore very precisely the frequency content with the smallest possible delay.

FUNCTIONAL DESCRIPTION: Amuencha gathers notes separated by an octave along the same directions of a spiral, so that chords clearly stand out, even reversed. You can also record yourself with a microphone (in red) while playing some recording (in blue), so you can work your tuning :-)

RELEASE FUNCTIONAL DESCRIPTION: Initial version

- Author: Nicolas Brodu
- Contact: Nicolas Brodu
- URL: https://nicolas.brodu.net/programmation/amuencha/

6.8. Manzana

KEYWORDS: 2D - Image processing - Filtering

SCIENTIFIC DESCRIPTION: Software library developed in the framework of I2S-GEOSTAT innovationlab and made of high-level image processing functionalities based on sparsity and non-convex optimization.

FUNCTIONAL DESCRIPTION: Library of software in image processing: filtering, hdr, inpainting etc.

- Partner: Innovative Imaging Solutions I2S
- Contact: Hussein Yahia

I4S Project-Team

5. New Software and Platforms

5.1. Platforms

5.1.1. Pegase

PEGASE is the wireless platform developed by the team. The milestones for the PEGASE platfom in 2019 are

- finalization of the PEGASE3 hardware and software platform: SDK, decoding FPGA-based GPS frames,
- capacity (demonstrated during work with CEA Lost) of synchronous transmission / reception and ultrasonic wave phase.
- Writing documentation associated with the platform (User Guide ...).
- Start of the valuation process.

A prototype for modal analysis with several PEGASE platforms was developed. To obtain detailed modal information of large and very large structures, many sensors would be required to cover the geometry of the structure with a reasonable accuracy. However, when only a limited amount of sensors is available, large structures can be measured in several sensor setups, where some sensors remain fixed and some are moved between different measurement setups. With the sensors connected to different wireless platforms, the synchronous acquisition of data is required. A solution of data acquisition synchronization, as well as signal processing for merging the information taking into account the change of sensor positions and environmental variability has been developed and presented at IWSHM [31].

INOCS Project-Team

6. New Software and Platforms

6.1. HappyChic-ApproPick

KEYWORDS: Operational research - Optimization - Java

FUNCTIONAL DESCRIPTION: This software is a prototype developed for the bilateral contract with the company HappyChic. This software is a solver for an integrated warehouse order picking problem with manual picking operations. More precisely, the following problems are solved: (1) the assignment of references to storage positions, based on the iterative solving of minimum cost flow problems, (2) the division of clients orders into several parcels, respecting weight and size constraints, using a dynamic programming algorithm based on the split algorithm, (3) the batching of parcels into trolleys to perform picking tours, using a dynamic programming algorithm based on the split algorithm. The objective function is to minimize the total walking distance. This software is designed to deal with the large-sized industrial instances of HappyChic (considering hundreds of clients, thousands of positions and product references) in a short computation time (few minutes).

- Contact: Maxime Ogier

6.2. KEOLIS-MEDIATOUR

KEYWORDS: Operational research - Mathematical Optimization - Staff scheduling

FUNCTIONAL DESCRIPTION: This software is a prototype developed under a bilateral contract with the company Keolis. This software is a solver which aims to optimize the schedule of mediation staff. More precisely, for each member of the mediation staff working in a public transportation network, MEDIATOUR determines his/her schedule along the day, i.e. when and where he/she is present. Various operational constraints must be taken into account such as the coverage of the network. This software is designed to solve large-scale industrial instances (the subway network of Lille) in short computation times (less than 1 minute).

- Contact: Frederic Semet

6.3. PARROT

Planning Adapter Performing ReRouting and Optimization of Timing

KEYWORDS: Decision aid - Railway - Scheduling

FUNCTIONAL DESCRIPTION: This is a decision support system addressing the problem of the rescheduling railway schedules on the Belgian network when maintenance operations are planned in the short term (2-3 weeks in advance). The deliverable is a software tool that will take as input: (1) the schedules initially planned for the different trains, (2) the initial routes of the trains, (3) maintenance operations / changes of elements in the form of constraints (unavailable routes etc.). It then provides in output: (1) the new train schedule, (2) the new routing of the fleet. The modifications must respect the constraints corresponding to the operations of maintenance. For example, in some cases it is common to leave at least a few minutes interval between two trains using the same track in the station. This constraint must then be propagated if a maintenance operation delays the arrival of a train. New schedules and routings have to be created following a specific goal. Changes made to schedules and routings must minimize: (1) variations on the time spent at the station, (2) the number of partially canceled trains (additional correspondence (s) or stations that are no longer served), (2) the number of fully canceled trains (no stations served).

- Contact: Martine Labbé

<p align="center" style="color:red">MATHERIALS Project-Team</p>

5. New Software and Platforms

5.1. DFTK

KEYWORDS: Molecular simulation - Quantum chemistry - Materials

FUNCTIONAL DESCRIPTION: DFTK, short for the density-functional toolkit, is a Julia library implementing plane-wave density functional theory for the simulation of the electronic structure of molecules and materials. It aims at providing a simple platform for experimentation and algorithm development for scientists of different backgrounds.

- Contact: Antoine Levitt
- URL: http://dftk.org

5.2. gen.parRep

KEYWORDS: Molecular simulation - MPI - HPC - C++

SCIENTIFIC DESCRIPTION: Metastability is one of the major encountered obstacle when performing long molecular dynamics simulations, and many methods were developed to address this challenge. The "Parallel Replica" (ParRep) dynamics is known for allowing to simulate very long trajectories of metastable Langevin dynamics in the materials science community, but it relies on assumptions that can hardly be transposed to the world of biochemical simulations. The later developed "Generalized ParRep" variant solves those issues, but it was not applied to significant systems of interest so far.

In a recent article article, we presented the program gen.parRep, the first publicly available implementation of the Generalized Parallel Replica method (BSD 3-Clause license), targeting frequently encountered metastable biochemical systems, such as conformational equilibria or dissociation of protein-ligand complexes. It was shown that the resulting C++ implementation exhibits a strong linear scalability, providing up to 70 % of the maximum possible speedup on several hundreds of CPUs.

FUNCTIONAL DESCRIPTION: gen.parRep is the first publicly available implementation of the Generalized Parallel Replica method (BSD 3-Clause license), targeting frequently encountered metastable biochemical systems, such as conformational equilibria or dissociation of protein-ligand complexes.

It was shown (https://hal.archives-ouvertes.fr/hal-01832823) that the resulting C++/MPI implementation exhibits a strong linear scalability, providing up to 70 % of the maximum possible speedup on several hundreds of CPUs.

RELEASE FUNCTIONAL DESCRIPTION: The software was modified in order to allow reproducibility in some cases (the limiting factor is OpenMM which does not always provides deterministic output even when using the same seeds (!), see http://docs.openmm.org/latest/userguide/library.html#determinism).

The main executable now has 2 more command line options, '–inp-seeds [fname]' or '–out-seeds [fname]' for respectively loading seeds or writing seeds from/to a unique binary file. See rand.hpp/rand.cpp, od the Doxygen doc for more details.

These modifications now allow Continuous Integration (CI) on the infrastructure provided by Inria : in mol/ci a small test case will be executed at each commit to the repository and compared to reference results.

The two other minor modifications concern the Lua scripts:

"get_minimised_energy_crdvels" was added to the set of functions that the user can call from the Lua script : it simply combines in one call what "get_minimised_energy" and "get_minimised_crdvels" already provided.

a extra optional parameter is available for the "simulation" parameters block when "simulation.algorithm" is "PARREP_FV" , this parameter is "simulation.minAccumulatedObs" : it will enforce that at least minAccumulatedObs observations of an observable have already been accumulated before the convergence test is performed , this may be useful if there is a risk of early pseudo-convergence for some of the observables when only a few samples have been accumulated.

Download sources:

https://gitlab.inria.fr/parallel-replica/gen.parRep/tags/v1.2.0

or

https://github.com/FHedin/gen.parRep/releases/tag/v1.2.0

NEWS OF THE YEAR: Corresponding publication : https://hal.archives-ouvertes.fr/hal-01832823

- Participants: Florent Hedin and Tony Lelièvre
- Partner: Ecole des Ponts ParisTech
- Contact: Florent Hedin
- Publication: gen.parRep: a first implementation of the Generalized Parallel Replica dynamics for the long time simulation of metastable biochemical systems
- URL: https://gitlab.inria.fr/parallel-replica/gen.parRep

MATHRISK Project-Team

6. New Software and Platforms

6.1. PREMIA

KEYWORDS: Financial products - Computational finance - Option pricing

SCIENTIFIC DESCRIPTION: The Premia project keeps track of the most recent advances in the field of computational finance in a well-documented way. It focuses on the implementation of numerical analysis techniques for both probabilistic and deterministic numerical methods. An important feature of the platform Premia is the detailed documentation which provides extended references in option pricing.

Premia is thus a powerful tool to assist Research and Development professional teams in their day-to-day duty. It is also a useful support for academics who wish to perform tests on new algorithms or pricing methods without starting from scratch.

Besides being a single entry point for accessible overviews and basic implementations of various numerical methods, the aim of the Premia project is: 1 - to be a powerful testing platform for comparing different numerical methods between each other, 2 - to build a link between professional financial teams and academic researchers, 3 - to provide a useful teaching support for Master and PhD students in mathematical finance.

FUNCTIONAL DESCRIPTION: Premia is a software designed for option pricing, hedging and financial model calibration.

- Participants: Agnes Sulem, Antonino Zanette, Aurélien Alfonsi, Benjamin Jourdain, Jérôme Lelong and Bernard Lapeyre
- Partners: Inria - Ecole des Ponts ParisTech - Université Paris-Est
- Contact: Agnes Sulem
- URL: http://www.premia.fr

6.2. Premia

6.2.1. Development of the quantitative platform Premia in 2019

Premia 21 has been delivered to the Premia Consortium on March 21th 2019.
In this version, the following algorithms have been implemented:

6.2.1.1. Machine Learning, Risk Management, Risk model, Insurance

- Machine Learning for Quantitative Finance: Fast Derivative Pricing, Hedging and Fitting. J. De Spiegeleer, D. B. Madan, S. Reyners, W. Schoutens
  Quantitative Finance 2018
- Gaussian Process Regression for Pricing Variable Annuities with Stochastic Volatility and Interest Rate. L.Goudenege A.Molent A.Zanette 2019
- Machine Learning for Pricing American Options in High Dimension. L.Goudenege A.Molent A.Zanette 2019
- Neural networks for American options. L.Goudenege
- Sampling of probability measures in the convex order and approximation of Martingale Optimal Transport problems. A. Alfonsi, J. Corbetta, B. Jourdain
- Computing Credit Valuation Adjustment solving coupled PIDEs in the Bates model. L. Goudenege, A. Molent, A. Zanette
  Computational Management Science, to appear 2019

- Valuation of variable annuities with Guaranteed Minimum Withdrawal Benefit under stochastic interest rate. P.V.Shevchenko, X.Luo
  Insurance: Mathematics and Economics, Volume 76, 2017

6.2.1.2. Equity Derivatives

- An adjoint method for the exact calibration of Stochastic Local Volatility models. M.Wins, K.J.in 't Hout.
  Journal of Computational Science, Volume 24, 2018

- Discretization of class of diffusions nonlinear in the sense of McKean including the calibrated LVSV model. B. Jourdain, A. Zhou

- On an efficient multiple time-step Monte Carlo simulation of the SABR model. A. Leitao, L.A. Grzelak, C.W. Oosterlee
  Applied Mathematics and Computation, Vol. 293, 2017

- Robust Barrier Option Pricing by Frame Projection under Exponential Levy Dynamics. J.L. Kirkby
  Applied Mathematical Finance, Volume 24, Issue 4, 2017

- Ultra-Fast Pricing Barrier Options and CDSs. S.Levendorskii
  International Journal of Theoretical and Applied Finance, 20(5), 2017

- Efficient Binomial tree for the discretization of the CEV model. L.Caramellino, E.Lombardo.

- Pricing path-dependent Bermudan options using Wiener chaos expansion: an embarrassingly parallel approach. J.Lelong

We benefited from the help of the engineer Pierre-Guillaume Raverdy.

<p style="text-align:center;color:red;font-weight:bold;">MCTAO Project-Team</p>

6. New Software and Platforms

6.1. Hampath

KEYWORDS: Optimal control - Second order conditions - Differential homotopy - Ordinary differential equations

FUNCTIONAL DESCRIPTION: Hampath is a software developped to solve optimal control problems by a combination of Hamiltonian et path following methods. Hampath includes shooting and computation of conjugate points. It is an evolution of the software cotcot (apo.enseeiht.fr/cotcot). It has a Fortran kernel, uses Tapenade (www-sop.inria.fr/tropics/tapenade.html) for automatic differentiation and has a Matlab interface.

- Participants: Jean-Baptiste Caillau, Joseph Gergaud and Olivier Cots
- Contact: Jean-Baptiste Caillau
- URL: http://www.hampath.org

<p style="text-align:center;color:red;font-weight:bold;">MEMPHIS Project-Team</p>

6. New Software and Platforms

6.1. COCOFLOW

KEYWORDS: 3D - Elasticity - MPI - Compressible multimaterial flows

FUNCTIONAL DESCRIPTION: The code is written in fortran 95 with a MPI parallelization. It solves equations of conservation modeling 3D compressible flows with elastic models as equation of state.

- Authors: Alexia De Brauer, Florian Bernard, Yannick Gorsse, Thomas Milcent and Angelo Iollo
- Partners: CNRS - Université Bordeaux 1
- Contact: Florian Bernard
- URL: https://gforge.inria.fr/projects/cocoflow

6.2. KOPPA

Kinetic Octree Parallel PolyAtomic

KEYWORDS: C++ - 3D - MPI

FUNCTIONAL DESCRIPTION: KOPPA is a C++/MPI numerical code solving a large range of rarefied flows from external to internal flows in 1D, 2D or 3D. Different kind of geometries can be treated such as moving geometries coming from CAO files or analytical geometries. The models can be solved on Octree grids with dynamic refinement.

- Participant: Florian Bernard
- Partners: Université de Bordeaux - INP Bordeaux - CNRS
- Contact: Angelo Iollo
- URL: https://git.math.cnrs.fr/gitweb/?p=plm/fbernard/KOPPA.git;a=summary

6.3. NaSCar

Navier-Stokes Cartesian

KEYWORDS: HPC - Numerical analyse - Fluid mechanics - Langage C - PETSc

SCIENTIFIC DESCRIPTION: NaSCar can be used to simulate both hydrodynamic bio-locomotion as fish like swimming and aerodynamic flows such wake generated by a wind turbine.

FUNCTIONAL DESCRIPTION: This code is devoted to solve 3D-flows in around moving and deformable bodies. The incompressible Navier-Stokes equations are solved on fixed grids, and the bodies are taken into account thanks to penalization and/or immersed boundary methods. The interface between the fluid and the bodies is tracked with a level set function or in a Lagrangian way. The numerical code is fully second order (time and space). The numerical method is based on projection schemes of Chorin-Temam's type. The code is written in C language and use Petsc library for the resolution of large linear systems in parallel.

NaSCar can be used to simulate both hydrodynamic bio-locomotion as fish like swimming and aerodynamic flows such wake generated by a wind turbine.

- Participant: Michel Bergmann
- Partner: Université de Bordeaux
- Contact: Michel Bergmann
- URL: https://gforge.inria.fr/projects/nascar/

6.4. NS-penal

Navier-Stokes-penalization

KEYWORDS: 3D - Incompressible flows - 2D

FUNCTIONAL DESCRIPTION: The software can be used as a black box with the help of a data file if the obstacle is already proposed. For new geometries the user has to define them. It can be used with several boundary conditions (Dirichlet, Neumann, periodic) and for a wide range of Reynolds numbers.

- Partner: Université de Bordeaux
- Contact: Charles-Henri Bruneau

MEPHYSTO Team (section vide)

MINGUS Project-Team

5. New Software and Platforms

5.1. Selalib

SEmi-LAgrangian LIBrary

KEYWORDS: Plasma physics - Semilagrangian method - Parallel computing - Plasma turbulence

SCIENTIFIC DESCRIPTION: The objective of the Selalib project (SEmi-LAgrangian LIBrary) is to develop a well-designed, organized and documented library implementing several numerical methods for kinetic models of plasma physics. Its ultimate goal is to produce gyrokinetic simulations.

Another objective of the library is to provide to physicists easy-to-use gyrokinetic solvers, based on the semi-lagrangian techniques developed by Eric Sonnendrücker and his collaborators in the past CALVI project. The new models and schemes from TONUS are also intended to be incorporated into Selalib.

FUNCTIONAL DESCRIPTION: Selalib is a collection of modules conceived to aid in the development of plasma physics simulations, particularly in the study of turbulence in fusion plasmas. Selalib offers basic capabilities from general and mathematical utilities and modules to aid in parallelization, up to pre-packaged simulations.

- Partners: Max Planck Insitute - Garching - Université de Strasbourg
- Contact: Philippe Helluy
- URL: http://selalib.gforge.inria.fr/

MISTIS Project-Team

6. New Software and Platforms

6.1. BOLD model FIT

KEYWORDS: Functional imaging - FMRI - Health

SCIENTIFIC DESCRIPTION: Physiological and biophysical models have been proposed to link neuronal activity to the Blood Oxygen Level-Dependent (BOLD) signal in functional MRI (fMRI). Those models rely on a set of parameter values that are commonly estimated using gradient-based local search methods whose initial values are taken from the literature. In some applications, interesting insight into the brain physiology or physiopathology can be gained from an estimation of the model parameters from measured BOLD signals. In this work we focus on the extended Balloon model and propose the estimation of 15 parameters using seven different approaches: three versions of the Expectation Maximization Gauss-Newton (EM/GN) approach (the *de facto* standard in the neuroscientific community) and four metaheuristics (Particle Swarm Optimization (PSO), Differential Evolution (DE), Real-Coded Genetic Algorithms (GA), and a Memetic Algorithm (MA) combining EM/GN and DE). To combine both the ability to escape local optima and to incorporate prior knowledge, we derive the target function from Bayesian modeling. The general behavior of these algorithms is analyzed and compared, providing very promising results on challenging real and synthetic fMRI data sets involving rats with epileptic activity. These stochastic optimizers provided a better performance than EM/GN in terms of distance to the ground truth in 4 out of 6 synthetic data sets and a better signal fitting in 12 out of 12 real data sets. Non-parametric statistical tests showed the existence of statistically significant differences between the real data results obtained by DE and EM/GN. Finally, the estimates obtained from DE for these parameters seem both more realistic and more stable or at least as stable across sessions as the estimates from EM/GN. This is the largest comparison of optimizers for the estimation of biophysical parameters in BOLD fMRI

FUNCTIONAL DESCRIPTION: This Matlab toolbox performs the automatic estimation of biophysical parameters using the extended Balloon model and BOLD fMRI data. It takes as input a MAT file and provides as output the parameter estimates achieved by using stochastic optimization

NEWS OF THE YEAR: The main differences with our previous work: 1) we also use synthetic data, 2) we use stochastic GN and MCMC+DE, 3) We evaluate results not only in physiological terms but also comparing fitness function values. Also changes were made to allow running on the cluster via MPI

- Participants: Pablo Mesejo Santiago, Florence Forbes and Jan Warnking
- Partner: University of Granada, Spain
- Contact: Pablo Mesejo Santiago
- Publication: A differential evolution-based approach for fitting a nonlinear biophysical model to fMRI BOLD data
- URL: https://hal.archives-ouvertes.fr/hal-01221115v2/

6.2. PyHRF

KEYWORDS: Medical imaging - Health - Brain - IRM - Neurosciences - Statistic analysis - FMRI

SCIENTIFIC DESCRIPTION: Functional Magnetic Resonance Imaging (fMRI) is a neuroimaging technique that allows the non-invasive study of brain function. It is based on the hemodynamic variations induced by changes in cerebral synaptic activity following sensory or cognitive stimulation. The measured signal depends on the variation of blood oxygenation level (BOLD signal) which is related to brain activity: a decrease in deoxyhemoglobin concentration induces an increase in BOLD signal. The BOLD signal is delayed with respect to changes in synaptic activity, which can be modeled as a convolution with the Hemodynamic Response Function (HRF) whose exact form is unknown and fluctuates with various parameters such as age, brain region or physiological conditions. In this work we propose to analyze fMRI data using a Joint Detection-Estimation (JDE) approach. It jointly detects cortical activation and estimates the HRF. In contrast to existing tools, PyHRF estimates the HRF instead of considering it as a given constant in the entire brain.

FUNCTIONAL DESCRIPTION: As part of fMRI data analysis, PyHRF provides a set of tools for addressing the two main issues involved in intra-subject fMRI data analysis : (i) the localization of cerebral regions that elicit evoked activity and (ii) the estimation of the activation dynamics also referenced to as the recovery of the Hemodynamic Response Function (HRF). To tackle these two problems, PyHRF implements the Joint Detection-Estimation framework (JDE) which recovers parcel-level HRFs and embeds an adaptive spatio-temporal regularization scheme of activation maps.

NEWS OF THE YEAR: The framework to perform software tests has been further developed. Some unitary tests have been set.

- Participants: Aina Frau Pascual, Christine Bakhous, Florence Forbes, Jaime Eduardo Arias Almeida, Laurent Risser, Lotfi Chaari, Philippe Ciuciu, Solveig Badillo, Thomas Perret and Thomas Vincent
- Partners: CEA - NeuroSpin
- Contact: Florence Forbes
- Publications: Flexible multivariate hemodynamics fMRI data analyses and simulations with PyHRF - Fast joint detection-estimation of evoked brain activity in event-related fMRI using a variational approach - A Bayesian Non-Parametric Hidden Markov Random Model for Hemodynamic Brain Parcellation
- URL: http://pyhrf.org

6.3. xLLiM

High dimensional locally linear mapping

KEYWORDS: Clustering - Regression

SCIENTIFIC DESCRIPTION: Building a regression model for the purpose of prediction is widely used in all disciplines. A large number of applications consists of learning the association between responses and predictors and focusing on predicting responses for the newly observed samples. In this work, we go beyond simple linear models and focus on predicting low-dimensional responses using high-dimensional covariates when the associations between responses and covariates are non-linear.

FUNCTIONAL DESCRIPTION: This is an R package available on the CRAN at https://cran.r-project.org/web/packages/xLLiM/index.html

XLLiM provides a tool for non linear mapping (non linear regression) using a mixture of regression model and an inverse regression strategy. The methods include the GLLiM model (Deleforge et al (2015)) based on Gaussian mixtures and a robust version of GLLiM, named SLLiM (see Perthame et al (2016)) based on a mixture of Generalized Student distributions.

NEWS OF THE YEAR: A new Hierarchical version of GLLiM has been developed in collaboration with University of Michigan, USA.

- Participants: Antoine Deleforge, Emeline Perthame and Florence Forbes
- Partner: University of Michigan, Ann Arbor, USA
- Contact: Florence Forbes

- Publications: Inverse regression approach to robust nonlinear high-to-low dimensional mapping - High-Dimensional Regression with Gaussian Mixtures and Partially-Latent Response Variables
- URL: https://cran.r-project.org/web/packages/xLLiM/index.html

6.4. MMST

Mixtures of Multiple Scaled Student T distributions

KEYWORDS: Health - Statistics - Brain MRI - Medical imaging - Robust clustering

SCIENTIFIC DESCRIPTION: A new family of multivariate heavy-tailed distributions that allow variable marginal amounts of tailweight is proposed and implemented. The originality comes from introducing multidimensional instead of univariate scale variables for the mixture of scaled Gaussian family of distributions. In contrast to most existing approaches, the derived distributions can account for a variety of shapes and have a simple tractable form with a closed-form probability density function whatever the dimension. We provide maximum likelihood estimation of the parameters and illustrate their modelling flexibility.

FUNCTIONAL DESCRIPTION: The package implements mixtures of so-called multiple scaled Student distributions, which are generalisation of multivariate Student T distribution allowing different tails in each dimension. Typical applications include Robust clustering to analyse data with possible outliers. In this context, the model and package have been used on large data sets of brain MRI to segment and identify brain tumors. Recent additions include a Markov random field implementation to account for spatial dependencies between observations, and a Bayesian implementation that can be used to select the number of mixture components automatically.

RELEASE FUNCTIONAL DESCRIPTION: Recent additions include a Markov random field implementation to account for spatial dependencies between observations, and a Bayesian implementation that can be used to select the number of mixture components automatically.

NEWS OF THE YEAR: Recent additions include a Markov random field implementation to account for spatial dependencies between observations, and a Bayesian implementation that can be used to select the number of mixture components automatically.

- Participants: Alexis Arnaud, Darren Wraith, Florence Forbes, Steven Quinito Masnada and Stéphane Despréaux
- Partner: Institut des Neurosciences Grenoble
- Contact: Florence Forbes
- Publications: A new family of multivariate heavy-tailed distributions with variable marginal amounts of tailweights: Application to robust clustering - Fully Automatic Lesion Localization and Characterization: Application to Brain Tumors Using Multiparametric Quantitative MRI Data
- URL: https://team.inria.fr/mistis/software/

MODAL Project-Team

6. New Software and Platforms

6.1. MixtComp

Mixture Computation

KEYWORDS: Clustering - Statistics - Missing data

FUNCTIONAL DESCRIPTION: MixtComp (Mixture Computation) is a model-based clustering package for mixed data originating from the Modal team (Inria Lille). It has been engineered around the idea of easy and quick integration of all new univariate models, under the conditional independence assumption. New models will eventually be available from researches, carried out by the Modal team or by other teams. Currently, central architecture of MixtComp is built and functionality has been field-tested through industry partnerships. Three basic models (Gaussian, multinomial, Poisson) are implemented, as well as two advanced models (Ordinal and Rank). MixtComp has the ability to natively manage missing data (completely or by interval). MixtComp is used as an R package, but its internals are coded in C++ using state of the art libraries for faster computation.

- Participants: Christophe Biernacki, Etienne Goffinet, Matthieu Marbac-Lourdelle, Quentin Grimonprez, Serge Iovleff and Vincent Kubicki
- Contact: Christophe Biernacki
- URL: https://cran.r-project.org/web/packages/RMixtComp/index.html

6.2. BlockCluster

Block Clustering

KEYWORDS: Statistic analysis - Clustering package

SCIENTIFIC DESCRIPTION: Simultaneous clustering of rows and columns, usually designated by biclustering, co-clustering or block clustering, is an important technique in two way data analysis. It consists of estimating a mixture model which takes into account the block clustering problem on both the individual and variables sets. The blockcluster package provides a bridge between the C++ core library and the R statistical computing environment. This package allows to co-cluster binary, contingency, continuous and categorical data-sets. It also provides utility functions to visualize the results. This package may be useful for various applications in fields of Data mining, Information retrieval, Biology, computer vision and many more.

FUNCTIONAL DESCRIPTION: BlockCluster is an R package for co-clustering of binary, contingency and continuous data based on mixture models.

RELEASE FUNCTIONAL DESCRIPTION: Initialization strategy enhanced

- Participants: Christophe Biernacki, Gilles Celeux, Parmeet Bhatia, Serge Iovleff, Vincent Brault and Vincent Kubicki
- Partner: Université de Technologie de Compiègne
- Contact: Serge Iovleff
- URL: http://cran.r-project.org/web/packages/blockcluster/index.html

6.3. CloHe

Clustering of Mixed data

KEYWORDS: Classification - Clustering - Missing data

FUNCTIONAL DESCRIPTION: Software of classification for mixed data with missing values with application to multispectral satellite image time-series

- Partners: CNRS - INRA
- Contact: Serge Iovleff
- URL: https://modal.lille.inria.fr/CloHe/

6.4. PACBayesianNMF

KEYWORDS: Statistics - Machine learning

FUNCTIONAL DESCRIPTION: Implementing NMF with a PAC-Bayesian approach relying upon block gradient descent

- Participants: Benjamin Guedj and Astha Gupta
- Contact: Benjamin Guedj
- URL: https://github.com/astha736/PACbayesianNMF

6.5. pycobra

KEYWORDS: Statistics - Data visualization - Machine learning

SCIENTIFIC DESCRIPTION: pycobra is a python library for ensemble learning, which serves as a toolkit for regression, classification, and visualisation. It is scikit-learn compatible and fits into the existing scikit-learn ecosystem.

pycobra offers a python implementation of the COBRA algorithm introduced by Biau et al. (2016) for regression.

Another algorithm implemented is the EWA (Exponentially Weighted Aggregate) aggregation technique (among several other references, you can check the paper by Dalalyan and Tsybakov (2007).

Apart from these two regression aggregation algorithms, pycobra implements a version of COBRA for classification. This procedure has been introduced by Mojirsheibani (1999).

pycobra also offers various visualisation and diagnostic methods built on top of matplotlib which lets the user analyse and compare different regression machines with COBRA. The Visualisation class also lets you use some of the tools (such as Voronoi Tesselations) on other visualisation problems, such as clustering.

- Participants: Bhargav Srinivasa Desikan and Benjamin Guedj
- Contact: Benjamin Guedj
- Publication: Pycobra: A Python Toolbox for Ensemble Learning and Visualisation
- URL: https://github.com/bhargavvader/pycobra

6.6. STK++

Statistical ToolKit

KEYWORDS: Statistics - Linear algebra - Framework - Learning - Statistical learning

FUNCTIONAL DESCRIPTION: STK++ (Statistical ToolKit in C++) is a versatile, fast, reliable and elegant collection of C++ classes for statistics, clustering, linear algebra, arrays (with an API Eigen-like), regression, dimension reduction, etc. The library is interfaced with lapack for many linear algebra usual methods. Some functionalities provided by the library are available in the R environment using rtkpp and rtkore.

STK++ is suitable for projects ranging from small one-off projects to complete data mining application suites.

- Participant: Serge Iovleff
- Contact: Serge Iovleff
- URL: http://www.stkpp.org

6.7. rtkore

STK++ core library integration to R using Rcpp

KEYWORDS: C++ - Data mining - Clustering - Statistics - Regression

FUNCTIONAL DESCRIPTION: STK++ (http://www.stkpp.org) is a collection of C++ classes for statistics, clustering, linear algebra, arrays (with an Eigen-like API), regression, dimension reduction, etc. The integration of the library to R is using Rcpp. The rtkore package includes the header files from the STK++ core library. All files contain only templated classes or inlined functions. STK++ is licensed under the GNU LGPL version 2 or later. rtkore (the stkpp integration into R) is licensed under the GNU GPL version 2 or later. See file LICENSE.note for details.

- Participant: Serge Iovleff
- Contact: Serge Iovleff
- URL: https://cran.r-project.org/web/packages/rtkore/index.html

6.8. MixAll

Clustering using Mixture Models

KEYWORDS: Clustering - Clustering package - Generative Models

FUNCTIONAL DESCRIPTION: MixAll is a model-based clustering package for modelling mixed data sets. It has been engineered around the idea of easy and quick integration of any kind of mixture models for any kind of data, under the conditional independence assumption. Currently five models (Gaussian mixtures, categorical mixtures, Poisson mixtures, Gamma mixtures and kernel mixtures) are implemented. MixAll has the ability to natively manage completely missing values when assumed as random. MixAll is used as an R package, but its internals are coded in C++ as part of the STK++ library (www.stkpp.org) for faster computation.

RELEASE FUNCTIONAL DESCRIPTION: clusterPredict allow to predcit membership for a new data set using a previously estimated model

- Participant: Serge Iovleff
- Partner: Université Lille 1
- Contact: Serge Iovleff
- URL: https://cran.r-project.org/web/packages/MixAll/

6.9. simerge

Statistical Inference for the Management of Extrem Risks, Genetics and Global epidemiology

KEYWORD: Biclustering

FUNCTIONAL DESCRIPTION: Allows to perform Co-Clustering on binary (Bernoulli) and counting variables (Poisson) using co-variables.

- Partner: Inria
- Contact: Serge Iovleff

6.10. MixtComp.V4

KEYWORDS: Clustering - Statistics - Missing data - Mixed data

FUNCTIONAL DESCRIPTION: MixtComp (Mixture Computation) is a model-based clustering package for mixed data originating from the Modal team (Inria Lille). It has been engineered around the idea of easy and quick integration of all new univariate models, under the conditional independence assumption. New models will eventually be available from researches, carried out by the Modal team or by other teams. Currently, central architecture of MixtComp is built and functionality has been field-tested through industry partnerships. Five basic models (Gaussian, Multinomial, Poisson, Weibull, NegativeBinomial) are implemented, as well as two advanced models (Functional and Rank). MixtComp has the ability to natively manage missing data (completely or by interval). MixtComp is used as an R package, but its internals are coded in C++ using state of the art libraries for faster computation.

RELEASE FUNCTIONAL DESCRIPTION: - New I/O system - Replacement of regex library - Improvement of initialization - Criteria for stopping the algorithm - Added management of partially missing data for several models - User documentation - Adding user features in R

- Participants: Christophe Biernacki, Vincent Kubicki, Matthieu Marbac-Lourdelle, Serge Iovleff, Quentin Grimonprez and Etienne Goffinet
- Partners: Université de Lille - CNRS
- Contact: Christophe Biernacki

6.11. MASSICCC

Massive Clustering with Cloud Computing

KEYWORDS: Statistic analysis - Big data - Machine learning - Web Application

SCIENTIFIC DESCRIPTION: The web application let users use several software packages developed by Inria directly in a web browser. Mixmod is a classification library for continuous and categorical data. MixtComp allows for missing data and a larger choice of data types. BlockCluster is a library for co-clustering of data. When using the web application, the user can first upload a data set, then configure a job using one of the libraries mentioned and start the execution of the job on a cluster. The results are then displayed directly in the browser allowing for rapid understanding and interactive visualisation.

FUNCTIONAL DESCRIPTION: The MASSICCC web application offers a simple and dynamic interface for analysing heterogeneous data with a web browser. Various software packages for statistical analysis are available (Mixmod, MixtComp, BlockCluster) which allow for supervised and supervised classification of large data sets.

- Contact: Christophe Biernacki
- URL: https://massiccc.lille.inria.fr

6.12. Platforms

6.12.1. MASSICCC Platform

MASSICCC is a demonstration platform giving access through a SaaS (service as a software) concept to data analysis libraries developed at Inria. It allows obtaining results either directly through a website specific display (specific and interactive visual outputs) or through an R data object download. It started in October 2015 for two years and is common to the Modal team (Inria Lille) and the Select team (Inria Saclay). In 2016, two packages have been integrated: Mixmod and MixtComp (see the specific section about MixtComp). In 2017, the BlockCluster package has been integrated and also a particular attention to provide meaningful graphical outputs (for Mixmod, MixtComp and BlockCluster) directly in the web platform itself has led to some specific developments. In 2019, a new version of the MixtComp software has been developed.

MOKAPLAN Project-Team

4. New Software and Platforms

4.1. ALG2

FUNCTIONAL DESCRIPTION: ALG2 for Monge Mean-Field Games, Monge problem and Variational problems under divergence constraint. A generalisation of the ALG2 algorithm has been implemented in FreeFem++.

- Contact: Jean-David Benamou
- URL: https://team.inria.fr/mokaplan/augmented-lagrangian-simulations/

4.2. Mokabajour

FUNCTIONAL DESCRIPTION: We design a software resolving the following inverse problem: define the shape of a mirror which reflects the light from a source to a defined target, distribution and support of densities being prescribed. Classical applications include the conception of solar oven, public lightning, car headlights... Mathematical modeling of this problem, related to the optimal transport theory, takes the form of a nonlinear Monge-Ampere type PDE. The numerical resolution of these models remained until recently a largely open problem. MOKABAJOUR project aims to develop, using algorithms invented especially at Inria and LJK, a reflector design software more efficient than geometrical methods used so far. The final step is to realize and physically test prototype reflectors.

- Participants: Boris Thibert, Jean-David Benamou and Quentin Mérigot
- Contact: Jean-David Benamou
- URL: https://project.inria.fr/mokabajour/

5. New Software and Platforms

5.1. DIOGENeS

DIscOntinuous GalErkin Nanoscale Solvers

KEYWORDS: High-Performance Computing - Computational electromagnetics - Discontinuous Galerkin - Computational nanophotonics

FUNCTIONAL DESCRIPTION: The DIOGENeS software suite provides several tools and solvers for the numerical resolution of light-matter interactions at nanometer scales. A choice can be made between time-domain (DGTD solver) and frequency-domain (HDGFD solver) depending on the problem. The available sources, material laws and observables are very well suited to nano-optics and nano-plasmonics (interaction with metals). A parallel implementation allows to consider large problems on dedicated cluster-like architectures.

- Authors: Stéphane Lanteri, Nikolai Schmitt, Alexis Gobé and Jonathan Viquerat
- Contact: Stéphane Lanteri
- URL: https://diogenes.inria.fr/

5.2. GERShWIN

discontinuous GalERkin Solver for microWave INteraction with biological tissues

KEYWORDS: High-Performance Computing - Computational electromagnetics - Discontinuous Galerkin - Computational bioelectromagnetics

FUNCTIONAL DESCRIPTION: GERShWIN is based on a high order DG method formulated on unstructured tetrahedral meshes for solving the 3D system of time-domain Maxwell equations coupled to a Debye dispersion model.

- Contact: Stéphane Lanteri
- URL: http://www-sop.inria.fr/nachos/index.php/Software/GERShWIN

5.3. HORSE

High Order solver for Radar cross Section Evaluation

KEYWORDS: High-Performance Computing - Computational electromagnetics - Discontinuous Galerkin

FUNCTIONAL DESCRIPTION: HORSE is based on a high order HDG (Hybridizable Discontinuous Galerkin) method formulated on unstructured tetrahedral and hybrid structured/unstructured (cubic/tetrahedral) meshes for the discretization of the 3D system of frequency-domain Maxwell equations, coupled to domain decomposition solvers.

- Authors: Ludovic Moya and Alexis Gobé
- Contact: Stéphane Lanteri
- URL: http://www-sop.inria.fr/nachos/index.php/Software/HORSE

NANO-D Team

5. New Software and Platforms

5.1. Knodle

KNOwledge-Driven Ligand Extractor

KEYWORDS: Bioinformatics - Machine learning

FUNCTIONAL DESCRIPTION: KNOwledge-Driven Ligand Extractor is a software library for the recognition of atomic types, their hybridization states and bond orders in the structures of small molecules. Its prediction model is based on nonlinear Support Vector Machines. The process of bond and atom properties perception is divided into several steps. At the beginning, only information about the coordinates and elements for each atom is available :

Connectivity is recognized. A search of rings is performed to find the Smallest Set of Smallest Rings (SSSR). Atomic hybridizations are predicted by the corresponding SVM model. Bond orders are predicted by the corresponding SVM model. Aromatic cycles are found. Atomic types are set in obedience to the functional groups. Some bonds are reassigned during this stage.

- Participants: Maria Kadukova and Sergei Grudinin
- Partner: MIPT Moscow
- Contact: Sergei Grudinin
- Publication: Knodle: A Support Vector Machines-Based Automatic Perception of Organic Molecules from 3D Coordinates
- URL: https://team.inria.fr/nano-d/software/Knodle/

5.2. DeepSymmetry

KEYWORDS: Bioinformatics - 3D modeling - Machine learning - Neural networks

FUNCTIONAL DESCRIPTION: DeepSymmetry is a method based on three-dimensional (3D) convolutional networks that detects structural repetitions in proteins and their density maps. It identifies tandem repeat proteins, proteins with internal symmetries, their symmetry order, and also the corresponding symmetry axes.

- Participants: Guillaume Pages and Sergei Grudinin
- Contact: Sergei Grudinin
- Publication: DeepSymmetry : Using 3D convolutional networks for identification of tandem repeats and internal symmetries in protein structures
- URL: https://team.inria.fr/nano-d/software/deepsymmetry/

5.3. Ananas

Analytical Analyzer of Symmetries

KEYWORDS: Bioinformatics - Structural Biology

FUNCTIONAL DESCRIPTION: Analytical Analyzer of Symmetries is a software for detection and assessment of the quality of symmetry in a protein assembly.

This software can : Detect the best axes of symmetry for any symmetry group in an assembly containing the right amount of chains, Provide the symmetry-aware RMSD for these axes, Detect the best axis of symmetry for cyclic assemblies with missing subunits, Compute the axes of symmetry with user-provided correspondences.

RELEASE FUNCTIONAL DESCRIPTION: Version 0.7 from 3 Sep 2018: mmCIF support added. A file can be gzipped. Version 0.8 from 30 July 2019: Checks the similarity between chains. Explicitly output when an incomplete assembly is detected as symmetric. Version 0.9 from 8 Nov 2019: Added lists of excluded chains for both PDB and CIF formats.

- Participants: Guillaume Pages and Sergei Grudinin
- Contact: Sergei Grudinin
- Publications: Analytical symmetry detection in protein assemblies. I. Cyclic symmetries - Analytical symmetry detection in protein assemblies. II. Dihedral and Cubic symmetries
- URL: https://team.inria.fr/nano-d/software/ananas/

5.4. Pepsi-SAXS

KEYWORDS: Bioinformatics - Structural Biology - Data modeling

FUNCTIONAL DESCRIPTION: Pepsi-SAXS (PEPSI stands for Polynomial Expansions of Protein Structures and Interactions) is new implementation of the multipole-based scheme initially proposed by Stuhrmann (Stuhrmann, 1970). Overall, our method is significantly faster with a similar accuracy compared to Crysol, FoXS, and the 3D-Zernike implementation from the SAStbx package.

RELEASE FUNCTIONAL DESCRIPTION: Version 1.0 from 6th March 2018: Added computation of P(r). Version 1.1 from 19th April 2018: Excluded solvent radii updated. Many more ions added. Version 1.2 from 24th April 2018: Added automatic identification of labile and nonlabile explicit hydrogens. Added bulk SLD option. Version 1.3 from 30th July 2018: Added initial prototype of 2D dcattering images. Version 1.4 from 1st August 2018: Added docking module. Version 2.0 from January 2019: Added flexible optimization of conformations. A bug with absolute contrast fixed. Default behaiviour of Pepsi-SAXS changed, now it reads all the hydrogen atoms if the –hyd flag is set. Otherwise, it reads only explicit hydrogens on non-standard residues. Version 2.1 from February 2019: First implimentation of the multi-structure fitting.

- Participant: Sergei Grudinin
- Partner: MIPT Moscow
- Contact: Sergei Grudinin
- Publication: Pepsi-SAXS : an adaptive method for rapid and accurate computation of small-angle X-ray scattering profiles
- URL: https://team.inria.fr/nano-d/software/pepsi-saxs/

5.5. NOLB

NOn-Linear rigid Block NMA method

KEYWORDS: Structural Biology - Bioinformatics - Elasticity - Proteins - Motion analysis

FUNCTIONAL DESCRIPTION: It's a new conceptually simple and computationally efficient method for non-linear normal mode analysis of macromolecules.

RELEASE FUNCTIONAL DESCRIPTION: Version 1.2 from January 2019: Exclusion interaction list added. Version 1.3 from April 2019: Sequence and structural alignment fixed thanks to Guillaume Pages. More advanced iterative structural alignment added. Version 1.4 from June 2019: Firt version of domain identification added. Please use the "–nDomains" option Version 1.5 from July 2019: Rigid block format updated. JSON and Text output formats added. Version 1.6 from December 2019: Added initial Voronota support.

- Participants: Sergei Grudinin and Alexandre Hoffmann
- Contact: Sergei Grudinin
- Publications: NOLB: Nonlinear Rigid Block Normal Mode Analysis Method - RapidRMSD: Rapid determination of RMSDs corresponding to motions of flexible molecules
- URL: https://team.inria.fr/nano-d/software/nolb-normal-modes/

5.6. SBROD

KEYWORDS: Bioinformatics - Machine learning

FUNCTIONAL DESCRIPTION: Smooth orientation-dependent scoring function (SBROD) for coarse-grained protein quality assessment uses only the conformation of the protein backbone, and hence it can be applied to scoring the coarse-grained protein models.

The workflow of SBROD consists in two stages. First, the method extracts features from each protein model in the dataset. Then, the scoring function assigns a score to each processed protein model depending on its features extracted at the first stage. Figure above schematically shows the workflow of SBROD. Here, four types of inter-atomic interactions, described in details below, are taken into account when extracting the features. After these features have been extracted and preprocessed, a Ridge Regression model is trained on them to predict the GDT-TS of protein models.

- Participants: Mikhail Karasikov, Guillaume Pages and Sergei Grudinin
- Contact: Sergei Grudinin
- Publication: Smooth orientation-dependent scoring function for coarse-grained protein quality assessment
- URL: https://team.inria.fr/nano-d/software/sbrod/

5.7. Ornate

KEYWORDS: Bioinformatics - Machine learning - Neural networks

FUNCTIONAL DESCRIPTION: Oriented Routed Neural network with Automatic Typing is a method for protein quality assessment. Ornate is a residue-wise scoring method. It first constructs a three dimensional map representing the structure of the residue, and its neighborhood.

- Participants: Guillaume Pages, Benoit Charmettant and Sergei Grudinin
- Contact: Sergei Grudinin
- Publication: Protein model quality assessment using 3D oriented convolutional neural networks
- URL: https://team.inria.fr/nano-d/software/ornate/

<div style="text-align:center">**NECS Team**</div>

6. New Software and Platforms

6.1. GTL

Grenoble Traffic Lab

FUNCTIONAL DESCRIPTION: The Grenoble Traffic Lab (GTL) initiative, led by the NeCS team, is a real-time traffic data Center (platform) that collects traffic road infrastructure information in real-time with minimum latency and fast sampling periods. The main elements of the GTL are: a real-time data-base, a show room, and a calibrated micro-simulator of the Grenoble South Ring. Sensed information comes from a dense wireless sensor network deployed on Grenoble South Ring, providing macroscopic traffic signals such as flows, velocities, densities, and magnetic signatures. This sensor network was set in place in collaboration with Inria spin-off Karrus-ITS, local traffic authorities (DIR-CE, CG38, La Metro), and specialized traffic research centers. In addition to real data, the project also uses simulated data, in order to validate models and to test the ramp-metering, the micro-simulator is a commercial software (developed by TSS AIMSUN ©). More details at http://necs.inrialpes.fr/pages/grenoble-traffic-lab.php

- Participants: Alain Kibangou, Andres Alberto Ladino Lopez, Anton Andreev, Carlos Canudas-de-Wit, Dominik Pisarski, Enrico Lovisari, Fabio Morbidi, Federica Garin, Hassen Fourati, Iker Bellicot, Maria Laura Delle Monache, Paolo Frasca, Pascal Bellemain, Pietro Grandinetti, Remi Piotaix, Rohit Singhal and Vadim Bertrand
- Contact: Carlos Canudas-de-Wit
- URL: http://necs.inrialpes.fr/pages/grenoble-traffic-lab.php

6.2. Benchmarks Attitude Smartphones

KEYWORDS: Experimentation - Motion analysis - Sensors - Performance analysis - Smartphone

SCIENTIFIC DESCRIPTION: We investigate the precision of attitude estimation algorithms in the particular context of pedestrian navigation with commodity smartphones and their inertial/magnetic sensors. We report on an extensive comparison and experimental analysis of existing algorithms. We focus on typical motions of smartphones when carried by pedestrians. We use a precise ground truth obtained from a motion capture system. We test state-of-the-art attitude estimation techniques with several smartphones, in the presence of magnetic perturbations typically found in buildings. We discuss the obtained results, analyze advantages and limits of current technologies for attitude estimation in this context. Furthermore, we propose a new technique for limiting the impact of magnetic perturbations with any attitude estimation algorithm used in this context. We show how our technique compares and improves over previous works.

- Participants: Hassen Fourati, Nabil Layaïda, Pierre Genevès and Thibaud Michel
- Partner: GIPSA-Lab
- Contact: Pierre Genevès
- URL: http://tyrex.inria.fr/mobile/benchmarks-attitude/

<p style="text-align:center">**POEMS Project-Team**</p>

5. New Software and Platforms

5.1. COFFEE

KEYWORDS: Numerical simulations - Wave propagation - Boundary element method

FUNCTIONAL DESCRIPTION: COFFEE is an adapted fast BEM solver to model acoustic and elastic wave propagation (full implementation in Fortran 90). The 3-D acoustic or elastodynamic equations are solved with the boundary element method accelerated by the multi-level fast multipole method or a hierarchical-matrices based representation of the system matrix. The fundamental solutions for the infinite space are used in this implementation. A boundary element-boundary element coupling strategy is also implemented so multi-region problems (strata inside a valley for example) can be solved. In order to accelerate the convergence of the iterative solver, various analytic or algebraic preconditioners are available. Finally, an anisotropic mesh adaptation strategy is used to further reduce the computational times.

- Contact: Stéphanie Chaillat

5.2. XLiFE++

KEYWORDS: Numerical simulations - Finite element modelling - Boundary element method

FUNCTIONAL DESCRIPTION: XLiFE++ is an FEM-BEM C++ code developed by POEMS laboratory and IRMAR laboratory, that can solve 1D/2D/3D, scalar/vector, transient/stationary/harmonic problems. Description: https://uma.ensta-paristech.fr/soft/XLiFE++/

- Contact: Eric Lunéville

QUANTIC Project-Team   (section vide)

RANDOPT Project-Team

6. New Software and Platforms

6.1. COCO

COmparing Continuous Optimizers

KEYWORDS: Benchmarking - Numerical optimization - Black-box optimization - Stochastic optimization

SCIENTIFIC DESCRIPTION: COmparing Continuous Optimisers (COCO) is a tool for benchmarking algorithms for black-box optimisation. COCO facilitates systematic experimentation in the field of continuous optimization. COCO provides: (1) an experimental framework for testing the algorithms, (2) post-processing facilities for generating publication quality figures and tables, including the easy integration of data from benchmarking experiments of 300+ algorithm variants, (3) LaTeX templates for scientific articles and HTML overview pages which present the figures and tables.

The COCO software is composed of two parts: (i) an interface available in different programming languages (C/C++, Java, Matlab/Octave, Python, external support for R) which allows to run and log experiments on several function test suites (unbounded noisy and noiseless single-objective functions, unbounded noiseless multiobjective problems, constrained problems) are provided (ii) a Python tool for generating figures and tables that can be looked at in every web browser and that can be used in the provided LaTeX templates to write scientific papers.

FUNCTIONAL DESCRIPTION: The Coco platform aims at supporting the numerical benchmarking of blackbox optimization algorithms in continuous domains. Benchmarking is a vital part of algorithm engineering and a necessary path to recommend algorithms for practical applications. The Coco platform releases algorithm developers and practitioners alike from (re-)writing test functions, logging, and plotting facilities by providing an easy-to-handle interface in several programming languages. The Coco platform has been developed since 2007 and has been used extensively within the "Blackbox Optimization Benchmarking (BBOB)" workshop series since 2009. Overall, 300+ algorithms and algorithm variants by contributors from all over the world have been benchmarked on the platform's supported test suites so far. The most recent extension has been towards large-scale problems and was used for the BBOB-2019 workshop at the ACM-GECCO conference.

- Participants: Anne Auger, Asma Atamna, Dejan Tusar, Dimo Brockhoff, Marc Schoenauer, Nikolaus HANSEN, Ouassim Ait Elhara, Raymond Ros, Tea Tusar, Thanh-Do Tran, Umut Batu and Konstantinos Varelas
- Partners: TU Dortmund University - Charles University Prague - Jozef Stefan Institute (JSI)
- Contact: Dimo Brockhoff
- URL: https://github.com/numbbo/coco

6.2. CMA-ES

Covariance Matrix Adaptation Evolution Strategy

KEYWORDS: Numerical optimization - Black-box optimization - Stochastic optimization

SCIENTIFIC DESCRIPTION: The CMA-ES is considered as state-of-the-art in evolutionary computation and has been adopted as one of the standard tools for continuous optimisation in many (probably hundreds of) research labs and industrial environments around the world. The CMA-ES is typically applied to unconstrained or bounded constraint optimization problems, and search space dimensions between three and a hundred. The method should be applied, if derivative based methods, e.g. quasi-Newton BFGS or conjugate gradient, (supposedly) fail due to a rugged search landscape (e.g. discontinuities, sharp bends or ridges, noise, local optima, outliers). If second order derivative based methods are successful, they are usually faster than the CMA-ES: on purely convex-quadratic functions, $f(x)=x^THx$, BFGS (Matlabs function fminunc) is typically faster by a factor of about ten (in terms of number of objective function evaluations needed to reach a target function value, assuming that gradients are not available). On the most simple quadratic function $f(x)=\|x\|2=x^Tx$ BFGS is faster by a factor of about 30.

FUNCTIONAL DESCRIPTION: The CMA-ES is an evolutionary algorithm for difficult non-linear non-convex black-box optimisation problems in continuous domain.

- Participant: Nikolaus HANSEN
- Contact: Nikolaus HANSEN
- URL: http://cma.gforge.inria.fr/cmaes_sourcecode_page.html

<h1 style="text-align: center; color: red;">RAPSODI Project-Team</h1>

6. New Software and Platforms

6.1. Platforms

6.1.1. Platform NS2DDV-M

`NS2DDV-M` [42] is a Matlab code, developed by C. Calgaro, E. Creusé, and A. Mouton (CNRS research engineer at Université de Lille), for the simulation of homogeneous and inhomogeneous fluid flows by a combined Finite Volume-Finite Element method. The code embeds parallel computation facilities, and is freely distributed, to allow for easy comparisons with concurrent codes on benchmark test-cases, and to promote new collaborations in the domain.

6.1.2. Platform KinDiff

`KinDiff` consists in a Python library and a Jupyter Notebook. It has been developed by M. Bessemoulin-Chatard (CNRS and Université de Nantes), M. Herda, and T. Rey. The `KinDiff` code approximates the solutions to the kinetic Fokker–Planck and linear BGK equations in a unidimensional periodic domain in space and a symmetric bounded unidimensional domain in velocity. Its outputs are the discretization of the distribution function in the phase space as well as the moments, along with some visualizations of these quantities. Kinetic equations display asymptotic behaviors such as return to equilibrium in large time, or convergence towards macroscopic equations in the diffusive limit. The finite volume method implemented within `KinDiff` reproduces these asymptotics at the discrete level. The presentation and numerical analysis of the scheme is available in the article [17]. The code is available at gitlab.com/thoma.rey/FV_HipoDiff.

REALOPT Project-Team

6. New Software and Platforms

6.1. BaPCod

A generic Branch-And-Price-And-Cut Code

KEYWORDS: Column Generation - Branch-and-Price - Branch-and-Cut - Mixed Integer Programming - Mathematical Optimization - Benders Decomposition - Dantzig-Wolfe Decomposition - Extended Formulation

FUNCTIONAL DESCRIPTION: BaPCod is a prototype code that solves Mixed Integer Programs (MIP) by application of reformulation and decomposition techniques. The reformulated problem is solved using a branch-and-price-and-cut (column generation) algorithms, Benders approaches, network flow and dynamic programming algorithms. These methods can be combined in several hybrid algorithms to produce exact or approximate solutions (primal solutions with a bound on the deviation to the optimum).

RELEASE FUNCTIONAL DESCRIPTION: An important update to make BaPCod compatible with VRPSolver. Correction of numerous bugs.

- Participants: Artur Alves Pessoa, Boris Detienne, Eduardo Uchoa Barboza, Franck Labat, François Clautiaux, Francois Vanderbeck, Halil Sen, Issam Tahiri, Michael Poss, Pierre Pesneau, Romain Leguay and Ruslan Sadykov
- Partners: Université de Bordeaux - CNRS - IPB - Universidade Federal Fluminense
- Contact: Ruslan Sadykov
- URL: https://wiki.bordeaux.inria.fr/realopt/pmwiki.php/Project/BaPCod

6.2. ORTOJ

Operation Research Tools Under Julia

KEYWORDS: Modeling - Processing - Dashboard

FUNCTIONAL DESCRIPTION: This set of tools currently includes : 1) BlockJuMP.jl: extension of JuMP to model decomposable mathematical programs (using either Benders or Dantzig-Wolfe decomposition paradign) 2) Scanner.jl: a default data parser to ease the reading of the input data in the form that they are often encountered in operational research. 3) BenchmarkUtils.jl: Tools to ease the setup of numerical experiments to benchmark algorithmic feature performances. The test automation permits to quickly calibrate the parameters of an arbitrary algorithm control function.

- Participants: Francois Vanderbeck, Guillaume Marques, Issam Tahiri and Ruslan Sadykov
- Contact: Issam Tahiri

6.3. pmtool

KEYWORDS: Scheduling - Task scheduling - StarPU - Heterogeneity - GPGPU - Performance analysis

FUNCTIONAL DESCRIPTION: Analyse post-mortem the behavior of StarPU applications. Provide lower bounds on makespan. Study the performance of different schedulers in a simple context. Provide implementations of many scheduling algorithms from the literature

NEWS OF THE YEAR: Included many new algorithms, in particular online algorithms Better integration with StarPU by accepting .rec files as input

- Participant: Lionel Eyraud-Dubois
- Contact: Lionel Eyraud-Dubois
- Publications: Approximation Proofs of a Fast and Efficient List Scheduling Algorithm for Task-Based Runtime Systems on Multicores and GPUs - Fast Approximation Algorithms for Task-Based Runtime Systems
- URL: https://gitlab.inria.fr/eyrauddu/pmtool

SEQUEL Project-Team

6. New Software and Platforms

6.1. gym-backgammon

Backgammon environment

KEYWORD: Artificial intelligence

FUNCTIONAL DESCRIPTION: This software program follows the openai gym API (https://gym.openai.com/), that is the interaction loop of reinforcement learning: the game is in a certain state, the agent selects an action, this action is simulated in the game, and the next state of the game as well as the return are returned to the agent. All these notions follows backgammon rules and should be understood as pertaining to the reinforcement learning vocabulary. As far as we are aware of, gym-backgammon is the only existing software of this type, and it is available in open source. Great care has been put into the debugging and the efficiency. This software program is developed in python. The ineteraction is made according to a client-server model.

- Author: Alessio Della Libera
- Contact: Philippe Preux
- URL: https://github.com/dellalibera/gym-backgammon

6.2. gym-rubik

Rubik's cube environment

KEYWORD: Artificial intelligence

FUNCTIONAL DESCRIPTION: This software program follows the openai gym API (https://gym.openai.com/), that is the interaction loop of reinforcement learning: the game is in a certain state, the agent selects an action, this action is simulated in the game, and the next state of the game as well as the return are returned to the agent. All these notions follows Rubik's cube rules and should be understood as pertaining to the reinforcement learning vocabulary. Great care has been put into the debugging and the efficiency. This software program is developped in python.

- Author: Raphaël Avalos Martinez De Escobar
- Contact: Philippe Preux
- URL: https://github.com/raphaelavalos/gym-rubikscube

6.3. highway-env

An environment for autonomous driving decision-making

KEYWORDS: Generic modeling environment - Simulation - Autonomous Cars - Artificial intelligence

FUNCTIONAL DESCRIPTION: The environment is composed of several variants, each of which corresponds to driving scenes: highway, roundabout, intersection, merge, parking, etc. The road network is described by a graph, and is then populated with simulated vehicles. Vehicle kinematics follows a simple Bicycle model, and their behavior is determined by models derived from road traffic simulation literature. The ego-vehicle has access to a description of the scene through several types of observations, and its behavior is controlled through an action space, either discrete (change of lanes, of cruising speed) or continuous (accelerator pedal, steering wheel angle). The objective function to maximize is also described by the environment and may vary depending on the task to be solved. The interface of the library is inherited from the standard defined by OpenAI Gym, consisting of four main methods: gym.make(id), env.step(action), env.reset(), and env.render().

- Author: Edouard Leurent
- Contact: Edouard Leurent

SIERRA Project-Team

6. New Software and Platforms

6.1. ProxASAGA

KEYWORD: Optimization

FUNCTIONAL DESCRIPTION: A C++/Python code implementing the methods in the paper "Breaking the Nonsmooth Barrier: A Scalable Parallel Method for Composite Optimization", F. Pedregosa, R. Leblond and S. Lacoste-Julien, Advances in Neural Information Processing Systems (NIPS) 2017. Due to their simplicity and excellent performance, parallel asynchronous variants of stochastic gradient descent have become popular methods to solve a wide range of large-scale optimization problems on multi-core architectures. Yet, despite their practical success, support for nonsmooth objectives is still lacking, making them unsuitable for many problems of interest in machine learning, such as the Lasso, group Lasso or empirical risk minimization with convex constraints. In this work, we propose and analyze ProxASAGA, a fully asynchronous sparse method inspired by SAGA, a variance reduced incremental gradient algorithm. The proposed method is easy to implement and significantly outperforms the state of the art on several nonsmooth, large-scale problems. We prove that our method achieves a theoretical linear speedup with respect to the sequential version under assumptions on the sparsity of gradients and block-separability of the proximal term. Empirical benchmarks on a multi-core architecture illustrate practical speedups of up to 12x on a 20-core machine.

- Contact: Fabian Pedregosa
- URL: https://github.com/fabianp/ProxASAGA

6.2. object-states-action

KEYWORD: Computer vision

FUNCTIONAL DESCRIPTION: Code for the paper Joint Discovery of Object States and Manipulation Actions, ICCV 2017: Many human activities involve object manipulations aiming to modify the object state. Examples of common state changes include full/empty bottle, open/closed door, and attached/detached car wheel. In this work, we seek to automatically discover the states of objects and the associated manipulation actions. Given a set of videos for a particular task, we propose a joint model that learns to identify object states and to localize state-modifying actions. Our model is formulated as a discriminative clustering cost with constraints. We assume a consistent temporal order for the changes in object states and manipulation actions, and introduce new optimization techniques to learn model parameters without additional supervision. We demonstrate successful discovery of seven manipulation actions and corresponding object states on a new dataset of videos depicting real-life object manipulations. We show that our joint formulation results in an improvement of object state discovery by action recognition and vice versa.

- Participants: Jean-Baptiste Alayrac, Josef Sivic, Ivan Laptev and Simon Lacoste-Julien
- Contact: Jean-Baptiste Alayrac
- Publication: Joint Discovery of Object States and Manipulation Actions
- URL: https://github.com/jalayrac/object-states-action

SIMSMART Project-Team (section vide)

<p style="text-align:center; color:red; font-weight:bold;">SPHINX Project-Team</p>

6. New Software and Platforms

6.1. GetDDM

KEYWORDS: Large scale - 3D - Domain decomposition - Numerical solver

FUNCTIONAL DESCRIPTION: GetDDM combines GetDP and Gmsh to solve large scale finite element problems using optimized Schwarz domain decomposition methods.

- Contact: Xavier Antoine
- URL: http://onelab.info/wiki/GetDDM

6.2. GPELab

Gross-Pitaevskii equations Matlab toolbox

KEYWORDS: 3D - Quantum chemistry - 2D

FUNCTIONAL DESCRIPTION: GPELab is a Matlab toolbox developed to help physicists for computing ground states or dynamics of quantum systems modeled by Gross-Pitaevskii equations. This toolbox allows the user to define a large range of physical problems (1d-2d-3d equations, general nonlinearities, rotation term, multi-components problems...) and proposes numerical methods that are robust and efficient.

- Contact: Xavier Antoine
- URL: http://gpelab.math.cnrs.fr/

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TAU Project-Team

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6. New Software and Platforms

6.1. io.datascience

Input Output Data Science

KEYWORDS: Open data - Semantic Web - FAIR (Findable, Accessible, Interoperable, and Reusable)

FUNCTIONAL DESCRIPTION: io.datascience (Input Output Data Science) is the instance of the Linked Wiki platform developed specifically in Paris-Saclay University as part of its Center for Data Science.

The goal of io.datascience: to facilitate the sharing and use of scientific data. The technological concept of io.datascience: the exploitation of semantic web advances, and in particular wiki technologies.

(Findable, Accessible, Interoperable, and Reusable) (Wilkinson, M., and The FAIR Guiding Principles for Scientific Data Management and Stewardship, Nature Scientific Data 2016)

io.datascience is both a data sharing platform and a framework for further development. It realizes a practical implementation of FAIR (Findable, Accessible, Interoperable, and Reusable - Wilkinson, M., Nature Scientific Data 2016) principles through a user-centric approach.

- Partners: Border Cloud - Paris Saclay Center for Data Science - Université Paris-Sud
- Contact: Cécile Germain
- Publications: Data acquisition for analytical platforms: Automating scientific workflows and building an open database platform for chemical anlysis metadata - A platform for scientific data sharing - TFT, Tests For Triplestores : Certifying the interoperability of RDF database systems using a continuous delivery workflow - Une autocomplétion générique de SPARQL dans un contexte multi-services - Certifying the interoperability of RDF database systems - Transforming Wikipedia into an Ontology-based Information Retrieval Search Engine for Local Experts using a Third-Party Taxonomy - The Grid Observatory 3.0 - Towards reproducible research and open collaborations using semantic technologies
- URL: https://io.datascience-paris-saclay.fr/

6.2. Codalab

KEYWORDS: Benchmarking - Competition

FUNCTIONAL DESCRIPTION: Challenges in machine learning and data science are competitions running over several weeks or months to resolve problems using provided datasets or simulated environments. Challenges can be thought of as crowdsourcing, benchmarking, and communication tools. They have been used for decades to test and compare competing solutions in machine learning in a fair and controlled way, to eliminate "inventor-evaluator" bias, and to stimulate the scientific community while promoting reproducible science. See our slide presentation.

As of June 2019 Codalab exceeded 40,000 users, 1000 competitions (300 public), and had over 300 submissions per day. Some of the areas in which Codalab is used include Computer vision and medical image analysis, natural language processing, time series prediction, causality, and automatic machine learning. Codalab was selected by the Région Ile de France to organize its challenges in the next three years.

TAU is going to continue expanding Codalab to accommodate new needs. One of our current focus is to support use of challenges for teaching (i.e. include a grading system as part of Codalab) and support for hooking up data simulation engines in the backend of Codalab to enable Reinforcement Learning challenges and simulate interactions of machines with an environment. For the fith year, we are using Codalab for student projects. M2 AIC students create mini data science challenges in teams of 6 students. L2 math and informatics students then solve them as part of their mini projects. We are collaborating with RPI (New York, USA) and Université de Grenoble to use this platform as part of a curriculum of medical students. We created a special application called ChaGrade to grade homework using challenges. Our PhD. students are involved in co-organizing challenges to expose the research community at large with the topic of their PhD. This helps them formalizing a task with rigor and allows them to disseminate their research.

- Contact: Isabelle Guyon
- URL: http://competitions.codalab.org

6.3. Cartolabe

KEYWORD: Information visualization

FUNCTIONAL DESCRIPTION: The goal of Cartolabe is to build a visual map representing the scientific activity of an institution/university/domain from published articles and reports. Using the HAL Database, Cartolabe provides the user with a map of the thematics, authors and articles . ML techniques are used for dimensionality reduction, cluster and topics identification, visualisation techniques are used for a scalable 2D representation of the results.

NEWS OF THE YEAR: This year, Cartolabe was applied to the Grand Debat dataset (3M individual propositions from french Citizen, see https://cartolabe.fr/map/debat). The results were used to test both the scaling capabilities of Cartolabe and its flexibility to non-scientific and non-english corpuses. We also Added submap capabilities to display the result of a year/lab/word filtering as an online generated heatmap with only the filtered points to facilitate the exploration.

- Participants: Philippe Caillou, Jean-Daniel Fekete, Jonas Renault and Anne-Catherine Letournel
- Partners: LRI - Laboratoire de Recherche en Informatique - CNRS
- Contact: Philippe Caillou
- URL: http://www.cartolabe.fr/

TOSCA Team

5. New Software and Platforms

5.1. diamss

KEYWORDS: High-performance calculation - Computation - Stochastic process

FUNCTIONAL DESCRIPTION: Numerical resolution of Keller-Segel equations and everal numerical tests.

- Participants: Denis Talay, Hector Olivero-Quinteros and Milica Tomasevic
- Contact: Denis Talay

5.2. ExitBM

FUNCTIONAL DESCRIPTION: The exitbm library provides methods to simulate random variables related to the first exit time and position of the Brownian motion from simple domains, namely intervals, squares and rectangles.

- Participants: Antoine Lejay and Madalina Deaconu
- Contact: Antoine Lejay
- URL: http://exitbm.gforge.inria.fr/

5.3. MOC

Models Of Chemostat

KEYWORD: Simulator

FUNCTIONAL DESCRIPTION: MOC (for Models of Chemostat) is a Python simulator of four chemostat models: a mass-structured stochastic individual based model, a mass-structured integro-differential model, the Crump-Young model and a system of ordinary differential equations. This software allows to simulate one or several of those models with different parameters, to plot graphics of evolution of biomass concentration, number of bacteria and substrate concentration as well as the phase portrait, to determine the law of the extinction time of the bacterial population in case of population extinction.

- Participants: Coralie Fritsch and Fabien Campillo
- Contact: Coralie Fritsch
- URL: https://github.com/coraliefritsch/modelsOfChemostat

5.4. SDM

Stochastic Downsaling Method

FUNCTIONAL DESCRIPTION: The computation of the wind at small scale and the estimation of its uncertainties is of particular importance for applications such as wind energy resource estimation. To this aim, starting in 2005, we have developed a new method based on the combination of an existing Numerical Weather Prediction model providing a coarse prediction, and a Lagrangian Stochastic Model for turbulent flows. This Stochastic Downscaling Method (SDM) requires a specific modeling of the turbulence closure, and involves various simulation techniques whose combination is totally original (such as Poisson solvers, optimal transportation mass algorithm, original Euler scheme for confined Langevin stochastic processes, and stochastic particle methods).

- Participants: Antoine Rousseau, Antoine Rousseau, Claire Chauvin, Frederic Bernardin and Mireille Bossy
- Contact: Mireille Bossy

5.5. SDM-Log

- Participants: Antoine Rousseau, Claire Chauvin, Frederic Bernardin, Jacques Morice and Mireille Bossy
- Contact: Mireille Bossy

5.6. WindPoS-SDM-LAM

KEYWORDS: Numerical simulations - 3D - Fluid mechanics

FUNCTIONAL DESCRIPTION: Software platform for wind modeling.

- Authors: Antoine Rousseau, Cristian Paris Ibarra, Jacques Morice, Mireille Bossy and Sélim Kraria
- Contact: Mireille Bossy
- URL: https://windpos.inria.fr

5.7. WindPoS-ATM

KEYWORDS: 3D - Co-simulation - Fluid mechanics

- Authors: Philippe Drobinski, Antoine Rousseau, Mireille Bossy, Jacques Morice and Thomas Dubos
- Partners: Ecole Polytechnique - Laboratoire de Météorologie Dynamique
- Contact: Mireille Bossy
- URL: https://windpos.inria.fr/projects/windpos/

5.8. WindPoS-CIV

WinsPoS-CIV (Configuration Interface and Visualization)

- Authors: Sélim Kraria, Antoine Rousseau and Mireille Bossy
- Contact: Mireille Bossy

5.9. SBM

Skew Brownian Motion

KEYWORDS: Monte-Carlo methods - Skew Brownian Motion

FUNCTIONAL DESCRIPTION: SBM is a code allowing exact or approximated simulations of the Skew Brownian Motion. This code is used for the simulation, with a Monte-Carlo approach, of a 1D diffusion process with a discontinuous diffusion coefficient. Several benchmark tests are also implemented.

NEWS OF THE YEAR: - Refactoring and Cmake compilation - Automatic non regression tests on ci-inria.fr - Full documentation - Open source project on gitlab-inria

- Authors: Antoine Lejay and Géraldine Pichot
- Contact: Antoine Lejay
- Publication: Simulating diffusion processes in discontinuous media: Benchmark tests
- URL: https://gitlab.inria.fr/lejay/sbm

<p style="text-align:center; color:red;">**TRIPOP Project-Team**</p>

5. New Software and Platforms

5.1. SICONOS

Participants: Vincent Acary, Maurice Brémond, Olivier Huber, Franck Pérignon.

In the framework of the FP5 European project Siconos (2002-2006), Bipop was the leader of the Work Package 2 (WP2), dedicated to the numerical methods and the software design for nonsmooth dynamical systems. This has given rise to the platform SICONOS which is the main software development task in the team. The aim of this work is to provide a common platform for the simulation, modeling, analysis and control of abstract nonsmooth dynamical systems. Besides usual quality attributes for scientific computing software, we want to provide a common framework for various scientific fields, to be able to rely on the existing developments (numerical algorithms, description and modeling software), to support exchanges and comparisons of methods, to disseminate the know-how to other fields of research and industry, and to take into account the diversity of users (end-users, algorithm developers, framework builders) in building expert interfaces in Python and end-user front-end through Scilab.

After the requirement elicitation phase, the Siconos Software project has been divided into 5 work packages which are identified to software products:

1. SICONOS/NUMERICS This library contains a set of numerical algorithms, already well identified, to solve non smooth dynamical systems. This library is written in low-level languages (C,F77) in order to ensure numerical efficiency and the use of standard libraries (Blas, Lapack, ...)

2. SICONOS/KERNEL This module is an object-oriented structure (C++) for the modeling and the simulation of abstract dynamical systems. It provides the users with a set of classes to describe their nonsmooth dynamical system (dynamical systems, intercations, nonsmooth laws, ...) and to perform a numerical time integration and solving.

3. SICONOS/FRONT-END. This module is mainly an auto-generated wrapper in Python which provides a user-friendly interface to the Siconos libraries. A scilab interface is also provided in the Front-End module.

4. SICONOS/CONTROL This part is devoted to the implementation of control strategies of non smooth dynamical systems.

5. SICONOS/MECHANICS. This part is dedicated to the modeling and the simulation of multi-body systems with 3D contacts, impacts and Coulomb's friction. It uses the Siconos/Kernel as simulation engine but relies on a industrial CAD library (OpenCascade and pythonOCC) to deal with complex body geometries and to compute the contact locations and distances between B-Rep description and on Bullet for contact detection between meshes.

Further informations may be found at http://siconos.gforge.inria.fr/

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TROPICAL Project-Team

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6. New Software and Platforms

6.1. Coq-Polyhedra

KEYWORDS: Coq - Polyhedra - Automated theorem proving - Linear optimization

SCIENTIFIC DESCRIPTION: Coq-Polyhedra is a library providing a formalization of convex polyhedra in the Coq proof assistant. While still in active development, it provides an implementation of the simplex method, and already handles the basic properties of polyhedra such as emptiness, boundedness, membership. Several fundamental results in the theory of convex polyhedra, such as Farkas Lemma, duality theorem of linear programming, and Minkowski Theorem, are also formally proved.

The formalization is based on the Mathematical Components library, and makes an extensive use of the boolean reflection methodology.

FUNCTIONAL DESCRIPTION: Coq-Polyhedra is a library which aims at formalizing convex polyhedra in Coq

NEWS OF THE YEAR: Coq-Polyhedra now provides most of the basic operations on polyhedra. They are expressed on a quotient type that avoids reasoning with particular inequality representations. They include : * the construction of elementary polyhedra (half-spaces, hyperplanes, affine spaces, orthants, simplices, etc) * basic operations such as intersection, projection (thanks to the formalization of the Fourier-Motzkin algorithm), image under linear functions, computations of convex hulls, finitely generated cones, etc. * computation of affine hulls of polyhedra, as well as their dimension

Thanks to this, we have made huge progress on the formalization of the combinatorics of polyhedra. The poset of faces, as well as its fundamental properties (lattice, gradedness, atomicity and co-atomicity, etc) are now formalized. The manipulation of the faces is based on an extensive use of canonical structures, that allows to get the most appropriate inequality representations for reasoning. In this way, we arrive at very concise and elegant proofs, closer to the pen-and-paper ones.

- Participants: Xavier Allamigeon, Vasileios Charisopoulos, Ricardo Katz and Pierre-Yves Strub
- Partners: CIFASIS - Ecole Polytechnique
- Contact: Xavier Allamigeon
- Publications: A Formalization of Convex Polyhedra Based on the Simplex Method - A Formalization of Convex Polyhedra Based on the Simplex Method - First steps in the formalization of convex polyhedra in Coq
- URL: https://github.com/nhojem/Coq-Polyhedra

6.2. EmergencyEval

KEYWORDS: Dynamic Analysis - Simulation - Ocaml - Emergency - Firefighters - Police

SCIENTIFIC DESCRIPTION: This software aims at enabling the definition of a Petri network execution semantic, as well as the instanciation and execution of said network using the aforedefined semantic.

The heart of the project dwells in its kernel which operates the step-by-step execution of the network, obeying rules provided by an oracle. This user-defined and separated oracle computes the information necessary to the kernel for building the next state using the current state. The base of our software is the framework for the instanciation and execution of Petri nets, without making assumptions regarding the semantic.

In the context of the study of the dynamics of emergency call centers, a second part of this software is the definition and implementation of the semantic of call centers modelized as Petri nets, and more specifically timed prioritized Petri nets. A module interoperating with the kernel enables to include all the operational specificities of call centers (urgency level, discriminating between operators and callers ...) while guaranteeing the genericity of the kernal which embeds the Petri net formalism as such.

FUNCTIONAL DESCRIPTION: In order to enable the quantitative study of the throughput of calls managed by emergency center calls and the assesment of various organisationnal configurations considered by the stakeholders (firefighters, police, medical emergency service of the 75, 92, 93 and 94 French departments), this software modelizes their behaviours by resorting to extensions of the Petri net formalism. Given a call transfer protocol in a call center, which corresponds to a topology and an execution semantic of a Petri net, the software generates a set of entering calls in accord with the empirically observed statistic ditributions (share of very urgent calls, conversation length), then simulates its management by the operators with respect to the defined protocol. Transitional regimes phenomenons (peak load, support) which are not yet handled by mathematical analysis could therefore be studied. The ouput of the software is a log file which is an execution trace of the simulation featuring extensive information in order to enable the analysis of the data for providing simulation-based insights for decision makers.

The software relies on a Petri net simulation kernel designed to be as modular and adaptable as possible, fit for simulating other Petri-net related phenomenons, even if their semantic differ greatly.

- Participants: Baptiste Colin and Xavier Allamigeon
- Contact: Baptiste Colin

<p style="text-align:center">**VALSE Project-Team**</p>

6. New Software and Platforms

6.1. Platforms

6.1.1. ControlHub

ControlHub is the platform for the rapid prototyping of control algorithms of cyber-physical systems. It allows the End-User to have a remote access to real experimental setups in order to validate mathematical control and estimation algorithms.

ABS Project-Team

4. New Software and Platforms

4.1. SBL

Structural Bioinformatics Library

KEYWORDS: Structural Biology - Biophysics - Software architecture

FUNCTIONAL DESCRIPTION: The SBL is a generic C++/python cross-platform software library targeting complex problems in structural bioinformatics. Its tenet is based on a modular design offering a rich and versatile framework allowing the development of novel applications requiring well specified complex operations, without compromising robustness and performances.

More specifically, the SBL involves four software components (1-4 thereafter). For end-users, the SBL provides ready to use, state-of-the-art (1) applications to handle molecular models defined by unions of balls, to deal with molecular flexibility, to model macro-molecular assemblies. These applications can also be combined to tackle integrated analysis problems. For developers, the SBL provides a broad C++ toolbox with modular design, involving core (2) algorithms, (3) biophysical models, and (4) modules, the latter being especially suited to develop novel applications. The SBL comes with a thorough documentation consisting of user and reference manuals, and a bugzilla platform to handle community feedback.

RELEASE FUNCTIONAL DESCRIPTION: In 2018, major efforts targeted two points. First, the simplification of installation procedures – now possible with conda/python. Second, the development of packages revolving on molecular flexibility at large: representations in internal and Cartesian coordinates, generic representation of molecular mechanics force fields (and computation of gradients), exploration algorithms for conformational spaces.

- Contact: Frédéric Cazals
- Publication: The Structural Bioinformatics Library: modeling in biomolecular science and beyond
- URL: https://sbl.inria.fr/

AIRSEA Project-Team

5. New Software and Platforms

5.1. AGRIF

Adaptive Grid Refinement In Fortran

KEYWORD: Mesh refinement

SCIENTIFIC DESCRIPTION: AGRIF is a Fortran 90 package for the integration of full adaptive mesh refinement (AMR) features within a multidimensional finite difference model written in Fortran. Its main objective is to simplify the integration of AMR potentialities within an existing model with minimal changes. Capabilities of this package include the management of an arbitrary number of grids, horizontal and/or vertical refinements, dynamic regridding, parallelization of the grids interactions on distributed memory computers. AGRIF requires the model to be discretized on a structured grid, like it is typically done in ocean or atmosphere modelling.

NEWS OF THE YEAR: In 2019, a new contract has been signed with CMEMS (Copernicus Marine Environment Moniroting Service) in order to extent the multiresolution capabilities of the AGRIF and its integration into the NEMO ocean system.

- Participants: Roland Patoum and Laurent Debreu
- Contact: Laurent Debreu
- Publications: Numerical and experimental approach for a better physical description of submesoscale processes : A north-western Mediterranean Sea case - AGRIF: Adaptive Grid Refinement in Fortran
- URL: http://www-ljk.imag.fr/MOISE/AGRIF

5.2. BALAISE

Bilbliothèque d'Assimilation Lagrangienne Adaptée aux Images Séquencées en Environnement

KEYWORDS: Multi-scale analysis - Data assimilation - Optimal control

FUNCTIONAL DESCRIPTION: BALAISE (Bilbliothèque d'Assimilation Lagrangienne Adaptée aux Images Séquencées en Environnement) is a test bed for image data assimilation. It includes a shallow water model, a multi-scale decomposition library and an assimilation suite.

- Contact: Arthur Vidard

5.3. NEMOVAR

Variational data assimilation for NEMO

KEYWORDS: Oceanography - Data assimilation - Adjoint method - Optimal control

FUNCTIONAL DESCRIPTION: NEMOVAR is a state-of-the-art multi-incremental variational data assimilation system with both 3D and 4D var capabilities, and which is designed to work with NEMO on the native ORCA grids. The background error covariance matrix is modelled using balance operators for the multivariate component and a diffusion operator for the univariate component. It can also be formulated as a linear combination of covariance models to take into account multiple correlation length scales associated with ocean variability on different scales. NEMOVAR has recently been enhanced with the addition of ensemble data assimilation and multi-grid assimilation capabilities. It is used operationnaly in both ECMWF and the Met Office (UK)

- Partners: CERFACS - ECMWF - Met Office
- Contact: Arthur Vidard

5.4. Sensitivity

FUNCTIONAL DESCRIPTION: This package is useful for conducting sensitivity analysis of complex computer codes.

- Contact: Laurent Gilquin
- URL: https://cran.r-project.org/web/packages/sensitivity/index.html

ANGE Project-Team

6. New Software and Platforms

6.1. Freshkiss

FREe Surface Hydrodynamics using KInetic SchemeS

KEYWORDS: Finite volume methods - Hydrostatic Navier-Stokes equations - Free surface flows

FUNCTIONAL DESCRIPTION: Freshkiss3D is a numerical code solving the 3D hydrostatic and incompressible Navier-Stokes equations with variable density.

- Participants: Fabien Souillé, Emmanuel Audusse, Jacques Sainte Marie and Marie-Odile Bristeau
- Partners: UPMC - CEREMA
- Contact: Jacques Sainte Marie

6.2. TSUNAMATHS

KEYWORDS: Modeling - Tsunamis

FUNCTIONAL DESCRIPTION: Tsunamaths is an educational platform aiming at simulating historical tsunamis. Real data and mathematical explanations are provided to enable people to better understand the overall process of tsunamis.

- Participants: Emmanuel Audusse, Jacques Sainte Marie and Raouf Hamouda
- Contact: Jacques Sainte Marie
- URL: http://tsunamath.paris.inria.fr/

6.3. Verdandi

KEYWORDS: HPC - Model - Software Components - Partial differential equation

FUNCTIONAL DESCRIPTION: Verdandi is a free and open-source (LGPL) library for data assimilation. It includes various such methods for coupling one or several numerical models and observational data. Mainly targeted at large systems arising from the discretization of partial differential equations, the library is devised as generic, which allows for applications in a wide range of problems (biology and medicine, environment, image processing, etc.). Verdandi also includes tools to ease the application of data assimilation, in particular in the management of observations or for a priori uncertainty quantification. Implemented in C++, the library may be used with models implemented in Fortran, C, C++ or Python.

- Participants: Dominique Chapelle, Gautier Bureau, Nicolas Claude, Philippe Moireau and Vivien Mallet
- Contact: Vivien Mallet
- URL: http://verdandi.gforge.inria.fr/

6.4. Polyphemus

KEYWORD: Simulation

FUNCTIONAL DESCRIPTION: Polyphemus is a modeling system for air quality. As such, it is designed to yield up-to-date simulations in a reliable framework: data assimilation, ensemble forecast and daily forecasts. Its completeness makes it suitable for use in many applications: photochemistry, aerosols, radionuclides, etc. It is able to handle simulations from local to continental scales, with several physical models. It is divided into three main parts:

libraries that gather data processing tools (SeldonData), physical parameterizations (AtmoData) and post-processing abilities (AtmoPy),

programs for physical pre-processing and chemistry-transport models (Polair3D, Castor, two Gaussian models, a Lagrangian model),

model drivers and observation modules for model coupling, ensemble forecasting and data assimilation.

- Participants: Sylvain Doré and Vivien Mallet
- Contact: Vivien Mallet
- URL: http://cerea.enpc.fr/polyphemus/

6.5. Urban noise analysis

KEYWORD: Environment perception

FUNCTIONAL DESCRIPTION: This software processes mobile observations collected by the application Ambiciti (previously known as SoundCity). It can merge simulated noise maps with the mobile observations.

- Authors: Raphaël Ventura, Vivien Mallet and Guillaume Chérel
- Contact: Vivien Mallet

6.6. Freshkiss3D

KEYWORDS: Python - Cython - Navier-Stokes

FUNCTIONAL DESCRIPTION: Tool for the numerical solution of free surface Navier-Stokes equations

- Participants: Cédric Doucet, Apolline El Baz and Jacques Sainte Marie
- Partner: UPMC
- Contact: Jacques Sainte Marie
- Publication: Numerical approximation of the 3d hydrostatic Navier-Stokes system with free surface

ARAMIS Project-Team

6. New Software and Platforms

6.1. Brain Networks Toolbox

KEYWORDS: Neuroimaging - Medical imaging

FUNCTIONAL DESCRIPTION: Brain Networks Toolbox is an open-source package of documented routines implementing new graph algorithms for brain network analysis. It mainly contains Matlab code of new methods developed by the team and associated to publications (e.g., brain network thresholding, extraction of the information redundancy, node accessibility, etc). It requires, as input, adjacency matrices representing brain connectivity networks. Thus, it is independent on the specific approach used to construct brain networks and it can be used to extract network properties from any neuroimaging modality in healthy and diseased subjects.

- Participants: Fabrizio de Vico Fallani, Jeremy Guillon and Mario Chavez
- Contact: Fabrizio de Vico Fallani
- URL: https://github.com/brain-network/bnt

6.2. Deformetrica

KEYWORDS: 3D modeling - C++ - Automatic Learning - Mesh - Anatomy - Image analysis

SCIENTIFIC DESCRIPTION: Deformetrica is a software for the statistical analysis of 2D and 3D shape data. It essentially computes deformations of the 2D or 3D ambient space, which, in turn, warp any object embedded in this space, whether this object is a curve, a surface, a structured or unstructured set of points, or any combination of them.

Deformetrica comes with two applications:

- Registration, which computes the best possible deformation between two sets of objects,

- Atlas construction, which computes an average object configuration from a collection of object sets, and the deformations from this average to each sample in the collection.

Deformetrica has very little requirements about the data it can deal with. In particular, it does not require point correspondence between objects!

- Participants: Alexandre Routier, Ana Fouquier, Barbara Gris, Benjamin Charlier, Cédric Doucet, Joan Alexis Glaunès, Marcel Prastawa, Michael Bacci, Pietro Gori and Stanley Durrleman
- Partners: University of Utah - Université de Montpellier 2 - Université Paris-Descartes
- Contact: Stanley Durrleman
- URL: http://www.deformetrica.org/

6.3. Clinica

KEYWORDS: Neuroimaging - Brain MRI - MRI - Clinical analysis - Image analysis - Machine learning

SCIENTIFIC DESCRIPTION: Clinica is a software platform for multimodal brain image analysis in clinical research studies. It makes it easy to apply advanced analysis tools to large scale clinical studies. For that purpose, it integrates a comprehensive set of processing tools for the main neuroimaging modalities: currently MRI (anatomical, functional, diffusion) and PET, in the future, EEG/MEG. For each modality, Clinica allows to easily extract various types of features (regional measures, parametric maps, surfaces, curves, networks). Such features are then subsequently used as input of machine learning, statistical modeling, morphometry or network analysis methods. Processing pipelines are based on combinations of freely available tools developed by the community. It provides an integrated data management specification to store raw and processing data. Clinica is written in Python. It uses the Nipype system for pipelining. It combines widely-used software for neuroimaging data analysis (SPM, Freesurfer, FSL, MRtrix...), morphometry (Deformetrica), machine learning (Scikit-learn) and the BIDS standard for data organization.

FUNCTIONAL DESCRIPTION: Clinica is a software platform for multimodal brain image analysis in clinical research studies. It makes it easy to apply advanced analysis tools to large scale clinical studies. For that purpose, it integrates a comprehensive set of processing tools for the main neuroimaging modalities: currently MRI (anatomical, functional, diffusion) and PET, in the future, EEG/MEG. For each modality, Clinica allows to easily extract various types of features (regional measures, parametric maps, surfaces, curves, networks). Such features are then subsequently used as input of machine learning, statistical modeling, morphometry or network analysis methods. Clinica also provides an integrated data management specification to store raw and processing data. Overall, Clinica helps to: i) apply advanced analysis tools to clinical research studies, ii) easily share data and results, iii) make research more reproducible.

NEWS OF THE YEAR: - Three clinical studies made with Clinica Clinica : Bertrand et al, JAMA Neurology, 2018 , Jacquemont et al, Neurobiol Aging, 2017, Wen et al, JNNP, 2018 - Clinica presented at OHBM 2018 conference - Clinica was the support for the tutorial "Pattern Recognition for Neuroimaging" at OHBM 2018

- Participants: Jeremy Guillon, Thomas Jacquemont, Pascal Lu, Arnaud Marcoux, Tristan Moreau, Alexandre Routier, Jorge Samper Gonzalez, Junhao Wen, Olivier Colliot, Stanley Durrleman, Michael Bacci, Simona Bottani, Ninon Burgos, Sabrina Fontanella, Pietro Gori, Mauricio Diaz and Elina Thibeau-Sutre

- Partners: Institut du Cerveau et de la Moelle épinière (ICM) - CNRS - INSERM - UPMC

- Contact: Olivier Colliot

- Publications: Amyloidosis and neurodegeneration result in distinct structural connectivity patterns in mild cognitive impairment - Yet Another ADNI Machine Learning Paper? Paving The Way Towards Fully-reproducible Research on Classification of Alzheimer's Disease - Reproducible evaluation of classification methods in Alzheimer's disease: Framework and application to MRI and PET data - Neurite density is reduced in the presymptomatic phase of C9orf72 disease - Early cognitive, structural and microstructural changes in c9orf72 presymptomatic carriers before 40 years of age

- URL: http://www.clinica.run

6.4. Platforms

6.4.1. Platform Brain-computer interface

Our team coordinates the developments of the Brain-Computer Interface (BCI) platform at the Centre EEG/MEG of the neuroimaging core facility of the ICM. Several projects, including our NETBCI NSF/NIH/ANR and ATTACK Big-brain theory funded projects, as well as experiments by different researchers of the Institute, are currently being run. To reinforce the impact of the platform we have recently recruited an engineer (J. Gonzalez-Astudillo) and a master student (Tristan Venot) for the software and technical development.

ATHENA Project-Team

6. New Software and Platforms

6.1. Dmipy

Diffusion MRI Multi-Compartment Modeling and Microstructure Recovery Made Easy

KEYWORDS: Diffusion MRI - Multi-Compartment Modeling - Microstructure Recovery

FUNCTIONAL DESCRIPTION: Non-invasive estimation of brain microstructure features using diffusion MRI (dMRI) – known as Microstructure Imaging – has become an increasingly diverse and complicated field over the last decades. Multi-compartment (MC)-models, representing the measured diffusion signal as a linear combination of signal models of distinct tissue types, have been developed in many forms to estimate these features. However, a generalized implementation of MC-modeling as a whole, providing deeper insights in its capabilities, remains missing. To address this fact, we present Diffusion Microstructure Imaging in Python (Dmipy), an open-source toolbox implementing PGSE-based MC-modeling in its most general form. Dmipy allows on-the-fly implementation, signal modeling, and optimization of any user-defined MC-model, for any PGSE acquisition scheme. Dmipy follows a "building block"-based philosophy to Microstructure Imaging, meaning MC-models are modularly constructed to include any number and type of tissue models, allowing simultaneous representation of a tissue's diffusivity, orientation, volume fractions, axon orientation dispersion, and axon diameter distribution. In particular, Dmipy is geared toward facilitating reproducible, reliable MC-modeling pipelines, often allowing the whole process from model construction to parameter map recovery in fewer than 10 lines of code. To demonstrate Dmipy's ease of use and potential, we implement a wide range of well-known MC-models, including IVIM, AxCaliber, NODDI(x), Bingham-NODDI, the spherical mean-based SMT and MC-MDI, and spherical convolution-based single- and multi-tissue CSD. By allowing parameter cascading between MC-models, Dmipy also facilitates implementation of advanced approaches like CSD with voxel-varying kernels and single-shell 3-tissue CSD. By providing a well-tested, user-friendly toolbox that simplifies the interaction with the otherwise complicated field of dMRI-based Microstructure Imaging, Dmipy contributes to more reproducible, high-quality research.

- Authors: Rutger Fick, Demian Wassermann and Rachid Deriche
- Contact: Rachid Deriche

6.2. High Performance Diffusion MRI

KEYWORDS: Health - Neuroimaging - Medical imaging

FUNCTIONAL DESCRIPTION: This library has been developed and transferred to the Cie Olea Medical currently in charge of its validation and inclusion in its Olea Sphere platform. We have been closely involved in pushing the frontiers of the diffusion MRI (dMRI) in the recent years, especially in the mathematical modelling and processing of the dMRI signal and have developed state-of-the-art software implementations in the form of a C++ library that can be effectively used to infer the complex microstructure of the cerebral white matter. The algorithms and software transfered to Olea Medical fall into four categories : (i) local tissue modelling, which includes both popular 2nd order models and advanced higher than 2nd order models such as DTI, higher order Cartesian tensors (HOTs), ODF, FOD, EAP, maxima extraction, regularization and segmentation, (ii) generation of scalar indices (or biomarkers), which include DTI biomarkers, Diffusion Kurtosis Imaging (DKI) and invariants of 4th order tensors, (iii) global structure estimation, which includes deterministic and probabilistic tractography, and (iv) data visualisation for scalar indices, local models and global structures.

- Participants: Aurobrata Ghosh, Rachid Deriche and Théodore Papadopoulo
- Partner: Olea Medical
- Contact: Rachid Deriche

6.3. OpenMEEG

KEYWORDS: Health - Neuroimaging - Medical imaging

SCIENTIFIC DESCRIPTION: OpenMEEG provides a symmetric boundary element method (BEM) implementation for solving the forward problem of electromagnetic propagation over heterogeneous media made of several domains of homogeneous and isotropic conductivities. OpenMEEG works for the quasistatic regime (frequencies < 100Hz and medium diameter < 1m).

FUNCTIONAL DESCRIPTION: OpenMEEG provides state-of-the art tools for modelling bio-electromagnetic propagation in the quasi-static regime. It is based on the symmetric BEM for the EEG/MEG forward problem, with a distributed source model. OpenMEEG has also been used to model the forward problem of ECoG, for modelling nerves or the cochlea. OpenMEEG is a free, open software written in C++ with python bindings. OpenMEEG is used through a command line interface, but is also interfaced in graphical interfaces such as BrainStorm, FieldTrip or SPM.

RELEASE FUNCTIONAL DESCRIPTION: OpenMEEG has had a large update including notably the parallelisation of some operators and bug corrections. The new version allows in addition the use of non-nested domains.

NEWS OF THE YEAR: OpenMEEG has had a large update including notably the parallelisation of some operators and bug corrections. The new version allows in addition the use of non-nested domains. These improvements have been ditributed with the two new releases (2.4.0 and 2.4.1) made in 2018.

- Participants: Alexandre Gramfort, Emmanuel Olivi, Geoffray Adde, Jan Kybic, Kai Dang, Maureen Clerc, Perrine Landreau, Renaud Keriven and Théodore Papadopoulo
- Contact: Théodore Papadopoulo
- Publications: inria-00467061v2 - inria-00584205v1 - hal-01278377v1
- URL: http://openmeeg.github.io/

6.4. OpenVIBE

KEYWORDS: Neurosciences - Interaction - Virtual reality - Health - Real time - Neurofeedback - Brain-Computer Interface - EEG - 3D interaction

FUNCTIONAL DESCRIPTION: OpenViBE is a free and open-source software platform devoted to the design, test and use of Brain-Computer Interfaces (BCI). The platform consists of a set of software modules that can be integrated easily and efficiently to design BCI applications. The key features of OpenViBE software are its modularity, its high-performance, its portability, its multiple-users facilities and its connection with high-end/VR displays. The designer of the platform enables to build complete scenarios based on existing software modules using a dedicated graphical language and a simple Graphical User Interface (GUI). This software is available on the Inria Forge under the terms of the AGPL licence, and it was officially released in June 2009. Since then, the OpenViBE software has already been downloaded more than 60000 times, and it is used by numerous laboratories, projects, or individuals worldwide. More information, downloads, tutorials, videos, documentations are available on the OpenViBE website.

- Participants: Cedric Riou, Thierry Gaugry, Anatole Lécuyer, Fabien Lotte, Jussi Tapio Lindgren, Laurent Bougrain, Maureen Clerc and Théodore Papadopoulo
- Partners: INSERM - GIPSA-Lab
- Contact: Anatole Lécuyer
- URL: http://openvibe.inria.fr

6.5. BCI-VIZAPP

BCI visual applications

KEYWORDS: Health - Brain-Computer Interface - GUI (Graphical User Interface)

SCIENTIFIC DESCRIPTION: Bci-Vizapp is a library that allows (in interaction with OpenViBE) to build BCI (Brain Computer Interfaces) applications based on the P300 speller principle. Bci-Vizapp provides a library that allows you to create the BCI's stimulation part as part of the Qt toolkit. Being able to use a standard toolkit to make BCI applications is a strong Bci-Vizapp originality. Indeed, in general the use of such toolkits is prohibited by the need for a very precise control of the display timings, which generally eliminates high-level graphic toolkits such as Qt.

FUNCTIONAL DESCRIPTION: BCI-VIZAPP includes a virtual keyboard for typing text, a photodiode monitoring application for checking timing issues. It communicates with the OpenViBE acquisition server for signal acquisition and with the OpenViBE designer for signal processing. The configuration is performed through a wizard.

This software is a new version following the CoAdapt P300 stimulator software.

NEWS OF THE YEAR: Bci-Vizapp is undergoing a profound transmutation with the help of CRISAM's SED in ADT BciBrowser (part of the AMDT). This change aims at integrating the functionality of Bci-Vizapp in third-party applications such as a web browsers.

- Participants: Nathanaël Foy, Romain Lacroix, Maureen Clerc and Théodore Papadopoulo
- Contact: Théodore Papadopoulo

<p style="text-align:center;color:red;font-weight:bold;">BEAGLE Project-Team</p>

6. New Software and Platforms

6.1. aevol

Artificial Evolution

KEYWORDS: Bioinformatics - Genomics - Evolution

FUNCTIONAL DESCRIPTION: Aevol is a digital genetics model: populations of digital organisms are subjected to a process of selection and variation, which creates a Darwinian dynamics. By modifying the characteristics of selection (e.g. population size, type of environment, environmental variations) or variation (e.g. mutation rates, chromosomal rearrangement rates, types of rearrangements, horizontal transfer), one can study experimentally the impact of these parameters on the structure of the evolved organisms. In particular, since Aevol integrates a precise and realistic model of the genome, it allows for the study of structural variations of the genome (e.g. number of genes, synteny, proportion of coding sequences).

The simulation platform comes along with a set of tools for analysing phylogenies and measuring many characteristics of the organisms and populations along evolution.

An extension of the model (R-Aevol), integrates an explicit model of the regulation of gene expression, thus allowing for the study of the evolution of gene regulation networks.

RELEASE FUNCTIONAL DESCRIPTION: Fix compilation error on Mac (tr1 included in std). The new mac compiler includes the tr1 directly in std which caused a compilation error. This issue was specific to aevol-4.4.1

- Participants: Antoine Frénoy, Bérénice Batut, Carole Knibbe, David P. Parsons, Dusan Misevic, Guillaume Beslon, Jonathan Rouzaud-Cornabas and Vincent Liard
- Partners: UCBL Lyon 1 - INSERM - Université Paris-Descartes - Insa de Lyon
- Contact: Guillaume Beslon
- URL: http://www.aevol.fr/

6.2. Treerecs

KEYWORDS: Bioinformatics - Biology - Computational biology

SCIENTIFIC DESCRIPTION: The reconciliation between gene trees and species trees is a modern method of molecular phylogeny, which does not yet have its standard software, as for example phylogeny from DNA or amino acid sequences. Treerecs has this ambition, incorporating the classic functionalities of reconciliation: annotating the vertices of a gene tree with the tops of a species tree, rooting and correcting the gene tree. Rooting and correction are calculated to minimize the number of duplications and losses in reconciliation. Medium-sized solutions are randomly sampled according to a uniform law. A likelihood can then be calculated using probabilistic methods. In addition, Treerecs is integrated into a standard software ecosystem of phylogeny, bio ++, ALE, Seaview, and has a graphical interface. Some original features are implemented, such as the possibility of combining two types of likelihoods, the one calculated from the sequences and the one calculated from the reconciliations, the possibility of estimating the costs of the evolutionary events, the possibility of exploring the space of trees according to a joined likelihood.

FUNCTIONAL DESCRIPTION: Treerecs takes as minimum input a gene tree and a species tree. It "reconciles" them, that is, it annotates gene tree nodes with events and assign them to species tree nodes. Biologically, it is a reconstruction of the gene history, given the species history, in terms of duplications, speciations, losses.

With the appropriate options Treerecs can root and correct the gene tree.

NEWS OF THE YEAR: Release of a 0.1 stable version

- Participants: Nicolas Comte, David P. Parsons, Eric Tannier and Benoît Morel
- Partner: Laboratoire de Biométrie et Biologie Evolutive (LBBE) - UMR CNRS 5558
- Contact: Eric Tannier

<p align="center" style="color:red">BIGS Project-Team</p>

6. New Software and Platforms

6.1. Angio-Analytics

KEYWORDS: Health - Cancer - Biomedical imaging

SCIENTIFIC DESCRIPTION: This tool allows the pharmacodynamic characterization of anti-vascular effects in anti-cancer treatments. It uses time series of in vivo images provided by intra-vital microscopy. Such in vivo images are obtained owing to skinfold chambers placed on mice skin. The automatized analysis is split up into two steps that were completely performed separately and manually before. The first steps corresponds to image processing to identify characteristics of the vascular network. The last step is the system identification of the pharmacodynamic response and the statistical analysis of the model parameters.

FUNCTIONAL DESCRIPTION: Angio-Analytics allows the pharmacodynamic characterization of anti-vascular effects in anti-cancer treatments.

- Participant: Thierry Bastogne
- Contact: Thierry Bastogne

6.2. ARMADA

A Statistical Methodology to Select Covariates in High-Dimensional Data under Dependence

KEYWORDS: Biostatistics - Aggregated methods - High Dimensional Data - Personalized medicine - Variable selection

FUNCTIONAL DESCRIPTION: Two steps variable selection procedure in a context of high-dimensional dependent data but few observations. First step is dedicated to eliminate dependence between variables (clustering of variables, followed by factor analysis inside each cluster). Second step is a variable selection using by aggregation of adapted methods. https://hal.archives-ouvertes.fr/hal-02173568

NEWS OF THE YEAR: This package is a new one.

- Participants: Aurélie Muller and Anne Gégout-Petit
- Contact: Aurélie Muller
- Publication: Package 'armada' : A Statistical Methodology to Select Covariates in High-Dimensional Data under Dependence
- URL: https://cran.r-project.org/web/packages/armada/

6.3. kosel

Variable Selection by Revisited Knockoffs Procedures

KEYWORDS: Variable selection - Regression

FUNCTIONAL DESCRIPTION: Performs variable selection for many types of L1-regularised regressions using the revisited knockoffs procedure. This procedure uses a matrix of knockoffs of the covariates independent from the response variable Y. The idea is to determine if a covariate belongs to the model depending on whether it enters the model before or after its knockoff. The procedure suits for a wide range of regressions with various types of response variables. Regression models available are exported from the R packages 'glmnet' and 'ordinalNet'. Based on the paper linked to via the URL below: Gegout A., Gueudin A., Karmann C. (2019) https://arxiv.org/abs/1907.03153

NEWS OF THE YEAR: This package is a new one.

- Participants: Clémence Karmann, Aurélie Muller and Anne Gégout-Petit
- Contact: Aurélie Muller
- Publication: The revisited knockoffs method for variable selection in L_1-penalised regressions.
- URL: https://cran.r-project.org/web/packages/kosel/kosel.pdf

6.4. SesIndexCreatoR

FUNCTIONAL DESCRIPTION: This package allows computing and visualizing socioeconomic indices and categories distributions from datasets of socioeconomic variables (These tools were developed as part of the EquitArea Project, a public health program).

- Participants: Benoît Lalloué, Jean-Marie Monnez, Nolwenn Le Meur and Severine Deguen
- Contact: Benoît Lalloué
- URL: http://www.equitarea.org/documents/packages_1.0-0/

6.5. In silico

In silico design of nanoparticles for the treatment of cancers by enhanced radiotherapy

KEYWORDS: Bioinformatics - Cancer - Drug development

FUNCTIONAL DESCRIPTION: To speed up the preclinical development of medical engineered nanomaterials, we have designed an integrated computing platform dedicated to the virtual screening of nanostructured materials activated by X-ray making it possible to select nano-objects presenting interesting medical properties faster. The main advantage of this in silico design approach is to virtually screen a lot of possible formulations and to rapidly select the most promising ones. The platform can currently handle the accelerated design of radiation therapy enhancing nanoparticles and medical imaging nano-sized contrast agents as well as the comparison between nano-objects and the optimization of existing materials.

- Participant: Thierry Bastogne
- Contact: Thierry Bastogne

6.6. HSPOR

Hidden Smooth Polynomial Regression for Rupture Detection

KEYWORDS: Polynomial regression - Rupture detection

FUNCTIONAL DESCRIPTION: Several functions that allow by different methods to infer a piecewise polynomial regression model under regularity constraints, namely continuity or differentiability of the link function. The implemented functions are either specific to data with two regimes, or generic for any number of regimes, which can be given by the user or learned by the algorithm.

NEWS OF THE YEAR: This package is a new one

- Participants: Florine Greciet, Romain Azais and Anne Gégout-Petit
- Contact: Florine Greciet
- URL: https://cran.r-project.org/web/packages/HSPOR/

BIOCORE Project-Team

6. New Software and Platforms

6.1. In@lgae

Numerical simulator of microalgae based processes

KEYWORDS: Simulation - Microalgae system - Productivity

FUNCTIONAL DESCRIPTION: In@lgae simulates the productivity of a microalgae production system, taking into account both the process type and its location and time of the year. The process is mainly defined by its thermal dynamics and by its associated hydrodynamics. For a given microalgal strain, a set of biological parameters describe the response to nitrogen limitation, temperature and light. As a result, the biomass production, CO_2 and nitrogen fluxes, lipid and sugar accumulation are predicted.

RELEASE FUNCTIONAL DESCRIPTION: The In@lgae platform has been optimised to make it faster. Some of the key models have been rewritten in C++ to allow a faster computation. Models have been improved to include, in the growth rate computation, the composition of the light spectrum. The graphical user interface has been enhanced and several sets of parameters describing different microalgal species have been stored.

- Participants: Étienne Delclaux, Francis Mairet, Olivier Bernard and Quentin Béchet
- Contact: Olivier Bernard

6.2. Odin

Platform for advanced monitoring, control and optimisation of bioprocesses

KEYWORDS: Bioinformatics - Biotechnology - Monitoring - Automatic control

SCIENTIFIC DESCRIPTION: This C++ application enables researchers and industrials to easily develop and deploy advanced control algorithms through the use of a Scilab interpreter. It also contains a Scilab-based process simulator which can be harnessed for experimentation and training purposes. ODIN is primarily developed in the C++ programming language and uses CORBA to define component interfaces and provide component isolation. ODIN is a distributed platform, enabling remote monitoring of the controlled processes as well as remote data acquisition.It is very modular in order to adapt to any plant and to run most of the algorithms, and it can handle the high level of uncertainties that characterises the biological processes through explicit management of confidence indexes.

FUNCTIONAL DESCRIPTION: ODIN is a software framework for bioprocess control and supervision. ODIN is a distributed platform, where algorithms are described with a common structure easy to implement. Finally, ODIN can perform remote data acquisition and process these data to compute the signals to be applied to the actuators, together with estimates of state variables or process state. ODIN can handle the high level of uncertainties that characterises the biological processes through explicit management of confidence indexes.

- Participants: Fabien Dilet, Florian Guenn, Francesco Novellis, Mathieu Lacage, Melaine Gautier, Olivier Bernard, Olivier Calabro, Romain Primet and Serigne Sow
- Contact: Olivier Bernard
- URL: https://team.inria.fr/biocore/software/odin/

<p style="text-align:center;color:red;font-weight:bold;">BIOVISION Project-Team</p>

6. New Software and Platforms

6.1. Virtual Retina

A biological retina model with contrast gain control for large scale simulations

KEYWORDS: Neurosciences - Simulation - Biology - Health

SCIENTIFIC DESCRIPTION: Virtual Retina has a variety of biological features implemented such as (i) spatio-temporal linear filter implementing the basic center/surround organization of retinal filtering, (ii) non-linear contrast gain control mechanism providing instantaneous adaptation to the local level of contrast, (iii) spike generation by one or several layers of ganglion cells paving the visual field.

FUNCTIONAL DESCRIPTION: Virtual Retina is a simulation software that allows large-scale simulations of biologically-plausible retinas.

- Participants: Adrien Wohrer, Pierre Kornprobst, Bruno Cessac, Maria-Jose Escobar and Thierry Viéville
- Contact: Pierre Kornprobst
- Publication: Virtual Retina: A biological retina model and simulator, with contrast gain control
- URL: https://team.inria.fr/biovision/virtualretina/

6.2. PRANAS

Platform for Retinal ANalysis And Simulation

KEYWORDS: Retina - Neural Code - Data management - Statistics - Modeling - Vision

SCIENTIFIC DESCRIPTION: PRANAS was designed as a user-friendly tool dedicated to the neuroscientist community in a large sense, i.e., not only experienced computational neuroscientists. It has two main goals : (i) to analyze retina data, especially spatio-temporal correlations, at single cell but also population levels, (ii) to simulate the spike response of the retina to a visual flow with a customizable retina simulator which evolves in synergy with experimental data analysis. In general, PRANAS allows us to explore several aspects of retinal image processing such as understanding how to reproduce accurately the statistics of the spiking activity at the population level, or reconciling connectomics and simple computational rules for visual motion detection. This makes this tool a unique platform to better understand how the retina works.

FUNCTIONAL DESCRIPTION: The retina encodes a visual scene by trains of action potentials sent to the brain via the optic nerve. PRANAS brings to neuroscientists and modelers tools to better understand this coding. It integrates a retina simulator allowing large scale simulations while keeping a strong biological plausibility and a toolbox for the analysis of spike trains population statistics. The statistical method (entropy maximization under constraints) takes into account both spatial and temporal correlations as constraints, allowing to analyze the effects of memory on statistics. PRANAS also integrates a tool computing and representing in 3D (time-space) receptive fields. All these tools are accessible through a friendly graphical user interface. The most CPU-costly of them has been implemented to run in parallel. The actual version simulates healty retinas but the long term goal is to study retinas with a pathology (DMLA, Retinitis Pigmentosa, Glaucoma).

- Authors: Bruno Cessac, Pierre Kornprobst, Sélim Kraria, Hassan Nasser, Daniela Pamplona, Geoffrey Portelli and Adrien Wohrer
- Contact: Bruno Cessac
- Publication: PRANAS: A New Platform for Retinal Analysis and Simulation
- URL: https://team.inria.fr/biovision/pranas-software/

6.3. Platforms

6.3.1. *Macular*

Macular https://team.inria.fr/biovision/macular-software/ is a platform for the numerical simulation of the retina and primary visual cortex. It aims to reproduce the response of the retina to visual or electrical stimulation – produced by retinal prostheses – under normal or pathological conditions. The objective is to develop a tool that can be used by neuroscience researchers to reproduce experimental results, but also to guide their experiments through hypotheses that can be tested in the simulator. This can save a considerable amount of experimental resources. Macular is based on the central idea that its use and its graphic interface can evolve according to the objective of the user. It can be used in several cases, such as the simulation of retinal waves, the simulation of retinal and cortical responses to electrosurgical stimulation, the study of the contribution of specific classes of retinal cells in the encoding of visual scenes. Macular's modular architecture makes it flexible and makes it easy to implement new features. It also includes a scripting option, which offers the user the ability to decode his own model, with a given set of equations, variables and parameters, without having to program a code. Finally, thanks to a highly parallelizable architecture, Macular makes it possible to simulate a large number of cells of different classes (see Fig. 1).
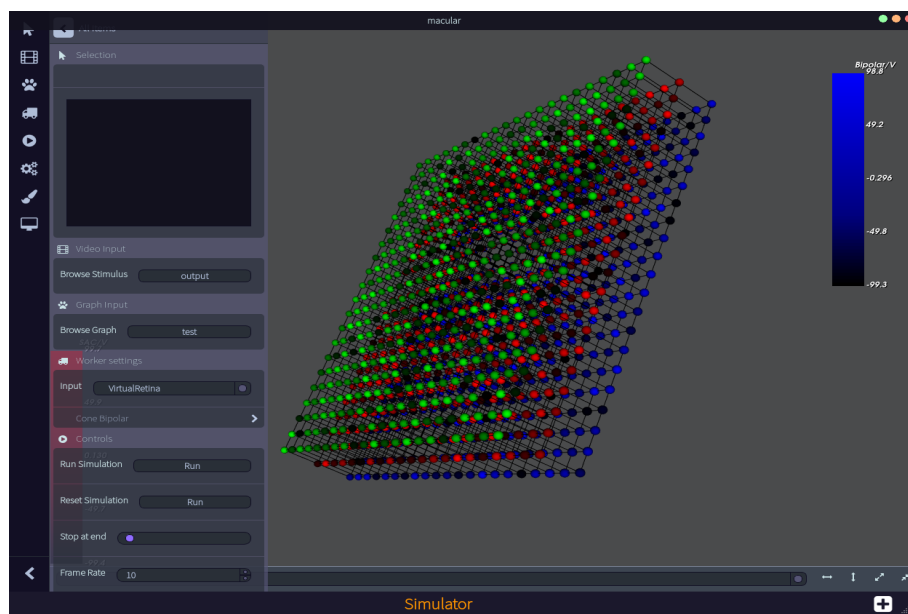

Figure 1. The Macular software. Here we see a three dimensional view of three retinal cells layers.

CAMIN Project-Team

5. New Software and Platforms

5.1. RT_Stim

Real-Time simulation for functional electrical Stimulation

KEYWORDS: Real time - Biomechanics - Control - Co-simulation

FUNCTIONAL DESCRIPTION: Hybrid simulation architecture gathering in a single framework and consistent time scales both the numerical integration of the continuous model of a bio-mechanical system (bones, joints and muscles) and a model of the hardware and software control architecture, including control tasks, communication protocols and real-time schedulers. Simulation run in real-time when possible, and otherwise consistent time scales are generated. The framework is intended to seamlessly evolve from purely software models to hardware-in-the-loop simulation.

- Authors: Daniel Simon and Samy Lafnoune
- Contact: Daniel Simon
- URL: https://gforge.inria.fr/projects/rtstim/trunk

5.2. Platforms

5.2.1. Platform : IMUSEF Modular embedded architecture for real time control of a FES system

Participants: Christine Azevedo Coste, Benoît Sijobert, Ronan Le Guillou, Martin Schmoll.

We have been working on the development of a new hardware and software architecture embedding a network of sensors and an electrical stimulator interfaced to a controller. The controller intends to be worn by the experiment participants.

A mini low-cost single board computer (Raspberry Pi3) was embedded in a 3D-printed case strapped around the waist of the subject. Using wireless inertial sensors connected as a WBAN, the sink node gets data from all the IMUs, therefore highly decreasing data flow when multiple IMUs are transmitting inside the network. To get rid of this limitation and guarantee an overall 100 Hz sampling rate no matter the number of IMUs, the wireless inertial sensors can be replaced by wired ones, low-cost with a high speed ARM Cortex-M0 based processor and a Kalman Filter directly providing quaternion estimation at 100 Hz for each IMU. The use of a multiplexer connected through an I2C interface (Inter Integrated Circuit) enabled to keep a 100 Hz rate using 4 IMUs.

The autonomous FES controller is able to acquire and process data, execute control algorithms and send the appropriate command to the stimulator. For safety reasons, in order to access to the FES controller and to enable a remote access to the stimulation from a computer, an ad-hoc Wi-Fi network is automatically provided by the Raspberry on start-up. The ad-hoc network enables to be independent from a network infrastructure where the connection is not always possible (e.g. Wi-Fi network from the hospital).

This scalable architecture (fig. 3), developed as a modular system, allowed us to implement new commands laws for Real Time closed loop control as well as giving us the possibility to use various types of sensors and stimulators to meet the needs of specific applications. To achieve this and in order for the FES architecture to directly control different electrical stimulators, Application Programming Interfaces (APIs) were developed for 3 main commercial stimulators in the team. They each corresponds to a specific need and use case. The Vivaltis Phoenix Stimulator allows for low-weight embedding, wireless network control, but only 2 stimulation channels are available at the moment, while being scalable, it is mainly used for experiments on gait. The BerkelBike Stimulator v2.0 presents a cumbersome but extended control compromise with 8 independent stimulation channels, which is an ideal solution for FES-assisted cycling. And finally the Hasomed Rehastim v1.0 allowing fine control but isn't battery powered in its commercial version, used mainly for upper limb experiments.
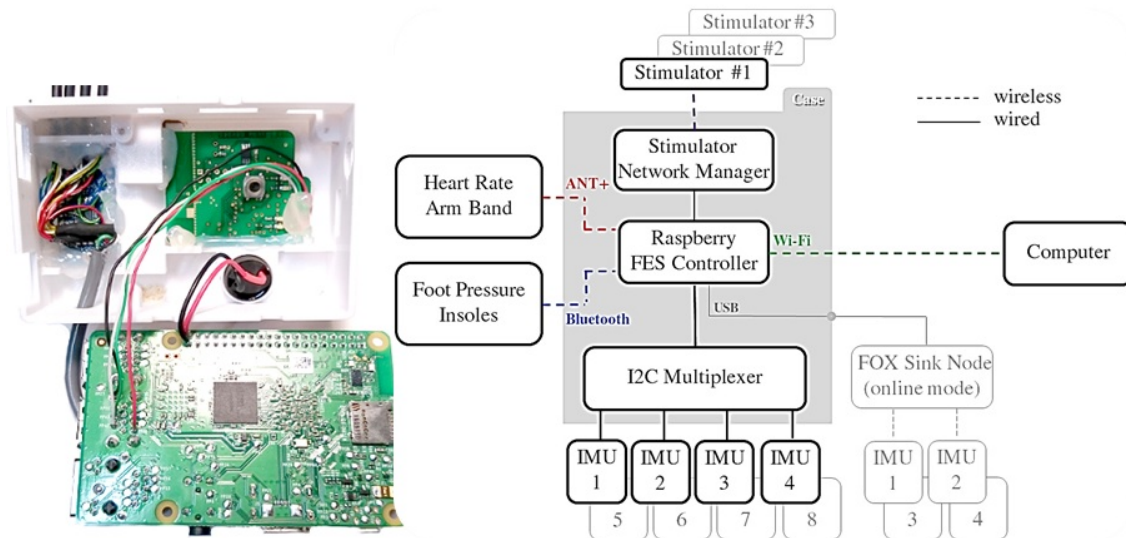
Figure 3. Experimental protocols have led to the development of a scalable hardware architecture decentralized on the subject.

This new architecture is currently used in clinical experiments and will continue to evolve with a goal of being easy to use, even by untrained clinicians (i.e. FES assisted cycling §6.8).

The software APP of this platform can be found at https://bil.inria.fr/fr/software/view/3520/tab as the *IMUSEF Project* with the Bil Id: Software_3520.

5.2.2. Platform : FESCYCLING FES-cycling platforms

Participants: Christine Azevedo Coste, Ronan Le Guillou, Martin Schmoll.

The embedded FES controller (IMUSEF) was reshaped for cycling application to improve modularity, performances and stability, using fully the capabilities of the Raspberry Pi 3B platform. These modifications now allow easier implementation, integration and usage of new control algorithms that could, in the future, be used for various end applications and contexts. Furthermore a Graphical User Interface (GUI) communicating with the embedded platform was developed, allowing on-the-fly modification of various parameters as well as safe control and monitoring of the running algorithms. An add-on relay box module allowing mechanical switching of the stimulating channels for more precise On/Off stimulation synchronization as well as more control and safety measures was also created. The two commercially available recumbent tricycles that we adapted for Spinal Cord Injured FES Cycling can be seen in Figure 4 .

5.2.3. Platform : MEDITAPARK Wearable Tremor monitoring system based on acceleration monitoring

Participants: Christine Azevedo Coste, Ronan Le Guillou, Marion Holvoet.

As part of a preliminary study on the effects of Mindfulness meditation on participants with Parkinson's Disease (PD) (§3), an application was developed to monitor at home tremor occurrence using a smartwatch Samsung Gear S3 and its newer model, the Samsung Galaxy Watch (Fig:5 a). A Python program has been developed to process and format data and present characteristics of the tremor under a user friendly and comprehensible format for clinicians. The goal of this system being to identify Parkinson's tremors
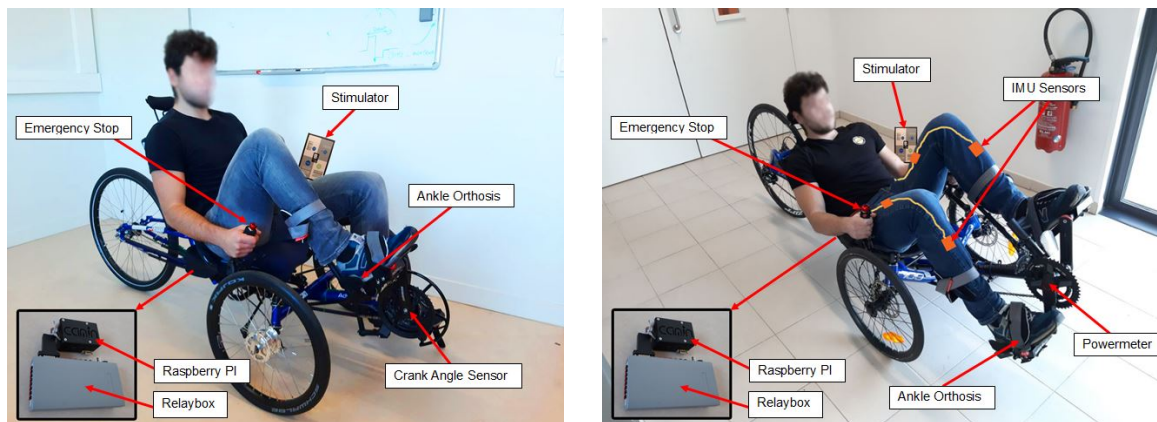
Figure 4. FES Cycling platforms developed in the CAMIN team. a) ICE Trike Adventure 26 setup adapted for Spinal Cord Injured FES Cycling b) CAT Trike 700 setup adapted for Spinal Cord Injured FES Cycling

characteristics qualitatively and quantitatively to highlight global tendencies and help objectively determine effectiveness of diverse treatments against PD tremors. This system was tested on long duration acquisitions (2 and 4 days) with 2 volunteers subject to PD tremors of moderate and high severity and proved to be able to highlight tremor tendencies and characteristics in real conditions. These acquisitions were done in order to experimentally validate the inner-workings of the developed system in real conditions and its capacity to detect PD tremors of moderate and high severity as well as to refine the classification and processing of the data. An example of 4 days acquisition is presented in Figure 5 b.

The created system allows qualification of tremors in punctual clinical check-ups in the Hospital as well as quantitative formatting of daily tendencies. This system should then allow to highlight the evolution of Parkinson's tremors characteristics throughout the MBSR (Mind-fullness Based Stress Reduction) meditation program which is yet to be undertaken. A protocol is still waiting for validation from the CPP to begin inclusions and conduct the MBSR meditation program, monitored with the developed system.

The software APP of this platform can be found at https://bil.inria.fr/fr/software/view/3565/tab as the *PARa-Keet Project* with the Bil Id: Software_3565.

5.2.4. *Platform : AGILIS-EX software*

Participants: Arthur Hiairrassary, Christine Azevedo Coste, David Guiraud.

The AGILIS-EX software was specially developed as part of the AGILIS project for exploratory clinical trials governed by the ID RCB research protocol: 2019-A02037-50. It allows the configuration and triggering of the stimulation generated by the STIMEP (neural stimulator) or the VIVALTIS (external stimulator) (Fig.6). The stimulation parameters are automatically selected according to predefined configurations (frequency, current and pulse-width) in order to obtain the functional movements of the hand desired by the subject (Fig.7). To detect and interpret patient voluntary movement or contraction to infer the activation or deactivation of the pre-programmed stimulation, it uses measurements from the DELSYS acquisition system (EMG, FSR, trigger).

This medical grade software is compliant with the IEC 62304 (class B).
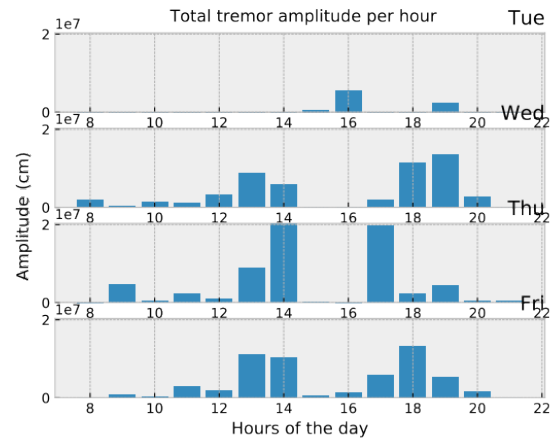
*Figure 5. Meditapark figures. a) Smart watch used as the embedded platform for this monitoring application :
Samsung Galaxy Watch b) Showcase of experimental data acquired in ecological conditions over 3.5 days
presenting a quantitative and objective evaluation of the Parkinson's tremors under a daily format condensed
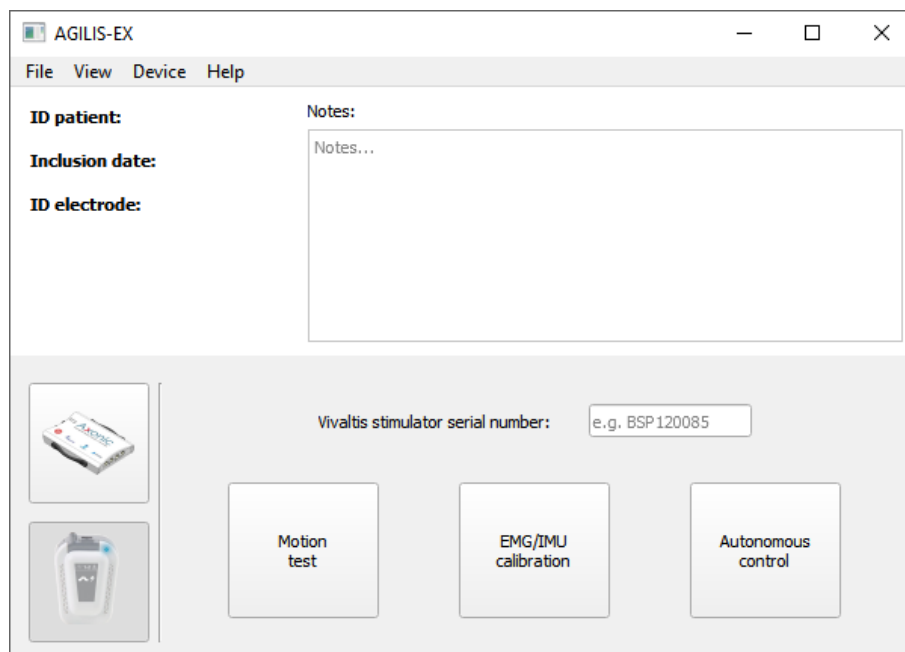hourly.*

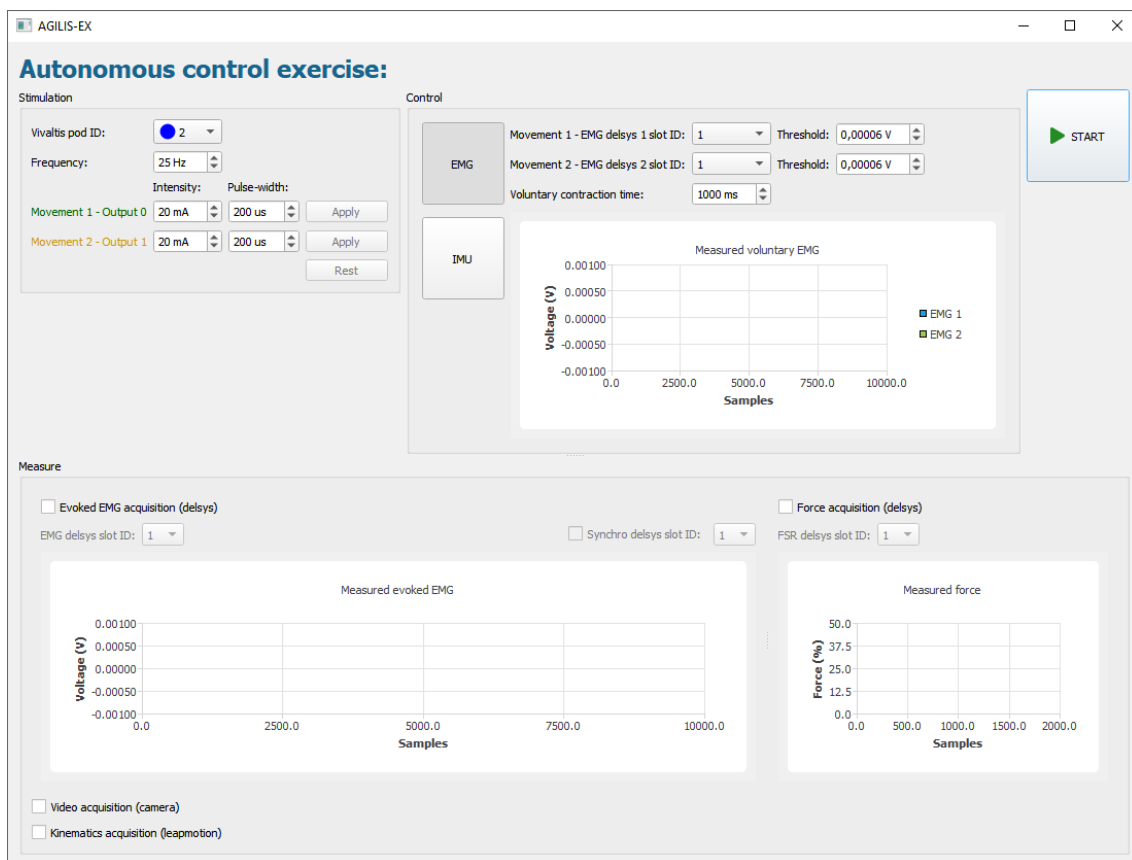*Figure 6. Main window of the AGILIS-EX software.*

Figure 7. Autonomous control exercise window used for external stimulation

<p style="text-align:center;color:red;font-weight:bold;">CAPSID Project-Team</p>

6. New Software and Platforms

6.1. lib3Dmol

Library in Rust for manipulating 3D representations of molecules

KEYWORDS: 3D modeling - Proteins - Molecules - Rust

FUNCTIONAL DESCRIPTION: The lib3Dmol library can be called by programs written in Rust for 3D modelling of biomolecules and their interactions.

RELEASE FUNCTIONAL DESCRIPTION: The 0.2.0 version can be used with any type of biomolécule.

- Contact: Philippe Noel
- URL: http://mbi.loria.fr

6.2. QRMSDmap

Parallelized computation of RMSD map of molecular structures after 3D alignment based on the quaternion method.

KEYWORDS: Molecules - RMSD - Rust - Bioinformatics

FUNCTIONAL DESCRIPTION: This program allows fast computing of 3D alignments and 3D distances on a large number of biomolecular structures.

RELEASE FUNCTIONAL DESCRIPTION: This 2.3.2 version improves CPU parallelization and decreases memory consumption.

- Contact: Philippe Noel
- URL: http://mbi.loria.fr

6.3. EROS-DOCK

Exhaustive Rotational Search using Branch-and-Bound algorithm for rigid docking

KEYWORDS: 3D modeling - Proteins - Docking

FUNCTIONAL DESCRIPTION: EROS-DOCK is a protein-protein docking program for Linux. It takes in input the 3D structures of two proteins in PDB format, and gives as output a list of transformation matrices describing the most probable relative positions of the two proteins in nature, together with a score (approximation of their binding energy for that position). On a modern workstation, docking times is in the order of few hours for a blind global search. The user can also provide nowledge of particular contact points at the surface of each protein, which accelerates the pruning of the solutions space. The underlying algorithm uses a pi-ball representation of the rotational 3D space, to accelerate the search for close-fitting orientations of the two molecules by a branch-and-bound technique.

- Contact: Isaure Chauvot de Beauchêne
- URL: https://erosdock.loria.fr

6.4. NAFRAGDB

Databases of nucleic acids fragments bound to proteins

KEYWORDS: Structural Biology - Nucleic Acids - Data base

FUNCTIONAL DESCRIPTION: NAfragDB is a python-based software for (i) the automated parsing, correction and annotation of all protein - nucleic acid structures in the public Protein Data Bank, (ii) the creation of libraries of non-redundant RNA/DNA structural fragments, (iii) the selection of sets of structures by customized queries, and (iv) the computation of statistics on sets of RNA/DNA - protein structures.

- Contact: Isaure Chauvot de Beauchêne

6.5. RNA-PDBComplete

Completing RNA structures in PDB files

KEYWORDS: Nucleic Acids - Structural Biology

FUNCTIONAL DESCRIPTION: PDBcomplete is a software and a webserver for the completion of missing atoms in an RNA structure provided in PDB format. PDBcomplete is capable of taking into account the presence of other molecules in the overall PDB structure to avoid atoms collisions. It uses as template an in-house library of mono-nucleotide libraries created with the NAfragDB tool.

- Contact: Isaure Chauvot de Beauchêne
- URL: https://pdbcomplete.loria.fr/

6.6. MBI platform for structural bioinformatics

Initiated during the previous CPER projects Intelligence Logicielle (1999-2005) and MISN: Modelisation, Interactions et Systèmes Numériques (2006-2013), the MBI platform (MBI = Modelling Biomolecules and their Interactions) is today part of the SMEC platform coordinated by MD Devignes and M Smaïl-Tabbone (SMEC: Simulation, Modélisation et Extraction de Connaissances), in the frame of the ongoing CPER projet ITM2P (Innovations Technologiques et Modélisation pour la Médecine Personnalisée ; 2015-2020). The MBI platform is composed of several HPC and storage servers that are shared between users mostly for structural bioinformatics usages. The MBI platform is part of the bioinformatic platform network of the French Institute of Bioinformatics (IFB ; http://www.france-bioinformatique.fr.

- Participants: Marie-Dominique Devignes [contact person], Isaure Chauvot de Beauchêne, Sjoerd de Vries, Antoine Moniot, Emmanuel Bresso, Philippe Noel, Patrice Ringot.
- URL: https://mbi.loria.fr

CARMEN Project-Team

6. New Software and Platforms

6.1. CEPS

Cardiac ElectroPhysiology Simulation

KEYWORDS: Simulation - Health - Mesh - Cardiac - 3D - Cardiac Electrophysiology

SCIENTIFIC DESCRIPTION: As compared to other existing softwares, CEPS aims at providing a more general framework of integration for new methods or models and a better efficiency in parallel. CEPS is designed to run on massively parallel architectures, and to make use of state-of-the-art and well known computing libraries to achieve realistic and complex heart simulations. CEPS also includes software engineering and validation tools.

FUNCTIONAL DESCRIPTION: CEPS is a modular high-performance computing software for performing numerical simulations in cardiac electrophysiology. It is based on modules : - management of geometries represented by meshes in 3D, 2D or 1D (volumes, surfaces, trees), - model simulation of cellular electrophysiology, - calculating the tissue propagation of the action potentials in the cardiac geometries, - calculation of extracardiac potentials, - time approximation methods in order 2, 3 and 4 specific to electrocardiography.

- Participants: Mehdi Juhoor, Nejib Zemzemi, Antoine Gerard, Charlie Douanla Lontsi, Pierre-Elliott Bécue, Marc Fuentes, Yves Coudière, Michael Leguebe, Andjela Davidovic, Pauline Migerditichan and Florian Caro
- Partners: Université de Bordeaux - Fondation Bordeaux Université - CHU de Bordeaux - Inria
- Contact: Michael Leguebe
- URL: https://gforge.inria.fr/projects/ceps/

6.2. OptimDBS

Optimizing the Deep Brain Stimulation

KEYWORDS: Image analysis - Deep brain stimulation - Statistical learning

FUNCTIONAL DESCRIPTION: Targeting software for deep brain stimulation

- Participants: Nejib Zemzemi, Louise-Amelie Schmitt, Emmanuel Cuny and Julien Engelhardt
- Partner: CHU de Bordeaux
- Contact: Nejib Zemzemi
- URL: https://gitlab.inria.fr/optimdbs/optimdbs-medinria/-/wikis/home

6.3. Platforms

6.3.1. CEMPACK

CEMPACK is a new collection of software that was previously archived in different places. It includes the high-performance simulation code Propag and a suite of software for the creation of geometric models, preparing inputs for Propag, and analysing its outputs. In 2017 the code was collected in an archive on Inria's GitLab platform, and a public website was created for documentation (http://cempack.gforge.inria.fr). The main components of CEMPACK are the following.

Propag-5.1   Applied modeling studies performed by the Carmen team in collaboration with IHU Liryc and foreign partners [7] [71], [60], [57], [53] rely on high-performance computations on the national supercomputers Irene, Occigen, and Turing. The Propag-5 code is optimized for these systems. It is the result of a decades-long development first at the *Université de Montréal* in Canada, then at Maastricht University in the Netherlands, and finally at the Institute of Computational Science of the *Università della Svizzera italiana* in Lugano, Switzerland. Since 2016 most of the development on Propag has been done by M. Potse at the Carmen team [72]. The code scales excellently to large core counts and, as it is controlled completely with command-line flags and configuration files, it can be used by non-programmers. It also features

- – a plugin system for membrane models,
- – a completely parallel workflow, including the initial anatomy input and mesh partitioning, which allows it to work with meshes of more than 10^9 nodes,
- – a flexible output scheme allowing hundreds of different state variables and transient variables to be output to file, when desired, using any spatial and temporal subsampling,
- – a configurable, LUSTRE-aware parallel output system in which groups of processes write HDF5/netCDF files, and
- – CWEB documentation of the entire code base.

The code has been stable and reliable for several years. It can be considered the workhorse for our HPC work until CEPS takes over.

Gepetto   The Gepetto suite, named after a famous model maker, transforms a surface mesh of the heart into a set of (semi-)structured meshes for use by the Propag software or others. It creates the different fiber orientations in the model, including the transmurally rotating ventricular fibers and the various bundle structures in the atria (figure 2), and creates layers with possibly different electrophysiological properties across the wall. A practically important function is that it automatically builds the matching heart and torso meshes that Propag uses to simulate potentials in the torso (at a resolution of 1 mm) after projecting simulation results from the heart model (at 0.1 to 0.2 mm) on the coarser torso mesh [68]. Like Propag, the Gepetto software results from a long-term development that started in Montreal, Canada, around 2002. The code for atrial fiber structure was developed by our team.

Blender plugins   Blender (https://www.blender.org) is a free software package for the production of 3-D models, renderings, and animations, comparable to commercial software such as Cinema4D. CEMPACK includes a set of plugins for Blender that facilitate the production of anatomical models and the visualization of measured and simulated data. It uses the MMG remeshing library, which is developed by the CARDAMOM team at Inria Bordeaux.

6.3.2. MUSIC

MUSIC is a multimodal platform for cardiac imaging developed by the imaging team at IHU LIRYC in collaboration with the Inria team Asclepios (https://bil.inria.fr/fr/software/view/1885/tab). It is based on the medInria software also developed by the Asclepios team. MUSIC is a cross-platform software for segmentation of medical imaging data, meshing, and ultimately also visualization of functional imaging data and model results.

Several members of the Carmen team use MUSIC for their work, and the team contributes to the software through the IDAM project.
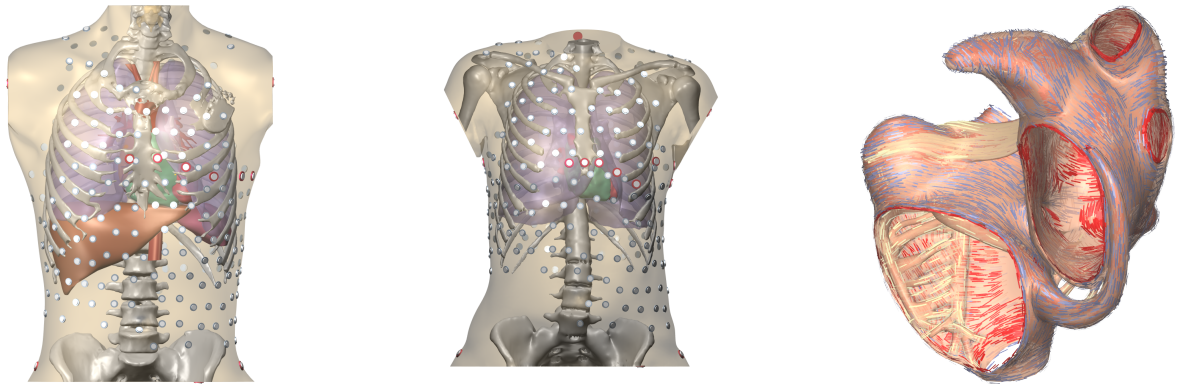
A   B   C

*Figure 2. **A and B:** Complete heart-torso geometries created with CEMPACK tools. **C:** Bundle structures and different layers of fiber orientation created by the Gepetto software.*

CASTOR Project-Team (section vide)

COFFEE Project-Team

5. New Software and Platforms

5.1. AP_PartFlow

FUNCTIONAL DESCRIPTION: We are developing experimental codes, mainly based on Finite Differences, for the simulation of particulate flows. A particular attention is paid to guaranty the asymptotic properties of the scheme, with respect to relaxation parameters.

- Contact: Thierry Goudon

5.2. Mka3d

KEYWORDS: Scientific computing - Elasticity - Elastodynamic equations

FUNCTIONAL DESCRIPTION: The Mka3d method simulates an elastic solid by discretizing the solid into rigid particles. An adequate choice of forces and torques between particles allows to recover the equations of elastodynamics.

- Partners: Ecole des Ponts ParisTech - CEA
- Contact: Laurent Monasse
- URL: http://cermics.enpc.fr/~monassel/Mka3D/

5.3. Compass

Computing Architecture to Speed up Simulation

KEYWORDS: Finite volume methods - Porous media - High performance computing

FUNCTIONAL DESCRIPTION: Compass is a parallel code initiated in 2012 and co-developed by LJAD-Inria Coffee and BRGM since 2015. It is devoted to the simulation of multiphase flows in porous media, it accounts for non isothermal and compositional flows and includes complex network of fractures or faults represented as interfaces of co-dimension one coupled to the surrounding matrix. The discretization is based on vertex and cell unknowns and is adapted to polyhedral meshes and heterogeneous media. The ComPASS code is co-developed since december 2016 by the partners of the ANR CHARMS project including BGRM, LJAD-Inria Coffee, Storengy, MdS and LJLL with the objective to develop a new generation simulator for geothermal systems focusing on fluids and accounting for complex fault networks and wells.

- Participants: Simon Lopez, Farid Smai, Michel Kern, Yacine Ould Rouis, Nabil Birgle, Laurence Beaude, Konstantin Brenner and Roland Masson
- Partners: Université de Nice Sophia Antipolis (UNS) - BRGM
- Contact: Roland Masson
- URL: http://www.anr-charms.org/page/compass-code

5.4. NS2DDV-M

2D Navier-Stokes equations with variable density

KEYWORDS: Partial differential equation - Finite volume methods - Finite element modelling

FUNCTIONAL DESCRIPTION: The NS2DDV Matlab toolbox is an open-source program written in Matlab for simulating 2D viscous, incompressible and inhomogeneous flows. The computation kernel of the code is based on Finite Elements - Finite Volumes hybrid methods applied on the 2D Navier-Stokes equations. It works on unstructured meshes and can include mesh refinements strategies. We develop and freely distribute a new version of the Matlab code NS2DDV-M (equipped with a graphic interface and an accurate documentation) to promote new collaborations in the domain, allow some easy comparisons with concurrent codes on the same benchmark cases, and compare alternative numerical solution methods.

- Partner: Laboratoire Paul Painlevé
- Contact: Caterina Calgaro
- URL: https://wikis.univ-lille1.fr/painleve/ns2ddv

5.5. SimBiof

KEYWORDS: Bioinformatics - Chemistry

FUNCTIONAL DESCRIPTION: We are developing numerical methods, currently by using Finite Differences approaches, for the simulation of biofilms growth. The underlying system of PDEs takes the form of multiphase flows equations with conservation constraints and vanishing phases. The numerical experiments have permitted to bring out the influence of physical parameters on the multidimensional growth dynamics.

- Contact: Thierry Goudon

5.6. CELIA3D

KEYWORDS: Fluid mechanics - Multi-physics simulation

FUNCTIONAL DESCRIPTION: The CELIA3D code simulates the coupling between a compressible fluid flow and a deformable structure. The fluid is handled by a Finite Volume method on a structured Cartesian grid. The solid is handled by a Discrete Element method (Mka3d scheme). The solid overlaps the fluid grid and the coupling is carried out with immersed boundaries (cut cells) in a conservative way.

- Partners: Ecole des Ponts ParisTech - CEA
- Contact: Laurent Monasse
- URL: http://cermics.enpc.fr/~monassel/CELIA3D/

COMMEDIA Project-Team

6. New Software and Platforms

6.1. FELiScE

Finite Elements for Life SCiences and Engineering problems

KEYWORDS: Finite element modelling - Cardiac Electrophysiology - Cardiovascular and respiratory systems

FUNCTIONAL DESCRIPTION: FELiScE is a finite element code which the M3DISIM and REO project-teams have decided to jointly develop in order to build up on their respective experiences concerning finite element simulations. One specific objective of this code is to provide in a unified software environment all the state-of-the-art tools needed to perform simulations of the complex respiratory and cardiovascular models considered in the two teams – namely involving fluid and solid mechanics, electrophysiology, and the various associated coupling phenomena. FELISCE is written in C++, and may be later released as an opensource library. FELiScE was registered in July 2014 at the Agence pour la Protection des Programmes under the Inter Deposit Digital Number IDDN.FR.001.350015.000.S.P.2014.000.10000.

- Participants: Matteo Aletti, Daniele Carlo Corti, Dominique Chapelle, Miguel Ángel Fernández, Benoit Fabreges, Axel Fourmont, Jean-Frédéric Gerbeau, Fannie Gerosa, Sébastien Gilles, Mikel Landajuela Larma, Damiano Lombardi, Philippe Moireau, Irène Vignon-Clementel and Marina Vidrascu
- Contact: Miguel Ángel Fernández
- URL: http://felisce.gforge.inria.fr

6.2. FELiScE-NS

KEYWORDS: Incompressible flows - Thin-walled solids

FUNCTIONAL DESCRIPTION: FELiScE-NS is a set finite elements solvers for incompressible fluids (fractional-step schemes) and non-linear thin-walled structures (3D shells, and 2D curved beams) developed in the framework of the FELiScE library. FELiSCe-NS was registered in 2018 at the Agence pour la Protection des Programmes Inter Deposit Digital Number IDDN.FR.001.270015.000.S.A.2018.000.31200.

- Participants: Benoit Fabreges, Miguel Ángel Fernández, Axel Fourmont, Jean-Frédéric Gerbeau and Marina Vidrascu
- Contact: Miguel Ángel Fernández

6.3. DCIMaL

KEYWORD: Cardiac Electrophysiology

FUNCTIONAL DESCRIPTION: DCIMaL is a Python and C++ software for safety pharmacology studies and particularly field potentials signals measured with micro-electrode array (MEA). The software includes a solver for field potential simulations and a dictionary of entries corresponding to features which can be extracted from real or simulated potential signals. It also includes an algorithm for drug classification (channel blockade or torsadogenic risk) and a tool for estimating ion channel activity (based on the CMAES library). DCIMaL was registered in 2018 at the Agence pour la Protection des Programmes Inter Deposit Digital Number IDDN.FR.001.270003.000.S.P.2018.000.31230

- Participants: Fabien Raphel, Jean-Frédéric Gerbeau and Damiano Lombardi
- Contact: Damiano Lombardi

DRACULA Project-Team

4. New Software and Platforms

4.1. CelDyn

KEYWORDS: Modeling - Bioinformatics - Biology

FUNCTIONAL DESCRIPTION: Software "Celdyn" is developed in order to model cell population dynamics for biological applications. Cells are represented either as soft spheres or they can have more complex structure. Cells can divide, move, interact with each other or with the surrounding medium. Different cell types can be introduced. When cells divide, the types of daughter cells are specified. A user interface is developed.

- Participants: Alen Tosenberger, Laurent Pujo-Menjouet, Nikolai Bessonov and Vitaly Volpert
- Contact: Vitaly Volpert

<p style="text-align:center; color:red;">**DYLISS Project-Team**</p>

6. New Software and Platforms

6.1. AskOmics

Convert tabulated data into RDF and create SPARQL queries intuitively and "on the fly".

KEYWORDS: RDF - SPARQL - Querying - Graph - LOD - Linked open data

FUNCTIONAL DESCRIPTION: AskOmics aims at bridging the gap between end user data and the Linked (Open) Data cloud. It allows heterogeneous bioinformatics data (formatted as tabular files) to be loaded in a RDF triplestore and then be transparently and interactively queried. AskOmics is made of three software blocks: (1) a web interface for data import, allowing the creation of a local triplestore from user's datasheets and standard data, (2) an interactive web interface allowing "à la carte" query-building, (3) a server performing interactions with local and distant triplestores (queries execution, management of users parameters).

NEWS OF THE YEAR: (1) migration to github, (2) complete re-engineering for cleaning the successive layers and accomodating further extensions, (3) integration of the Corese triplestore (https://corese.inria.fr/) in addition to fuseki and virtuoso, (4) improved user interface, (5) capability to save queries for sharing and reusing them, (6) automatic generation of askomics-compliant graph of entity types (abstraction), (7) capability to use askomics to query remote endpoints (including Uniprot and neXtProt), (8) support for federated queries involving remote endpoints and local data

- Authors: Charles Bettembourg, Xavier Garnier, Anthony Bretaudeau, Fabrice Legeai, Olivier Dameron, Olivier Filangi and Yvanne Chaussin
- Partners: Université de Rennes 1 - CNRS - INRA
- Contact: Olivier Dameron
- URL: https://github.com/askomics/askomics

6.2. AuReMe

Automatic Reconstruction of Metabolic networks

KEYWORDS: Workflow - Bioinformatics - Metabolic networks - Omic data - Toolbox - Data management

FUNCTIONAL DESCRIPTION: AuReMe enables the reconstruction of metabolic networks from different sources based on sequence annotation, orthology, gap-filling and manual curation. The metabolic network is exported as a local wiki allowing to trace back all the steps and sources of the reconstruction. It is highly relevant for the study of non-model organisms, or the comparison of metabolic networks for different strains or a single organism.

Five modules are composing AuReMe: 1) The Model-management PADmet module allows manipulating and traceing all metabolic data via a local database. 2) The meneco python package allows the gaps of a metabolic network to be filled by using a topological approach that implements a logical programming approach to solve a combinatorial problem 3) The shogen python package allows genome and metabolic network to be aligned in order to identify genome units which contain a large density of genes coding for enzymes, it also implements a logical programming approach. 4) The manual curation assistance PADmet module allows the reported metabolic networks and their metadata to be curated. 5) The Wiki-export PADmet module enables the export of the metabolic network and its functional genomic unit as a local wiki platform allowing a user-friendly investigation.

RELEASE FUNCTIONAL DESCRIPTION: - Reworking padmet and padmet-utils to allow full-python workflow in the future - Adding new script padmet-utils/exploration/prot2genome with exonerate - Fixing minor errors

NEWS OF THE YEAR: (1) Pantograph replaced by OrthoFinder (2) Create a readthedocs for AuReMe, padmet and padmet-utils (3) Reworking padmet and padmet-utils to allow full python workflow (4) Adding new script padmet-utils/exploration/prot2genome with exonerate (5) Modify template data structure (6) Fixing errors

- Participants: Marie Chevallier, Meziane Aite, Guillaume Collet, Nicolas Loira, Sylvain Prigent, Jeanne Cambefort, Anne Siegel and Alejandro Maass
- Partner: University of Chile
- Contact: Meziane Aite
- Publication: Traceability, reproducibility and wiki-exploration for "à-la-carte" reconstructions of genome-scale metabolic models
- URL: http://aureme.genouest.org/

6.3. biseau

KEYWORDS: ASP - Answer Set Programming - Graph - Formal concept analysis

SCIENTIFIC DESCRIPTION: Use ASP as a Domain Specific Language to specify dot-based visualizations.

NEWS OF THE YEAR: First release.

- Contact: Lucas Bourneuf
- Publication: An Answer Set Programming Environment for High-Level Specification and Visualization of FCA
- URL: https://gitlab.inria.fr/lbourneu/biseau

6.4. Metage2Metabo

KEYWORDS: Metabolic networks - Microbiota - Metagenomics - Workflow

FUNCTIONAL DESCRIPTION: Metabolic networks are graphs which nodes are compounds and edges are biochemical reactions. To study the metabolic capabilities of microbiota, Metage2Metabo uses multiprocessing to reconstruct metabolic networks at large-scale. The individual and collective metabolic capabilities (number of compounds producible) are computed and compared. From these comparisons, a set of compounds only producible by the community is created. These newly producible compounds are used to find minimal communities that can produce them. From these communities, the keytstone species in the production of these compounds are identified.

NEWS OF THE YEAR: First release.

- Contact: Anne Siegel
- Publication: Metage2Metabo: metabolic complementarity applied to genomes of large-scale microbiotas for the identification of keystone species
- URL: https://github.com/AuReMe/metage2metabo

6.5. Pathmodel

KEYWORDS: ASP - Answer Set Programming - Metabolic networks - Metabolic Pathway Drift - Bioinformatics - Systems Biology - Metabolomics

SCIENTIFIC DESCRIPTION: This tool is a prototype of the Metabolic Pathway Drift concept. This concept states that metabolic pathways undergo substantial turnover. The reactions involved in a pathway can change between species (change in reaction order or replacement of an enzyme by another one). Another goal of this tool is to linked genomics and metabolomics data. To implement this concept, Pathmodel uses the Answer Set Programming language. The input are the reactants and products involved in the pathway, known reactions occurring between these molecules, known m/z ratio, known domains shard by these molecules, an initial molecule and a goal molecule. Using these data, Pathmodel will infer reactions between molecules to reach the goal molecule using the known reactions. The result consist of potential alternative pathways for the studied organism.

FUNCTIONAL DESCRIPTION: A metabolic pathway is a series of biochemical reactions. These reactions modify metabolites in order to synthesize a new metabolite or to produce energy. One difficulties when dealing with pathways in non-model organism is their incomplete conservation during evolution. To deal with this problem, we developed a prototype inferring new biochemical reactions using reactions and metabolites from known metabolic pathways and metabolomics data. This method produce alternative pathway that could occurred in the species of interest.

RELEASE FUNCTIONAL DESCRIPTION: Fix an issue with test data.

NEWS OF THE YEAR: (1) Add a container in Singularity Hub (https://singularity-hub.org/collections/3758). (2) Rewrite data files (sterol and MAA). (3) Add creation of pictures of new molecules from MZ. (4) Add new output files to ease understanding of PathModel output. (5) Rewrite the Readme.

- Participants: Arnaud Belcour, Jacques Nicolas, Gabriel Markov and Anne Siegel
- Partner: Station Biologique de Roscoff
- Contact: Anne Siegel
- Publication: Inferring biochemical reactions and metabolite structures to cope with metabolic pathway drift
- URL: https://github.com/pathmodel

6.6. CADBIOM

Computer Aided Design of Biological Models

KEYWORDS: Health - Biology - Biotechnology - Bioinformatics - Systems Biology

FUNCTIONAL DESCRIPTION: The Cadbiom software provides a formal framework to help the modeling of biological systems such as cell signaling network with Guarder Transition Semantics. It allows synchronization events to be investigated in biological networks among large-scale network in order to extract signature of controllers of a phenotype. Three modules are composing Cadbiom. 1) The Cadbiom graphical interface is useful to build and study moderate size models. It provides exploration, simulation and checking. For large-scale models, Cadbiom also allows to focus on specific nodes of interest. 2) The Cadbiom API allows a model to be loaded, performing static analysis and checking temporal properties on a finite horizon in the future or in the past. 3) Exploring large-scale knowledge repositories, since the translations of the large-scale PID repository (about 10,000 curated interactions) have been translated into the Cadbiom formalism.

NEWS OF THE YEAR: - Comprehensive command line to run the calculations and analyze the generated results. - Module designed to produce models through the interpretation of various databases or ontologies, formalized according to the BioPAX standard. - Update of the site and the documentation.

We recently developed a framework that integrates an updated version of the CADBIOM core software and visualization tools. We provided a command line interface allowing users to translate the interactions between biomolecules described in data sources in BioPAX format into the formalism based on the guarded transitions used by CADBIOM. The command line also makes it easy to search for scenarios based on the constraints of a model, to compare scenarios with each other and to visualize interaction graphs facilitating the biologist's expertise (Vignet et al 2019 JOBIM)

- Participants: Geoffroy Andrieux, Michel Le Borgne, Nathalie Theret, Nolwenn Le Meur, Pierre Vignet and Anne Siegel
- Contact: Anne Siegel
- URL: http://cadbiom.genouest.org

EMPENN Project-Team

6. New Software and Platforms

6.1. Anima

KEYWORDS: Filtering - Medical imaging - Diffusion imaging - Registration - Relaxometry

SCIENTIFIC DESCRIPTION: Anima is a set of libraries and tools developed by the team as a common repository of research algorithms. As of now, it contains tools for image registration, statistical analysis (group comparison, patient to group comparison), diffusion imaging (model estimation, tractography, etc.), quantitative MRI processing (quantitative relaxation times estimation, MR simulation), image denoising and filtering, and segmentation tools. All of these tools are based on stable libraries (ITK, VTK), making it simple to maintain.

- Participants: Aymeric Stamm, Fang Cao, Florent Leray, Guillaume Pasquier, Laurence Catanese, Olivier Commowick, Renaud Hedouin and René-Paul Debroize
- Contact: Olivier Commowick
- URL: https://github.com/Inria-Visages/Anima-Public/wiki

6.2. autoMRI

KEYWORDS: FMRI - MRI - ASL - FASL - SPM - Automation

SCIENTIFIC DESCRIPTION: This software is highly configurable in order to fit a wide range of needs. Pre-processing includes segmentation of anatomical data, as well as co-registration, spatial normalization and atlas building of all data types. The analysis pipelines perform either within-group analysis or between-group or one subject-versus-group comparison, and produce statistical maps of regions with significant differences. These pipelines can be applied to structural data to exhibit patterns of atrophy or lesions, to ASL (both pulsed or pseudo-continuous sequences) or PET data to detect perfusion or metabolic abnormalities, to relaxometry data to detect deviations from a template, to functional data - either BOLD or ASL - to outline brain activations related to block or event-related paradigms. In addition to the standard General Linear Model approach, the ASL pipelines implement an a contrario approach and, for patient-specific perfusion study, an heteroscedastic variance model. Besides, the vascular pipeline processes 4D MRA data and enables accurate assessment of hemodynamic patterns.

FUNCTIONAL DESCRIPTION: AutoMRI Based on MATLAB and the SPM8 toolbox, autoMRI provides complete pipelines to pre-process and analyze various types of images (anatomical, functional, perfusion, metabolic, relaxometry, vascular).

- Participants: Camille Maumet, Cédric Meurée, Elise Bannier, Fang Cao, Isabelle Corouge, Pierre Maurel, Quentin Duché and Julie Coloigner
- Contact: Isabelle Corouge
- URL: https://team.inria.fr/visages/software/

6.3. MedInria

KEYWORDS: Visualization - DWI - Health - Segmentation - Medical imaging

SCIENTIFIC DESCRIPTION: MedInria aims at creating an easily extensible platform for the distribution of research algorithms developed at Inria for medical image processing. This project has been funded by the D2T (ADT MedInria-NT) in 2010, renewed in 2012. A fast-track ADT was awarded in 2017 to transition the software core to more recent dependencies and study the possibility of a consortium creation.The Empenn team leads this Inria national project and participates in the development of the common core architecture and features of the software as well as in the development of specific plugins for the team's algorithm.

FUNCTIONAL DESCRIPTION: MedInria is a free software platform dedicated to medical data visualization and processing.

- Participants: Maxime Sermesant, Olivier Commowick and Théodore Papadopoulo
- Partners: HARVARD Medical School - IHU - LIRYC - NIH
- Contact: Olivier Commowick
- URL: https://med.inria.fr

6.4. QtShanoir

KEYWORDS: Qt - Nifti - Medical imaging - Plug-in - DICOM - Health - C++ - Soap - Webservices - Shanoir

SCIENTIFIC DESCRIPTION: QtShanoir is based on Qt/C++ library. It interacts with the Shanoir server using SOAP web services. This application queries the server and displays hierarchical data extracted in tree view. Data could also be easily downloaded or uploaded on the server. In order to extend the Shanoir environment, QtShanoir is developed to contain two shared libraries: - « GUI » that represents all user interfaces. - « DAO » that takes in charge the data model. This library assures the connection to the server and provides all QtShanoir services : search, download and upload of Processed Dataset (NIfTI). QtShanoir dynamic libraries are already reused and integrated in other projects: in the software medInria and in an under development command line program.

FUNCTIONAL DESCRIPTION: QtShanoir is a graphical client application of the medical imaging database Shanoir. This application provides various functionalities to satisfy researchers' needs. It allows users to: - explore neuroimaging data derived from multicenter research trials. Through an intuitive user interface, users could easily visualize voluminous amount of structured data: studies, patients and datasets extracted from Shanoir - download and to upload data from the server. This application is available on Windows, UNIX, MacOs X. It is integrated as a plugin in medInria, a multi-plateform for medical image processing and visualization.

- Participants: Alexandre Abadie, Guillaume Renard, Nicolas Wiest Daessle, Olivier Commowick and Wefa Hakem
- Contact: Christian Barillot
- URL: http://qtshanoir.gforge.inria.fr

6.5. Shanoir

SHAring NeurOImaging Resources

KEYWORDS: Neuroimaging - Medical imaging - PACS - Nifti - Data Sharing - DICOM - Health - Shanoir - Webservices - Data base - Biology - Web Application

FUNCTIONAL DESCRIPTION: SHAring NeurOImaging Resources (Shanoir, Previously InriaNeuroTk) is an open source software platform designed to share, archive, search and visualize neuroimaging data.

It provides a user-friendly secure web access and offers an intuitive workflow to facilitate the collecting and retrieving of neuroimaging data from multiple sources and a wizzard to make the completion of metadata easy. Shanoir comes along many features such as anonymization of data, support for multi-centric clinical studies on subjects or group of subjects.

Shanoir offers an ontology-based data organization (OntoNeuroLOG). Among other things, this facilitates the reuse of data and metadata, the integration of processed data and provides traceability through an evolutionary approach. Shanoir allows researchers, clinicians, PhD students and engineers to undertake quality research projects with an emphasis on remote collaboration. As a secured J2EE web application, it therefore allows safely storing and archiving, with no more requirements than a computer with an internet connection!

Furthermore, Shanoir is not only a web application: it is also a complete neuroinformatics platform in which you can easily integrate your existing processing tools or develop your own ones (see ShanoirTk).

The clinical scores resulting from instrument-based assessments (e.g. neuropsychological tests) can also be entered and easily retrieved and exported in different formats (Excel, CSV, Xml). Scores and image acquisitions are bound together which makes relationship analysis possible. The instrument database is scalable and new measures can be added in order to meet specific project needs, by use of intuitive graphical interfaces.

Using cross-data navigation and advanced search criteria, the users can quickly point to a subset of data of data to be downloaded. Client side applications have as well been developed to illustrate how to locally access and exploit data through the available web services. With regard to security, the system requires authentication and user rights are tunable for each hosted study. The person responsible for the study can define which users are allowed to see, download or import data.

Shanoir serves neuroimaging researchers in organizing efficiently their studies, while cooperating with other laboratories. By managing patient privacy, Shanoir allows the exploitation of clinical data in a research context. It is finally a handy solution to publish and share data with a broader community.

- Participants: Adrien Férial, Anthony Baire, Bernard Gibaud, Christian Barillot, Guillaume Renard, Justine Guillaumont, Michael Kain and Yao Yao
- Partners: Université de Rennes 1 - CNRS - INSERM
- Contact: Christian Barillot
- URL: http://shanoir.gforge.inria.fr

6.6. ShanoirUploader

KEYWORDS: Webservices - PACS - Medical imaging - Neuroimaging - DICOM - Health - Biology - Java - Shanoir

SCIENTIFIC DESCRIPTION: ShanoirUploader is a desktop application on base of JavaWebStart (JWS). The application can be downloaded and installed using an internet browser. It interacts with a PACS to query and retrieve the data stored on it. After this ShanoirUploader sends the data to a Shanoir server instance in order to import these data. This application bypasses the situation, that in most of the clinical network infrastructures a server to server connection is complicated to set up between the PACS and a Shanoir server instance.

FUNCTIONAL DESCRIPTION: ShanoirUploader is a Java desktop application that transfers data securely between a PACS and a Shanoir server instance (e.g., within a hospital). It uses either a DICOM query/retrieve connection or a local CD/DVD access to search and access images from a local PACS or the local CD/DVD. After having retrieved the data, the DICOM files are locally anonymized and then uploaded to the Shanoir server. A possible integration of a hash creation application for patient identifiers is provided as well. The primary goals of that application are to enable mass data transfers between different remote server instances and therefore reduce the waiting time of the users, when importing data into Shanoir. Most of the time during import is spent with data transfers.

- Participants: Christian Barillot, Inès Fakhfakh, Justine Guillaumont, Michael Kain and Yao Yao
- Contact: Christian Barillot
- URL: http://shanoir.gforge.inria.fr

6.7. Anima medInria plugins

KEYWORDS: IRM - Medical imaging - Diffusion imaging

FUNCTIONAL DESCRIPTION: Plugins for the medInria software based on the open source software Anima developed in the Visages / Empenn team. These plugins are interfaces between anima and medinria allowing to use Anima functionalities within the clinical user interface provided by medInria. The current functionalities included in the plugins are right now: image registration, denoising, quantitative image (relaxometry), and model estimation and visualization from diffusion imaging.

- Participants: Olivier Commowick, René-Paul Debroize and Guillaume Pasquier
- Contact: Olivier Commowick

6.8. Platforms

6.8.1. *The Neurinfo Platform*

Empenn is the founding actor of an experimental research platform which was installed in August 2009 at the University Hospital of Rennes. The University of Rennes 1, Inria, CNRS for the academic side, and the University Hospital of Rennes and the Cancer Institute "Eugene Marquis" for the clinical side, are partners of this neuroinformatics platform called Neurinfo (https://www.neurinfo.org).

Concerning the Neurinfo Platform, the activity domain is a continuum between methodological and technological research built around specific clinical research projects. On the medical field, the translational research domain mainly concerns medical imaging and more specifically the clinical neurosciences. Among them are multiple sclerosis, epilepsy, neurodegenerative, neurodevelopmental and psychiatric diseases, surgical procedures of brain lesions, neuro-oncology and radiotherapy planning. Beyond these central nervous system applications, the platform is also open to alternative applications. Neurinfo ambitions to support the emergence of research projects based on their level of innovation, their pluri-disciplinarity and their ability to foster collaborations between different actors (public and private research entities, different medical specialties, different scientific profiles).

In this context, a research 3T MRI system (Siemens Verio) was acquired in summer 2009 in order to develop the clinical research in the domain of morphological, functional, structural and cellular in-vivo imaging. A new 3T Siemens Prisma MRI scanner was installed at the Neuroinfo platform in February 2018. In 2014, an equipment for simultaneous recording of EEG and MRI images was acquired from Brain Product. In 2015, a mock scanner for experimental set-up was acquired as well as a High Performance Computing environment made of one large computing cluster and a data center that is shared and operated by the Inria center and IRISA (UMR CNRS 6074). The computation cluster (480 cores) and the data center (up to 150 TB) are dedicated to host and process imaging data produced by the Neurinfo platform, but also by other research partners that share their protocols on the Neurinfo neuroinformatics system (currently more than 60 sites). In 2019, an MRI and EEG-compatible fNIRS system was acquired through a co-funding from the INS2I institute of CNRS and FEDER. At the end of 2019, GIS IBISA awarded the Neurinfo platform with a complementary funding that will be dedicated to supplement the current system with additional sensors (from 8x8 optodes to 16x16 optodes).

EPIONE Project-Team

5. New Software and Platforms

5.1. CardiacSegmentationPropagation

KEYWORDS: 3D - Segmentation - Cardiac - MRI - Deep learning

FUNCTIONAL DESCRIPTION: Training of a deep learning model which is used for cardiac segmentation in short-axis MRI image stacks.

- Authors: Qiao Zheng, Hervé Delingette, Nicolas Duchateau and Nicholas Ayache
- Contact: Qiao Zheng
- Publication: 3D Consistent & Robust Segmentation of Cardiac Images by Deep Learning with Spatial Propagation

5.2. CardiacMotionFlow

KEYWORDS: 3D - Deep learning - Cardiac - Classification

FUNCTIONAL DESCRIPTION: Creation of a deep learning model for the motion tracking of the heart, extraction of characteristic quantities of the movement and shape of the heart to classify a sequence of cine-MRI cardiac images in terms of the types of pathologies (infarcted heart, dilated , hypertrophied, abnormality of the right ventricle).

- Contact: Qiao Zheng

5.3. MedInria

KEYWORDS: Visualization - DWI - Health - Segmentation - Medical imaging

SCIENTIFIC DESCRIPTION: MedInria aims at creating an easily extensible platform for the distribution of research algorithms developed at Inria for medical image processing. This project has been funded by the D2T (ADT MedInria-NT) in 2010, renewed in 2012. A fast-track ADT was awarded in 2017 to transition the software core to more recent dependencies and study the possibility of a consortium creation.The Empenn team leads this Inria national project and participates in the development of the common core architecture and features of the software as well as in the development of specific plugins for the team's algorithm.

FUNCTIONAL DESCRIPTION: MedInria is a free software platform dedicated to medical data visualization and processing.

- Participants: Maxime Sermesant, Olivier Commowick and Théodore Papadopoulo
- Partners: HARVARD Medical School - IHU - LIRYC - NIH
- Contact: Olivier Commowick
- URL: https://med.inria.fr

5.4. GP-ProgressionModel

GP progression model

KEYWORDS: Data modeling - Data visualization - Data integration - Machine learning - Biostatistics - Statistical modeling - Medical applications - Evolution - Brain - Uncertainly - Uncertainty quantification - Alzheimer's disease - Probability - Stochastic models - Stochastic process - Trajectory Modeling - Marker selection - Health - Statistic analysis - Statistics - Bayesian estimation

FUNCTIONAL DESCRIPTION: Disease progression modeling (DPM) of Alzheimer's disease (AD) aims at revealing long term pathological trajectories from short term clinical data. Along with the ability of providing a data-driven description of the natural evolution of the pathology, DPM has the potential of representing a valuable clinical instrument for automatic diagnosis, by explicitly describing the biomarker transition from normal to pathological stages along the disease time axis.

In this software we reformulate DPM within a probabilistic setting to quantify the diagnostic uncertainty of individual disease severity in an hypothetical clinical scenario, with respect to missing measurements, biomarkers, and follow-up information. The proposed formulation of DPM provides a statistical reference for the accurate probabilistic assessment of the pathological stage of de-novo individuals, and represents a valuable instrument for quantifying the variability and the diagnostic value of biomarkers across disease stages.

This software is based on the publication:

Probabilistic disease progression modeling to characterize diagnostic uncertainty: Application to staging and prediction in Alzheimer's disease. Marco Lorenzi, Maurizio Filippone, Daniel C. Alexander, Sebastien Ourselin Neuroimage. 2019 Apr 15,190:56-68. doi: 10.1016/j.neuroimage.2017.08.059. Epub 2017 Oct 24. HAL Id : hal-01617750 https://hal.archives-ouvertes.fr/hal-01617750/

RELEASE FUNCTIONAL DESCRIPTION: - New interface and output - Completely based on pytorch

- Participant: Marco Lorenzi
- Contact: Marco Lorenzi
- Publication: Probabilistic disease progression modeling to characterize diagnostic uncertainty: application to staging and prediction in Alzheimer's disease
- URL: http://gpprogressionmodel.inria.fr

5.5. Music

Multi-modality Platform for Specific Imaging in Cardiology

KEYWORDS: Medical imaging - Cardiac Electrophysiology - Computer-assisted surgery - Cardiac - Health

FUNCTIONAL DESCRIPTION: MUSIC is a software developed by the Asclepios research project in close collaboration with the IHU LIRYC in order to propose functionalities dedicated to cardiac interventional planning and guidance. This includes specific tools (algorithms of segmentation, registration, etc.) as well as pipelines. The software is based on the MedInria platform.

- Participants: Florent Collot, Mathilde Merle and Maxime Sermesant
- Partner: IHU- Bordeau
- Contact: Maxime Sermesant
- URL: https://team.inria.fr/asclepios/software/music/

5.6. SOFA

Simulation Open Framework Architecture

KEYWORDS: Real time - Multi-physics simulation - Medical applications

FUNCTIONAL DESCRIPTION: SOFA is an Open Source framework primarily targeted at real-time simulation, with an emphasis on medical simulation. It is mostly intended for the research community to help develop new algorithms, but can also be used as an efficient prototyping tool. Based on an advanced software architecture, it allows : the creation of complex and evolving simulations by combining new algorithms with algorithms already included in SOFA, the modification of most parameters of the simulation (deformable behavior, surface representation, solver, constraints, collision algorithm, etc.) by simply editing an XML file, the building of complex models from simpler ones using a scene-graph description, the efficient simulation of the dynamics of interacting objects using abstract equation solvers, the reuse and easy comparison of a variety of available methods.

- Participants: Christian Duriez, François Faure, Hervé Delingette and Stéphane Cotin
- Partner: IGG
- Contact: Hugo Talbot
- URL: http://www.sofa-framework.org

5.7. geomstats

Computations and statistics on manifolds with geometric structures

KEYWORD: Geometry

FUNCTIONAL DESCRIPTION: Geomstats is a python package that performs computations on manifolds such as hyperspheres, hyperbolic spaces, spaces of symmetric positive definite matrices and Lie groups of transformations. It provides efficient and extensively unit-tested implementations of these manifolds, together with useful Riemannian metrics and associated Exponential and Logarithm maps. The corresponding geodesic distances provide a range of intuitive choices of Machine Learning loss functions. We also give the corresponding Riemannian gradients. The operations implemented in geomstats are available with different computing backends such as numpy, tensorflow and keras. Geomstats manifold computations have are integrated into keras deep learning framework thanks to GPU-enabled implementations.

- Partner: Stanford Department of Statistics
- Contact: Nina Miolane
- URL: https://github.com/geomstats/

5.8. MC-VAE

Multi Channel Variational Autoencoder

KEYWORDS: Machine learning - Artificial intelligence - Medical applications - Dimensionality reduction - High Dimensional Data - Unsupervised learning - Heterogeneity

SCIENTIFIC DESCRIPTION: Interpretable modeling of heterogeneous data channels is essential in medical applications, for example when jointly analyzing clinical scores and medical images. Variational Autoencoders (VAE) are powerful generative models that learn representations of complex data. The flexibility of VAE may come at the expense of lack of interpretability in describing the joint relationship between heterogeneous data. To tackle this problem, in this work we extend the variational framework of VAE to bring parsimony and interpretability when jointly account for latent relationships across multiple channels. In the latent space, this is achieved by constraining the variational distribution of each channel to a common target prior. Parsimonious latent representations are enforced by variational dropout. Experiments on synthetic data show that our model correctly identifies the prescribed latent dimensions and data relationships across multiple testing scenarios. When applied to imaging and clinical data, our method allows to identify the joint effect of age and pathology in describing clinical condition in a large scale clinical cohort.

FUNCTIONAL DESCRIPTION: This software implements the work published in the paper "Sparse Multi-Channel Variational Autoencoder for the Joint Analysis of Heterogeneous Data" presented at the conference ICML 2019 (Long Beach, California, USA).

The software extends classical variational autoencoders by identifying a joint latent code associated to heterogeneous data represented in different channels. The software is implemented in python and is based on pytorch. It can be applied to any kind of data arrays, and provides functions for optimisation, visualisation and writing of the modelling results.

RELEASE FUNCTIONAL DESCRIPTION: First release

NEWS OF THE YEAR: Method presented in the International Conference on Machine Learning (ICML 2019).

- Participants: Luigi Antelmi, Marco Lorenzi and Nicholas Ayache
- Partner: CoBteK
- Contact: Luigi Antelmi
- URL: https://gitlab.inria.fr/epione_ML/mcvae

5.9. SOFA-CardiacReduction

KEYWORDS: Simulation - 3D modeling - Model Order Reduction - Cardiac

SCIENTIFIC DESCRIPTION: Modification of a finite element deformation model : meshless approach and frame-based description, reduction in the number of affine degrees of freedom and integration points.

FUNCTIONAL DESCRIPTION: This SOFA plugin is intented to build a reduced model for deformable solids (especially cardiac simulations).

- Participants: Gaetan Desrues, Hervé Delingette and Maxime Sermesant
- Contact: Gaetan Desrues

ERABLE Project-Team

5. New Software and Platforms

5.1. C3Part/Isofun

KEYWORDS: Bioinformatics - Genomics

FUNCTIONAL DESCRIPTION: The C3PART / ISOFUN package implements a generic approach to the local alignment of two or more graphs representing biological data, such as genomes, metabolic pathways or protein-protein interactions, in order to infer a functional coupling between them.

- Participants: Alain Viari, Anne Morgat, Frédéric Boyer, Marie-France Sagot and Yves-Pol Deniélou
- Contact: Alain Viari
- URL: http://www.inrialpes.fr/helix/people/viari/lxgraph/index.html

5.2. Cassis

KEYWORDS: Bioinformatics - Genomics

FUNCTIONAL DESCRIPTION: Implements methods for the precise detection of genomic rearrangement breakpoints.

- Participants: Christian Baudet, Christian Gautier, Claire Lemaitre, Eric Tannier and Marie-France Sagot
- Contact: Marie-France Sagot
- URL: http://pbil.univ-lyon1.fr/software/Cassis/

5.3. Coala

CO-evolution Assessment by a Likelihood-free Approach

KEYWORDS: Bioinformatics - Evolution

FUNCTIONAL DESCRIPTION:COALA stands for "COevolution Assessment by a Likelihood-free Approach". It is thus a likelihood-free method for the co-phylogeny reconstruction problem which is based on an Approximate Bayesian Computation (ABC) approach.

- Participants: Beatrice Donati, Blerina Sinaimeri, Catherine Matias, Christian Baudet, Christian Gautier, Marie-France Sagot and Pierluigi Crescenzi
- Contact: Blerina Sinaimeri
- URL: http://coala.gforge.inria.fr/

5.4. CSC

KEYWORDS: Genomics - Algorithm

FUNCTIONAL DESCRIPTION: Given two sequences x and y, CSC (which stands for Circular Sequence Comparison) finds the cyclic rotation of x (or an approximation of it) that minimises the blockwise q-gram distance from y.

- Contact: Nadia Pisanti
- URL: https://github.com/solonas13/csc

5.5. Cycads

KEYWORDS: Systems Biology - Bioinformatics

FUNCTIONAL DESCRIPTION: Annotation database system to ease the development and update of enriched BIOCYC databases. CYCADS allows the integration of the latest sequence information and functional annotation data from various methods into a metabolic network reconstruction. Functionalities will be added in future to automate a bridge to metabolic network analysis tools, such as METEXPLORE. CYCADS was used to produce a collection of more than 22 arthropod metabolism databases, available at ACYPICYC (http://acypicyc.cycadsys.org) and ARTHROPODACYC (https://arthropodacyc.cycadsys.org). It will continue to be used to create other databases (newly sequenced organisms, Aphid biotypes and symbionts...).

- Participants: Augusto Vellozo, Hubert Charles, Marie-France Sagot and Stefano Colella
- Contact: Hubert Charles
- URL: http://www.cycadsys.org/

5.6. DBGWAS

KEYWORDS: Graph algorithmics - Genomics

FUNCTIONAL DESCRIPTION:DBGWAS is a tool for quick and efficient bacterial GWAS. It uses a compacted De Bruijn Graph (cDBG) structure to represent the variability within all bacterial genome assemblies given as input. Then cDBG nodes are tested for association with a phenotype of interest and the resulting associated nodes are then re-mapped on the cDBG. The output of DBGWAS consists of regions of the cDBG around statistically significant nodes with several informations related to the phenotypes, offering a representation helping in the interpretation. The output can be viewed with any modern web browser, and thus easily shared.

- Contact: Leandro Ishi Soares de Lima
- URL: https://gitlab.com/leoisl/dbgwas

5.7. Eucalypt

KEYWORDS: Bioinformatics - Evolution

FUNCTIONAL DESCRIPTION:EUCALYPT stands for "EnUmerator of Coevolutionary Associations in PoLYnomial-Time delay". It is an algorithm for enumerating all optimal (possibly time-unfeasible) mappings of a symbiont tree unto a host tree.

- Participants: Beatrice Donati, Blerina Sinaimeri, Christian Baudet, Marie-France Sagot and Pierluigi Crescenzi
- Contact: Blerina Sinaimeri
- URL: http://eucalypt.gforge.inria.fr/

5.8. Fast-SG

KEYWORDS: Genomics - Algorithm - NGS

FUNCTIONAL DESCRIPTION:FAST-SG enables the optimal hybrid assembly of large genomes by combining short and long read technologies.

- Participants: Alex Di Genova, Marie-France Sagot, Alejandro Maass and Gonzalo Ruz Heredia
- Contact: Alex Di Genova
- URL: https://github.com/adigenova/fast-sg

5.9. Gobbolino-Touché

KEYWORDS: Bioinformatics - Graph algorithmics - Systems Biology

FUNCTIONAL DESCRIPTION: Designed to solve the metabolic stories problem, which consists in finding all maximal directed acyclic subgraphs of a directed graph G whose sources and targets belong to a subset of the nodes of G, called the black nodes.

- Participants: Etienne Birmelé, Fabien Jourdan, Ludovic Cottret, Marie-France Sagot, Paulo Vieira Milreu, Pierluigi Crescenzi, Vicente Acuna Aguayo and Vincent Lacroix
- Contact: Marie-France Sagot
- URL: http://gforge.inria.fr/projects/gobbolino

5.10. HapCol

KEYWORDS: Bioinformatics - Genomics

FUNCTIONAL DESCRIPTION: A fast and memory-efficient DP approach for haplotype assembly from long reads that works until 25x coverage and solves a constrained minimum error correction problem exactly.

- Contact: Nadia Pisanti
- URL: http://hapcol.algolab.eu/

5.11. HgLib

HyperGraph Library

KEYWORDS: Graph algorithmics - Hypergraphs

FUNCTIONAL DESCRIPTION: The open-source library hglib is dedicated to model hypergraphs, which are a generalisation of graphs. In an *undirected* hypergraph, an hyperedge contains any number of vertices. A *directed* hypergraph has hyperarcs which connect several tail and head vertices. This library, which is written in C++, allows to associate user defined properties to vertices, to hyperedges/hyperarcs and to the hypergraph itself. It can thus be used for a wide range of problems arising in operations research, computer science, and computational biology.

RELEASE FUNCTIONAL DESCRIPTION: Initial version

- Participants: Martin Wannagat, David P. Parsons, Arnaud Mary and Irene Ziska
- Contact: Arnaud Mary
- URL: https://gitlab.inria.fr/kirikomics/hglib

5.12. KissDE

KEYWORDS: Bioinformatics - NGS

FUNCTIONAL DESCRIPTION:KISSDE is an R Package enabling to test if a variant (genomic variant or splice variant) is enriched in a condition. It takes as input a table of read counts obtained from an NGS data preprocessing and gives as output a list of condition-specific variants.

RELEASE FUNCTIONAL DESCRIPTION: This new version improved the recall and made more precise the size of the effect computation.

- Participants: Camille Marchet, Aurélie Siberchicot, Audric Cologne, Clara Benoît-Pilven, Janice Kielbassa, Lilia Brinza and Vincent Lacroix
- Contact: Vincent Lacroix
- URL: http://kissplice.prabi.fr/tools/kissDE/

5.13. KisSplice

KEYWORDS: Bioinformatics - Bioinfirmatics search sequence - Genomics - NGS

FUNCTIONAL DESCRIPTION: Enables to analyse RNA-seq data with or without a reference genome. It is an exact local transcriptome assembler, which can identify SNPs, indels and alternative splicing events. It can deal with an arbitrary number of biological conditions, and will quantify each variant in each condition.

RELEASE FUNCTIONAL DESCRIPTION: Improvements : The KissReads module has been modified and sped up, with a significant impact on run times. Parameters : –timeout default now at 10000: in big datasets, recall can be increased while run time is a bit longer. Bugs fixed : –Reads containing only 'N': the graph construction was stopped if the file contained a read composed only of 'N's. This is was a silence bug, no error message was produced. –Problems compiling with new versions of MAC OSX (10.8+): KisSplice is now compiling with the new default C++ compiler of OSX 10.8+.

KISSPLICE was applied to a new application field, virology, through a collaboration with the group of Nadia Naffakh at Institut Pasteur. The goal is to understand how a virus (in this case influenza) manipulates the splicing of its host. This led to new developments in KISSPLICE. Taking into account the strandedness of the reads was required, in order not to mis-interpret transcriptional readthrough. We now use BCALM instead of DBG-V4 for the de Bruijn graph construction and this led to major improvements in memory and time requirements of the pipeline. We still cannot scale to very large datasets like in cancer, the time limiting step being the quantification of bubbles.

- Participants: Alice Julien-Laferrière, Leandro Ishi Soares de Lima, Vincent Miele, Rayan Chikhi, Pierre Peterlongo, Camille Marchet, Gustavo Akio Tominaga Sacomoto, Marie-France Sagot and Vincent Lacroix
- Contact: Vincent Lacroix
- URL: http://kissplice.prabi.fr/

5.14. KisSplice2RefGenome

KEYWORDS: Bioinformatics - NGS - Transcriptomics

FUNCTIONAL DESCRIPTION:KISSPLICE identifies variations in RNA-seq data, without a reference genome. In many applications however, a reference genome is available. KISSPLICE2REFGENOME enables to facilitate the interpretation of the results of KISSPLICE after mapping them to a reference genome.

- Participants: Audric Cologne, Camille Marchet, Camille Sessegolo, Alice Julien-Laferrière and Vincent Lacroix
- Contact: Vincent Lacroix
- URL: http://kissplice.prabi.fr/tools/kiss2refgenome/

5.15. KisSplice2RefTranscriptome

KEYWORDS: Bioinformatics - NGS - Transcriptomics

FUNCTIONAL DESCRIPTION:KISSPLICE2REFTRANSCRIPTOME enables to combine the output of KISSPLICE with the output of a full length transcriptome assembler, thus allowing to predict a functional impact for the positioned SNPs, and to intersect these results with condition-specific SNPs. Overall, starting from RNA-seq data only, we obtain a list of condition-specific SNPs stratified by functional impact.

- Participants: Helene Lopez Maestre, Mathilde Boutigny and Vincent Lacroix
- Contact: Vincent Lacroix
- URL: http://kissplice.prabi.fr/tools/kiss2rt/

5.16. MetExplore

KEYWORDS: Systems Biology - Bioinformatics

FUNCTIONAL DESCRIPTION: Web-server that allows to build, curate and analyse genome-scale metabolic networks. METEXPLORE is also able to deal with data from metabolomics experiments by mapping a list of masses or identifiers onto filtered metabolic networks. Finally, it proposes several functions to perform Flux Balance Analysis (FBA). The web-server is mature, it was developed in PHP, JAVA, Javascript and Mysql. METEXPLORE was started under another name during Ludovic Cottret's PhD in Bamboo, and is now maintained by the METEXPLORE group at the Inra of Toulouse.

- Participants: Fabien Jourdan, Hubert Charles, Ludovic Cottret and Marie-France Sagot
- Contact: Fabien Jourdan
- URL: https://metexplore.toulouse.inra.fr/index.html/

5.17. Mirinho

KEYWORDS: Bioinformatics - Computational biology - Genomics - Structural Biology

FUNCTIONAL DESCRIPTION: Predicts, at a genome-wide scale, microRNA candidates.

- Participants: Christian Gautier, Christine Gaspin, Cyril Fournier, Marie-France Sagot and Susan Higashi
- Contact: Marie-France Sagot
- URL: http://mirinho.gforge.inria.fr/

5.18. Momo

Multi-Objective Metabolic mixed integer Optimization

KEYWORDS: Metabolism - Metabolic networks - Multi-objective optimisation

FUNCTIONAL DESCRIPTION: MOMO is a multi-objective mixed integer optimisation approach for enumerating knockout reactions leading to the overproduction and/or inhibition of specific compounds in a metabolic network.

- Participants: Ricardo Luiz de Andrade Abrantes, Nuno Mira, Susana Vinga and Marie-France Sagot
- Contact: Marie-France Sagot
- URL: http://momo-sysbio.gforge.inria.fr

5.19. Moomin

Mathematical explOration of Omics data on a MetabolIc Network

KEYWORDS: Metabolic networks - Transcriptomics

FUNCTIONAL DESCRIPTION: MOOMIN is a tool for analysing differential expression data. It takes as its input a metabolic network and the results of a DE analysis: a posterior probability of differential expression and a (logarithm of a) fold change for a list of genes. It then forms a hypothesis of a metabolic shift, determining for each reaction its status as "increased flux", "decreased flux", or "no change". These are expressed as colours: red for an increase, blue for a decrease, and grey for no change. See the paper for full details: https://doi.org/10.1093/bioinformatics/btz584

- Participants: Henri Taneli Pusa, Mariana Ferrarini, Ricardo Luiz de Andrade Abrantes, Arnaud Mary, Alberto Marchetti-Spaccamela, Leen Stougie and Marie-France Sagot
- Contact: Marie-France Sagot
- URL: https://github.com/htpusa/moomin

5.20. MultiPus

KEYWORDS: Systems Biology - Algorithm - Graph algorithmics - Metabolic networks - Computational biology

FUNCTIONAL DESCRIPTION:MULTIPUS (for "MULTIple species for the synthetic Production of Useful biochemical Substances") is an algorithm that, given a microbial consortium as input, identifies all optimal sub-consortia to synthetically produce compounds that are either exogenous to it, or are endogenous but where interaction among the species in the sub-consortia could improve the production line.

- Participants: Alberto Marchetti-Spaccamela, Alice Julien-Laferrière, Arnaud Mary, Delphine Parrot, Laurent Bulteau, Leen Stougie, Marie-France Sagot and Susana Vinga
- Contact: Marie-France Sagot
- URL: http://multipus.gforge.inria.fr/

5.21. Pitufolandia

KEYWORDS: Bioinformatics - Graph algorithmics - Systems Biology

FUNCTIONAL DESCRIPTION: The algorithms in PITUFOLANDIA (PITUFO / PITUFINA / PAPAPITUFO) are designed to solve the minimal precursor set problem, which consists in finding all minimal sets of precursors (usually, nutrients) in a metabolic network that are able to produce a set of target metabolites.

- Participants: Vicente Acuna Aguayo, Paulo Vieira Milreu, Alberto Marchetti-Spaccamela, Leen Stougie, Martin Wannagat and Marie-France Sagot
- Contact: Marie-France Sagot
- URL: http://gforge.inria.fr/projects/pitufo/

5.22. Sasita

KEYWORDS: Bioinformatics - Graph algorithmics - Systems Biology

FUNCTIONAL DESCRIPTION:SASITA is a software for the exhaustive enumeration of minimal precursor sets in metabolic networks.

- Participants: Vicente Acuna Aguayo, Ricardo Luiz de Andrade Abrantes, Paulo Vieira Milreu, Alberto Marchetti-Spaccamela, Leen Stougie, Martin Wannagat and Marie-France Sagot
- Contact: Marie-France Sagot
- URL: http://sasita.gforge.inria.fr/

5.23. Savage

KEYWORDS: Algorithm - Genomics

FUNCTIONAL DESCRIPTION: Reconstruction of viral quasi species without using a reference genome.

- Contact: Alexander Schonhuth
- URL: https://bitbucket.org/jbaaijens/savage

5.24. Smile

KEYWORDS: Bioinformatics - Genomic sequence

FUNCTIONAL DESCRIPTION: Motif inference algorithm taking as input a set of biological sequences.

- Participant: Marie-France Sagot
- Contact: Marie-France Sagot

5.25. Rime

KEYWORDS: Bioinformatics - Genomics - Sequence alignment

FUNCTIONAL DESCRIPTION: Detects long similar fragments occurring at least twice in a set of biological sequences.

- Participants: Nadia Pisanti and Marie-France Sagot
- Contact: Nadia Pisanti

5.26. Totoro & Kotoura

KEYWORDS: Bioinformatics - Graph algorithmics - Systems Biology

FUNCTIONAL DESCRIPTION: Both TOTORO and KOTOURA decipher the reaction changes during a metabolic transient state, using measurements of metabolic concentrations. These are called metabolic hyperstories. TOTORO (for TOpological analysis of Transient metabOlic RespOnse) is based on a qualitative measurement of the concentrations in two steady-states to infer the reaction changes that lead to the observed differences in metabolite pools in both conditions. In the currently available release, a pre-processing and a post-processing steps are included. After the post-processing step, the solutions can be visualised using DINGHY (http://dinghy.gforge.inria.fr). KOTOURA (for Kantitative analysis Of Transient metabOlic and regUlatory Response And control) infers quantitative changes of the reactions using information on measurement of the metabolite concentrations in two steady-states.

- Participants: Alice Julien-Laferrière, Ricardo Luiz de Andrade Abrantes, Arnaud Mary, Mariana Ferrarini, Susana Vinga, Irene Ziska and Marie-France Sagot
- Contact: Marie-France Sagot
- URL: http://hyperstories.gforge.inria.fr/

5.27. VG-Flow

Viral haplotype reconstruction from contigs using variation graphs

KEYWORD: Haplotyping

FUNCTIONAL DESCRIPTION: The goal of haplotype-aware genome assembly is to reconstruct all individual haplotypes from a mixed sample and to provide corresponding abundance estimates. VG-FLOW provides a reference-genome-independent solution based on the construction of a variation graph, capturing all quasispecies diversity present in the sample. We solve the contig abundance estimation problem and propose a greedy algorithm to efficiently build full-length haplotypes. Finally, we obtain accurate frequency estimates for the reconstructed haplotypes through linear programming techniques.

- Contact: Alexander Schonhuth
- URL: https://bitbucket.org/jbaaijens/vg-flow

5.28. Virus-VG

Viral haplotype reconstruction from contigs using variation graphs

KEYWORD: Haplotyping

FUNCTIONAL DESCRIPTION: Viruses populate their hosts as a viral quasispecies: a collection of genetically related mutant strains. Viral quasispecies assembly refers to reconstructing the strain-specific haplotypes from read data, and predicting their relative abundances within the mix of strains, an important step for various treatment-related reasons. Reference-genome-independent (de novo) approaches have yielded benefits over reference-guided approaches, because reference-induced biases can become overwhelming when dealing with divergent strains. While being very accurate, extant de novo methods only yield rather short contigs. VIRUS-VG aims to reconstruct full-length haplotypes together with their abundances from such contigs, represented as a genome variation graph.

- Contact: Alexander Schonhuth
- URL: https://bitbucket.org/jbaaijens/virus-vg

5.29. Wengan

Making the path

KEYWORD: Genome assembly

FUNCTIONAL DESCRIPTION:WENGAN is a new genome assembler that unlike most of the current long-reads assemblers avoids entirely the all-vs-all read comparison. The key idea behind WENGAN is that long-read alignments can be inferred by building paths on a sequence graph. To achieve this, WENGAN builds a new sequence graph called the Synthetic Scaffolding Graph. The SSG is built from a spectrum of synthetic mate-pair libraries extracted from raw long-reads. Longer alignments are then built by performing a transitive reduction of the edges. Another distinct feature of WENGAN is that it performs self-validation by following the read information. WENGAN identifies miss-assemblies at differents steps of the assembly process.

- Participants: Alex Di Genova and Marie-France Sagot
- Contact: Marie-France Sagot
- URL: https://github.com/adigenova/wengan

5.30. WhatsHap

KEYWORDS: Bioinformatics - Genomics

FUNCTIONAL DESCRIPTION:WHATSHAP is a DP approach for haplotype assembly from long reads that works until 20x coverage and solves the minimum error correction problem exactly. PWHATSHAP is a parallelisation of the core dynamic programming algorithm of WHATSHAP.

- Contact: Nadia Pisanti
- URL: https://bitbucket.org/whatshap/whatshap

FLUMINANCE Project-Team

5. New Software and Platforms

5.1. 2DLayeredMotion

Estimation of 2D independent mesoscale layered atmospheric motion fields

FUNCTIONAL DESCRIPTION: This software enables to estimate a stack of 2D horizontal wind fields corresponding to a mesoscale dynamics of atmospheric pressure layers. This estimator is formulated as the minimization of a global energy function. It relies on a vertical decomposition of the atmosphere into pressure layers. This estimator uses pressure data and classification clouds maps and top of clouds pressure maps (or infra-red images). All these images are routinely supplied by the EUMETSAT consortium which handles the Meteosat and MSG satellite data distribution. The energy function relies on a data model built from the integration of the mass conservation on each layer. The estimator also includes a simplified and filtered shallow water dynamical model as temporal smoother and second-order div-curl spatial regularizer. The estimator may also incorporate correlation-based vector fields as additional observations. These correlation vectors are also routinely provided by the Eumetsat consortium.

- Participant: Étienne Mémin
- Contact: Étienne Mémin
- URL: http://fluid.irisa.fr/index.html

5.2. 3DLayeredMotion

Estimation of 3D interconnected layered atmospheric motion fields

FUNCTIONAL DESCRIPTION: This software extends the previous 2D version. It allows (for the first time to our knowledge) the recovery of 3D wind fields from satellite image sequences. As with the previous techniques, the atmosphere is decomposed into a stack of pressure layers. The estimation relies also on pressure data and classification clouds maps and top of clouds pressure maps. In order to recover the 3D missing velocity information, physical knowledge on 3D mass exchanges between layers has been introduced in the data model. The corresponding data model appears to be a generalization of the previous data model constructed from a vertical integration of the continuity equation.

- Contact: Étienne Mémin
- URL: http://fluid.irisa.fr

5.3. DenseMotion

Estimation of 2D dense motion fields

FUNCTIONAL DESCRIPTION: This code allows the computation from two consecutive images of a dense motion field. The estimator is expressed as a global energy function minimization. The code enables the choice of different data models and different regularization functionals depending on the targeted application. Generic motion estimators for video sequences or fluid flows dedicated estimators can be set up. This software allows in addition the users to specify additional correlation based matching measurements. It enables also the inclusion of a temporal smoothing prior relying on a velocity vorticity formulation of the Navier-Stoke equation for Fluid motion analysis applications.

- Participant: Étienne Mémin
- Contact: Étienne Mémin
- URL: http://fluid.irisa.fr/index.html

5.4. Low-Order-Motion

Estimation of low order representation of fluid motion

FUNCTIONAL DESCRIPTION: This code enables the estimation of a low order representation of a fluid motion field from two consecutive images.The fluid motion representation is obtained using a discretization of the vorticity and divergence maps through regularized Dirac measure. The irrotational and solenoidal components of the motion fields are expressed as linear combinations of basis functions obtained through the Biot-Savart law. The coefficient values and the basis function parameters are formalized as the minimizer of a functional relying on an intensity variation model obtained from an integrated version of the mass conservation principle of fluid mechanics.

- Participants: Anne Cuzol and Étienne Mémin
- Contact: Étienne Mémin
- URL: http://fluid.irisa.fr

5.5. TYPHOON

KEYWORD: Fluid mechanics

FUNCTIONAL DESCRIPTION: Typhoon is a fluid motion estimator from image sequences. It is almost real-time dedicated to the measurement of LIDAR sequences, multi-scale, fast and precise to make a fine scale analysis of fluid flows with applications in the fields of energy, transport and environment.

- Participants: Christopher Mauzey, Étienne Mémin and Pierre Dérian
- Partner: CSU Chico
- Contact: Étienne Mémin
- URL: https://phys.csuchico.edu/lidar/typhoon/

5.6. H2OLab

KEYWORDS: Simulation - Energy - Contamination - Groundwater - Hydrogeology - Heterogeneity - Uncertainly - Multiscale

SCIENTIFIC DESCRIPTION: The software platform contains a database which is interfaced through the web portal H2OWeb. It contains also software modules which can be used through the interface H2OGuilde. The platform H2OLab is an essential tool for the dissemination of scientific results. Currently, software and database are shared by the partners of the h2mno4 project.

FUNCTIONAL DESCRIPTION: The software platform H2OLab is devoted to stochastic simulations of groundwater flow and contaminant transport in highly heterogeneous porous and fractured geological media.

-Modeling and numerical simulation of aquifers -Porous and fractured heterogeneous media -Flow with mixed finite elements -Solute transport with a Lagrangian method -Stochastic modeling for data uncertainty.

- Participants: Géraldine Pichot, Grégoire Lecourt, Jean-Raynald De Dreuzy and Jocelyne Erhel
- Partners: Université de Rennes 1 - CNRS - Université de Lyon - Université de Poitiers
- Contact: Jocelyne Erhel
- URL: http://h2olab.inria.fr/

5.7. PALMTREE

KEYWORD: Monte-Clarlo

FUNCTIONAL DESCRIPTION: We present an easy-to-use package for the parallelization of Lagrangian methods for partial differential equations. In addition to the reduction of computation time, the code aims at satisfying three properties:

simplicity: the user just has to add the algorithm governing the behaviour of the particles. portability: the possibility to use the package with any compiler and OS. action-replay: the ability of the package to replay a selected batch of particles.

The last property allows the user to replay and capture the whole sample path for selected particles of a batch. This feature is very useful for debugging and catching some relevant information.

- Authors: Lionel Lenôtre, Géraldine Pichot
- Contact: Géraldine Pichot

5.8. GRT3D

Global Reactive Transport in 3D

KEYWORDS: Geochemistry - Dispersion - Scientific calculation - Simulation - Advection

SCIENTIFIC DESCRIPTION: Participants : Édouard Canot, Jocelyne Erhel [correspondant] .

Version: version 2.0, April 2014

APP: registered

Programming language: C

Abstract: Reactive transport modeling has become an essential tool for understanding complex environmental problems. It is an important issue for MoMaS and C2S@EXA partners (see sections 8.2.5 , 8.2.3), in particular Andra. We have developed a method coupling transport and chemistry, based on a method of lines such that spatial discretization leads to a semi-discrete system of algebraic differential equations (DAE system). The main advantage is to use a complex DAE solver, which controls simultaneously the timestep and the convergence of Newton algorithm. The approach SIA uses a fixed-point method to solve the nonlinear system at each timestep, whereas the approach SNIA uses an explicit scheme.

The software suite GRT3D has four executable modules:

SIA1D: Sequential Iterative Approach for 1D domains,

GDAE1D: Global DAE approach for 1D domains,

SNIA3D: Sequential Non Iterative Approach for 1D, 2D or 3D domains.

GDAE3D: Global DAE approach for 1D, 2D or 3D domains. This module has three variants: the original one with logarithms, an optimized one still with logarithms, an optimized one which does not use logarithms.

Current work: extension of the chemistry module and parallelization.

FUNCTIONAL DESCRIPTION: Reactive transport modeling has become an essential tool for understanding complex environmental problems. It is an important issue for MoMaS and C2S@EXA partners, in particular Andra. We have developed a method coupling transport and chemistry, based on a method of lines such that spatial discretization leads to a semi-discrete system of algebraic differential equations (DAE system). The main advantage is to use a complex DAE solver, which controls simultaneously the timestep and the convergence of Newton algorithm. The approach SIA uses a fixed-point method to solve the nonlinear system at each timestep, whereas the approach SNIA uses an explicit scheme.

The software suite GRT3D has four executable modules:

SIA1D: Sequential Iterative Approach for 1D domains,

GDAE1D: Global DAE approach for 1D domains,

SNIA3D: Sequential Non Iterative Approach for 1D, 2D or 3D domains.

GDAE3D: Global DAE approach for 1D, 2D or 3D domains. This module has three variants: the original one with logarithms, an optimized one still with logarithms, an optimized one which does not use logarithms.

- Participants: Caroline De Dieuleveult, Édouard Canot, Jocelyne Erhel, Nadir Soualem and Souhila Sabit
- Partner: ANDRA
- Contact: Jocelyne Erhel

GENSCALE Project-Team

6. New Software and Platforms

6.1. SVJedi

KEYWORDS: High throughput sequencing - Structural Variation - Genome analysis

FUNCTIONAL DESCRIPTION: SVJedi is a structural variation (SV) genotyper for long read data. Based on a representation of the different alleles, it estimates the genotype of each variant in a given individual sample based on allele-specific alignment counts. SVJedi takes as input a variant file (VCF), a reference genome (fasta) and a long read file (fasta/fastq) and outputs the initial variant file with an additional column containing genotyping information (VCF).

- Participants: Claire Lemaitre, Lolita Lecompte, Pierre Peterlongo and Dominique Lavenier
- Contact: Claire Lemaitre
- URL: https://github.com/llecompte/SVJedi

6.2. MinYS

MineYourSymbiont

KEYWORDS: High throughput sequencing - Genome assembly - Metagenomics

FUNCTIONAL DESCRIPTION: MinYS allows targeted assembly of a bacterial genome of interest in a metagenomic short read sequencing sample using a reference-guided pipeline. First, taking advantage of a potentially distant reference genome, a subset of the metagenomic reads is assembled into a set of backbone contigs. Then, this first draft assembly is completed using the whole metagenomic readset in a de novo manner. The resulting assembly is output as a genome graph, allowing to distinguish different strains with potential structural variants coexisting in the sample.

- Contact: Claire Lemaitre
- URL: https://github.com/cguyomar/MinYS

6.3. Simka

KEYWORDS: Comparative metagenomics - K-mer - Distance - Ecology

FUNCTIONAL DESCRIPTION: Simka is a comparative metagenomics method dedicated to NGS datasets. It computes a large collection of distances classically used in ecology to compare communities by approximating species counts by k-mer counts. The method scales to a large number of datasets thanks to an efficient and parallel kmer-counting strategy that processes all datasets simultaneoulsy. SimkaMin is distributed also with Simka. SimkaMin is a faster and more resource-frugal version of Simka. It outputs approximate (but very similar) results by subsampling the kmer space.

RELEASE FUNCTIONAL DESCRIPTION: Since release version 1.5.0, SimkaMin is distributed alongside Simka. SimkaMin is also a de novo comparative metagenomics tool. It is a faster and more resource-frugal version of Simka. It outputs approximate (but very similar) results as Simka by subsampling the kmer space. With this strategy, and with default parameters, SimkaMin is an order of magnitude faster, uses 10 times less memory and 70 times less disk than Simka.

- Participants: Claire Lemaitre, Dominique Lavenier, Gaëtan Benoit and Pierre Peterlongo
- Contact: Claire Lemaitre
- URL: https://gatb.inria.fr/software/simka/

6.4. DiscoSnpRad

DISCOvering Single Nucleotide Polymorphism, Indels in RAD seq data

KEYWORD: RAD-seq

FUNCTIONAL DESCRIPTION: Software discoSnpRad is designed for discovering Single Nucleotide Polymorphism (SNP) and insertions/deletions (indels) from raw set(s) of RAD-seq data. Note that number of input read sets is not constrained, it can be one, two, or more. Note also that no other data as reference genome or annotations are needed. The software is composed of several modules. First module, kissnp2, detects SNPs from read sets. A second module, kissreads2, enhances the kissnp2 results by computing per read set and for each variant found i/ its mean read coverage and ii/ the (phred) quality of reads generating the polymorphism. Then, variants are grouped by RAD locus, and a VCF file is finally generated. We also provide several scripts to further filter and select informative variants for downstream population genetics studies.

This tool relies on the GATB-Core library.

RELEASE FUNCTIONAL DESCRIPTION: * Substantive improvements: better quality of results (accuracy and recall), better filtering of obtained results * Formal improvements: better organization of scripts, better presentation of results

- Participants: Pierre Peterlongo and Claire Lemaitre
- Contact: Pierre Peterlongo
- URL: https://github.com/GATB/DiscoSnp

<p align="center">**IBIS Project-Team**</p>

5. New Software and Platforms

5.1. WellFARE

KEYWORDS: Bioinformatics - Statistics - Data visualization - Data modeling

SCIENTIFIC DESCRIPTION: WellFARE is a Python library implementing linear inversion methods for the reconstruction of gene expression profiles from fluorescent or luminescent reporter gene data. WellFARE form the computational core of the WellInverter web application.

FUNCTIONAL DESCRIPTION: As input, WellFARE reads the primary data file produced by a 96-well microplate reader, containing time-series measurements of the absorbance (optical density) as well as the fluorescence and luminescence intensities in each well (if available). Various functions exist to analyze the data, in particular for detecting outliers, subtracting background, estimating growth rates, promoter activities and protein concentrations, visualizing expression profiles, synchronizing replicate profiles, etc. WellFARE is the computational core of the web application WellInverter.

NEWS OF THE YEAR: Publication in BMC Bioinformatics describing the new version of WellFARE
- Participants: Delphine Ropers, Hans Geiselmann, Hidde de Jong, Michel Page, Valentin Zulkower and Yannick Martin
- Partner: UGA
- Contact: Hidde de Jong
- Publication: Robust reconstruction of gene expression profiles from reporter gene data using linear inversion
- URL: https://github.com/ibis-inria/wellfare

5.2. WellInverter

KEYWORDS: Bioinformatics - Statistics - Data visualization - Data modeling

SCIENTIFIC DESCRIPTION: WellInverter is a web application that implements linear inversion methods for the reconstruction of gene expression profiles from fluorescent or luminescent reporter gene data. WellInverter makes the methods available to a broad audience of biologists and bioinformaticians. In particular, we have put in place a parallel computing architecture with a load balancer to distribute the analysis queries over several back-end servers, redesigned the graphical user interface, and developed a plug-in system for defining high-level routines for parsing data files produced by microplate readers from different manufacturers.

FUNCTIONAL DESCRIPTION: As input, WellInverter reads the primary data file produced by a 96-well microplate reader, containing time-series measurements of the absorbance (optical density) as well as the fluorescence and luminescence intensities in each well (if available). Various modules exist to analyze the data, in particular for detecting outliers, subtracting background, estimating growth rates, promoter activities and protein concentrations, visualizing expression profiles, synchronizing replicate profiles, etc. The computational core of the web application consists of the Python library WellFARE.

NEWS OF THE YEAR: Deployment of WellInverter on an Inria server and on the new cloud of the French Institute for Bioinformatics (see the web page for details). Publication in BMC Bioinformatics describing the new version of the application.
- Participants: Delphine Ropers, Hans Geiselmann, Hidde de Jong, Johannes Geiselmann, Michel Page, Valentin Zulkower and Yannick Martin
- Partner: UGA
- Contact: Hidde de Jong
- Publication: Robust reconstruction of gene expression profiles from reporter gene data using linear inversion
- URL: https://team.inria.fr/ibis/wellinverter/

5.3. GNA

Genetic Network Analyzer

KEYWORDS: Model Checking - Bioinformatics - Gene regulatory networks - Qualitative simulation

SCIENTIFIC DESCRIPTION: Genetic Network Analyzer (GNA) is the implementation of methods for the qualitative modeling and simulation of gene regulatory networks developed in the IBIS project-team.

FUNCTIONAL DESCRIPTION: The input of GNA consists of a model of the regulatory network in the form of a system of piecewise-linear differential equations (PLDEs), supplemented by inequality constraints on the parameters and initial conditions. From this information, GNA generates a state transition graph summarizing the qualitative dynamics of the system. In order to analyze large graphs, GNA allows the user to specify properties of the qualitative dynamics of a network in temporal logic, using high-level query templates, and to verify these properties on the state transition graph by means of standard model-checking tools, either locally installed or accessible through a remote web server.

RELEASE FUNCTIONAL DESCRIPTION: (1) it supports the editing and visualization of regulatory networks, in an SBGN-compatible format, (2) it semi-automatically generates a prototype model from the network structure, thus accelerating the modeling process, and (3) it allows models to be exported in the SBML Qual standard.

NEWS OF THE YEAR: New mode of distribution from the IBIS web site. Tutorial on the use of the model formalism for analyzing synthetic genetic circuits.

- Participants: Hidde de Jong, Michel Page and Delphine Ropers
- Partner: UGA
- Contact: Hidde de Jong
- Publications: Genetic Network Analyzer: A Tool for the Qualitative Modeling and Simulation of Bacterial Regulatory Networks - Piecewise linear approximations to model the dynamics of adaptation to osmotic stress by food-borne pathogens
- URL: http://www-helix.inrialpes.fr/gna

LEMON Project-Team

5. New Software and Platforms

5.1. SW2D

Shallow Water 2 Dimensions

KEYWORDS: Numerical simulations - Shallow water equations

FUNCTIONAL DESCRIPTION: Urban floods are usually simulated using two-dimensional shallow water models. A correct representation of the urban geometry and hydraulics would require that the average computational cell size be between 0.1 m and 1 m. The meshing and computation costs make the simulation of entire districts/conurbations impracticable in the current state of computer technology.

An alternative approach consists in upscaling the shallow water equations using averaging techniques. This leads to introducing storage and conveyance porosities, as well as additional source terms, in the mass and momentum balance equations. Various versions of porosity-based shallow water models have been proposed in the literature. The Shallow Water 2 Dimensions (SW2D) computational code embeds various finite volume discretizations of these models. Ituses fully unstructured meshes with arbitrary numbers of edges. The key features of the models and numerical techniques embedded in SW2D are :

- specific momentum/energy dissipation models that are active only under transient conditions. Such models, that are not present in classical shallow water models, stem from the upscaling of the shallow water equations and prove essential in modeling the features of fast urban flow transients accurately

- modified HLLC solvers for an improved discretization of the momentum source terms stemming from porosity gradients

- higher-order reconstruction techniques that allow for faster and more stable calculations in the presence of wetting/drying fronts.

RELEASE FUNCTIONAL DESCRIPTION: GUI, C++ translation

- Participant: Vincent Guinot
- Partner: Université de Montpellier
- Contact: Vincent Guinot

5.2. WindPoS-SDM-LAM

KEYWORDS: Numerical simulations - 3D - Fluid mechanics

FUNCTIONAL DESCRIPTION: Software platform for wind modeling.

- Authors: Antoine Rousseau, Cristian Paris Ibarra, Jacques Morice, Mireille Bossy and Sélim Kraria
- Contact: Mireille Bossy
- URL: https://windpos.inria.fr

5.3. SDM

Stochastic Downsaling Method

FUNCTIONAL DESCRIPTION: The computation of the wind at small scale and the estimation of its uncertainties is of particular importance for applications such as wind energy resource estimation. To this aim, starting in 2005, we have developed a new method based on the combination of an existing Numerical Weather Prediction model providing a coarse prediction, and a Lagrangian Stochastic Model for turbulent flows. This Stochastic Downscaling Method (SDM) requires a specific modeling of the turbulence closure, and involves various simulation techniques whose combination is totally original (such as Poisson solvers, optimal transportation mass algorithm, original Euler scheme for confined Langevin stochastic processes, and stochastic particle methods).

- Participants: Antoine Rousseau, Antoine Rousseau, Claire Chauvin, Frederic Bernardin and Mireille Bossy
- Contact: Mireille Bossy

5.4. OceaPoS-SDM

KEYWORDS: 3D - Turbulence - Oceanography - Numerical simulations - Stochastic models - Marine Energies

FUNCTIONAL DESCRIPTION: Simulation platform for ocean turbulence and interaction with hydroturbines

- Partner: MERIC
- Contact: Mireille Bossy

LIFEWARE Project-Team

6. New Software and Platforms

6.1. BIOCHAM

The Biochemical Abstract Machine

KEYWORDS: Systems Biology - Bioinformatics

FUNCTIONAL DESCRIPTION: The Biochemical Abstract Machine (BIOCHAM) is a software environment for modeling, analyzing and synthesizing biochemical reaction networks (CRNs) with respect to a formal specification of the observed or desired behavior of a biochemical system. BIOCHAM is compatible with the Systems Biology Markup Language (SBML) and contains some unique features about formal specifications in quantitative temporal logic, sensitivity and robustness analyses and parameter search in high dimension w.r.t. behavioral specifications, static analyses, and synthesis of CRNs.

RELEASE FUNCTIONAL DESCRIPTION: – notebooks of Master classes – graphical user interface on top of Jupyter – synthesis of at most binary reactions with minimisation of the variables for negative values – detection of model reduction by subgraph epimorphism – option for partial tropical equilibrations

- Participants: François Fages, David Coudrin, Sylvain Soliman and Mathieu Hemery
- Contact: François Fages
- URL: http://lifeware.inria.fr/biocham4/

6.2. casq

CellDesigner as SBML-Qual

KEYWORDS: SBML - Logical Framework - Knowledge representation

FUNCTIONAL DESCRIPTION: CaSQ transforms a big knowledge map encoded as an SBGN-compliant SBML file in CellDesigner into an executable Logical Model in SBML-Qual

- Authors: Sylvain Soliman and Anna Niarakis
- Partner: Université d'Evry-Val d'Essonne
- Contact: Sylvain Soliman
- URL: https://gitlab.inria.fr/soliman/casq/

6.3. Platforms

6.3.1. *Smart experimental platforms to automate microbiology experiments*

Models play a central role in our work, either to test our understanding or to guide the design of novel systems. Model development and parameter calibration necessitate informative experiments. We develop methods to assist with the optimal design of experiments. In consequence, we have to perform, in sequence or in parallel, experiments with possibly complex input profiles. This led us to develop experimental platforms that allow for flexible and automated stimulations and measurements. Three platforms are being developed, based on (i) a microplate photometer, (ii) a bioreactor platform coupled with a flow cytometer, and (iii) a microscope equipped with microfluidic systems, respectively. In all cases, the real-time measurement and actuation capabilities allow for making reactive experiments, notably including real-time control experiments.

M3DISIM Project-Team

5. New Software and Platforms

5.1. HeartLab

KEYWORDS: Computational geometry - Image analysis - Cardiac - Health - Simulation

FUNCTIONAL DESCRIPTION: The heartLab software is a library designed to perform both simulation and estimation of the heart mechanical behavior (based on various types of measurements, e.g. images).

Also included are geometric data and tools in the code to define cardiac anatomical models compatible with the simulation requirements in terms of mesh quality, fiber direction data defined within each element, and the referencing necessary for handling boundary conditions and estimation, in particular. These geometries are analytical or come from computerized tomography (CT) or magnetic resonance (MR) image data of humans or animals.

- Participants: Radomir Chabiniok, Gautier Bureau, Martin Genet, Federica Caforio, Ustim Khristenko, Dominique Chapelle and Philippe Moireau
- Contact: Philippe Moireau
- URL: https://raweb.inria.fr/rapportsactivite/RA2013/m3disim/uid14.html

5.2. Verdandi

KEYWORDS: HPC - Model - Software Components - Partial differential equation

FUNCTIONAL DESCRIPTION: Verdandi is a free and open-source (LGPL) library for data assimilation. It includes various such methods for coupling one or several numerical models and observational data. Mainly targeted at large systems arising from the discretization of partial differential equations, the library is devised as generic, which allows for applications in a wide range of problems (biology and medicine, environment, image processing, etc.). Verdandi also includes tools to ease the application of data assimilation, in particular in the management of observations or for a priori uncertainty quantification. Implemented in C++, the library may be used with models implemented in Fortran, C, C++ or Python.

- Participants: Dominique Chapelle, Gautier Bureau, Nicolas Claude, Philippe Moireau and Vivien Mallet
- Contact: Vivien Mallet
- URL: http://verdandi.gforge.inria.fr/

5.3. CardiacLab

KEYWORDS: Cardiovascular and respiratory systems - Matlab - Real time

FUNCTIONAL DESCRIPTION: CardiacLab is a MATLAB toolbox allowing to perform "real-time" cardiac simulations using 0D models of the cardiovascular systems. Its modular development includes (1) a module integrating the mechanical dynamics of the cavity taking into account its particular geometry, (2) a module allowing to choose a micro-model of the cardiac contraction, (3) a module of phase management, (4) a circulation module based on Windkessel models or more advanced 1D flows models, and (5) a perfusion module. The objective of this code is threefold: (1) demonstrate to students, engineers, medical doctors, the interest of modeling in cardiac applications, (2) unify our original modeling developments with the possibility to evaluate them with previous team developments before integrating them into 3D complex formulations, and (3) explore some avenues pertaining to real-time simulat

- Participants: Sebastien Impériale, Martin Genet, Federica Caforio, Ustim Khristenko, Peter Baumgartner, Radomir Chabiniok, François Kimmig and Arthur Le Gall
- Contact: Philippe Moireau
- URL: https://gitlab.inria.fr/M3DISIM/CardiacLab

5.4. MoReFEM

Modeling Research with the Finite Element Method

KEYWORDS: HPC - Multiphysics modelling - Data assimilation

FUNCTIONAL DESCRIPTION: MoReFEM is a HPC finite element library for simulating multiphysics evolution problems like the ones encounter in cardiac modeling (electrophysiology, structure and fluid mechanics, transport-diffusion, wave equations)

- Participants: Philippe Moireau, Patrick Le Tallec, Antoine Olivier, Dominique Chapelle, Ustim Khristenko, François Kimmig, Gautier Bureau and Sébastien Gilles
- Contact: Sébastien Gilles
- URL: https://gitlab.inria.fr/MoReFEM

<p style="text-align:center; color:red">MAGIQUE-3D Project-Team</p>

6. New Software and Platforms

6.1. Elasticus

KEYWORDS: Discontinuous Galerkin - Acoustic equation - Elastodynamic equations - Elastoacoustic - 2D - 3D - Time Domain

SCIENTIFIC DESCRIPTION: Elasticus simulate acoustic and elastic wave propagation in 2D and in 3D, using Discontinuous Galerkin Methods. The space discretization is based on two kind of basis functions, using Lagrange or Jacobi polynomials. Different kinds of fluxes (upwind and centered) are implemented, coupled with RK2 and RK4 time schemes.

FUNCTIONAL DESCRIPTION: Elasticus is a sequential library, independent of Total plateform and developed in Fortran, to simulate wave propagation in geophysical environment, based on a DG method. It is meant to help PhD students and post-doctoral fellows to easily implement their algorithms in the library. Thus, readability of the code is privileged to optimization of its performances. Developped features should be easily transferred in the computing platform of Total. Elasticus manages arbitrary orders for the spatial discretization with DG method.

NEWS OF THE YEAR: In 2018, we implemented the coupling between hexahedra and tetrahedra and the coupling between Discontinuous Galerkin methods and Spectral Element methods in 2D and in 3D. We also introduced Perfectly Matched layers in the Spectral Element kernel.

- Participants: Julien Diaz, Lionel Boillot and Simon Ettouati
- Contact: Julien Diaz
- Publications: Spectral Element Method and Discontinuous Galerkin approximation for elasto-acoustic problems - Hybrid space discretization to solve elasto-acoustic coupling - On the coupling of Spectral Element Method with Discontinuous Galerkin approximation for elasto-acoustic problems - SEM-DG Approximation for elasto-acoustics

6.2. Hou10ni

KEYWORDS: 2D - 3D - Elastodynamic equations - Acoustic equation - Elastoacoustic - Frequency Domain - Time Domain - Discontinuous Galerkin

SCIENTIFIC DESCRIPTION: Hou10ni simulates acoustic and elastic wave propagation in time domain and in harmonic domain, in 2D and in 3D. It is also able to model elasto acoustic coupling. It is based on the second order formulation of the wave equation and the space discretization is achieved using Interior Penalty Discontinuous Galerkin Method. Recently, the harmonic domain solver has been extended to handle Hybridizable Discontinuous Galerkin Methods.

FUNCTIONAL DESCRIPTION: This software simulates the propagation of waves in heterogeneous 2D and 3D media in time-domain and in frequency domain. It is based on an Interior Penalty Discontinuous Galerkin Method (IPDGM) and allows for the use of meshes composed of cells of various order (p-adaptivity in space).

NEWS OF THE YEAR: In 2019, we have implemented the elasto-acoustic coupling and the poroelastic equations for the HDG formulation.

- Participants: Conrad Hillairet, Elodie Estecahandy, Julien Diaz, Lionel Boillot and Marie Bonnasse
- Contact: Julien Diaz

- Publications: Hybridizable discontinuous Galerkin method for the two-dimensional frequency-domain elastic wave equations - Convergence of seismic full waveform inversion and extension to Cauchy data - Convergence Analysis for Seismic Full Waveform Inversion - Stability and convergence analysis for seismic depth imaging using FWI - On the use of a laser ablation as a laboratory seismic source - Towards Energy-Efficient Storage Servers - Equivalent Robin Boundary Conditions for Acoustic and Elastic Media - Comparison of solvers performance when solving the 3D Helmholtz elastic wave equations over the Hybridizable Discontinuous Galerkin method - Comparison of solvers performance when solving the 3D Helmholtz elastic wave equations using the Hybridizable Discontinuous Galerkin method - Resolution strategy for the Hybridizable Discontinuous Galerkin system for solving Helmholtz elastic wave equations - Seismic imaging in laboratory trough laser Doppler vibrometry - Absorbing Boundary Conditions for 3D Elastic TTI Modeling, Application to Time-Based and Time-Harmonic Simulations - Shape and material parameter reconstruction of an isotropic or anisotropic solid immersed in a fluid - Modelling and advanced simulation of wave propagation phenomena in 3D geophysical media. - Multi-level explicit local time-stepping methods for second-order wave equations - Absorbing Boundary Conditions for 3D elastic TTI modeling - Modeling of elastic Helmholtz equations by hybridizable discontinuous Galerkin method (HDG) for geophysical applications - Performance Assessment on Hybridizable Dg Approximations for the Elastic Wave Equation in Frequency Domain - High-Order IPDG Approximations for Elasto-Acoustic Problems - High-order Discontinuous Galerkin approximations for elasto-acoustic scattering problems - Modelling of seismic waves propagation in harmonic domain by hybridizable discontinuous Galerkin method (HDG) - Absorbing Boundary Conditions for 3D Tilted Transverse Isotropic media - Performance comparison between hybridizable DG and classical DG methods for elastic waves simulation in harmonic domain - Polynomial speeds in a Discontinuous Galerkin code - Hybridizable Discontinuous Galerkin method for the simulation of the propagation of the elastic wave equations in the frequency domain - Discontinuous Galerkin methods for the simulation of the propagation of the elastic wave equations in the frequency domain - High order discontinuous Galerkin methods for time-harmonic elastodynamics - Hybridizable discontinuous Galerkin method for the two-dimensional frequency-domain elastic wave equations - Efficient DG-like formulation equipped with curved boundary edges for solving elasto-acoustic scattering problems - Numerical schemes for the simulation of seismic wave propagation in frequency domain - Performance analysis of DG and HDG methods for the simulation of seismic wave propagation in harmonic domain - Hybridizable Discontinuous Galerkin method for solving Helmholtz elastic wave equations - Discontinuous Galerkin methods for solving Helmholtz elastic wave equations for seismic imaging - Performance comparison of HDG and classical DG method for the simulation of seismic wave propagation in harmonic domain - Contributions to the mathematical modeling and to the parallel algorithmic for the optimization of an elastic wave propagator in anisotropic media - Contribution to the mathematical analysis and to the numerical solution of an inverse elasto-acoustic scattering problem
- URL: https://team.inria.fr/magique3d/software/hou10ni/

6.3. MONTJOIE

KEYWORDS: High order finite elements - Edge elements - Aeroacoustics - High order time schemes

SCIENTIFIC DESCRIPTION: Montjoie is designed for the efficient solution of time-domain and time-harmonic linear partial differential equations using high-order finite element methods. This code is mainly written for quadrilateral/hexahedral finite elements, partial implementations of triangular/tetrahedral elements are provided. The equations solved by this code, come from the "wave propagation" problems, particularly acoustic, electromagnetic, aeroacoustic, elastodynamic problems.

FUNCTIONAL DESCRIPTION: Montjoie is a code that provides a C++ framework for solving partial differential equations on unstructured meshes with finite element-like methods (continuous finite element, discontinuous Galerkin formulation, edge elements and facet elements). The handling of mixed elements (tetrahedra,

prisms, pyramids and hexahedra) has been implemented for these different types of finite elements methods. Several applications are currently available : wave equation, elastodynamics, aeroacoustics, Maxwell's equations.

- Participants: Gary Cohen, Juliette Chabassier, Marc Duruflé and Morgane Bergot
- Contact: Marc Duruflé
- URL: http://montjoie.gforge.inria.fr/

6.4. tmodeling-DG

Time-domain Wave-equation Modeling App

KEYWORDS: 2D - 3D - Elastoacoustic - Elastodynamic equations - Discontinuous Galerkin - Time Domain

SCIENTIFIC DESCRIPTION: tmodeling-DG simulate acoustic and elastic wave propagation in 2D and in 3D, using Discontinuous Galerkin Methods. The space discretization is based on two kind of basis functions, using Lagrange or Jacobi polynomials. Different kinds of fluxes (upwind and centered) are implemented, coupled with RK2 and RK4 time schemes.

FUNCTIONAL DESCRIPTION: tmodelling-DG is the follow up to DIVA-DG that we develop in collaboration with our partner Total. Its purpose is more general than DIVA-DG and should contains various DG schemes, basis functions and time schemes. It models wave propagation in acoustic media, elastic (isotropic and TTI) media and elasto-acoustic media, in two and three dimensions.

NEWS OF THE YEAR: In 2018, we have coupled the code with a Reverse Time Migration algorithm.

- Participants: Julien Diaz, Lionel Boillot, Simon Ettouati and Hélène Barucq
- Partner: TOTAL
- Contact: Julien Diaz

6.5. OpenWind

Open Wind Instrument Design

KEYWORDS: Wave propagation - Inverse problem - Experimental mechanics - Image processing

FUNCTIONAL DESCRIPTION: Computes resonating pipes' impedance using one-dimensional finite element method with tonholes and fingering chart.

RELEASE FUNCTIONAL DESCRIPTION: account for toneholes as a pipe network using transmission matrices for pipe junctions [Chaigne & Kergomard]

- Authors: Robin Tournemenne, Juliette Chabassier, Alexis Thibault, Augustin Ernoult and Guillaume Castera
- Contact: Juliette Chabassier
- Publication: hal-01963674v2
- URL: https://gitlab.inria.fr/openwind/release

6.6. ffwi

Frequency-domain Full Waveform Inversion

KEYWORDS: 2D - 3D - Discontinuous Galerkin - Inverse problem - Frequency Domain - Acoustic equation - Elasticity

FUNCTIONAL DESCRIPTION: ffwi is developed in partnership with Total in the context of the Depth Imaging Partnership (DIP). It is devoted to perform seismic imaging using the Full Waveform Inversion method, in the frequency domain. It is based upon the software Fmodeling, which is itself dedicated to the forward problem. In FWI, the forward problem is solved using Hybridizable Discontinuous Galerkin Methods. The reconstruction of medium parameter is conducted with an iterative minimization scheme, which uses gradient descent techniques. The software can work with acoustic and elastic media, in two and three dimensions.

- Partner: TOTAL
- Contact: Florian Faucher

MAMBA Project-Team

6. New Software and Platforms

6.1. TiQuant

Tissue Quantifier

KEYWORDS: Systems Biology - Bioinformatics - Biology - Physiology

FUNCTIONAL DESCRIPTION: Systems biology and medicine on histological scales require quantification of images from histological image modalities such as confocal laser scanning or bright field microscopy. The latter can be used to calibrate the initial state of a mathematical model, and to evaluate its explanatory value, which hitherto has been little recognized. We generated a software for image analysis of histological material and demonstrated its use in analysing liver confocal micrografts, called TiQuant (Tissue Quantifier). The software is part of an analysis chain detailing protocols of imaging, image processing and analysis in liver tissue, permitting 3D reconstructions of liver lobules down to a resolution of less than a micrometer.

- Author: Dirk Drasdo
- Contact: Dirk Drasdo

6.2. TiSim

Tissue Simulator

KEYWORDS: Systems Biology - Bioinformatics - Biology - Physiology

SCIENTIFIC DESCRIPTION: TiSim (Tissue Simulator) is a versatile and efficient simulation environment for tissue models. TiSim is a software for agent-based models of multicellular systems. It permits model development with center-based models and deformable cell models, it contains modules for monolayer and multicellular spheroid simulations as well as for simulations of liver lobules. Besides agent-based simulations, the flow of blood and the transport of molecules can be modelled in the extracellular space, intracellular processes such as signal transduction and metabolism can be simulated, for example over an interface permitting integration of SBML-formulated ODE models. TiSim is written in modern C++ , keeping central model constituents in modules to be able to reuse them as building blocks for new models. For user interaction, the GUI Framework Qt is used in combination with OpenGL for visualisation. The simulation code is in the process of being published. The modeling strategy and approaches slowly reach systems medicine and toxicology. The diffusion of software is a fundamental component as it provides the models that are complex and difficult to implement (implementing a liver lobule model from scratch takes about 2-2.5yrs) in form of a software to the developer and users who like to build upon them. This increases significantly the speed of implementing new models. Moreover, standardization is indispensible as it permits coupling different software tools that may have implemented models at different scales / levels.

FUNCTIONAL DESCRIPTION: TiSim is a software that permits agent-based simulations of multicellular systems. - center-based lattice-free agent-based model - modular - C++, Qt, OpenGL, GUI, batch mode - permits multiscale simulations by integration of molecular pathways (for signaling, metabolisms, drug) into each individual cell - applications so far: monolayer growth, multicellular spheroids - Boolean networks (development time = coding time (60 MMs) + model development time (264 MMs)) - in follow-up version 1: - liver lobule regeneration - SBML interface - in follow-up version 2: - deformable cell model (by triangulation of cell surface) - deformable rod models - extracellular matrix - vascular flow and transport TiSim can be directly fed by processed image data from TiQuant.

- Participants: Andreas Buttenschoen, Dirk Drasdo, Eugenio Lella, Géraldine Cellière, Johannes Neitsch, Margaretha Palm, Nick Jagiella, Noémie Boissier, Paul van Liedekerke, Stefan Hoehme and Tim Johann
- Partner: IZBI, Université de Leipzig
- Contact: Dirk Drasdo

6.3. Platforms

6.3.1. TiSim

The deformable cell model [123], [52] has been integrated in addition to the center-based model in the software TiSim (Tissue Simulator), a follow-up of former CellSys [113]. Center-based models of cells represent forces between cells as forces between cell centers but lacks an explicit representation of cell shape. The deformable cell model represents cell shape explicitly. Applications are monolayers, multicellular spheroids and simulations of liver regeneration, whereby intracellular pathways can be integrated. The model shall be distributed as binary and will permit to use the deformable cell model to calibrate intercellular forces at high cell densities, where the two-body force models so far applied in center-based models fail.

6.3.2. TiQuant

This image processing and analysis software ([103]) now integrates a machine learning component. This is fundamental as it is more general and permits quicker adaptation to new images.

MATHNEURO Project-Team (section vide)

<p style="text-align:center; color:red;">**MIMESIS Team**</p>

6. New Software and Platforms

6.1. SOFA

Simulation Open Framework Architecture

KEYWORDS: Real time - Multi-physics simulation - Medical applications

FUNCTIONAL DESCRIPTION: SOFA is an Open Source framework primarily targeted at real-time simulation, with an emphasis on medical simulation. It is mostly intended for the research community to help develop new algorithms, but can also be used as an efficient prototyping tool. Based on an advanced software architecture, it allows : the creation of complex and evolving simulations by combining new algorithms with algorithms already included in SOFA, the modification of most parameters of the simulation (deformable behavior, surface representation, solver, constraints, collision algorithm, etc.) by simply editing an XML file, the building of complex models from simpler ones using a scene-graph description, the efficient simulation of the dynamics of interacting objects using abstract equation solvers, the reuse and easy comparison of a variety of available methods.

- Participants: Christian Duriez, François Faure, Hervé Delingette and Stéphane Cotin
- Partner: IGG
- Contact: Hugo Talbot
- URL: http://www.sofa-framework.org

6.2. SofaNeedleInsertion

Needle Insertion Plugin

KEYWORD: Simulation

FUNCTIONAL DESCRIPTION: This plugin contains needle/tissue interaction models for real-time simulations of needle insertion in deformable objects using the open-source sofa frame-work. This allows for modeling the different forces playing a role during the insertion process (penetration forces, friction along the shaft...) using a constrained-based formulation. This formulation provides a fast and stable solution for the simulation of complex insertions (and reinsertion) of the needle in deformations Finite Element models

- Contact: Hadrien Courtecuisse

6.3. SOFA Optimus

Optimization methods in SOFA: stochastic filtering and data assimilation.

KEYWORDS: Data assimilation - Kalman filter - Stochastic optimization

FUNCTIONAL DESCRIPTION: Optimus is a plugin to work with advanced methods of state estimation and parameter identification. It was created to provide a testing environment for data-driven physics-based modeling (typically finite elements). While currently the plugin implements only stochastic methods based on Kalman filtering, its architecture allows for the implementation of generic prediction–correction schemes where the model is employed as a predictor and correction is performed using given observation data.

- Contact: Stéphane Cotin
- URL: https://gitlab.inria.fr/mimesis/Optimus

MNEMOSYNE Project-Team

6. New Software and Platforms

6.1. DANA

Distributed Asynchronous Numerical and Adaptive computing framework

KEYWORD: Neural networks

FUNCTIONAL DESCRIPTION: DANA is a python framework whose computational paradigm is grounded on the notion of a unit that is essentially a set of time dependent values varying under the influence of other units via adaptive weighted connections. The evolutions of a unit's value are defined by a set of differential equations expressed in standard mathematical notation which greatly ease their definition. The units are organized into groups that form a model. Each unit can be connected to any other unit (including itself) using a weighted connection. The DANA framework offers a set of core objects needed to design and run such models. The modeler only has to define the equations of a unit as well as the equations governing the training of the connections. The simulation is completely transparent to the modeler and is handled by DANA. This allows DANA to be used for a wide range of numerical and distributed models as long as they fit the proposed framework (e.g. cellular automata, reaction-diffusion system, decentralized neural networks, recurrent neural networks, kernel-based image processing, etc.).

- Participant: Nicolas Rougier
- Contact: Nicolas Rougier
- URL: http://dana.loria.fr/

6.2. Virtual Enaction

KEYWORDS: Neurosciences - Simulation - Health

FUNCTIONAL DESCRIPTION: VirtualEnaction: A Platform for Systemic Neuroscience Simulation. The computational models studied in this project have applications that extend far beyond what is possible to experiment yet in human or non-human primate subjects. Real robotics experimentations are also impaired by rather heavy technological constraints, for instance, it is not easy to dismantle a given embedded system in the course of emerging ideas. The only versatile environment in which such complex behaviors can be studied both globally and at the level of details of the available modeling is a virtual environment, as in video games, Such a system can be implemented as "brainy-bot" (a programmed player based on our knowledge of the brain architecture) which goal is to survive in a complete manipulable environment.

In order to attain this rather ambitious objective we both (i) deploy an existing open-source video game middleware in order to be able to shape the survival situation to be studied and (ii) revisit the existing models in order to be able to integrate them as an effective brainy-bot. It consists of a platform associated to a scenario that is the closest possible to a survival situation (foraging, predator-prey relationship, partner approach to reproduction) and in which it is easy to integrate an artificial agent with sensory inputs (visual, touch and smell), emotional and somatosensory cues (hunger, thirst, fear, ..) and motor outputs (movement, gesture, ..) connected to a "brain" whose architecture will correspond to the major anatomical regions involved in the issues of learning and action selection (cortex areas detailed here, basal ganglia, hippocampus, and areas dedicated to sensorimotor processes). The internal game clock can be slowed down enough to be able to run non trivial brainy-bot implementations. This platform has already being used by two students of the team and is now a new deliverable of the KEOpS project.

- Participants: André Garenne, Frédéric Alexandre, Nicolas Rougier and Thierry Viéville
- Contact: Frédéric Alexandre

6.3. ReservoirPy

KEYWORDS: Recurrent network - Artificial intelligence - Reservoir Computing - Multi-label classification - Timeseries Prediction - Time Series - Machine learning - Classification

FUNCTIONAL DESCRIPTION: This toolbox provides a class of Echo State Networks that can be used with Python and its scientific librairies like Numpy, Scipy and Matplolib. It includes useful expertise to train recurrent neural networks of ESN architecture kind.

ESN is a particular kind of recurrent neural network (RNN) with or without leaky neurons. The input stream is projected to a random recurrent layer and a linear output layer (called "read-out") is modified by learning (which can also be done in an online fashion).

Compared to other RNNs, the input layer and the recurrent layer (called "reservoir") do not need to be trained. For other RNNs, the structure of the recurrent layer evolves in most cases by gradient descent algorithms like Backpropagation-Through-Time, which is not biologically plausible and is adapted iteratively to be able to hold a representaion of the input sequence. In contrast, the random weights of the ESN's reservoir are not trained, but adapted to possess the "Echo State Property" (ESP) or at least suitable dynamics (e.g. 'edge of chaos') to generalize, which includes a non-linear transformation of the input that can be learned by a linear classifier. The weights are adapted by scaling the weights based on the maximum absolute eigenvalue (also called spectral radius), which is a hyperparameter specific to the task. The states of the reservoir are linearly separable and can be mapped to the output layer by a computationally cheap linear regression, as no gradient descent is necessary. The weights of the input layer can be scaled by the input scaling hyperparameter, which also depends on the nature of the inputs.

- Partners: Université de Hamburg - University of Hamburg
- Contact: Xavier Hinaut
- URL: https://github.com/neuronalX/reservoirpy

6.4. Platforms

6.4.1. Platform AIDE

Keywords : computational thinking initiation, learning analytics, machine learning

Functional description : This package provides source files to control a tapletop setup allowing to initiate learners to computational thinking using unplugged activities and connected objects, and collecting automatically learning activities including thanks to neuroinspired machine learning mechanisms, developed in collaboration with pobot and the Inria mission of science outreach and the LINE laboratory.

MONC Project-Team

6. New Software and Platforms

6.1. August

Antibody Drug Uptake Simulator

KEYWORD: Mechanistic modeling

FUNCTIONAL DESCRIPTION: Numerical code to compute the uptake of an antibody drug at the scale of an histopathology blade. The computation domain (reconstructed from segmented images) is completely meshed and sub-divided accross computational nodes to distribute the load efficiently. The model (based on reaction-diffusion equations) is then solved in parallel using a domain decomposition method. C ++

- Contact: Olivier Saut

<h1 style="text-align:center;">MORPHEME Project-Team</h1>

5. New Software and Platforms

5.1. Obj.MPP

KEYWORDS: Object detection - Marked Point Process - Parametric model

FUNCTIONAL DESCRIPTION: Obj.MPP implements the detection of parametric objects using a Marked Point Process (MPP). A parametric object is an n-dimensional piece of signal defined by a finite set of parameters. Detecting an object in a signal amounts to finding a position at which the signal can be described well enough by a specific set of parameters (unknowns of the detection problem). The detection task amounts to finding all such objects. Typically, the signal is a 2-dimensional grayscale image and the parametric objects are bright disks on a dark background. In this case, each object is defined by a single parameter: the disk radius. Note however that the core function of Obj.MPP is not tied to a particular context (2-dimensional imaging is just an example).

- Author: Eric Debreuve
- Contact: Eric Debreuve
- Publications: Stochastic geometry for image analysis - Multiple objects detection in biological images using a marked point process framework - An efficient optimizer for simple point process models - Multiple Birth and Cut Algorithm for Multiple Object Detection
- URL: https://team.inria.fr/morpheme/obj-mpp-object-detection-using-a-marked-point-process/

5.2. ATOLS

Adaptative Threshold Operator based on Level Sets

KEYWORDS: Object detection - Level Set

FUNCTIONAL DESCRIPTION: Atols is a Python script allowing to detect features on images using a contrast scoring. Thus, it's possible to detect features at different levels of intensity unlike a simple threshold which would only keep features above its value.

- Authors: Kevin Giulietti and Guillaume Lavisse
- Contact: Xavier Descombes
- URL: https://team.inria.fr/morpheme/software/

5.3. Small particle detection

KEYWORDS: Image processing - Image segmentation - Object detection - Computational biology - Fluorescence microscopy - Biomedical imaging

FUNCTIONAL DESCRIPTION: An algorithm primarily design to detect objects whose sizes aren't larger a few pixels (particles) on fluorescence microscopy images.

It is an simplified version of marked point process.

- Contact: Nicolas Cedilnik
- Publications: SPADE: A Small Particle Detection Method Using A Dictionary Of Shapes Within The Marked Point Process Framework - SPADE: A Small Particle Detection Method Using A Dictionary Of Shapes Within The Marked Point Process Framework
- URL: https://gitlab.inria.fr/ncedilni/spade

<h1 style="color:red; text-align:center">MOSAIC Project-Team</h1>

5. New Software and Platforms

5.1. cellcomplex

KEYWORDS: Polyhedral meshes - 3D

FUNCTIONAL DESCRIPTION: The cellcomplex library is a Python library that allows manipulating 2D or 3D multicellular complexes, with the study of plant tissues as a main application. It is mostly structured around a data structure that is used to represent such complexes as incidence graphs of dimension 2 or 3, and provides several key functionalities:

* The creation of structures from more basic representation (polygons of points for instance), from some geometrical primitives (2D or 3D) and the generation of synthetic regular or irregular grids, allowing notably the simulation of tissues.

* The computation of topological and geometrical properties on the multicellular complex structures, including notably useful computations on triangle meshes, a specific case of complexes with simplicial faces (areas, normals, triangle eccentricity, curvature estimator).

* The edition of structures by local topological operations, notably in th case of triangle meshes (edge flip, subdivision, vertex insertion) and multi-criteria geometrical optimization processes and isotropic remeshing.

* The import and export in various standard file formats for geometries (.obj, .ply, .msh) and notably in the standard formad defined by the community of plant tissue modelling (PLY, Saisnbury Computational Workshop 2015).

RELEASE FUNCTIONAL DESCRIPTION: * Major restructuration involving a change of namespace and a simplification of module architecture. * Inclusion of 3D visualization functionalities based on VTK.

- Participant: Guillaume Cerutti
- Contact: Guillaume Cerutti

5.2. draco_stem

DRACO-STEM : Dual Reconstruction by Adjacency Complex Optimization & SAM Tissue Enhanced Mesh

KEYWORDS: Meshing - Image segmentation - Computational biology - Optimization

FUNCTIONAL DESCRIPTION: Draco-stem provides a computational pipeline that allows going from multi-label segmented images of living tissue (typically resulting from a watershed segmentation of 3D microscopy image stacks) to topologically consistent, FEM-ready triangular meshes of all cell interfaces in the tissue.

It relies on an original topological optimization method that aims at reconstructing the simplicial complex of cellular adjacencies from the image, and on dualization and geometrical optimization to obtain a triangle mesh that satisfies simultaneously several quality criteria (triangle regularity, adequation to image, biological priors). The library provides implementations for 3D tissue reconstruction, single-layer 2.5D reconstruction and advanced 2D reconstruction.

RELEASE FUNCTIONAL DESCRIPTION: * Major refactoring, python3 compatibility * Addition of Draco2D functionalities

- Contact: Guillaume Cerutti
- Publication: DRACO-STEM: An Automatic Tool to Generate High-Quality 3D Meshes of Shoot Apical Meristem Tissue at Cell Resolution
- URL: https://gitlab.inria.fr/mosaic/draco_stem.git

5.3. Gnomon

KEYWORDS: 4D - Modelization and numerical simulations - Finite element modelling - Computational biology - Data visualization

SCIENTIFIC DESCRIPTION: Gnomon is a user-friendly computer platform developed by the Mosaic team for seamless simulation of form development in silico. It is intended to be a major tool for the team members to develop, integrate and share their models, algorithms and tools. In Gnomon, a developing form is represented at any time by a central data-structure that contains topological, geometric, genetic and physiological information and that represents the state of the growing form. Flexible components (plugins) make it possible to up-load or to create such data-structures, to program their development, to analyze, visualize them and interact with them in 3D+time.

FUNCTIONAL DESCRIPTION: Gnomon is a plugin-based computational platform for the analysis and simulation of morphogenesis. It relies on a scalable software architecture based on the dtk kernel developed by the group of software engineers (SED) from the Sophia-Antipolis Inria Center. The development of Gnomon aims at answering four main challenges:

* Provide an easily accessible computational tool for the exploration of morphogenesis, by focusing on the deployability of the software (using conda), on the ergonomics of the user interface and the availability of the documentation.

* Give access to powerful tools for the exploration of dynamical forms, through an interactive visualization framework allowing the exploration in space in time and the access to algorithmic resources developed by the team for image sequences of multicellular tissues or collections of branching forms.

* Ensure the interoperability of computational libraries within the platform and its extensibility by a generalized plugin-based architecture (facilitated by the dtk framework) for algorithms, visualizations and data structures, enabling the members of the team and future users to feed the platform with their own C++ and Python libraries.

* Bridge the gap between experimental data and computational simulations by offering the possibility to go from one to the other in the same platform in a nearly transparent way, thanks to a common dynamical system framework integrated to the core of the platform.

Gnomon project organization: * Project leader: Christophe Godin * Software development coordinator: Guillaume Cerutti * DTK coordinators: Julien Wintz, Thibaud Kloczko * Plugin coordinators: Jonathan Legrand, Romain Azais, Olivier Ali, Frédéric Boudon. * Diffusion coordinator: Teva Vernoux

This work is part of the Gnomon ADT project supported by the Inria centers of Grenoble Rhône-Alpes and Sophia-Antipolis Méditerranée.

RELEASE FUNCTIONAL DESCRIPTION: A major technical update has been carried out on the Gnomon platform with the switch of the platform core to dtk2, implying an upgrade of all involved Python code to python 3.6+. The newer version 0.13 displays a clearer and more customizable interface and all functionalities from the version 0.9. In terms of functionalities, a major effort has been put on recovering former applications of the team (LPy and PlantGL) and including them in a robust way in the scope of the platform. A release of the version 1.0 is planned for early 2020 including validated algorithms for the quantitative analysis of 3D images of tissue, a much more robust user interface and an extensive user and developer documentation made available online.

- Participants: Olivier Ali, Frédéric Boudon, Guillaume Cerutti, Florian Gacon, Christophe Godin, Jonathan Legrand and Grégoire Malandain
- Contact: Christophe Godin

5.4. MorphoNet

KEYWORDS: 3D web - Morphogenesis - Big data - 3D reconstruction

FUNCTIONAL DESCRIPTION: MorphoNet is an open-source web-based morphological browser. It consists of a web application, exploiting the Unity3D gaming engine, which offers the user a comprehensive palette of interactions with the data, in order to explore the structure, the dynamics and the variability of biological systems. Users can also project quantitative and genetic properties onto the morphological scaffold, allowing for instance to easily explore the correlation between shape dynamics and gene expression patterns. On top of that, datasets and associated information can be shared with other selected users or with entire groups. This possibility of directly sharing results within and between research communities, together with the use of a unified, human readable format, makes MorphoNet a unique tool for multidisciplinary research. Its web-based, user-friendly and open-source structure is also ideal for science dissemination and teaching.

- Partner: CRBM - Centre de Recherche en Biologie cellulaire de Montpellier
- Contact: Emmanuel Faure
- URL: http://www.morphonet.org

5.5. TimageTK

Tissue Image ToolKit

KEYWORDS: 3D - Image segmentation - Fluorescence microscopy - Image registration - Image processing - Image filter

FUNCTIONAL DESCRIPTION: TimageTK (Tissue Image Toolkit) is a Python package dedicated to image processing of multicellular architectures such as plants or animals and is intended for biologists and modelers. It provides grayscale or labeled image filtering and mathematical morphology algorithms, as well as image registration and segmentation methods.

- Contact: Jonathan Legrand
- URL: https://mosaic.gitlabpages.inria.fr/timagetk/index.html

5.6. treex

KEYWORDS: Graph algorithmics - Data structures - Combinatorics - Machine learning

SCIENTIFIC DESCRIPTION: Trees form an expanded family of combinatorial objects that offers a wide range of application fields, especially in biology, from plant modeling to blood vessels network analysis through study of lineages. Consequently, it is crucial for the team to develop numerical tools and algorithms for processing tree data, in particular to answer questions about the representation of biological organisms and their forms in silico.

treex is a Python 3 library dedicated to the manipulation of tree objects, whatever they are ordered or not, with or without quantitative or qualitative labels.

FUNCTIONAL DESCRIPTION: The package provides a data structure for rooted trees as well as the following main functionalities: - Random generation algorithms - DAG compression for ordered or not, labeled or not, trees - Approximation algorithms for unordered trees - Edit distance for unordered labeled trees - Kernels for ordered or not, labeled or not, trees - Computation of coding processes (Harris path, Lukasiewicz walk and height process) - Visualization algorithms in Matplotlib or in LaTeX

RELEASE FUNCTIONAL DESCRIPTION: In 2019, treex has been published in JOSS (Journal of Open Source Software). The subtree kernel has been released to accompany an article submitted to Journal of Machine Learning Research. In addition, the DAG class and the kernel class have been extensively redesigned to be more user-friendly.

- Participants: Romain Azais, Guillaume Cerutti, Didier Gemmerle and Florian Ingels
- Contact: Romain Azais
- Publication: treex: a Python package for manipulating rooted trees
- URL: https://gitlab.inria.fr/azais/treex

NEUROSYS Project-Team

6. New Software and Platforms

6.1. OpenVIBE

KEYWORDS: Neurosciences - Interaction - Virtual reality - Health - Real time - Neurofeedback - Brain-Computer Interface - EEG - 3D interaction

FUNCTIONAL DESCRIPTION: OpenViBE is a free and open-source software platform devoted to the design, test and use of Brain-Computer Interfaces (BCI). The platform consists of a set of software modules that can be integrated easily and efficiently to design BCI applications. The key features of OpenViBE software are its modularity, its high-performance, its portability, its multiple-users facilities and its connection with high-end/VR displays. The designer of the platform enables to build complete scenarios based on existing software modules using a dedicated graphical language and a simple Graphical User Interface (GUI). This software is available on the Inria Forge under the terms of the AGPL licence, and it was officially released in June 2009. Since then, the OpenViBE software has already been downloaded more than 60000 times, and it is used by numerous laboratories, projects, or individuals worldwide. More information, downloads, tutorials, videos, documentations are available on the OpenViBE website.

- Participants: Cedric Riou, Thierry Gaugry, Anatole Lécuyer, Fabien Lotte, Jussi Tapio Lindgren, Laurent Bougrain, Maureen Clerc and Théodore Papadopoulo
- Partners: INSERM - GIPSA-Lab
- Contact: Anatole Lécuyer
- URL: http://openvibe.inria.fr

<p style="text-align:center;color:red;">**NUMED Project-Team**</p>

4. New Software and Platforms

4.1. Bingham flows

FUNCTIONAL DESCRIPTION: A 1D and 2D code with a new method for the computation of viscoplatic flows with free-surface. It essentially couples Optimization methods and Well-Balanced Finite-Volumes schemes for viscous shallow-water equations (induced by the viscoplastic nature of the fluid). Currently applied to avalanches of dense snow, it is a private code currently actively developed (in C++). One of the key feature is that its well-balanced property allows to obtained the stationary states which are linked to the stopping of the snow avalanche for this highly non-linear type of fluid.
- Contact: Emmanuel Grenier

4.2. OptimChemo

FUNCTIONAL DESCRIPTION: OptimChemo is a userfriendly software designed to study numerically the effect of multiple chemotherapies on simple models of tumour growth and to optimize chemotherapy schedules.
- Participants: Ehouarn Maguet, Emmanuel Grenier, Paul Vigneaux and Violaine Louvet
- Contact: Emmanuel Grenier

4.3. SETIS

KEYWORDS: Health - DICOM - Medical imaging - Drug development

FUNCTIONAL DESCRIPTION: SETIS software is a GUI allowing to treat DICOM medical images to extract pathological data. These data can then be exported and used in a SAEM software (including Monolix (Inria & Lixoft)) for the parameters' estimation of models in the context of population approaches. As an example SETIS can be used to segment and compute the tumor size of a patients from MRI scans taken at different times. The software is sufficiently general to be used in various situations by clinicians (already done by colleagues in Lyon Hospital).
- Participants: Ehouarn Maguet and Paul Vigneaux
- Partner: ENS Lyon
- Contact: Paul Vigneaux

4.4. SIMPHYT

KEYWORDS: Bioinformatics - Cancer - Drug development

FUNCTIONAL DESCRIPTION: SimPHyt is an implementation in Python of the low grad glioma model. The aim is to predict the evolution of the glioma size of patients.
- Participant: Benjamin Ribba
- Contact: Benjamin Ribba

4.5. SITLOG

- Participants: Benjamin Ribba and Morgan Martinet
- Contact: Emmanuel Grenier

4.6. VAXSIMSTAB

KEYWORDS: Bioinformatics - Health - Drug development

FUNCTIONAL DESCRIPTION: VAXSIMSTAB is a modeler stability prediction of vaccine software.
- Participants: Benjamin Ribba, Emmanuel Grenier and Vincent Calvez
- Contact: Benjamin Ribba

<p align="center" style="color:red">OPIS Project-Team</p>

6. New Software and Platforms

6.1. Platforms

6.1.1. The Proximity Operator Repository

Participants: Emilie Chouzenoux and Jean-Christophe Pesquet (in collaboration with Giovanni Chierchia, Univ. Paris Est, and Patrick Combettes, North Carolina State University).
link: http://proximity-operator.net/
Proximity operators have become increasingly important tools as basic building blocks of proximal splitting algorithms, a class of algorithms that decompose complex composite convex optimization methods into simple steps involving one of the functions present in the model. This website provides formulas for efficiently computing the proximity operator of various functions, along with the associated codes.

6.1.2. FIGARO

Participants: Emilie Chouzenoux and Jean-Christophe Pesquet (in collaboration with Claire Lefort, XLIM, Limoges).
link: https://imagejdocu.tudor.lu/plugin/analysis/figaro_psf_3d_optical_microscopy/start
The plugin FIGARO, for ImageJ software, helps tracking resolution of microscope systems by extracting dimensions and orientation of standardized microbeads images, acquired from test samples. In the development of optical microscopes for biomedical imaging, the evaluation of resolution is a fundamental parameter achieved by Point Spread Function (PSF) measurements. Sometimes, PSF measurement procedure is not easy or impossible in case of microspheres images presenting a high noise level. The current method proposed into the plugin FIGARO is based on a variational approach for PSF modeling through multivariate Gaussian fitting, adapted to images acquired in a high noise context [12].

6.1.3. Kymatio

Participant: Edouard Oyallon.
link: http://www.kymat.io
The website shares the software Kymatio for Scattering Transform, that computes cascade of wavelets and modulus non-linearity. The codes have been optimized for GPUs and work on the open-source framework *PyTorch*.

6.1.4. BiasedWalk: Learning latent node features with biased random walks

Participants: Fragkiskos Malliaros and Duong Nguyen (UC San Diego)
link: https://github.com/duong18/BiasedWalk/
The BiasedWalk network representation learning algorithm, computes latent node features on graphs based on biased random walks. The framework has been implemented in Python and has been built upon widely used modules, including `networkx`, `numpy`, `gensim` and `scikit-learn`.

6.1.5. DiffuGreedy: Influence maximization in complex networks based on diffusion cascades

Participants: Fragkiskos Malliaros, Georgios Panagopoulos and Michalis Vazirgiannis (École Polytechnique)
link: https://goo.gl/GpfCVZ
The DiffuGreedy is an algorithm for influence maximization in complex networks, that is based on diffusion cascades. It has been implemented in Python and has been built upon widely used modules, including `networkx`, `igraph`, `numpy` and `pandas`.

6.1.6. Graph-based text categorization

Participants: Fragkiskos Malliaros, Konstantinos Skianis and Michalis Vazirgiannis (École Polytechnique)
link: https://github.com/y3nk0/Graph-Based-TC/
Graph-based TC is a framework for text categorization that relies on a graph representation of documents. The framework uses various graph centrality criteria to determine the importance of a term within a document. It also makes use of word embeddings to further boost the performance of graph-based methods. It has been implemented in Python and has been built upon widely used modules, including `networkx`, `igraph`, `numpy` and `scikit-learn`.

6.1.7. KernelNE - Topical Node Embeddings

Participants: Abdulkadir Çelikkanat, Fragkiskos Malliaros
link: https://abdcelikkanat.github.io/projects/kernelNE/
KernelNE learns node representations on graphs based on a weighted matrix factorization model which encodes random walk-based information about the nodes, as described in [53].

6.1.8. EFGE - Exponential Family Graph Embeddings

Participants: Abdulkadir Çelikkanat, Fragkiskos Malliaros
link: https://abdcelikkanat.github.io/projects/EFGE/
EFGE learns node embeddings generalizing random walk-based network representation learning techniques to exponential family conditional distributions, as described in [54].

6.1.9. Semi-supervised Fake News Detection

Participants: Adrien Benamira, Benjamin Devillers, Etienne Lesot, Ayush K. Ray, Manal Saadi, and Fragkiskos Malliaros
link: https://github.com/bdvllrs/misinformation-detection-tensor-embeddings
We propose a graph-based semi-supervised fake news detection method, based on graph neural networks, as described in [34].

6.1.10. The PINK image library

Participant: Hugues Talbot
link: http://ibipio.hu/joomla/
The PINK image library is a general-purpose, open-source, portable image processing library specializing in discrete geometry and mathematical morphology. It is the result of several decades of research in these domains and features state-of-the art algorithmic implementation of both classical and leading edge DG and MM operators. These include nD parallel thinning and skeletonization methods and efficient hierarchical morphological transforms.

6.1.11. The Vivabrain AngioTK toolkit

Participant: Hugues Talbot
link: https://github.com/vivabrain/angiotk
AngioTK is a toolkit supported by Kitware (the authors of VTK) for the filtering, segmentation, generation and simulation of blood vessels. It was started in the context of the Vivabrain ANR project in 2012, but continues with the same as well as new partners. Applications are numerous, from the simulation and understanding of perfusion (see associated theme) to the simulation of realistic blood flow MRI images with associated ground truth, via the generation of blood vessel atlases.

6.1.12. The PET/CT FIJI Viewer

Participant: Hugues Talbot
link: http://petctviewer.org/
Quantitive Positron Emission Tomography is a new area for which software is not readily availble. With our partners from Toulouse and Beth Israel hospitals, we have proposed a free open-source plugin allowing clinicians to view, interact and perform automated and interactive lesion segmentation in the context of PET/CT.

<p style="text-align:center; color:red;">**PARIETAL Project-Team**</p>

6. New Software and Platforms

6.1. Mayavi

FUNCTIONAL DESCRIPTION: Mayavi is the most used scientific 3D visualization Python software. Mayavi can be used as a visualization tool, through interactive command line or as a library. It is distributed under Linux through Ubuntu, Debian, Fedora and Mandriva, as well as in PythonXY and EPD Python scientific distributions. Mayavi is used by several software platforms, such as PDE solvers (fipy, sfepy), molecule visualization tools and brain connectivity analysis tools (connectomeViewer).

- Contact: Gaël Varoquaux
- URL: http://mayavi.sourceforge.net/

6.2. Nilearn

NeuroImaging with scikit learn

KEYWORDS: Health - Neuroimaging - Medical imaging

FUNCTIONAL DESCRIPTION: NiLearn is the neuroimaging library that adapts the concepts and tools of scikit-learn to neuroimaging problems. As a pure Python library, it depends on scikit-learn and nibabel, the main Python library for neuroimaging I/O. It is an open-source project, available under BSD license. The two key components of NiLearn are i) the analysis of functional connectivity (spatial decompositions and covariance learning) and ii) the most common tools for multivariate pattern analysis. A great deal of efforts has been put on the efficiency of the procedures both in terms of memory cost and computation time.

- Participants: Alexandre Abraham, Alexandre Gramfort, Bertrand Thirion, Elvis Dohmatob, Fabian Pedregosa Izquierdo, Gaël Varoquaux, Loïc Estève, Michael Eickenberg and Virgile Fritsch
- Contact: Bertrand Thirion
- URL: http://nilearn.github.io/

6.3. Scikit-learn

KEYWORDS: Regession - Clustering - Learning - Classification - Medical imaging

SCIENTIFIC DESCRIPTION: Scikit-learn is a Python module integrating classic machine learning algorithms in the tightly-knit scientific Python world. It aims to provide simple and efficient solutions to learning problems, accessible to everybody and reusable in various contexts: machine-learning as a versatile tool for science and engineering.

FUNCTIONAL DESCRIPTION: Scikit-learn can be used as a middleware for prediction tasks. For example, many web startups adapt Scikitlearn to predict buying behavior of users, provide product recommendations, detect trends or abusive behavior (fraud, spam). Scikit-learn is used to extract the structure of complex data (text, images) and classify such data with techniques relevant to the state of the art.

Easy to use, efficient and accessible to non datascience experts, Scikit-learn is an increasingly popular machine learning library in Python. In a data exploration step, the user can enter a few lines on an interactive (but non-graphical) interface and immediately sees the results of his request. Scikitlearn is a prediction engine . Scikit-learn is developed in open source, and available under the BSD license.

- Participants: Alexandre Gramfort, Bertrand Thirion, Fabian Pedregosa Izquierdo, Gaël Varoquaux, Loïc Estève, Michael Eickenberg and Olivier Grisel
- Partners: CEA - Logilab - Nuxeo - Saint Gobain - Tinyclues - Telecom Paris
- Contact: Olivier Grisel
- URL: http://scikit-learn.org

6.4. MODL

Massive Online Dictionary Learning

KEYWORDS: Pattern discovery - Machine learning

FUNCTIONAL DESCRIPTION: Matrix factorization library, usable on very large datasets, with optional sparse and positive factors.

- Participants: Arthur Mensch, Gaël Varoquaux, Bertrand Thirion and Julien Mairal
- Contact: Arthur Mensch
- Publications: Subsampled online matrix factorization with convergence guarantees - hal-01431618v3
- URL: http://github.com/arthurmensch/modl

6.5. MNE

MNE-Python

KEYWORDS: Neurosciences - EEG - MEG - Signal processing - Machine learning

FUNCTIONAL DESCRIPTION: Open-source Python software for exploring, visualizing, and analyzing human neurophysiological data: MEG, EEG, sEEG, ECoG, and more.

RELEASE FUNCTIONAL DESCRIPTION: http://martinos.org/mne/stable/whats_new.html

- Partners: HARVARD Medical School - New York University - University of Washington - CEA - Aalto university - Telecom Paris - Boston University - UC Berkeley
- Contact: Alexandre Gramfort
- URL: http://martinos.org/mne/

6.6. Dmipy

Diffusion MRI Multi-Compartment Modeling and Microstructure Recovery Made Easy

KEYWORDS: Diffusion MRI - Multi-Compartment Modeling - Microstructure Recovery

FUNCTIONAL DESCRIPTION: Non-invasive estimation of brain microstructure features using diffusion MRI (dMRI) – known as Microstructure Imaging – has become an increasingly diverse and complicated field over the last decades. Multi-compartment (MC)-models, representing the measured diffusion signal as a linear combination of signal models of distinct tissue types, have been developed in many forms to estimate these features. However, a generalized implementation of MC-modeling as a whole, providing deeper insights in its capabilities, remains missing. To address this fact, we present Diffusion Microstructure Imaging in Python (Dmipy), an open-source toolbox implementing PGSE-based MC-modeling in its most general form. Dmipy allows on-the-fly implementation, signal modeling, and optimization of any user-defined MC-model, for any PGSE acquisition scheme. Dmipy follows a "building block"-based philosophy to Microstructure Imaging, meaning MC-models are modularly constructed to include any number and type of tissue models, allowing simultaneous representation of a tissue's diffusivity, orientation, volume fractions, axon orientation dispersion, and axon diameter distribution. In particular, Dmipy is geared toward facilitating reproducible, reliable MC-modeling pipelines, often allowing the whole process from model construction to parameter map recovery in fewer than 10 lines of code. To demonstrate Dmipy's ease of use and potential, we implement a wide range of well-known MC-models, including IVIM, AxCaliber, NODDI(x), Bingham-NODDI, the spherical mean-based SMT and MC-MDI, and spherical convolution-based single- and multi-tissue CSD. By allowing parameter cascading between MC-models, Dmipy also facilitates implementation of advanced approaches like CSD with voxel-varying kernels and single-shell 3-tissue CSD. By providing a well-tested, user-friendly toolbox that simplifies the interaction with the otherwise complicated field of dMRI-based Microstructure Imaging, Dmipy contributes to more reproducible, high-quality research.

- Authors: Rutger Fick, Demian Wassermann and Rachid Deriche
- Contact: Rachid Deriche

6.7. PySAP

Python Sparse data Analysis Package

KEYWORDS: Image reconstruction - Image compression

FUNCTIONAL DESCRIPTION: The PySAP (Python Sparse data Analysis Package, https://github.com/CEA-COSMIC/pysap) open-source image processing software package has been developed for the 3 years between the Compressed Sensing group at Iniria-CEA Parietal team led by Philippe Ciuciu and the CosmoStat team (CEA/IRFU) led by Jean-Luc Statck. It has been developed for the COmpressed Sensing for Magnetic resonance Imaging and Cosmology (COSMIC) project. This package provides a set of flexible tools that can be applied to a variety of compressed sensing and image reconstruction problems in various research domains. In particular, PySAP offers fast wavelet transforms and a range of integrated optimisation algorithms. It also offers a variety of plugins for specific application domains: on top of Pysap-MRI and PySAP-astro plugins, several complementary modules are now in development for electron tomography and electron microscopy for CEA colleagues. In October 2019, PySAP has been released on PyPi (https://pypi.org/project/python-pySAP/, currently version 0.0.3) and in conda (https://anaconda.org/agrigis/python-pysap).

The Pysap-MRI has been advertised through a specific abstract accepted to the next workshop of ISMRM on Data Sampling & Image Reconstruction in late January 2020. It will be presented during a power pitch session together wih an hands-on demo session using JuPyter notebooks.

- Partner: CEA
- Contact: Philippe Ciuciu

PLEIADE Project-Team

6. New Software and Platforms

6.1. magecal

KEYWORD: Genomics

SCIENTIFIC DESCRIPTION: Magecal independently runs training and prediction steps for Augustus, Conrad, GeneID, GeneMark, and Snap. The results are cleaned and integrated into a common format. Jigsaw is trained and used for model reconciliation. Consistency constraints are applied to ensure that phase and intron structure are biologically plausible.

FUNCTIONAL DESCRIPTION: Magecal predicts a set of protein coding genes in fungal genomic sequences, using different de novo prediction algorithms, and reconciling the predictions with the aid of comparative data. Magecal applies consistency constraints to guarantee that the predicted genes are biologically valid.

RELEASE FUNCTIONAL DESCRIPTION: Dockerization and compatibility with Alcyone

- Participants: Pascal Durrens and David James Sherman
- Contact: David James Sherman
- URL: https://gitlab.inria.fr/magecal/magecal

6.2. Declic

KEYWORDS: Data analysis - Machine learning - Taxonomies

FUNCTIONAL DESCRIPTION: Declic is a Python library that provides several tools for data analysis in the domains of multivariate data analysis, machine learning, and graph based methods. It can be used to study in-depth the accuracy of the dictionary between molecular based and morphological based taxonomy.

Declic includes an interpreter for a Domain Specific Language (DSL) to make its Python library easy to use for scientists familiar with environments such as R.

- Partner: INRA
- Contact: Alain Franc
- URL: https://gitlab.inria.fr/pleiade/declic

6.3. Magus

KEYWORDS: Bioinformatics - Genomic sequence - Knowledge database

SCIENTIFIC DESCRIPTION: MAGUS can be used on small installations with a web server and a relational database on a single machine, or scaled out in clusters or elastic clouds using Apache Cassandra for NoSQL data storage and Apache Hadoop for Map-Reduce.

FUNCTIONAL DESCRIPTION: The MAGUS genome annotation system integrates genome sequences and sequences features, in silico analyses, and views of external data resources into a familiar user interface requiring only a Web navigator. MAGUS implements annotation workflows and enforces curation standards to guarantee consistency and integrity. As a novel feature the system provides a workflow for simultaneous annotation of related genomes through the use of protein families identified by in silico analyses this has resulted in a three-fold increase in curation speed, compared to one-at-a-time curation of individual genes. This allows us to maintain standards of high-quality manual annotation while efficiently using the time of volunteer curators.

NEWS OF THE YEAR: Magus is now available as a Docker image, and can be integrated with other containerized services using Pleiade's Alcyone system.

- Participants: David James Sherman, Florian Lajus, Natalia Golenetskaya, Pascal Durrens and Xavier Calcas
- Partners: Université de Bordeaux - CNRS - INRA
- Contact: David James Sherman
- Publication: High-performance comparative annotation
- URL: http://magus.gforge.inria.fr

6.4. Mimoza

KEYWORDS: Systems Biology - Bioinformatics - Biotechnology

FUNCTIONAL DESCRIPTION: Mimoza uses metabolic model generalization and cartographic paradigms to allow human experts to explore a metabolic model in a hierarchical manner. Mimoza generalizes genome-scale metabolic models, by factoring equivalent reactions and metabolites while preserving reaction consistency. The software creates an zoomable representation of a model submitted by the user in SBML format. The most general view represents the compartments of the model, the next view shows the visualization of generalized versions of reactions and metabolites in each compartment , and the most detailed view visualizes the initial model with the generalization-based layout (where similar metabolites and reactions are placed next to each other). The resulting map can be explored on-line, or downloaded in a COMBINE archive. The zoomable representation is implemented using the Leaflet JavaScript library for mobile-friendly interactive maps. Users can click on reactions and compounds to see the information about their annotations.

NEWS OF THE YEAR: Mimoza is now available as a Docker image, and can be integrated with other containerized services using Pleiade's Alcyone system.

- Participants: Anna Zhukova and David James Sherman
- Contact: David James Sherman
- Publications: Knowledge-based generalization of metabolic models - Knowledge-based zooming for metabolic models - Knowledge-based generalization of metabolic networks: a practical study
- URL: http://mimoza.bordeaux.inria.fr/

6.5. Diagno-Syst

diagno-syst: a tool for accurate inventories in metabarcoding

KEYWORDS: Biodiversity - Clustering - Ecology

FUNCTIONAL DESCRIPTION: Diagno-syst builds accurate inventories for biodiversity. It performs supervised clustering of reads obtained from a next-generation sequencing experiment, mapping onto an existing reference database, and assignment of taxonomic annotations.

- Participants: Alain Franc, Jean-Marc Frigerio, Philippe Chaumeil and Franck Salin
- Partner: INRA
- Contact: Alain Franc
- Publication: diagno-syst: a tool for accurate inventories in metabarcoding

6.6. Alcyone

Alcyone instantiates bioinformatics environments from specifications committed to a Git repository

KEYWORDS: Docker - Orchestration - Bioinformatics - Microservices - Versioning

SCIENTIFIC DESCRIPTION: Alcyone conceives the user's computing environment as a microservices architecture, where each bioinformatics tool in the specification is a separate containerized Docker service. Alcyone builds a master container for the specified environment that is responsible for building, updating, deploying and stopping these containers, as well as recording and sharing the environment in a Git repository. The master container can be manipulated using a command-line interface.

FUNCTIONAL DESCRIPTION: Alcyone defines a file structure for the specifying bioinformatics analysis environments, including tool choice, interoperability, and sources of raw data. These specifications are recorded in a Git repository. Alcyone compiles a specification into a master Docker container that deploys and orchestrates containers for each of the component tools. Alcyone can restore any version of an environment recorded in the Git repository.

NEWS OF THE YEAR: Alcyone was designed and implemented this year.

- Participants: Louise-Amelie Schmitt and David James Sherman
- Contact: David James Sherman
- URL: https://team.inria.fr/pleiade/alcyone/

6.7. family-3d

KEYWORDS: Biodiversity - Point cloud - 3D modeling

SCIENTIFIC DESCRIPTION: The method statistically selects a subset of pairwise distances between proteins in the family, constructs a weighted graph, and lays it out using an adaptation of the three-dimensional extension of the Kamada-Kawai force-directed layout.

FUNCTIONAL DESCRIPTION: Family-3D lays out high-dimension protein family point clouds in 3D space. The resulting lower-dimension forms can be printed, so that they can be explored and compared manually. They can also be explored interactively or stereographically.

Comparison of the 3D forms reveals classes of structurally similar families, whose characteristic shapes correspond to different evolutionary scenarios. Some of these scenarios are: neofunctionalization, subfunctionalization, founder gene effect, ancestral family.

To facilitate curator training, Family-3D includes an interactive terminal containing a microcontroller, an RFID reader, and an LED ring. A set of shapes that fall in predetermined classes is printed, with a unique RFID tag in each shape. Trainees classify family shapes by manual inspection and submit their classes to the terminal, which evaluates the proposed class and provides visual feedback.

- Participant: David James Sherman
- Contact: David James Sherman
- URL: https://gitlab.inria.fr/pleiade/family-3d

6.8. Yapotu

Yet Another Pipeline for OTU building

KEYWORDS: Taxonomies - Distance matrices - Clustering - Metagenomics

FUNCTIONAL DESCRIPTION: OTU building is one of the key operation in metabarcoding: how to delimit Operational Taxonomic Units in the "soup" where all amplicons of thousands of unicellular organisms have been lumped together (from visible plankton to nano- and picoplankton, for example). Yapotu is a software tool that enables approaches to unsupervised clustering on very large matrices of distances: each element is a distance between two reads produced by a sequencer. It permits one to select one method among several, like building MultiDimensional Scaling to produce an Euclidean image, and clustering within the point cloud, or building a graph where a node is a sequence and there is an edge if both sequences are at a distance smaller than a given threshold, and then after build connected components or communities on this graph. Other functions visualize the OTUs as clusters or subgraphs.

- Contact: Alain Franc
- URL: https://gitlab.inria.fr/afranc/diodon/tree/master/yapotu

6.9. Diodon

KEYWORDS: Dimensionality reduction - Data analysis

FUNCTIONAL DESCRIPTION: Most of dimension reduction methods inherited from Multivariate Data Analysis, and currently implemented as element in statistical learning for handling very large datasets (the dimension of spaces is the number of features) rely on a chain of pretreatments, a core with a SVD for low rank approximation of a given matrix, and a post-treatment for interpreting results. The costly part in computations is the SVD, which is in cubic complexity. Diodon is a list of functions and drivers which implement (i) pre-treatments, SVD and post-treatments on a large diversity of methods, (ii) random projection methods for running the SVD which permits to bypass the time limit in computing the SVD, and (iii) an implementation in C++ of the SVD with random projection at prescribed rank or precision, connected to MDS.

- Contact: Alain Franc
- URL: https://gitlab.inria.fr/afranc/diodon

REO Team (section vide)

SERENA Project-Team

6. New Software and Platforms

6.1. CELIA3D

KEYWORDS: Fluid mechanics - Multi-physics simulation

FUNCTIONAL DESCRIPTION: The CELIA3D code simulates the coupling between a compressible fluid flow and a deformable structure. The fluid is handled by a Finite Volume method on a structured Cartesian grid. The solid is handled by a Discrete Element method (Mka3d scheme). The solid overlaps the fluid grid and the coupling is carried out with immersed boundaries (cut cells) in a conservative way.

- Partners: Ecole des Ponts ParisTech - CEA
- Contact: Laurent Monasse
- URL: http://cermics.enpc.fr/~monassel/CELIA3D/

6.2. DiSk++

Discontinuous Skeletal C++ Library

KEYWORDS: High order methods - Polyhedral meshes - C++

SCIENTIFIC DESCRIPTION: Discontinuous Skeletal methods approximate the solution of boundary-value problems by attaching discrete unknowns to mesh faces (hence the term skeletal) while allowing these discrete unknowns to be chosen independently on each mesh face (hence the term discontinuous). Cell-based unknowns, which can be eliminated locally by a Schur complement technique (also known as static condensation), are also used in the formulation. Salient examples of high-order Discontinuous Skeletal methods are Hybridizable Discontinuous Galerkin methods and the recently-devised Hybrid High-Order methods. Some major benefits of Discontinuous Skeletal methods are that their construction is dimension-independent and that they offer the possibility to use general meshes with polytopal cells and non-matching interfaces. The mathematical flexibility of Discontinuous Skeletal methods can be efficiently replicated in a numerical software: by using generic programming, the DiSk++ library offers an environment to allow a programmer to code mathematical problems in a way completely decoupled from the mesh dimension and the cell shape.

FUNCTIONAL DESCRIPTION: The software provides a numerical core to discretize partial differential equations arising from the engineering sciences (mechanical, thermal, diffusion). The discretization is based on the "Hybrid high-order" or "Discontinuous Skeletal" methods, which use as principal unknowns polynomials of arbitrary degree on each face of the mesh. An important feature of these methods is that they make it possible to treat general meshes composed of polyhedral cells. The DiSk ++ library, using generic programming techniques, makes it possible to write a code for a mathematical problem independently of the mesh. When a user writes the code for his problem using the basic operations offered by DiSk ++, that code can be executed without modifications on all types of mesh already supported by the library and those that will be added in the future.

- Author: Matteo Cicuttin
- Partner: CERMICS
- Contact: Matteo Cicuttin
- Publication: Implementation of Discontinuous Skeletal methods on arbitrary-dimensional, polytopal meshes using generic programming
- URL: https://github.com/wareHHOuse/diskpp

6.3. NEF-Draw

Numerical Experiments involving Fractures -Visualisation

KEYWORD: Fracture network

SCIENTIFIC DESCRIPTION: This version includes Matlab vectorization of the operations which makes it possible to load flow solution on meshes with more than one million fractures. It includes a text menu allowing the user to choose between different visualisation options (geometry, mesh together with the aspect ratio or together with the flow solution). A selective visualisation of fractures is also possible, by loading only the fractures that carry most of the flow.

FUNCTIONAL DESCRIPTION: This software is a visualization tool of discrete fractured networks. It allows the visualization of the network geometry, the mesh of the network together with several quantities of interest (mesh quality, flow solution including wells) computed with the software NEF-Flow.

NEWS OF THE YEAR: Add vizualization of new quantities (a posteriori estimators, velocity fields,...). New features for user-friendly usage of NEF-Draw.

- Participant: Géraldine Pichot
- Contact: Géraldine Pichot
- URL: https://gitlab.inria.fr/gpichot/NEF

6.4. NEF-Flow

KEYWORDS: Hydrogeology - Numerical simulations - 3D

SCIENTIFIC DESCRIPTION: NEF-Flow is a Matlab software for the simulation of steady state single phase flow in Discrete Fracture Networks (DFNs) using the Mixed Hybrid Finite Element (MHFEM) method for conforming and non conforming discretizations. It includes: wells, sink/source terms boundary conditions, implementation of RT0 and P1 non conforming finite elements, data structures to save the information local to each fracture, a set of non regression tests to check the solution on the Inria continuous integration platform, wells and sink/sources boundary conditions in the function that check the solution.

FUNCTIONAL DESCRIPTION: The software NEF-Flow solves the problem of an incompressible fluid flowing through a network of fractures. The software is interfaced with different mesh generators, among which BLSURF from the GAMMA3 team. A mixed hybrid finite element method is implemented.

NEWS OF THE YEAR: The last version includes new features (new APP v1.1): a full documentation of the code, new 2D test cases with analytical solutions to study the convergence of the non-conforming (Mortar) method, new organization of the non regression tests and automatic run on the Inria continuous integration platform, a refactoring of the solver parts, new developments of an iterative solver to solve flow in fractures networks (research work with Pr. Ludmil Zikatanov, PennState University), the computation of the velocity fields with P1 non conforming FE.

- Participants: Géraldine Pichot, Jean-Raynald De Dreuzy and Jocelyne Erhel
- Contact: Géraldine Pichot
- Publication: A mixed hybrid Mortar method for solving flow in discrete fracture networks
- URL: https://gitlab.inria.fr/gpichot/NEF

6.5. NEF++

KEYWORDS: Fracture network - Finite element modelling - High order methods

SCIENTIFIC DESCRIPTION: NEF++ is able to solve in a very efficient way flow in large scale fractures networks using the HHO method.

FUNCTIONAL DESCRIPTION: The software NEF++ allows to solve flow problems in fractured rocks. It is based on a hybrid high order (HHO) method. It is based on the C++17 standard. It relies on the Eigen library, which is a C++ template library for linear algebra and on the DiSk++ library for HHO https://bil.inria.fr/fr/software/view/3143/tab. The linear systems can be solved with direct solvers or with iterative solvers like the preconditioned conjugate gradient or multigrid solvers.

RELEASE FUNCTIONAL DESCRIPTION: Work in progress, no production release yet.

NEWS OF THE YEAR: NEF++ has been successfully tested on networks that contain up to 500,000 fractures. The following two direct solvers can be called: Pardiso from Intel MKL library or SuiteSparse. Both solvers support tasks parallelism, either using OpenMP or Intel TBB and support SIMD (Single Instruction, Multiple Data) vectorization. The input parameters are JSON files. The mesh data are in .vector files (see Appendix A, publication hal-00735675). The outputs are written in HDF5 files.

- Participants: Florent Hedin, Géraldine Pichot, Alexandre Ern and Nicolas Pignet
- Contact: Géraldine Pichot
- Publication: A hybrid high-order method for flow simulations in discrete fracture networks.
- URL: https://gitlab.inria.fr/nef/NEFpp

6.6. NEF-Flow-a-posteriori

KEYWORD: A posteriori error estimates

SCIENTIFIC DESCRIPTION: The a posteriori error estimates that are implemented are the ones described in the publication https://hal.archives-ouvertes.fr/hal-00019800/document.

FUNCTIONAL DESCRIPTION: Compute a posteriori estimators for diffusion problems.

NEWS OF THE YEAR: New software: implementation of the estimators, management of input files with Json.

- Participants: Géraldine Pichot and Martin Vohralík
- Contact: Géraldine Pichot
- Publication: A posteriori error estimates for lowest-order mixed finite element discretizations of convection-diffusion-reaction equations
- URL: https://gitlab.inria.fr/gpichot/nef-flow-a-posteriori

6.7. SBM

Skew Brownian Motion

KEYWORDS: Monte-Carlo methods - Skew Brownian Motion

FUNCTIONAL DESCRIPTION: SBM is a code allowing exact or approximated simulations of the Skew Brownian Motion. This code is used for the simulation, with a Monte-Carlo approach, of a 1D diffusion process with a discontinuous diffusion coefficient. Several benchmark tests are also implemented.

NEWS OF THE YEAR: - Refactoring and Cmake compilation - Automatic non regression tests on ci-inria.fr - Full documentation - Open source project on gitlab-inria

- Authors: Antoine Lejay and Géraldine Pichot
- Contact: Antoine Lejay
- Publication: Simulating diffusion processes in discontinuous media: Benchmark tests
- URL: https://gitlab.inria.fr/lejay/sbm

SERPICO Project-Team

6. New Software and Platforms

6.1. GcoPS

KEYWORDS: Photonic imaging - Fluorescence microscopy - Image processing - Statistic analysis

FUNCTIONAL DESCRIPTION: The GcoPS (Geo-Co-Positioning System) software is dedicated to the co-localization of fluorescence image pairs for both conventional and super-resolution microscopy. The procedure is only controlled by a p-value and tests whether the Pearson correlation between two binary images is significantly positive. Colocalization amounts here to quantifying the interaction strength by the area/volume of the intersection between the two binary images viewed as random distributions of geometrical objects. Under mild assumptions, it turns out that the appropriately normalized Pearson correlation follows a standard normal distribution under the null hypothesis if the number of image pixels is large. Unlike previous methods, GcoPS handles 2D and 3D images, variable SNRs and any kind of cell shapes. It is able to co-localize large regions with small dots, as it is the case in TIRF-PALM experiments and to detect negative co-localization. The typical processing time is two milliseconds per image pair in 2D and a few seconds in 3D, with no dependence on the number of objects per image. In addition, the method provides maps to geo-co-localize molecule interactions in specific image regions.

- Participants: Thierry Pécot, Frédéric Lavancier, Charles Kervrann and Liu Zengzhen
- Partners: Université de Nantes - UMR 144 CNRS - Institut Curie - Hollings Cancer Center at the Medical University of South Carolina, Charleston SC, USA
- Contact: Charles Kervrann
- Publication: Testing independence between two random sets for the analysis of colocalization in bioimaging
- URL: http://icy.bioimageanalysis.org/plugin/GcoPS

6.2. THOTH

Testing HypOtheses for diffusion TricHotomy

KEYWORDS: Photonic imaging - Fluorescence microscopy - Biomedical imaging - Classification - Statistical categorisation techniques - Statistics - Image sequence - Visual tracking

FUNCTIONAL DESCRIPTION: The THOTH software classifies biomolecule trajectories of biomolecules (computed with tracking algorithms) into three groups of diffusion: (i) free diffusion, (ii) subdiffusion or (iii) superdiffusion. Brownian motion corresponds to the NULL hypothesis. THOTH is a nonparametric three-decision test whose alternatives are subdiffusion and superdiffusion. Single and multiple testing procedures control respectively the type I error and the false discovery rate. THOTH can be considered as an alternative to the Mean Square Displacement (MSD) method commonly used to address this issue. It gives more reliable results as confirmed by our Monte Carlo simulations and evaluations on real sequences of images depicting protein dynamics acquired with TIRF or SPT-PALM microscopy.

- Participants: Vincent Briane, Charles Kervrann and Myriam Vimond
- Partner: ENSAI
- Contact: Charles Kervrann
- Publication: Statistical analysis of particle trajectories in living cells
- URL: https://team.inria.fr/serpico/software/thot/

6.3. SparseVolution

Sparse Variation for 2D Image Decovolution

KEYWORDS: Fluorescence microscopy - Image processing - Deconvolution - Inverse problem

FUNCTIONAL DESCRIPTION: In order to improve the resolution of acquired fluorescence images, we introduced a method of image deconvolution by considering a family of convex regularizers. The considered regularizers are generalized from the concept of Sparse Variation which combines the L1 norm and the first (Total Variation) or second (Hessian Variation) derivatives to favor the colocalization of high-intensity pixels and high-magnitude gradient. The experiments showed that the proposed regularization approach produces competitive deconvolution results on fluorescence images, compared to those obtained with other approaches such as TV or the Schatten norm of Hessian matrix. The final algorithm has been dedicated to deconvolve very large 2D (e.g. 20 000 x 20 000) images or 3D images.

- Participants: Hoai Nam Nguyen, Charles Kervrann, Sylvain Prigent and Cesar Augusto Valades Cruz
- Partners: Innopsys - UMR 144 CNRS - Institut Curie
- Contact: Charles Kervrann

6.4. AiryscanJ

Reconstruction of AiryScan microscopy images

KEYWORDS: Image reconstruction - Fluorescence microscopy - Photonic imaging - Deconvolution - Image analysis

FUNCTIONAL DESCRIPTION: The AiryscanJ software enables to reconstruct a high resolution image from an array of multiple raw images acquired with the Airyscan technology (32 detectors). Airyscanning is a recent technique based on confocal laser scanning microscopy. The AiryscanJ software gathers four reconstruction methods (ISM, IFED, ISFED, ISM-Deconvolution) to compute a high resolution image: 1/ ISM amounts to summing the preliminarily registered raw images. 2/ IFED is the weighted difference between the inner detectors and the outer detector. 3/ ISFED is the weighted difference between the registered outer detectors and the original outer detectors. AiryscanJ automatically estimates the parameter controlling the IFED and ISFED algorithms. 4/ ISM-Deconvolution allows reconstructing a high resolution image by applying a deconvolution algorithm on the ISM image.

- Participants: Sylvain Prigent, Stephanie Dutertre and Charles Kervrann
- Partners: Université de Rennes 1 - CNRS
- Contact: Charles Kervrann
- URL: https://gitlab.inria.fr/serpico/airyscanj_bin

6.5. DeepFinder

Deep learning for macromolecule identification within 3D cellular cryo-electron tomograms

KEYWORDS: Image analysis - Deep learning - Cryo-electron microscopy - Object detection

FUNCTIONAL DESCRIPTION: DeepFinder is a computational approach that uses artificial neural networks to accurately and jointly localize multiple types and/or states of macromolecules in 3D cellular cryo-electron tomograms. DeepFinder leverages deep learning and outperforms the commonly-used template matching method on ideal data. On synthetic image data (SHREC 2019 challenge), DeepFinder is very fast and produces superior detection results when compared to other competitive deep learning methods, especially on small macromolecules. On experimental cryo-ET data depicting ribosomes, the detection results obtained by DeepFinder are consistent with expert annotations. We have got a high overlap of 86% and a similar structure resolution determined by subtomogram averaging.

- Participants: Emmanuel Moebel, Antonio Martinez and Charles Kervrann
- Partners: Max Planck Institute Martinsried - Fondation Fourmentin-Guilbert
- Contact: Charles Kervrann
- URL: https://gitlab.inria.fr/serpico/deep-finder

6.6. CPAnalysis

Change point detection algorithm for detecting switches of diffusion along 2D-3D single particle trajectories

KEYWORDS: Statistical modeling - Statistical physics - Fluorescence microscopy - Motion analysis

FUNCTIONAL DESCRIPTION: The change point detection algorithm is designed for detecting switches of diffusion along a given 2D-3D particle trajectory. We consider that the particle can switch between three main motion modes: 1/ Superdiffusion which occurs when the particle is transported via molecular motors along the cytoskeleton, 2/ Free diffusion (or Brownian motion) which arises when the particle evolves freely inside the cytosol, 3/ Subdiffusion observed when the particle is confined in a domain or evolves in a crowded area. The algorithm is a sequential nonparametric procedure based on a nonparametric three-decision test computed on local sliding windows along the trajectory.

- Participants: Antoine Salomon, Vincent Briane, Myriam Vimond, Jean Salamero and Charles Kervrann
- Partners: ENSAI - UMR 144 CNRS - Institut Curie
- Contact: Charles Kervrann
- Publication: A sequential algorithm to detect diffusion switching along intracellular particle trajectories
- URL: https://team.inria.fr/serpico/software/cpanalysis/

6.7. FlowScope

Optical flow computation for 3D fluorescence microscopy

KEYWORDS: Motion analysis - Fluorescence microscopy - Image analysis - Data visualization

FUNCTIONAL DESCRIPTION: The FLOWSCOPE software is able to estimate 3D motion between two fluorescence microscopy volumes. The underlying variational method amounts to minimizing an energy functional made up of two terms: a data term and a regularization term. The data term is derived from the continuous form of Census signature and the smoothness of the flow field is imposed by a L2 regularization term. The method is implemented for a single core CPU. FLOWSCOPE outputs three separate files corresponding to the motion vector components. The flow fields can be visualized with an appropriate color code named 3PHS. The 3PHS map projects the flow field onto the three orthogonal planes selected by the user. The projections of the vector field is color coded in the Hue (direction) and the Saturation (amplitude) spaces.

- Participants: Patrick Bouthemy, Charles Kervrann, Sylvain Prigent, Leo Maury and Philippe Roudot
- Partner: Danuser lab, University of Texas Southwestern, Dallas, USA
- Contact: Sandeep Manandhar
- Publication: 3D Flow Field Estimation and Assessment for Live Cell Fluorescence Microscopy
- URL: https://gitlab.inria.fr/smanandh/flowscope

6.8. MWR

Missing Wedge Restoration (MWR) and Noise Removal in 3D Cryo-Tomography

KEYWORDS: Image analysis - Inverse problem - Cryo-electron microscopy - Monte-Carlo methods - Bayesian estimation

FUNCTIONAL DESCRIPTION: The Missing Wedge Restoration (MWR) software enables to reduce the high amount of noise and artifacts observed in 3D cellular cryo-tomograms, induced by the presence of a missing wedge (MW) in the spectral domain. MWR takes as input a 3D tomogram derived from limited-angle tomography, and gives as output a 3D denoised and artifact compensated volume. The artifact compensation is achieved by filling up the MW with meaningful information. A Minimum Mean Square Error (MMSE) estimator is computed by applying a dedicated Markov Chain Monte-Carlo (MCMC) sampling procedure based on the Metropolis-Hasting algorithm. MWR can be used to enhance visualization or as a pre-processing step for image analysis, including segmentation and classification of macromolecules.

- Participants: Emmanuel Moebel and Antonio Martinez
- Partners: Max Planck Institute Martinsried - Fondation Fourmentin-Guilbert
- Contact: Charles Kervrann
- Publication: A Monte Carlo framework for missing wedge restoration and noise removal in cryo-electron tomography
- URL: https://gitlab.inria.fr/serpico/mwr

6.9. Platforms

6.9.1. *Mobyle@serpico platform and software distribution*
Participants: Sylvain Prigent, Léo Maury, Charles Kervrann.

Figure 2. Mobyle@serpico web portal.

The objective is to disseminate the distribution of SERPICO image processing software in the community of cell biology and cell imaging.

Free binaries: software packages have been compiled for the main operating systems (Linux, MacOS, Windows) using CMake (see http://www.cmake.org/). A few of them are freely available on the team website https://team.inria.fr/serpico/software/ under a proprietary license.

Mobyle@serpico web portal: An on-line version (http://mobyle-serpico.rennes.inria.fr) of the image processing algorithms has been developed using the Mobyle framework (Institut Pasteur, see http://mobyle.pasteur.fr/). The main role of this web portal (see Fig. 2) is to demonstrate the performance of the programs developed by the team: QuantEv, C-Craft[9], Atlas[1], Hullkground[48], KLTracker[52], Motion2D[51], MS-detect[49], ND-Safir[4], OpticalFlow and Flux Estimation [9]. The web interface makes our image processing methods available for biologists at Mobyle@serpico without any installation or configuration on their own. The size of submitted images is limited to 200 MegaBytes per user and all the results are kept 15 days. The web portal and calculations run on a server with 2 CPU x 8 cores, 64 GigaBytes of RAM (500 MegaBytes for each user. Data is saved for 3 months).

ImageJ plugins: ImageJ (see http://rsb.info.nih.gov/ij/) is a widely used image visualization and analysis software for biologist users. We have developed ImageJ plug-in Java versions of the following software: ND-Safir [4], Hullkground [48], Motion2D [51], Atlas [1]. The C-Craft [9], QuantEv and GcoPS [19] algorithms have been developed for the image processing ICY platform (http://icy.bioimageanalysis.org/).

Partners: CNRS-UMR 144 Institut Curie & France-BioImaging (UMS 3714 CEMIBIO).

6.9.2. *Bioimage-IT for bioimage management and processing*

Participants: Sylvain Prigent, Cesar Augusto Valades Cruz, Léo Maury, Jean Salamero, Charles Kervrann.

New image acquisition systems generate large number of images and large volume images. Such data sets are hard to store, to process and to analyze for one user in a workstation. Many solutions exist for data management (e.g. Omero, OpenImadis), image analysis (e.g. Fiji, Icy, CellProfiler) and statistics (e.g R). Each of them has its specificities and several bridges have been developed between pieces of software. Nevertheless, in many use-cases, we need to perform analysis using tools that are available in different pieces of software and different languages. It is then tedious to create a workflow that brings the data from one tool to another. It needs programing skills and most of the time, a dedicated script using a dedicated file system for processed data management is developed. The aim of BioImage-IT is to create a "bandmaster" application that allow any scientist to annotate, process, and analyze data using only one single high level application. This BioImage-IT application is based on 3 components:

- an image annotation method based on a JSON file system,
- an image processing and analysis tools integration method based on Docker and XML commands description,
- an application with a graphical interface to easily annotate data, run processing tools, and visualize data and results.

This software architecture has three main goals. First, data are annotated using a file system. This means that data are not dependent on any software like a SQL database, and each experiment can then be stored in a different directory and can be moved from one server to another or to any drive with a simple copy pasting operation. Second, the processing tools are used as binary packages managed by the Docker technology. Docker enables to gently handle dependencies and several versions of the same tool. Any existing tool can then be integrated in its native programming language. Third, using a single "bandmaster" application allows one to automatically generate metadata for any processed data, improving the traceability and the repeatability of any experimental result.

BioImage-IT (https://project.inria.fr/bioimageit) is developed in the context of the France-BioImaging research infrastructure in coordination with the IPDM-FBI (Image Processing and Data Management) node in order to provide a standardized image processing tool set and data management for the imaging facilities.

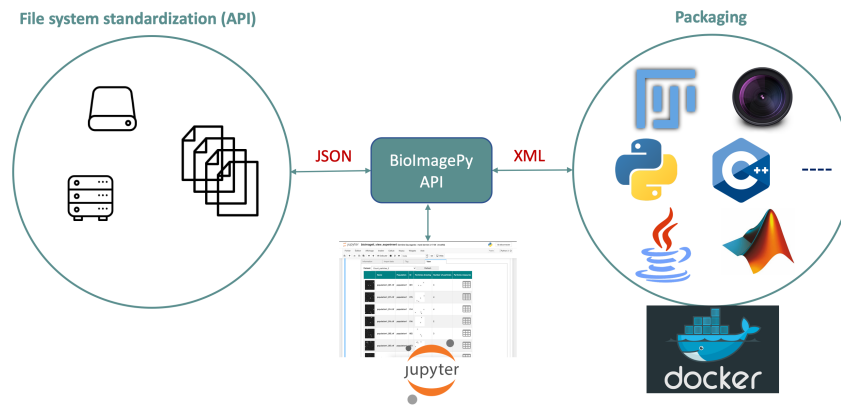**Partners:** CNRS-UMR 144 and U1143 INSERM/CNRS-UMR 3666, Institut Curie & France-BioImaging (UMS 3714 CEMIBIO).

Figure 3. Scheme of the BioImage-IT components interactions.

SISTM Project-Team

6. New Software and Platforms

6.1. marqLevAlg

KEYWORDS: Optimization - Biostatistics

FUNCTIONAL DESCRIPTION: An R package for function optimization. Available on CRAN, this package performs a minimization of function based on the Marquardt-Levenberg algorithm. This package is really useful when the surface to optimize is non-strictly convex or far from a quadratic function. A new convergence criterion, the relative distance to maximum (RDM), allows the user to have a better confidence in the stopping points, other than basic algorithm stabilization.

RELEASE FUNCTIONAL DESCRIPTION: This package has been updated so that the optimization is done in parallel and goes faster. This update has been done in collaboration Viviane Philipps and Cecile Proust-Lima from Inserm BPH

- Partner: INSERM
- Contact: Melanie Prague
- URL: https://cran.r-project.org/web/packages/marqLevAlg/index.html

6.2. VSURF

Variable Selection Using Random Forests

KEYWORDS: Classification - Statistics - Machine learning - Regression

FUNCTIONAL DESCRIPTION: An R package for Variable Selection Using Random Forests. Available on CRAN, this package performs an automatic (meaning completely data-driven) variable selection procedure. Originally designed to deal with high dimensional data, it can also be applied to standard datasets.

RELEASE FUNCTIONAL DESCRIPTION: * add RFimplem parameter which allows to choose between randomForest, ranger and Rborist to compute random forests predictors. This can be a vector of length 3 to chose a different implementation for each step of VSURF() * update of the parallel and clusterType parameters to also give the possibility to choose which step to perform in parallel with a clusterType per step * add progress bars and information of the progress of the algorithm, and also an estimated computational time for each step

- Contact: Robin Genuer
- URL: https://github.com/robingenuer/VSURF

6.3. NPflow

Bayesian Nonparametrics for Automatic Gating of Flow-Cytometry Data

KEYWORDS: Bayesian estimation - Bioinformatics - Biostatistics

FUNCTIONAL DESCRIPTION: Dirichlet process mixture of multivariate normal, skew normal or skew t-distributions modeling oriented towards flow-cytometry data pre-processing applications.

- Contact: Boris Hejblum
- URL: https://CRAN.R-project.org/package=NPflow

6.4. COVVSURF

Combination of Clustering Of Variables and Variable Selection Using Random Forests

KEYWORDS: Classification - Statistics - Cluster - Machine learning - Regression

- Contact: Robin Genuer
- URL: https://github.com/robingenuer/CoVVSURF

6.5. clogitLasso

KEYWORDS: Biostatistics - Bioinformatics - Machine learning - Regression

FUNCTIONAL DESCRIPTION: R package to fit a sequence of conditional logistic regression models with lasso, for small to large sized samples.

RELEASE FUNCTIONAL DESCRIPTION: Optimisation

- Partner: DRUGS-SAFE
- Contact: Marta Avalos Fernandez
- URL: https://cran.r-project.org/web/packages/clogitLasso/index.html

6.6. TcGSA

Time-course Gene Set Analysis

KEYWORDS: Bioinformatics - Genomics

FUNCTIONAL DESCRIPTION: An R package for the gene set analysis of longitudinal gene expression data sets. This package implements a Time-course Gene Set Analysis method and provides useful plotting functions facilitating the interpretation of the results.

- Contact: Boris Hejblum
- URL: https://CRAN.R-project.org/package=TcGSA

6.7. NIMROD

Normal approximation Inference in Models with Random effects based on Ordinary Differential equations

KEYWORDS: Ordinary differential equations - Statistical modeling

FUNCTIONAL DESCRIPTION: We have written a specific program called NIMROD for estimating parameter of ODE based population models.

- Contact: Melanie Prague
- URL: http://etudes.isped.u-bordeaux2.fr/BIOSTATISTIQUE/NIMROD/documentation/html/index.html

6.8. tcgsaseq

Time-Course Gene Set Analysis for RNA-Seq Data

KEYWORDS: Genomics - Biostatistics - Statistical modeling - RNA-seq - Gene Set Analysis

FUNCTIONAL DESCRIPTION: Gene set analysis of longitudinal RNA-seq data with variance component score test accounting for data heteroscedasticity through precision weights.

- Contact: Boris Hejblum
- URL: https://CRAN.R-project.org/package=tcgsaseq

6.9. cytometree

KEYWORDS: Clustering - Biostatistics - Bioinformatics

FUNCTIONAL DESCRIPTION: Given the hypothesis of a bimodal distribution of cells for each marker, the algorithm constructs a binary tree, the nodes of which are subpopulations of cells. At each node, observed cells and markers are modeled by both a family of normal distributions and a family of bimodal normal mixture distributions. Splitting is done according to a normalized difference of AIC between the two families.

- Contact: Boris Hejblum
- URL: https://CRAN.R-project.org/package=cytometree

6.10. CRTgeeDR

KEYWORDS: Missing data - Statistics - Regression

FUNCTIONAL DESCRIPTION: The CRTgeeDR package allows you to estimates parameters in a regression model (with possibly a link function). It allows treatment augmentation and IPW for missing outcome. It is particularly of use when the goal is to estimate the intervention effect of a prevention strategy agains epidemics in cluster randomised trials.

- Contact: Melanie Prague
- URL: https://cran.r-project.org/web/packages/CRTgeeDR/index.html

6.11. ludic

KEYWORDS: Probability - Biostatistics

FUNCTIONAL DESCRIPTION: An R package to perform probabilistic record Linkage Using only DIagnosis Codes without direct identifiers, using C++ code to speed up computations. Available on CRAN, development version on github.

- Contact: Boris Hejblum
- URL: https://CRAN.R-project.org/package=ludic

6.12. CoDaPCA

KEYWORDS: Unsupervised learning - PCA

FUNCTIONAL DESCRIPTION: R functions associated to the article Avalos et al. Representation Learning of Compositional Data. NeurIPS 2018 http://papers.nips.cc/paper/7902-representation-learning-of-compositional-data

- Contact: Marta Avalos Fernandez
- URL: https://github.com/sistm/CoDa-PCA

6.13. Left-censored Lasso

KEYWORDS: Biostatistics - Machine learning

FUNCTIONAL DESCRIPTION: R function associatied to the article Soret et al. Lasso regularization for left-censored Gaussian outcome and high-dimensional predictors. BMC Medical Research Methodology (2018) 18:159 https://doi.org/10.1186/s12874-018-0609-4

RELEASE FUNCTIONAL DESCRIPTION: https://github.com/psBiostat/left-censored-Lasso

- Contact: Marta Avalos Fernandez

6.14. dd-sPLS

Data-Driven Sparse PLS

KEYWORDS: Marker selection - Classification - Regression - Missing data - Multi-Block - High Dimensional Data - PLS - SVD

SCIENTIFIC DESCRIPTION: Allows to build Multi-Data-Driven Sparse PLS models. Multi-blocks with high-dimensional settings are particularly sensible to this. Whatsmore it deals with missing samples (entire lines missing per block) thanks to the Koh-Lanta algorithm. SVD decompositions permit to offer a fast and controlled method.

FUNCTIONAL DESCRIPTION: That software solves the missing samples problem selecting interesting variables under multi-block supervised settings.

- Contact: Hadrien Lorenzo
- URL: https://hadrienlorenzo.netlify.com/projects/ddspls/

6.15. kernscr

KEYWORDS: Genomics - Biostatistics

FUNCTIONAL DESCRIPTION: An R package to perform KERNel machine score test for pathway analysis in the presence of Semi-Competing Risks

- Contact: Boris Hejblum
- URL: https://CRAN.R-project.org/package=kernscr

6.16. phenotypr

KEYWORDS: Phenotyping - Automatic labelling - Automatic Learning

FUNCTIONAL DESCRIPTION: Machine learning prediction algorithm for predicting a clinical phenotype from structured diagnostic data and CUI occurrence data collected from medical reports, previously processed by NLP approaches.

- Contact: Boris Hejblum
- URL: https://github.com/borishejblum/phenotypr

6.17. R2GUESS

Graphical processing Unit Evolutionary Stochastic Search

FUNCTIONAL DESCRIPTION: R2GUESS package is a wrapper of the GUESS (Graphical processing Unit Evolutionary Stochastic Search) program. GUESS is a computationally optimised C++ implementation of a fully Bayesian variable selection approach that can analyse, in a genome-wide context, single and multiple responses in an integrated way. The program uses packages from the GNU Scientific Library (GSL) and offers the possibility to re-route computationally intensive linear algebra operations towards the Graphical Processing Unit (GPU) through the use of proprietary CULA-dense library.

- Contact: Rodolphe Thiebaut

STEEP Project-Team

5. New Software and Platforms

5.1. USAT

Urban Sprawl Analysis Toolkit

KEYWORDS: Urban sprawl - Urban planning

FUNCTIONAL DESCRIPTION: This software allows to calculate and analyse indices of urban sprawl from open data (OpenStreetMap), aimed to be used by urban scientists and urban planners. A spatialized version of indices measuring the accessibility, dispersion and land use mix is calculated. The implemented methods are described in [15].

NEWS OF THE YEAR: In 2019 we started a refactoring of this software, together with an overhaul of the associated web service USAT-WEB.

- Participants: Luciano Gervasoni, Serge Fenet, Peter Sturm and Roger Pissard-Gibollet
- Partner: LIRIS
- Contact: Peter Sturm
- URL: https://github.com/lgervasoni/urbansprawl

5.2. USAT WEB

Urban Sprawl Analysis Toolkit Web-service

KEYWORDS: Urban planning - Urban sprawl

FUNCTIONAL DESCRIPTION: This is a web-service on top of the software USAT described above. The web-service will allow any user to select a region of interest and to launch the calculation and display of sprawl indices using USAT. It is in the process of being hosted on the HPC platform of IN2P3, after which it will be made open to the public. The source code for this web-service is already available at the below site.

The web-service is described in [21].

NEWS OF THE YEAR: In 2019 we started a complete overhaul of this software, together with a factorization of the underlying computation core (USAT).

- Participants: Lucas Rezakhanlou, Peter Sturm, Luciano Gervasoni, Serge Fenet and Roger Pissard-Gibollet
- Contact: Peter Sturm
- Publication: USAT (Urban Sprawl Analysis Toolkit) : une plateforme web d'analyse de l'étalement urbain à partir de données massives ouvertes
- URL: https://gitlab.inria.fr/lrezakha/usat-web

5.3. LUM_OSM

Land Use Mix calculation from OpenStreepMap data

KEYWORD: Urban sprawl

FUNCTIONAL DESCRIPTION: The software uses Mapzen Metro Extracts to retrieve the OpenStreetMap data of a given region in the PostgreSQL format. Afterwards, a continuous representation of residential and activity land uses is created. Finally, a GIS output containing the degree of land use mixture is calculated by means of using the land uses maps. The implemented approach is documented in the paper "A framework for evaluating urban land use mix from crowd-sourcing data", http://hal.inria.fr/hal-01396792

- Participants: Luciano Gervasoni, Marti Bosch Padros, Peter Sturm, Serge Fenet and Roger Pissard-Gibollet
- Partners: EPFL - Ecole Polytechnique Fédérale de Lausanne - LIRIS
- Contact: Peter Sturm
- URL: http://github.com/martibosch/landusemix

5.4. Comptabilité Ecologique

FUNCTIONAL DESCRIPTION: Databases, database handling tools and data visualization tools (on the website). Databases include socio-economic and environmental datasets. Visualization tools include interactive piecharts, maps and Sankey diagrams.

- Participants: Jean-Yves Courtonne and Pierre-Yves Longaretti
- Contact: Jean-Yves Courtonne
- URL: http://www.eco-data.fr

5.5. REDEM

REDuction Of EMission

KEYWORD: Climate change

FUNCTIONAL DESCRIPTION: REDEM soft is a tool designed for the benchmarking of national GHG emission reduction trajectories. The actual version of the software is implemented in Visual Basic under Microsoft Excel in order to facilitate handling and diffusion to climate/energy economists.

NEWS OF THE YEAR: In 2019, the database underlying REDEM was updated with recent national emission trajectory information.

- Participants: Constantin Ilasca, Hélène Benveniste, Olivier Boucher, Patrick Criqui and Roger Pissard-Gibollet
- Partners: EDDEN - IPSL
- Contact: Emmanuel Prados
- URL: http://redem.gforge.inria.fr/

5.6. REDEM web

REDEM Web

KEYWORDS: Benchmarking - Climate change - Global warming - Greenhouse gas emissions

FUNCTIONAL DESCRIPTION: Python Library of REDEM model and its web application.

- Participants: Constantin Ilasca, Emmanuel Prados, Hélène Benveniste, Nicolas Assouad, Olivier Boucher, Patrick Criqui and Roger Pissard-Gibollet
- Partners: UPMC - EDDEN
- Contact: Emmanuel Prados
- URL: http://redem.inria.fr/

<p style="text-align:center">**TONUS Project-Team**</p>

6. New Software and Platforms

6.1. CLAC

Conservation Laws Approximation on many Cores

SCIENTIFIC DESCRIPTION: It is clear now that future computers will be made of a collection of thousands of interconnected multicore processors. Globally it appears as a classical distributed memory MIMD machine. But at a lower level, each of the multicore processors is itself made of a shared memory MIMD unit (a few classical CPU cores) and a SIMD unit (a GPU). When designing new algorithms, it is important to adapt them to this kind of architecture. Our philosophy will be to program our algorithms in such a way that they can be run efficiently on this kind of computers. Practically, we will use the MPI library for managing the coarse grain parallelism, while the OpenCL library will efficiently operate the fine grain parallelism.

We have invested for several years until now into scientific computing on GPUs, using the open standard OpenCL (Open Computing Language). We were recently awarded a prize in the international AMD OpenCL innovation challenge thanks to an OpenCL two-dimensional Vlasov-Maxwell solver that fully runs on a GPU. OpenCL is a very interesting tool because it is an open standard now available on almost all brands of multicore processors and GPUs. The same parallel program can run on a GPU or a multicore processor without modification.

Because of the envisaged applications of CLAC, which may be either academic or commercial, it is necessary to conceive a modular framework. The heart of the library is made of generic parallel algorithms for solving conservation laws. The parallelism can be both fine-grained (oriented towards GPUs and multicore processors) and coarse-grained (oriented towards GPU clusters). The separate modules allow managing the meshes and some specific applications. In this way, it is possible to isolate parts that should be protected for trade secret reasons.

FUNCTIONAL DESCRIPTION: CLAC is a generic Discontinuous Galerkin solver, written in C/C++, based on the OpenCL and MPI frameworks.

- Partner: AxesSim
- Contact: Philippe Helluy
- URL: http://clac.gforge.inria.fr/

6.2. Selalib

SEmi-LAgrangian LIBrary

KEYWORDS: Plasma physics - Semilagrangian method - Parallel computing - Plasma turbulence

SCIENTIFIC DESCRIPTION: The objective of the Selalib project (SEmi-LAgrangian LIBrary) is to develop a well-designed, organized and documented library implementing several numerical methods for kinetic models of plasma physics. Its ultimate goal is to produce gyrokinetic simulations.

Another objective of the library is to provide to physicists easy-to-use gyrokinetic solvers, based on the semilagrangian techniques developed by Eric Sonnendrücker and his collaborators in the past CALVI project. The new models and schemes from TONUS are also intended to be incorporated into Selalib.

FUNCTIONAL DESCRIPTION: Selalib is a collection of modules conceived to aid in the development of plasma physics simulations, particularly in the study of turbulence in fusion plasmas. Selalib offers basic capabilities from general and mathematical utilities and modules to aid in parallelization, up to pre-packaged simulations.

- Partners: Max Planck Insitute - Garching - Université de Strasbourg
- Contact: Philippe Helluy
- URL: http://selalib.gforge.inria.fr/

6.3. SCHNAPS

Solver for Conservative Hyperbolic Nonlinear Applications for PlasmaS

KEYWORDS: Discontinuous Galerkin - StarPU - Kinetic scheme

FUNCTIONAL DESCRIPTION: Generic systems of conservation laws. Specific models: fluids, Maxwell, Vlasov, acoustics (with kinetic representation). Multitasking with StarPU. Explicit solvers (RK2, RK3, RK4): accelerated with OpenCL Implicit solvers: through kinetic representations and palindromic time integration.

- Participants: Philippe Helluy, Matthieu Boileau and Bérenger Bramas
- Contact: Philippe Helluy
- URL: http://schnaps.gforge.inria.fr/

6.4. Slappy

KEYWORDS: Python - Opencl

FUNCTIONAL DESCRIPTION: The code Slappy solves the advection equations on multi-patch and non-conform complex geometries with the Semi-Lagrangian method. Using this we can also treat some hyperbolic/parabolic PDE with the Approximate BGK method which, allows to write a PDE as a transport plus a local relaxation step. The code is written in PyOpcenCL and can be used on CPU/GPU.

- Contact: Emmanuel Franck

6.5. Patapon

Parallel Task in Python

KEYWORDS: Python - Parallel computing - High order time schemes

FUNCTIONAL DESCRIPTION: Patapon is a code in PyOpenCL which allows to solve PDE like MHD using the vectorial Lattice Boltzmann method on Cartesian grids.

- Participant: Philippe Helluy
- Contact: Philippe Helluy

6.6. tofu

Tomography for Fusion

KEYWORDS: 3D - Data visualization - Visualization - Magnetic fusion - Tomography - Diagnostics - Plasma physics - Ray-tracing - Python

FUNCTIONAL DESCRIPTION: tofu aims at providing the fusion and plasma community with an object-oriented, transparent and documented tool for designing tomography diagnostics, computing synthetic signal (direct problem) as well as tomographic inversions (inverse problem). It gives access to a full 3D description of the diagnostic geometry, thus reducing the impact of geometrical approximations on the direct and, most importantly, on the inverse problem.

RELEASE FUNCTIONAL DESCRIPTION: Python 2.7 is not supported anymore Python 3.6 and 3.7 are supported Several changes to try and make installation easier (on clusters, windows, mac....) and less verbose for users More explicit names for default saved configurations Major bug fix in one of the methods for computing synthetic signal Minor bug fixes in interactive figures Minor bug fixes in Plasma2D interpolation New configuration (ITER) available First version of a class handling 2D XRay bragg spectrometers First tools for magnetic field line tracing available on WEST Better documentation, more ressources More informative error messages extra tools for computing LOS length, closest point to magnetic axis... Better PEP8 compliance

- Partner: CEA
- Contact: Laura Mendoza
- URL: https://github.com/ToFuProject/tofu

XPOP Project-Team

6. New Software and Platforms

6.1. mlxR

KEYWORDS: Simulation - Data visualization - Clinical trial simulator

FUNCTIONAL DESCRIPTION: The models are encoded using the model coding language 'Mlxtran', automatically converted into C++ codes, compiled on the fly and linked to R using the 'Rcpp' package. That allows one to implement very easily complex ODE-based models and complex statistical models, including mixed effects models, for continuous, count, categorical, and time-to-event data.

- Contact: Marc Lavielle
- URL: http://simulx.webpopix.org/

6.2. Rsmlx

R speaks Monolix

KEYWORDS: Data modeling - Nonlinear mixed effects models - Statistical modeling

FUNCTIONAL DESCRIPTION: Among other tasks, 'Rsmlx' provides a powerful tool for automatic PK model building, performs statistical tests for model assessment, bootstrap simulation and likelihood profiling for computing confidence intervals. 'Rsmlx' also proposes several automatic covariate search methods for mixed effects models.

- Partner: Lixoft
- Contact: Marc Lavielle
- URL: http://rsmlx.webpopix.org/

6.3. SPIX

KEYWORDS: Data modeling - Mass spectrometry - Chemistry

FUNCTIONAL DESCRIPTION: SPIX allows you to - automatically identify, on the basis of statistical approaches, small but significant differences in spectra measured under different conditions, - model the kinetics of entities that evolve over time

- Authors: Marc Lavielle and Yao Xu
- Partner: Laboratoire de Chimie Moléculaire - Ecole Polytechnique
- Contact: Marc Lavielle
- URL: http://spix.webpopix.org/

<h1 style="text-align: center; color: red;">AGORA Project-Team</h1>

6. New Software and Platforms

6.1. TAPASCologne

Travel and Activity PAtterns Simulation Cologne

KEYWORDS: Mobility - Traces

FUNCTIONAL DESCRIPTION: TAPASCologne is an initiative by the Institute of Transportation Systems at the German Aerospace Center (ITS-DLR), aimed at reproducing, with the highest level of realism possible, car traffic in the greater urban area of the city of Cologne, in Germany.

To that end, different state-of-art data sources and simulation tools are brought together, so to cover all of the specific aspects required for a proper characterization of vehicular traffic:

The street layout of the Cologne urban area is obtained from the OpenStreetMap (OSM) database, The microscopic mobility of vehicles is simulated with the Simulation of Urban Mobility (SUMO) software, The traffic demand information on the macroscopic traffic flows across the Cologne urban area (i.e., the O/D matrix) is derived through the Travel and Activity PAtterns Simulation (TAPAS) methodology, The traffic assignment of the vehicular flows described by the TAPASCologne O/D matrix over the road topology is performed by means of Gawron's dynamic user assignment algorithm.

- Participants: Marco Fiore and Razvan Stanica
- Contact: Marco Fiore
- URL: http://kolntrace.project.citi-lab.fr/#download

6.2. Sense in the City

KEYWORDS: Sensors - Sensors network - Wireless Sensor Networks

FUNCTIONAL DESCRIPTION: Sense in the city is a lightweight experimentation platform for wireless sensor networks in development. The main objective of this platform is to be easily transferable and deployable on the field. It allows a simplified deployment of the code running on the sensors and the collection of logs generated by the instrumentation of the code on a centralized database. In the early stage of the platform, the sensors are powered by small PCs, e.g. Raspberry Pi, but we are investigating the integration of energy harvesting capabilities such as solar panels.

- Participants: Hervé Rivano and Khaled Boussetta
- Contact: Khaled Boussetta

6.3. PrivaMovApp

KEYWORD: Crowd-sensing

FUNCTIONAL DESCRIPTION: Agora is leading the development of an Android application for user data collection purposes. The application is based on the Funf framework, and is currently available on Google Play.

- Participants: Stéphane d'Alu, Hervé Rivano, Razvan Stanica and Solohaja Rabenjamina
- Contact: Razvan Stanica

6.4. WSNet

KEYWORD: Network simulator

FUNCTIONAL DESCRIPTION: WSNet is a modular event-driven simulator targeted to Wireless Sensor Networks. Its main goals are to offer scalabiliy, extensibility and modularity for the integration of new protocols/hardware models and a precise radio medium simulation. We still hope to find the proper resource to make WSNet evolve into a wireless capillary network simulator suitable for conducting simulations at the urban scale.

- Participants: Rodrigue Domga Komguem and Fabrice Valois
- Partner: CEA-LETI
- Contact: Guillaume Chelius
- URL: https://gforge.inria.fr/projects/wsnet-3/

6.5. Platforms

6.5.1. PPAIR Plateforme LoRa - Campus Connecté

The project aims at providing a platform that offers connectivity through a long-range, low-energy network to smart objects. The platform uses LoRa technology, which offers a wide connectivity, covering the entire INSA Lyon campus and providing a data collection service to all campus users. The main purpose of the LoRa plateform is: *(i)* research (researchers can use it for studying reliability and capacity problems, privacy related challenges, etc.), and *(ii)* teaching (several courses from INSA, especially in the Telecom department can use this platform as a pedagogical tool).

Part of the software is mutualized with the University of Paris 13, where a LoRaWan testbed project is under deployment at the campus of Villetaneuse. This project, is supported by a local BQR and is lead by Khaled Boussetta. The mutualization of the software tools will allow us to conduct multi sites experiments, at Lyon and at Paris. Since 2019, this platform is used in the European Project Interreg Med ESMARTCITY and for the PHC Ulysses (joint collaboration with Nimbus Center, Ireland).

6.5.2. UrPolSens Platform

We designed from scratch an energy efficient air pollution sensor network using Atmega micro-controllers and electrochemical air pollution probes. The micro-controller is integrated into a lab-designed printed circuit which includes among others: a high precision ADC, a micro-SD card reader and a radio communication module. The designed nodes measure the nitrogen dioxide (NO_2) pollutant in addition to temperature and humidity and transmit data using LoRa to a gateway, which is connected to our servers using a 4G connection. The sensors are also equipped with solar panels in order to extend their lifetime when their batteries are drained. Our platform has been operational in the downtown of the Lyon city with 12 sensor nodes deployed in the Garibaldi street from mid-July to Mid-October 2018.

6.5.3. 3M'air sensor platform

We developed the 3M'Air sensor platform to be used in participatory sensing of temperature and air quality. We have built our own nodes equipped with multiple sensors measuring Nitrogen-Dioxide (NO_2), Particulate Matter (PM1, PM2.5, PM10), temperature and humidity. They are battery-powered and equipped with a GPS module to have the position of the measurements. Data are stored on a micro SD card and at the same time sent over LoRa to a server we have developed that is responsible to store these data for future analyses. A web platform has also been developed to display the collected concentration measurements in real time. This developed solution is used in several participatory planned measurement campaigns in Lyon city.

ALPINES Project-Team

6. New Software and Platforms

6.1. FreeFem++

FeeFrem++

SCIENTIFIC DESCRIPTION: FreeFem++ is a partial differential equation solver. It has its own language. freefem scripts can solve multiphysics non linear systems in 2D and 3D.

Problems involving PDE (2d, 3d) from several branches of physics such as fluid-structure interactions require interpolations of data on several meshes and their manipulation within one program. FreeFem++ includes a fast 2d^-tree-based interpolation algorithm and a language for the manipulation of data on multiple meshes (as a follow up of bamg (now a part of FreeFem++).

FreeFem++ is written in C++ and the FreeFem++ language is a C++ idiom. It runs on Macs, Windows, Unix machines. FreeFem++ replaces the older freefem and freefem+.

FUNCTIONAL DESCRIPTION: FreeFem++ is a PDE (partial differential equation) solver based on a flexible language that allows a large number of problems to be expressed (elasticity, fluids, etc) with different finite element approximations on different meshes.

- Partner: UPMC
- Contact: Frederic Hecht
- URL: http://www.freefem.org/ff++/

6.2. HPDDM

SCIENTIFIC DESCRIPTION: HPDDM is an efficient implementation of various domain decomposition methods (DDM) such as one- and two-level Restricted Additive Schwarz methods, the Finite Element Tearing and Interconnecting (FETI) method, and the Balancing Domain Decomposition (BDD) method. This code has been proven to be efficient for solving various elliptic problems such as scalar diffusion equations, the system of linear elasticity, but also frequency domain problems like the Helmholtz equation. A comparison with modern multigrid methods can be found in the thesis of Pierre Jolivet.

FUNCTIONAL DESCRIPTION: HPDDM is an efficient implementation of various domain decomposition methods (DDM) such as one- and two-level Restricted Additive Schwarz methods, the Finite Element Tearing and Interconnecting (FETI) method, and the Balancing Domain Decomposition (BDD) method.

- Participants: Frédéric Nataf and Pierre Jolivet
- Contact: Pierre Jolivet
- URL: https://github.com/hpddm

6.3. LORASC

LORASC preconditioner

KEYWORD: Preconditioner

- Participants: Laura Grigori and Rémi Lacroix
- Contact: Laura Grigori

6.4. Platforms

6.4.1. *preAlps*

KEYWORD: Preconditioned enlarged Krylov subspace methos

FUNCTIONAL DESCRIPTION: Contains enlarged Conjugate Gradient Krylov subspace method and Lorasc preconditioner.

- Partners: Inria
- Contact: Simplice Donfack, Laura Grigori, Olivier Tissot
- URL: https://github.com/NLAFET/preAlps

6.4.2. BemTool

KEYWORD: Boundary Element Method
FUNCTIONAL DESCRIPTION: BemTool is a C++ header-only library implementing the boundary element method for the discretisation of the Laplace, Helmholtz and Maxwell equations, in 2D and 3D. Its main purpose is the assembly of classic boundary element matrices, which can be compressed and inverted through its interface with HTOOL.

- Partners: UPMC - ANR NonlocalDD
- Contact: Xavier Claeys
- URL: https://github.com/xclaeys/BemTool

6.4.3. HTool

KEYWORD: Hierarchical Matrices
FUNCTIONAL DESCRIPTION: HTOOL is a C++ header-only library implementing compression techniques (e.g. Adaptive Cross Approximation) using hierarchical matrices. The library uses MPI and OpenMP for parallelism, and is interfaced with HPDDM for the solution of linear systems.

- Partners: CNRS - UPMC - ANR NonlocalDD
- Contact: Pierre Marchand
- URL: https://github.com/PierreMarchand20/htool

AVALON Project-Team

5. New Software and Platforms

5.1. DIET

Distributed Interactive Engineering Toolbox

KEYWORDS: Scheduling - Clusters - Grid - Cloud - HPC - Middleware - Data management.

FUNCTIONAL DESCRIPTION: Middleware for grids and clouds. Toolbox for the use and porting of intensive computing applications on heterogeneous architectures.

RELEASE FUNCTIONAL DESCRIPTION: - Native Google Drive Support for the data manager - Standardization of internal integer types. - New types (see Changelog for more information)

NEWS OF THE YEAR: New DIET release (DIET 2.11) is avaible since may 2019 Batch's GENCI support to use the GENCI resources

- Participants: Joel Faubert, Hadrien Croubois, Abdelkader Amar, Arnaud Lefray, Aurélien Bouteiller, Benjamin Isnard, Daniel Balouek, Eddy Caron, Eric Bois, Frédéric Desprez, Frédéric Lombart, Gaël Le Mahec, Guillaume Verger, Huaxi Zhang, Jean-Marc Nicod, Jonathan Rouzaud-Cornabas, Lamiel Toch, Maurice Faye, Peter Frauenkron, Philippe Combes, Philippe Laurent, Raphaël Bolze, Yves Caniou and Cyril Seguin
- Partners: CNRS - ENS Lyon - UCBL Lyon 1 - Sysfera
- Contact: Eddy Caron
- URL: http://graal.ens-lyon.fr/diet/

5.2. SimGrid

KEYWORDS: Large-scale Emulators - Grid Computing - Distributed Applications

SCIENTIFIC DESCRIPTION: SimGrid is a toolkit that provides core functionalities for the simulation of distributed applications in heterogeneous distributed environments. The simulation engine uses algorithmic and implementation techniques toward the fast simulation of large systems on a single machine. The models are theoretically grounded and experimentally validated. The results are reproducible, enabling better scientific practices.

Its models of networks, cpus and disks are adapted to (Data)Grids, P2P, Clouds, Clusters and HPC, allowing multi-domain studies. It can be used either to simulate algorithms and prototypes of applications, or to emulate real MPI applications through the virtualization of their communication, or to formally assess algorithms and applications that can run in the framework.

The formal verification module explores all possible message interleavings in the application, searching for states violating the provided properties. We recently added the ability to assess liveness properties over arbitrary and legacy codes, thanks to a system-level introspection tool that provides a finely detailed view of the running application to the model checker. This can for example be leveraged to verify both safety or liveness properties, on arbitrary MPI code written in C/C++/Fortran.

NEWS OF THE YEAR: There were 3 major releases in 2019: Python bindings were introduced, SMPI now partially supports some of the MPI/IO functions, a new model for Wifi networks was proposed, and the API for the simulation of storage resources was completely revisited. We also pursued our efforts to improve the documentation of the software, simplified the web site, and made a lot of bug fixing and code refactoring.

- Participants: Adrien Lèbre, Arnaud Legrand, Augustin Degomme, Florence Perronnin, Frédéric Suter, Jean-Marc Vincent, Jonathan Pastor, Luka Stanisic and Martin Quinson
- Partners: CNRS - ENS Rennes
- Contact: Martin Quinson
- URL: https://simgrid.org/

5.3. SeeDep

Seed based Deployment

KEYWORDS: Reproducibility - Deployment - Cloud

SCIENTIFIC DESCRIPTION: SeeDep aims at devising a new way where researchers can communicate in a comprehensive and accurate way the experimentation set-up used in their work. It lies on two components: (i) a public algorithm that generates experimentation networks, and (ii) a generation key (i.e. a seed) that can be shared which specifies the said network. Therefore, researchers only need to share (in their paper for instance) the "generation key" that corresponds to their experimentation network. With such key, any other researcher/professional will be able to re-generate a comprehensive and accurate model of the same network.

FUNCTIONAL DESCRIPTION: SeeDep is a framework aiming at generating, reproducing and deploying experiments set-up on different Cloud platforms.

- Participants: Cyril Seguin and Eddy Caron
- Partner: Nokia Bell Labs
- Contact: Eddy Caron

5.4. libkomp

Runtime system libkomp

KEYWORDS: HPC - Multicore - OpenMP

FUNCTIONAL DESCRIPTION: libKOMP is a runtime support for OpenMP compatible with différent compiler: GNU gcc/gfortran, Intel icc/ifort or clang/llvm. It is based on source code initially developed by Intel for its own OpenMP runtime, with extensions from Kaapi software (task representation, task scheduling). Moreover it contains an OMPT module for recording trace of execution.

RELEASE FUNCTIONAL DESCRIPTION: Initial version

- Contact: Thierry Gautier
- URL: http://gitlab.inria.fr/openmp/libkomp

5.5. XKBLAS

KEYWORDS: BLAS - Dense linear algebra - GPU

FUNCTIONAL DESCRIPTION: XKBLAS is yet an other BLAS library (Basic Linear Algebra Subroutines) that targets multi-GPUs architecture thanks to the XKaapi runtime and with block algorithms from PLASMA library. The library offers a wrapper library able to capture calls to BLAS (C or Fortran). The internal API is based on asynchronous invocations in order to enable overlapping between communication by computation and also to better composed sequences of calls to BLAS.

This current version of XKBlas is the first public version and contains only BLAS level 3 algorithms, including XGEMMT:

XGEMM XGEMMT: see MKL GEMMT interface XTRSM XTRMM XSYMM XSYRK XSYR2K XHEMM XHERK XHER2K

For classical precision Z, C, D, S.

RELEASE FUNCTIONAL DESCRIPTION: XKBlas has following limitations:

0.1 versions: calls to BLAS kernels must be initiate by the same thread that initializes the XKBlas library.

- Participants: Thierry Gautier and João Vicente Ferreira Lima
- Contact: Thierry Gautier
- URL: https://gitlab.inria.fr/xkblas/versions

5.6. Concerto

KEYWORDS: Reconfiguration - Distributed Software - Component models - Dynamic software architecture

FUNCTIONAL DESCRIPTION: Concerto is an implementation of the formal model Concerto written in Python. Concerto aloows to : 1. describe the life-cycle and the dependencies of software components, 2. describe a components assembly that forms the overall life-cycle of a distributed software, 3. automatically reconfigure a Concerto assembly of components by using a set of reconfiguration instructions as well as a formal operational semantics.

- Partners: IMT Atlantique - LS2N - LIP
- Contact: Maverick Chardet
- URL: https://gitlab.inria.fr/VeRDi-project/concerto

5.7. Kwapi

KiloWatt API

KEYWORD: Power monitoring

FUNCTIONAL DESCRIPTION: Kwapi is a software framework dealing with energy monitoring of large scale infrastructures through heterogeneous energy sensors. Kwapi has been designed inside the FSN XLCloud project for Openstack infrastructures. Through the support of Hemera Inria project, kwapi has been extended and deployed in production mode to support easy and large scale energy profiling of the Grid5000 resources. Kwapi now supports high frequency powermeters of the Grid5000 Lyon platform.

RELEASE FUNCTIONAL DESCRIPTION: - many bugfixes - multiprocessing instead of multithreading - many optimizations

- Participants: François Rossigneux, Jean-Patrick Gelas, Laurent Lefèvre, Laurent Pouilloux, Simon Delamare and Matthieu Imbert
- Contact: Laurent Lefèvre
- URL: https://launchpad.net/kwapi

5.8. execo

KEYWORDS: Toolbox - Deployment - Orchestration - Python

FUNCTIONAL DESCRIPTION: Execo offers a Python API for asynchronous control of local or remote, standalone or parallel, unix processes. It is especially well suited for quickly and easily scripting workflows of parallel/distributed operations on local or remote hosts: automate a scientific workflow, conduct computer science experiments, perform automated tests, etc. The core python package is execo. The execo_g5k package provides a set of tools and extensions for the Grid5000 testbed. The execo_engine package provides tools to ease the development of computer sciences experiments.

RELEASE FUNCTIONAL DESCRIPTION: - misc python3 support fixes - basic documentation for wheezy compatible package build - remove some debug outputs - fix crash in processes conductor in some situations - improve/fix process stdout/stderr handlers - fix get_cluster_network_equipments - add a FAQ

- Participants: Florent Chuffart, Laurent Pouilloux and Matthieu Imbert
- Contact: Matthieu Imbert
- URL: http://execo.gforge.inria.fr

5.9. Platforms

5.9.1. Platform: Grid'5000
Participants: Laurent Lefèvre, Simon Delamare, David Loup, Christian Perez.

FUNCTIONAL DESCRIPTION

The Grid'5000 experimental platform is a scientific instrument to support computer science research related to distributed systems, including parallel processing, high performance computing, cloud computing, operating systems, peer-to-peer systems and networks. It is distributed on 10 sites in France and Luxembourg, including Lyon. Grid'5000 is a unique platform as it offers to researchers many and varied hardware resources and a complete software stack to conduct complex experiments, ensure reproducibility and ease understanding of results. In 2018, a new generation of high speed wattmeters has been deployed on the Lyon site. They allow energy monitoring with up to 50 measurements per second. In parallel, a new version of kwapi (software stack for energy monitoring) has been proposed and redesigned.

- Contact: Laurent Lefèvre
- URL: https://www.grid5000.fr/

5.9.2. Platform: Leco

Participants: Thierry Gautier, Laurent Lefèvre, Christian Perez.

FUNCTIONAL DESCRIPTION

The LECO experimental platform is a new medium size scientific instrument funded by DRRT to investigate research related to BigData and HPC. It is located in Grenoble as part of the the HPCDA computer managed by UMS GRICAD. The platform has been deployed in 2018 and was available for experiment since the summer. All the nodes of the platform are instrumented to capture the energy consumption and data are available through the Kwapi software.

- Contact: Thierry Gautier

5.9.3. Platform: SILECS

Participants: Laurent Lefèvre, Simon Delamare, Christian Perez.

FUNCTIONAL DESCRIPTION

The SILECS infrastructure (IR ministère) aims at providing an experimental platform for experimental computer Science (Internet of things, clouds, HPC, big data, *etc.*). This new infrastructure is based on two existing infrastructures, Grid'5000 and FIT.

- Contact: Christian Perez
- URL: https://www.silecs.net/

<p style="text-align:center">**COAST Project-Team**</p>

6. New Software and Platforms

6.1. MUTE

Multi-User Text Editor

KEYWORD: Collaborative systems

SCIENTIFIC DESCRIPTION: MUTE is a peer 2 peer collaborative editing platform that is used to evaluate replication algorithms in editing situations regarding their performances and to understand how it affects user experience.

FUNCTIONAL DESCRIPTION: Existing collaborative systems generally rely on a service provider that stores and has control over user data which is a threat for privacy. MUTE (Multi-User Text Editor) is a web-based real-time collaborative editor that overcomes this limitation by using a peer-to-peer architecture relying on WebRTC. Several users may edit in real-time a shared document and their modifications are immediately sent to the other users without transiting through a central server. Our editor offers support for working offline while still being able to reconnect at a later time, which gives it a unique feature. Data synchronisation is achieved by using the LogootSplit algorithm developed by team Coast.

NEWS OF THE YEAR: In 2019 we implemented a new algorithm, dotted logoot-split. We integrated a group key management algorithm to evaluate a secure version of the algorithm in dynamic situation. We also incorporated probes to evaluate collaboration situation.

- Participants: Claudia Ignat, François Charoy, Gérald Oster, Luc André, Matthieu Nicolas and Victorien Elvinger
- Contact: Gérald Oster
- URL: https://github.com/coast-team/mute

<div align="center">

COATI Project-Team

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6. New Software and Platforms

6.1. GRPH

The high performance graph library for Java

KEYWORDS: Graph - Graph algorithmics - Java

FUNCTIONAL DESCRIPTION: Grph is an open-source Java library for the manipulation of graphs. Its design objectives are to make it portable, simple to use/extend, computationally/memory efficient, and, according to its initial motivation: useful in the context of graph experimentation and network simulation. Grph also has the particularity to come with tools like an evolutionary computation engine, a bridge to linear programming solvers, a framework for distributed computing, etc.

Grph offers a very general model of graphs. Unlike other graph libraries which impose the user to first decide if he wants to deal with directed, undirected, hyper (or not) graphs, the model offered by Grph is unified in a general class that supports mixed graphs made of undirected and directed simple and hyper edges. Grph achieves great efficiency through the use of multiple code optimization techniques such as multi-core parallelism, caching, adequate data structures, use of primitive objects, exploitation of low-level processor caches, on-the-fly compilation of specific C/C++ code, etc. Grph attempts to access the Internet in order to check if a new version is available and to report who is using it (login name and hostname). This has no impact whatsoever on performance and security.

- Participants: Aurélien Lancin, David Coudert, Issam Tahiri, Luc Hogie and Nathann Cohen
- Contact: Luc Hogie
- URL: http://www.i3s.unice.fr/~hogie/grph/

6.2. BigGraphs

KEYWORDS: Graph algorithmics - Distributed computing - Java - Graph processing

FUNCTIONAL DESCRIPTION: The objective of BigGraphs is to provide a distributed platform for very large graphs processing. A typical data set for testing purpose is a sample of the Twitter graph : 240GB on disk, 398M vertices, 23G edges, average degree of 58 and max degree of 24635412.

We started the project in 2014 with the evaluation of existing middlewares (GraphX / Spark and Giraph / Hadoop). After having tested some useful algorithms (written according to the Bulk Synchronous Parallel (BSP) model) we decided to develop our own platform.

This platform is based on the existing BIGGRPH library and we are now working on improving the quality of the code. In particular we have designed strong test suites and some non trivial bugs have been fixed. We also have solved problems of scalability, in particular concerning the communication layer with billions of messages exchanged between BSP steps. We also have implemented specific data structures for BSP and support for distributed debugging. This comes along with the implementation of algorithms such as BFS or strongly connected components that are run on the NEF cluster.

In 2017 we have developed a multi-threaded shared-memory parallel version of the BSP framework. This new version uses advanced synchronization mechanisms and strategies to minimize the congestion of multiple threads working on the same graph. Using the NEF cluster (Inria Sophia Antipolis), this parallel version exhibits speed-ups up to 6.5 using 8 nodes (16 cores each) when computing a BFS on the 23 G edges Twitter graph sample.

- Participants: Luc Hogie, Michel Syska and Nicolas Chleq
- Partner: CNRS
- Contact: Luc Hogie
- URL: http://www.i3s.unice.fr/~hogie/software/?name=biggrph

6.3. JMaxGraph

KEYWORDS: Java - HPC - Graph algorithmics

FUNCTIONAL DESCRIPTION: JMaxGraph is a collection of techniques for the computation of large graphs on one single computer. The motivation for such a centralized computing platform originates in the constantly increasing efficiency of computers which now come with hundred gigabytes of RAM, tens of cores and fast drives. JMaxGraph implements a compact adjacency-table for the representation of the graph in memory. This data structure is designed to 1) be fed page by page, à-la GraphChi, 2) enable fast iteration, avoiding memory jumps as much as possible in order to benefit from hardware caches, 3) be tackled in parallel by multiple-threads. Also, JMaxGraph comes with a flexible and resilient batch-oriented middleware, which is suited to executing long computations on shared clusters. The first use-case of JMaxGraph allowed F. Giroire, T. Trolliet and S. Pérennes to count K2,2s, and various types of directed triangles in the Twitter graph of users (23G arcs, 400M vertices). The computation campaign took 4 days, using up to 400 cores in the NEF Inria cluster.

- Contact: Luc Hogie
- URL: http://www.i3s.unice.fr/~hogie/software/?name=jmaxgraph

6.4. Sagemath

SageMath

KEYWORDS: Graph algorithmics - Graph - Combinatorics - Probability - Matroids - Geometry - Numerical optimization

SCIENTIFIC DESCRIPTION: SageMath is a free open-source mathematics software system. It builds on top of many existing open-source packages: NumPy, SciPy, matplotlib, Sympy, Maxima, GAP, FLINT, R and many more. Access their combined power through a common, Python-based language or directly via interfaces or wrappers.

FUNCTIONAL DESCRIPTION: SageMath is an open-source mathematics software initially created by William Stein (Professor of mathematics at Washington University). We contribute the addition of new graph algorithms along with their documentations and the improvement of underlying data structures.

RELEASE FUNCTIONAL DESCRIPTION: See http://www.sagemath.org/changelogs/

NEWS OF THE YEAR: 1) Improvement of shortest path computation algorithms. Done in the context of Google Summer of Code 2019. 2) Main contributor for making the graph module (more than 100,000 lines of code) of SageMath compatible with Python3. Version 9.0 of Sagemath, released on January 1st, 2020, is 100% Python3 compliant.

- Participant: David Coudert
- Contact: David Coudert
- URL: http://www.sagemath.org/

CTRL-A Project-Team

6. New Software and Platforms

6.1. Heptagon

KEYWORDS: Compilers - Synchronous Language - Controller synthesis

FUNCTIONAL DESCRIPTION: Heptagon is an experimental language for the implementation of embedded real-time reactive systems. It is developed inside the Synchronics large-scale initiative, in collaboration with Inria Rhones-Alpes. It is essentially a subset of Lucid Synchrone, without type inference, type polymorphism and higher-order. It is thus a Lustre-like language extended with hierchical automata in a form very close to SCADE 6. The intention for making this new language and compiler is to develop new aggressive optimization techniques for sequential C code and compilation methods for generating parallel code for different platforms. This explains much of the simplifications we have made in order to ease the development of compilation techniques.

The current version of the compiler includes the following features: - Inclusion of discrete controller synthesis within the compilation: the language is equipped with a behavioral contract mechanisms, where assumptions can be described, as well as an "enforce" property part. The semantics of this latter is that the property should be enforced by controlling the behaviour of the node equipped with the contract. This property will be enforced by an automatically built controller, which will act on free controllable variables given by the programmer. This extension has been named BZR in previous works. - Expression and compilation of array values with modular memory optimization. The language allows the expression and operations on arrays (access, modification, iterators). With the use of location annotations, the programmer can avoid unnecessary array copies.

- Participants: Adrien Guatto, Brice Gelineau, Cédric Pasteur, Eric Rutten, Gwenaël Delaval, Léonard Gérard and Marc Pouzet
- Partners: UGA - ENS Paris - Inria - LIG
- Contact: Gwenaël Delaval
- URL: http://heptagon.gforge.inria.fr

<h1 style="text-align: center; color: red;">DANTE Project-Team</h1>

6. New Software and Platforms

6.1. GraSP

Graph Signal Processing

KEYWORDS: Matlab - LaTeX - Graph - Graph visualization - Signal processing - GNU Octave

FUNCTIONAL DESCRIPTION: Matlab / GNU Octave toolbox to manipulate and visualize signals on graphs. LaTeX package to draw signals.

- Contact: Benjamin Girault

6.2. IoT-LAB aggregation-tools

KEYWORD: Internet of things

FUNCTIONAL DESCRIPTION: IoT-LAB aggregation-tools allow aggregating data results from many nodes at a time. It connects to several tcp connections and handle the received data.

- Participant: Gaetan Harter
- Contact: Eric Fleury
- URL: https://github.com/iot-lab/aggregation-tools

6.3. IoT-LAB cli-tools

KEYWORD: Internet of things

FUNCTIONAL DESCRIPTION: IoT-LAB cli-tools provide a basic set of operations for managing IoT-LAB experiments from the command-line.

- Participants: Frederic Saint-Marcel and Gaetan Harter
- Contact: Eric Fleury
- URL: https://github.com/iot-lab/cli-tools

6.4. IoT-LAB gateway

KEYWORD: Internet of things

FUNCTIONAL DESCRIPTION: IoT-LAB software embedded on a IoT-LAB gateway node new generation provides the local management of the experiment on that node. It is a software bridge between the IoT-LAB server, the user open node and the control node.

- Contact: Frederic Saint-Marcel
- URL: https://github.com/iot-lab/iot-lab-gateway

6.5. IoT-LAB robots

KEYWORDS: Internet of things - Robotics

FUNCTIONAL DESCRIPTION: IoT-LAB robots is an embedded robot controler on a Turtlebot2 providing the IoT-LAB node mobility functionnality

- Partner: Université de Strasbourg
- Contact: Julien Vandaele
- URL: https://github.com/iot-lab/

6.6. Queueing Systems

FUNCTIONAL DESCRIPTION: This tool aims at providing a simple web interface to promote the use of our proposed solutions to numerically solve classical queueing systems.

- Participants: Alexandre Brandwajn and Thomas Begin
- Contact: Thomas Begin
- URL: http://queueing-systems.ens-lyon.fr/

6.7. WSNet

KEYWORD: Network simulator

FUNCTIONAL DESCRIPTION: WSNet is a modular event-driven simulator targeted to Wireless Sensor Networks. Its main goals are to offer scalabiliy, extensibility and modularity for the integration of new protocols/hardware models and a precise radio medium simulation. We still hope to find the proper resource to make WSNet evolve into a wireless capillary network simulator suitable for conducting simulations at the urban scale.

- Participants: Rodrigue Domga Komguem and Fabrice Valois
- Partner: CEA-LETI
- Contact: Guillaume Chelius
- URL: https://gforge.inria.fr/projects/wsnet-3/

<div align="center">

DATAMOVE Project-Team

</div>

6. New Software and Platforms

6.1. FlowVR

SCIENTIFIC DESCRIPTION: FlowVR adopts the "data-flow" paradigm, where your application is divided as a set of components exchanging messages (think of it as a directed graph). FlowVR enables to encapsulate existing codes in components, interconnect them through data channels, and deploy them on distributed computing resources. FlowVR takes care of all the heavy lifting such as application deployment and message exchange.

The base entity, called a module or component, is an autonomous process, potentially multi-threaded with tools like OpenMP, TBB, or deferring computations to a GPU or Xeon Phi. This module processes data coming from input ports and write data on output ports. A module has no global insight on where the data comes from or goes to. The programming interface is designed to limit code refactoring, easing turning an existing code into a FlowVR component. The three main functions are:

wait(): Blocking function call that waits for the availability of new messages on input ports. get(): Retrieve a handle to access the message received at the previous wait() call on a given input port. put(): Notify FlowVR that a new message on a given output port is ready for dispatch. FlowVR manages data transfers. Intra-node communications between two components take place through a shared memory segment, avoiding copies. Once the sender has prepared the data in a shared memory segment, it simply handles a pointer to the destination that can directly access them. Inter-node communications extend this mechanism, FlowVR taking care of packing and transferring the data from the source shared memory segment to the destination shared memory segment.

Assembling components to build an application consists in writing a Python script, instanciate it according to the target machine. FlowVR will process it and prepare everything so that in one command line you can deploy and start your application.

FUNCTIONAL DESCRIPTION: FlowVR adopts the "data-flow" paradigm, where your application is divided as a set of components exchanging messages (think of it as a directed graph). FlowVR enables to encapsulate existing codes in components, interconnect them through data channels, and deploy them on distributed computing resources. FlowVR takes care of all the heavy lifting such as application deployment and message exchange.

- Participants: Bruno Raffin, Clément Ménier, Emmanuel Melin, Jean Denis Lesage, Jérémie Allard, Jérémy Jaussaud, Matthieu Dreher, Sébastien Limet, Sophie Robert and Valérie Gourantou
- Contact: Bruno Raffin
- URL: http://flowvr.sf.net

6.2. OAR

KEYWORDS: HPC - Cloud - Clusters - Resource manager - Light grid

SCIENTIFIC DESCRIPTION: This batch system is based on a database (PostgreSQL (preferred) or MySQL), a script language (Perl) and an optional scalable administrative tool (e.g. Taktuk). It is composed of modules which interact mainly via the database and are executed as independent programs. Therefore, formally, there is no API, the system interaction is completely defined by the database schema. This approach eases the development of specific modules. Indeed, each module (such as schedulers) may be developed in any language having a database access library.

FUNCTIONAL DESCRIPTION: OAR is a versatile resource and task manager (also called a batch scheduler) for HPC clusters, and other computing infrastructures (like distributed computing experimental testbeds where versatility is a key).

- Participants: Bruno Bzeznik, Olivier Richard and Pierre Neyron
- Partners: LIG - CNRS - Grid'5000 - CIMENT
- Contact: Olivier Richard
- URL: http://oar.imag.fr

6.3. MELISSA

Modular External Library for In Situ Statistical Analysis

KEYWORD: Sensitivity Analysis

FUNCTIONAL DESCRIPTION: Melissa is an in situ solution for sensitivity analysis. It implements iterative algorithms to compute spatio-temporal statistic fields over results of large scale sensitivity studies. Melissa relies on a client/server architecture, composed of three main modules:

Melissa Server: an independent parallel executable. It receives data from the simulations, updates iterative statistics as soon as possible, then trow data away. Melissa API: a shared library to be linked within the simulation code. It mainly transmit simulation data to Melissa Server at each timestep. The simulations of the sensitivity analysis become the clients of Melissa Server. Melissa Launcher: A Python script in charge of generating and managing the whole global sensitivity analysis.

- Authors: Theophile Terraz, Bruno Raffin, Alejandro Ribes and Bertrand Iooss
- Partner: Edf
- Contact: Bruno Raffin
- Publications: In Situ Statistical Analysis for Parametric Studies - Melissa: Large Scale In Transit Sensitivity Analysis Avoiding Intermediate Files
- URL: https://melissa-sa.github.io

6.4. Platforms

6.4.1. Grid'5000 (https://www.grid5000.fr/) and Meso Center Ciment (http://ciment.univ-grenoble-alpes.fr/)

We have been very active in promoting the factorization of compute resources at a regional and national level. We have a three level implication, locally to maintain a pool of very flexible experimental machines (hundreds of cores), regionally through the CIMENT meso center (Equipex Grant), and nationally by contributing to the Grid'5000 platform, our local resources being included in this platform. Olivier Richard is member of Grid'5000 scientific committee and Pierre Neyron is member of the technical committee. The OAR scheduler in particular is deployed on both infrastructures. We are currently preparing proposals for the next generation machines within the context of the new university association (Univ. Grenoble-Alpes).

DELYS Project-Team (section vide)

<h1 style="color:red; text-align:center">DIANA Project-Team</h1>

5. New Software and Platforms

5.1. ACQUAmobile

KEYWORDS: Android - Internet access - Performance measure - Quality of Experience

FUNCTIONAL DESCRIPTION: ACQUA is an Application for prediCting QUality of Experience (QoE) at Internet Access [21]. It is developed by the Diana team at Inria Sophia Antipolis – Méditerranée and was supported by Inria under the ADT ACQUA grant. The scientific project around ACQUA is supported by Inria Project Lab BetterNet and the French National Project ANR BottleNet. The project also got the approval of Inria COERLE and French CNIL for the part on experimentation with real users. ACQUA presents a new way for the evaluation of the performance of Internet access. Starting from network-level measurements as the ones we often do today (bandwidth, delay, loss rates, jitter, etc), ACQUA targets the estimated Quality of Experience (QoE) related to the different applications of interest to the user without the need to run them (e.g., estimated Skype quality, estimated video streaming quality).

An application in ACQUA is a function, or a model, that links the network-level and device-level measurements to the expected Quality of Experience. Supervised machine learning techniques are used to establish such link between measurements both at the network level and the device level, and estimations of the Quality of Experience for different Internet applications. The required data for such learning can be obtained either by controlled experiments as we did in [26] on YouTube Quality of Experience, or by soliciting the crowd (i.e. crowdsourcing) for combinations (i.e. tuples) of measurements and corresponding application-level Quality of Experience. Our current work is concentrating on using the ACQUA principle in the estimation and prediction of the Quality of Experience for main user's applications. We refer to the web site of the project for further details.

The ACQUA Android application is supposed to be on one hand the reference application for QoE forecasting and troubleshooting for end users at their Internet access, and on the other hand, the feedback channel that allows end users to report to us (if they are willing) on their experience together with the corresponding network measurements so as to help us calibrating better and more realistic models. For this calibration, we are currently performing extensive, efficient and automatic measurements in the laboratory, we will count on end users to help us completing this dataset with further applications and more realistic network and user conditions.

ACQUA is mainly meant for end users, but it is also of interest to (mobile) network operators and to content providers to estimate the QoE of their customers and their networks without each time having to run expensive application-level traffic and to involve real users.

Assessment: Audience = 3, Software Originality = 4, Software Maturity = 3, Evolution and Maintenance = 3, Software Distribution and Licensing = 5.

- Authors: Thierry Spetebroot and Chadi Barakat
- Contact: Chadi Barakat
- URL: http://project.inria.fr/acqua/

5.2. ElectroSmart

KEYWORDS: Crowd-sourcing - UMTS - GSM - Bluetooth - Wi-Fi - 4G - 3G - 2G - Electromagnetic waves - Android - LTE

FUNCTIONAL DESCRIPTION: The Internet and new devices such as smartphones have fundamentally changed the way people communicate, but this technological revolution comes at the price of a higher exposition of the general population to microwave electromagnetic fields (EMF). This exposition is a concern for health agencies and epidemiologists who want to understand the impact of such an exposition on health, for the general public who wants a higher transparency on its exposition and the health hazard it might represent, but also for cellular operators and regulation authorities who want to improve the cellular coverage while limiting the exposition, and for computer scientists who want to better understand the network connectivity in order to optimize communication protocols. Despite the fundamental importance to understand the exposition of the general public to EMF, it is poorly understood because of the formidable difficulty to measure, model, and analyze this exposition.

The goal of the ElectroSmart project is to develop the instrument, methods, and models to compute the exposition of the general public to microwave electromagnetic fields used by wireless protocols and infrastructures such as Wi-Fi, Bluetooth, or cellular. Using a pluri-disciplinary approach combining crowd-based measurements, in-lab experiments, and modeling using sparse and noisy data, we address challenges such as designing and implementing a measuring instrument leveraging on crowd-based measurements from mobile devices such as smartphones, modeling the exposition of the general public to EMF to compute the most accurate estimation of the exposition, and analyzing the evolution of the exposition to EMF with time. This technological breakthrough will have scientific, technical, and societal applications, notably on public health politics, by providing the scientific community and potential users with a unique measuring instrument, methods, and models to exploit the invaluable data gathered by the instrument.

This project is supported by the UCN@Sophia Labex in 2016/2017/2018 (funding the engineer Mondi Ravi), by an Inria ADT (funding the engineer Abdelhakim Akodadi) 2017/2018, by and Inria ATT (funding the business developer David Migliacci) in 2017/2018, and by the academy 1 of UCAJedi (funding a Ph.D. student Yanis Boussad) 2017/2020.

In August 2016, we released the first stable public release of ElectroSmart. On the 07th January 2020, we acquire 1000 new daily users, and have 20k weekly active users.

Assessment: A-5, SO-4, SM-4, EM-3-up4, SDL-1

We are in a process of creating a startup to commercialize the exposition maps we can build with the data we are collecting.

- Participants: Arnaud Legout, Abdelhakim Akodadi, Hackob Melconian, Inderjeet Singh and Mondi Ravi
- Contact: Arnaud Legout
- URL: https://es.inria.fr/home/index?path_prefix=en

5.3. nepi-ng

KEYWORDS: Wireless network - Experimentation

FUNCTIONAL DESCRIPTION: In the specific context of R2lab, we have created a tool suite for orchestrating network experiments, that for historical reasons we refer to collectively as `nepi-ng`, for NEPI new generation. An umbrella website is available at https://nepi-ng.inria.fr/.

At this point, `nepi-ng` has a much smaller scope than its NEPI ancestor used to have, in that it only supports remote control of network experiments over `ssh`. As a matter of fact, in practice, this is the only access mechanism that we need to have for running experiments on both R2lab, and PlanetLab Europe.

The design of `nepi-ng` of course is modular, so that it will be perfectly possible to add other control mechanisms to this core if and when it becomes necessary.

`nepi-ng` is currently made of two separate Python libraries:

- asynciojobs:
    - URL: http://asynciojobs.readthedocs.io/en/latest/
    - Version: asynciojobs v0.5.4
    - Keywords: networking experimentation, orchestration
    - License: CC BY-SA 4.0
    - Type of human computer interaction: Python library
    - OS/Middleware: Linux
    - Required library or software: Python-3.5 / asyncio
    - Programming language: Python3
- apssh:
    - URL: http://apssh.readthedocs.io/en/latest/
    - Version: apssh v0.7.1
    - Keywords: networking experimentation, orchestration
    - License: CC BY-SA 4.0
    - Type of human computer interaction: Python library
    - OS/Middleware: Linux
    - Required library or software: Python-3.5 / asyncio
    - Programming language: Python3

Assessment: A-2, SO-3, SM-3, EM-3, DSL-4

- Contact: Thierry Parmentelat
- URL: http://nepi-ng.inria.fr

5.4. Distrinet

KEYWORDS: SDN - Emulation - Large-scale Emulators - Network simulator

SCIENTIFIC DESCRIPTION: Networks have become complex systems that combine various concepts, techniques, and technologies. As a consequence, modelling or simulating them is now extremely complicated and researchers massively resort to prototyping techniques. Two experimental techniques are mainly used when it comes to testing a network: simulation and emulation. Emulation provides a good accuracy and allows to test the applications directly in an environment that is similar to a real one. Most of the emulators do not take into account the scalability, because usually they are designed to be executed in a single machine. Among other tools, Mininet is the most popular when it comes to evaluate SDN propositions. It allows to emulate SDN networks on a single computer. Unfortunately, Mininet shows its limitations with resource intensive experiments as the emulating host may become overloaded. To tackle this issue, we propose Distrinet, a distributed implementation of Mininet over multiple hosts. Distrinet uses the same API than Mininet, meaning that it is compatible with Mininet programs. It is generic and can deploy experiments in Linux clusters or in the Amazon EC2 cloud.

Assessment: A5, SO3, SM2, EM2-down, SDL4

FUNCTIONAL DESCRIPTION: Distrinet is an extension of Mininet that relies on LXC to be distributed in the cloud, and particularly in Amazon.

RELEASE FUNCTIONAL DESCRIPTION: First release

- Participants: Damien Saucez, Giuseppe Di Lena, Andrea Tomassilli, Frédéric Giroire, Thierry Turletti and Walid Dabbous
- Partner: Orange Labs
- Contact: Walid Dabbous
- URL: https://distrinet-emu.github.io

5.5. Platforms

5.5.1. *Reproducible research Lab - R2lab*

Scientific work around network protocols and related software stacks requires experiments, hence experimental conditions, to be reproducible. This is a particularly challenging requirement in the wireless networking area, where characteristics of wireless channels are known to be variable, unpredictable and hardly controllable.

The R2lab wireless testbed was designed with reproducibility as its central characteristics; it is built around an isolated and anechoic chamber, featuring RF absorbers that prevent radio waves reflections, and a Faraday cage blocking external interferences. R2lab thus provides an ideal environment for running reproducible wireless experiments.

R2lab has been operated for 4 years now, in the context of the FIT (Future Internet of Things) Equipment of Excellence project, and as such, it is now federated with the other testbeds that are part of the FIT initiative. As of early 2019, it is now also federated within the Fed4Fire initiative.

Available toolsets, both hardware and software, are mostly stable apart from low noise marginal deployment of new kinds of radio devices, that now encompass among 5G and LoRa, among others. Our focus at this point of the project is to leverage our initial technical and financial investment, and to produce scientific work around reproducibility, particularly from a methodological standpoint, as illustrated by various publications [33], [34].

Worth being mentioned as well, as part of a partnership with the OpenAirInterface initiative, R2lab is used on a daily basis for system-wide regression tests of the OAI stack, which in return allows us to offer up-to-date images for running OAI-based experiments.

Access to R2lab is open 24/7. We currently have around 200 active users from all over the world among them 40 new users registered in 2019. For more details see http://r2lab.inria.fr.

5.5.2. *Network simulator for aircrafts*

- Keywords: network, simulation, real-time
- Functional Description: In collaboration with Safran Electrical and Power we produced a network design tool for aircrafts. This tool simulates aircraft networks. The tool is about 10,000 lines of code, out of which we produced 2,000.
- Assessment: A-2up,SO-3,SM-2up,EM-4,SDL-3,OC-DA-CD-TPM
- Licence: confidential
- URL: confidential
- Contact: Damien Saucez

<p align="center">**DIONYSOS Project-Team**</p>

6. New Software and Platforms

6.1. IPv6 Test Toolkit

FUNCTIONAL DESCRIPTION: These test suites are developed using the TTCN-3 environment.

The packages contains the full Abstract Test Suites written in TTCN-3 and the source files for building the codecs and adapters with the help of T3DevKit.

- Participants: Annie Floch, Anthony Baire, Ariel Sabiguero, Bruno Deniaud, César Viho and Frédéric Roudaut
- Contact: César Viho

6.2. Passive Test Tool

- Participants: Anthony Baire and César Viho
- Contact: Anthony Baire

6.3. T3DevKit

KEYWORDS: IPv6 - Conformance testing - TTCN-3

SCIENTIFIC DESCRIPTION: We have built a toolkit for easing executing tests written in the standardized TTCN-3 test specification language. This toolkit is made of a C++ library together with a highly customizable CoDec generator that allows fast development of external components (that are required to execute a test suite) such as CoDec (for message Coding/Decoding), System and Platform Adapters. It also provides a framework for representing and manipulating TTCN-3 events so as to ease the production of test reports. The toolkit addresses issues that are not yet covered by ETSI standards while being fully compatible with the existing standard interfaces: TRI (Test Runtime Interfaces) and TCI (Test Control Interfaces), it has been tested with four TTCN-3 environments (IBM, Elvior, Danet and Go4IT) and on three different platforms (Linux, Windows and Cygwin).

FUNCTIONAL DESCRIPTION: T3DevKit is a free open source toolkit to ease the development of test suites in the TTCN-3 environment. It provides:

a CoDec generator (t3cdgen) that automates the development process of the CoDec needed for coding TTCN-3 values into physically transmittable messages and decoding incoming messages a library (t3devlib) that provides an object oriented framework to manipulate TTCN-3 entities (values, ports, timers, external functions...) an implementation of the TRI and TCI standard interfaces default implementations for the system adapter (SA), platform adapter (PA), test management (TM), test logging (TL) and component handling (CH) modules default codecs build scripts for the generation of executable test suites, these are tool-independent and facilitate the distribution of test suite sources

- Participants: Annie Floch, Anthony Baire, Ariel Sabiguero, César Viho and Frédéric Roudaut
- Contact: Federico Sismondi

6.4. ttproto

Testing Tool Prototype

KEYWORDS: Interoperability - Conformance testing - TTCN-3

FUNCTIONAL DESCRIPTION: ttproto is an experimental tool for implementing testing tools, for conformance and interoperability testing.

It was first implemented to explore new features and concepts for the TTCN-3 standard, but we also used it to implement a passive interoperability test suite we provided for the CoAP interoperability event held in Paris in March 2012.

This tool is implemented in python3 and its design was influenced mainly by TTCN-3 (abstract model, templates, snapshots, behaviour trees, communication ports, logging) and by Scapy (syntax, flexibility, customisability)

Its purpose is to facilitate rapid prototyping rather than experimentations (rather than production use). We choosed to maximise its modularity and readability rather than performances and real-time considerations.

Now you should have a look at the Features page: https://www.irisa.fr/tipi/wiki/doku.php/testing_tool_prototype:features

- Contact: Federico Sismondi
- URL: https://www.irisa.fr/tipi/wiki/doku.php/testing_tool_prototype

6.5. CoAP Testing Tool

KEYWORDS: Test - Interoperability - Conformance testing - Plugtests

FUNCTIONAL DESCRIPTION: The software helps developers of the CoAP protocol assessing if their implementations (either CoAP clients or CoAP servers) are conformant to protocol specifications, and interoperable with other implementations. It encompasses:

- Coordination of CoAP interoperability tests
- Analysis of CoAP traces & issuing verdicts
- Automation of open source CoAP implementations for based reference interop testing
- Authors: Federico Sismondi and César Viho
- Contact: Federico Sismondi

6.6. ioppytest

Interoperability testing

KEYWORDS: Interoperability - Conformance testing - CoAP - 6LoWPAN - OneM2M

FUNCTIONAL DESCRIPTION: The software is a framework for developing interoperability tests. The interoperability tests help developers of network protocol assessing if their implementations are conformant to protocol specifications, and interoperable with other implementations.

The software already integrates interoperability tests for CoAP, OneM2M and 6LoWPAN The framework provides the following features to the users:

- Coordination of the interoperability tests (enabling remote testing)
- VPN-like connectivity between users' implementations (enabling remote testing)
- Analysis of exchanged network traces & issuing verdicts
- Automation of open source implementations for based reference interop testing

This framework is the evolution of the CoAP Testing Tool (https://bil.inria.fr/fr/software/view/2937/tab)

- Contact: Federico Sismondi
- URL: https://gitlab.f-interop.eu/f-interop-contributors/ioppytest

DIVERSE Project-Team

5. New Software and Platforms

5.1. amiunique

KEYWORDS: Privacy - Browser fingerprinting

SCIENTIFIC DESCRIPTION: The amiunique web site has been deployed in the context of the DiverSE's research activities on browser fingerprinting and how software diversity can be leveraged in order to mitigate the impact of fingerprinting on the privacy of users. The construction of a dataset of genuine fingerprints is essential to understand in detail how browser fingerprints can serve as unique identifiers and hence what should be modified in order to mitigate its impact privacy. This dataset also supports the large-scale investigation of the impact of web technology advances on fingerprinting. For example, we can analyze in detail the impact of the HTML5 canvas element or the behavior of fingerprinting on mobile devices.

The whole source code of amiunique is open source and is distributed under the terms of the MIT license.

- Panopticlick https://panopticlick.eff.org/
- BrowserSpy http://browserspy.dk/

Main innovative features:

- canvas fingerprinting
- WebGL fingerprinting
- advanced JS features (platform, DNT, etc.)

Impact: The website has been showcased in several professional forums in 2014 and 2015 (Open World Forum 2014, FOSSA'14, FIC'15, ICT'15) and it has been visited by more than 100,000 unique visitors in one year.

FUNCTIONAL DESCRIPTION: This web site aims at informing visitors about browser fingerprinting and possible tools to mitigate its effect, as well as at collecting data about the fingerprints that can be found on the web. It collects browser fingerprints with the explicit agreement of the users (they have to click on a button on the home page). Fingerprints are composed of 17 attributes, which include regular HTTP headers as well as the most recent state of the art techniques (canvas fingerprinting, WebGL information).

- Participants: Benoit Baudry and Pierre Laperdrix
- Partner: INSA Rennes
- Contact: Benoit Baudry
- URL: https://amiunique.org/

5.2. FAMILIAR

KEYWORDS: Software line product - Configators - Customisation

SCIENTIFIC DESCRIPTION: FAMILIAR (for FeAture Model scrIpt Language for manIpulation and Automatic Reasoning) is a language for importing, exporting, composing, decomposing, editing, configuring, computing "diffs", refactoring, reverse engineering, testing, and reasoning about (multiple) feature models. All these operations can be combined to realize complex variability management tasks. A comprehensive environment is proposed as well as integration facilities with the Java ecosystem.

FUNCTIONAL DESCRIPTION: Familiar is an environment for large-scale product customisation. From a model of product features (options, parameters, etc.), Familiar can automatically generate several million variants. These variants can take many forms: software, a graphical interface, a video sequence or even a manufactured product (3D printing). Familiar is particularly well suited for developing web configurators (for ordering customised products online), for providing online comparison tools and also for engineering any family of embedded or software-based products.

- Participants: Aymeric Hervieu, Benoit Baudry, Didier Vojtisek, Edward Mauricio Alferez Salinas, Guillaume Bécan, Joao Bosco Ferreira-Filho, Julien Richard-Foy, Mathieu Acher, Olivier Barais and Sana Ben Nasr

- Contact: Mathieu Acher

- URL: http://familiar-project.github.com

5.3. GEMOC Studio

KEYWORDS: DSL - Language workbench - Model debugging

SCIENTIFIC DESCRIPTION: The language workbench put together the following tools seamlessly integrated to the Eclipse Modeling Framework (EMF):

- Melange, a tool-supported meta-language to modularly define executable modeling languages with execution functions and data, and to extend (EMF-based) existing modeling languages.

- MoCCML, a tool-supported meta-language dedicated to the specification of a Model of Concurrency and Communication (MoCC) and its mapping to a specific abstract syntax and associated execution functions of a modeling language.

- GEL, a tool-supported meta-language dedicated to the specification of the protocol between the execution functions and the MoCC to support the feedback of the data as well as the callback of other expected execution functions.

- BCOoL, a tool-supported meta-language dedicated to the specification of language coordination patterns to automatically coordinates the execution of, possibly heterogeneous, models.

- Sirius Animator, an extension to the model editor designer Sirius to create graphical animators for executable modeling languages.

FUNCTIONAL DESCRIPTION: The GEMOC Studio is an eclipse package that contains components supporting the GEMOC methodology for building and composing executable Domain-Specific Modeling Languages (DSMLs). It includes the two workbenches: The GEMOC Language Workbench: intended to be used by language designers (aka domain experts), it allows to build and compose new executable DSMLs. The GEMOC Modeling Workbench: intended to be used by domain designersto create, execute and coordinate models conforming to executable DSMLs. The different concerns of a DSML, as defined with the tools of the language workbench, are automatically deployed into the modeling workbench. They parametrize a generic execution framework that provide various generic services such as graphical animation, debugging tools, trace and event managers, timeline, etc.

- Participants: Didier Vojtisek, Dorian Leroy, Erwan Bousse, Fabien Coulon and Julien DeAntoni

- Partners: IRIT - ENSTA - I3S - OBEO - Thales TRT

- Contact: Benoît Combemale

- URL: http://gemoc.org/studio.html

5.4. Kevoree

KEYWORDS: M2M - Dynamic components - Iot - Heterogeneity - Smart home - Cloud - Software architecture - Dynamic deployment

SCIENTIFIC DESCRIPTION: Kevoree is an open-source models@runtime platform (http://www.kevoree.org) to properly support the dynamic adaptation of distributed systems. Models@runtime basically pushes the idea of reflection [132] one step further by considering the reflection layer as a real model that can be uncoupled from the running architecture (e.g. for reasoning, validation, and simulation purposes) and later automatically resynchronized with its running instance.

Kevoree has been influenced by previous work that we carried out in the DiVA project [132] and the Entimid project [135] . With Kevoree we push our vision of models@runtime [131] farther. In particular, Kevoree provides a proper support for distributed models@runtime. To this aim we introduced the Node concept to model the infrastructure topology and the Group concept to model semantics of inter node communication during synchronization of the reflection model among nodes. Kevoree includes a Channel concept to allow for multiple communication semantics between remoteComponents deployed on heterogeneous nodes. All Kevoree concepts (Component, Channel, Node, Group) obey the object type design pattern to separate deployment artifacts from running artifacts. Kevoree supports multiple kinds of very different execution node technology (e.g. Java, Android, MiniCloud, FreeBSD, Arduino, ...).

Kevoree is distributed under the terms of the LGPL open source license.

Main competitors:

- the Fractal/Frascati eco-system (http://frascati.ow2.org/doc/1.4/frascati-userguide.html).
- SpringSource Dynamic Module (http://spring.io/)
- GCM-Proactive (http://proactive.inria.fr/)
- OSGi (http://www.osgi.org)
- Chef
- Vagran (http://vagrantup.com/)

Main innovative features:

- distributed models@runtime platform (with a distributed reflection model and an extensible models@runtime dissemination set of strategies).
- Support for heterogeneous node type (from Cyber Physical System with few resources until cloud computing infrastructure).
- Fully automated provisioning model to correctly deploy software modules and their dependencies.
- Communication and concurrency access between software modules expressed at the model level (not in the module implementation).

FUNCTIONAL DESCRIPTION: Kevoree is an open-source models@runtime platform to properly support the dynamic adaptation of distributed systems. Models@runtime basically pushes the idea of reflection one step further by considering the reflection layer as a real model that can be uncoupled from the running architecture (e.g. for reasoning, validation, and simulation purposes) and later automatically resynchronized with its running instance.

- Participants: Aymeric Hervieu, Benoit Baudry, Francisco-Javier Acosta Padilla, Inti Gonzalez Herrera, Ivan Paez Anaya, Jacky Bourgeois, Jean Emile Dartois, Johann Bourcier, Manuel Leduc, Maxime Tricoire, Mohamed Boussaa, Noël Plouzeau and Olivier Barais
- Contact: Olivier Barais
- URL: http://kevoree.org/

5.5. Melange

KEYWORDS: Model-driven engineering - Meta model - MDE - DSL - Model-driven software engineering - Dedicated langage - Language workbench - Meta-modelisation - Modeling language - Meta-modeling

SCIENTIFIC DESCRIPTION: Melange is a follow-up of the executable metamodeling language Kermeta, which provides a tool-supported dedicated meta-language to safely assemble language modules, customize them and produce new DSMLs. Melange provides specific constructs to assemble together various abstract syntax and operational semantics artifacts into a DSML. DSMLs can then be used as first class entities to be reused, extended, restricted or adapted into other DSMLs. Melange relies on a particular model-oriented type system that provides model polymorphism and language substitutability, i.e. the possibility to manipulate a model through different interfaces and to define generic transformations that can be invoked on models written using different DSLs. Newly produced DSMLs are correct by construction, ready for production (i.e., the result can be deployed and used as-is), and reusable in a new assembly.

Melange is tightly integrated with the Eclipse Modeling Framework ecosystem and relies on the meta-language Ecore for the definition of the abstract syntax of DSLs. Executable meta-modeling is supported by weaving operational semantics defined with Xtend. Designers can thus easily design an interpreter for their DSL in a non-intrusive way. Melange is bundled as a set of Eclipse plug-ins.

FUNCTIONAL DESCRIPTION: Melange is a language workbench which helps language engineers to mashup their various language concerns as language design choices, to manage their variability, and support their reuse. It provides a modular and reusable approach for customizing, assembling and integrating DSMLs specifications and implementations.

- Participants: Arnaud Blouin, Benoît Combemale, David Mendez Acuna, Didier Vojtisek, Dorian Leroy, Erwan Bousse, Fabien Coulon, Jean-Marc Jézéquel, Olivier Barais and Thomas Degueule
- Contact: Benoît Combemale
- URL: http://melange-lang.org

5.6. DSpot

KEYWORDS: Software testing - Test amplification

FUNCTIONAL DESCRIPTION: DSpot is a tool that generates missing assertions in JUnit tests. DSpot takes as input a Java project with an existing test suite. As output, DSpot outputs new test cases on console. DSpot supports Java projects built with Maven and Gradle

- Participants: Benoit Baudry, Martin Monperrus and Benjamin Danglot
- Partner: KTH Royal Institute of Technology
- Contact: Benjamin Danglot
- URL: https://github.com/STAMP-project/dspot

5.7. ALE

Action Language for Ecore

KEYWORDS: Meta-modeling - Executable DSML

FUNCTIONAL DESCRIPTION: Main features of ALE include:

- Executable metamodeling: Re-open existing EClasses to insert new methods with their implementations
- Metamodel extension: The very same mechanism can be used to extend existing Ecore metamodels and insert new features (eg. attributes) in a non-intrusive way
- Interpreted: No need to deploy Eclipse plugins, just run the behavior on a model directly in your modeling environment
- Extensible: If ALE doesn't fit your needs, register Java classes as services and invoke them inside your implementations of EOperations.
- Partner: OBEO
- Contact: Benoît Combemale
- URL: http://gemoc.org/ale-lang/

5.8. InspectorGuidget

KEYWORDS: Static analysis - Software testing - User Interfaces

FUNCTIONAL DESCRIPTION: InspectorGuidget is a static code analysing tool. InspectorGuidget analyses UI (user interface/interaction) code of a software system to extract high level information and metrics. InspectorGuidget also finds bad UI coding pratices, such as Blob listener instances. InspectorGuidget analyses Java code.

- Participants: Arnaud Blouin and Benoit Baudry
- Contact: Arnaud Blouin
- Publications: hal-01499106v5 - hal-01308625v2
- URL: https://github.com/diverse-project/InspectorGuidget

5.9. Descartes

KEYWORDS: Software testing - Mutation analysis

FUNCTIONAL DESCRIPTION: Descartes evaluates the capability of your test suite to detect bugs using extreme mutation testing.

Descartes is a mutation engine plugin for PIT which implements extreme mutation operators as proposed in the paper *Will my tests tell me if I break this code?*.

- Participants: Oscar Luis Vera Perez, Benjamin Danglot, Benoit Baudry and Martin Monperrus
- Partner: KTH Royal Institute of Technology
- Contact: Benoit Baudry
- Publications: Descartes: a PITest engine to detect pseudo-tested methods - Tool Demonstration - A Comprehensive Study of Pseudo-tested Methods
- URL: https://github.com/STAMP-project/pitest-descartes

5.10. PitMP

PIT for Multi-module Project

KEYWORDS: Mutation analysis - Mutation testing - Java - JUnit - Maven

FUNCTIONAL DESCRIPTION: PIT and Descartes are mutation testing systems for Java applications, which allows you to verify if your test suites can detect possible bugs, and so to evaluate the quality of your test suites. They evaluate the capability of your test suite to detect bugs using mutation testing (PIT) or extreme mutation testing (Descartes). Mutation testing does it by introducing small changes or faults into the original program. These modified versions are called mutants. A good test suite should able to kill or detect a mutant. Traditional mutation testing works at the instruction level, e.g., replacing ">" by "<=", so the number of generated mutants is huge, as the time required to check the entire test suite. That's why Extreme Mutation strategy appeared. In Extreme Mutation testing, the whole body of a method under test is removed. Descartes is a mutation engine plugin for PIT which implements extreme mutation operators. Both provide reports combining, line coverage, mutation score and list of weaknesses in the source.

- Partners: CSQE - KTH Royal Institute of Technology - ENGINEERING
- Contact: Caroline Landry
- URL: https://github.com/STAMP-project/pitmp-maven-plugin

DYOGENE Project-Team

6. New Software and Platforms

6.1. Platforms

6.1.1. CapRadio

Cellular network dimensioning toolbox *CapRadio* is being developed by Orange in a long-term collaboration between TREC/DYOGENE represented by B. Błaszczyszyn, and Orange Labs, represented by M. K. Karray. This year we are working on taking into account the "massive MIMO" in 5G cellular networks; see 8.1.1 .

EASE Project-Team

5. New Software and Platforms

5.1. THEGAME

KEYWORD: Contextual service

SCIENTIFIC DESCRIPTION: Context-aware applications have to sense the environment in order to adapt themselves and provide with contextual services. This is the case of Smart Homes equipped with sensors and augmented appliances. However, sensors can be numerous, heterogeneous and unreliable. Thus the data fusion is complex and requires a solid theory to handle those problems. The aim of the data fusion, in our case, is to compute small pieces of context we call context attributes. Those context attributes are diverse and could be for example the presence in a room, the number of people in a room or even that someone may be sleeping in a room. For this purpose, we developed an implementation of the belief functions theory (BFT). THE GAME (THeory of Evidence in a lanGuage Adapted for Many Embedded systems) is made of a set of C-Libraries. It provides the basics of belief functions theory, computations are optimized for an embedded environment (binary representation of sets, conditional compilation and diverse algorithmic optimizations).

THE GAME is published under apache licence (https://github.com/bpietropaoli/THEGAME/). It is maintained and experimented by Aurélien Richez within a sensor network platform developed by TACOMA since June 2013.

FUNCTIONAL DESCRIPTION: THEGAME is a set of software services for detecting different types of situation in a building (presence in a room, activity level, etc.) based on a set of raw data sourced from all sorts of sensors. Written in C or Java, it can be integrated in an embedded computer: tablet, smartphone, box, etc., and can be connected to different sensor networks. It can be used to implement context-aware services: for example, to alert the user if s/he forgets to close a window when leaving the building, or to turn off the heating in an empty room, etc.

- Participants: Aurélien Richez and Bastien Pietropaoli
- Contact: Frédéric Weis
- URL: https://github.com/bpietropaoli/THEGAME/

5.2. Platform Pervasive_RFID

SCIENTIFIC DESCRIPTION

The RFID experiment testbed has been designed and deployed in collaboration with IETR (see Figure 2). This system allows both interactive testing as well as long running experiments of RFID reading protocols. It comprises a software platform allowing fine control over all dynamic aspects influencing RFID readings: movements for target and antenna, RFID reader configuration, and smart antenna configuration (diversity and power control).

KEYWORDS: Composite objects - RFID

- Participants: Paul Couderc and Alexis Girard (Univ. Rennes 1)
- Partner: Univ. Rennes 1 (IETR - lab bringing together researchers in the electronics and telecommunications)
- Contact: Paul Couderc

5.3. ISO/IEC 15118-2 Open source Implementation
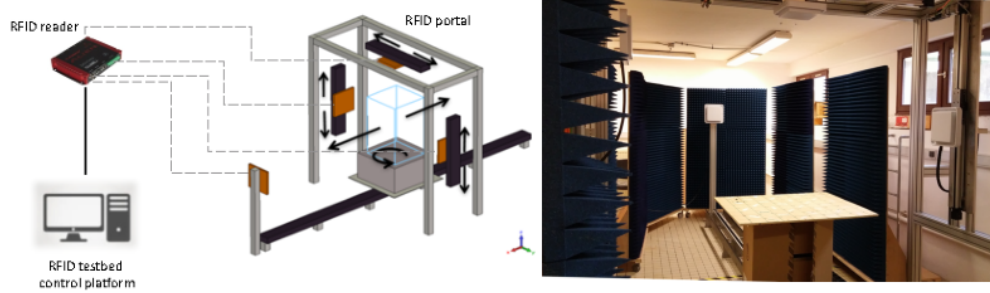
SCIENTIFIC DESCRIPTION

Figure 2. RFID testbed

The ISO/IEC 15118 standard, named "Road vehicles – Vehicle-to-Grid Communication Interface", defines how an electric vehicle and a charging station should communicate. It enables the Smart Charging of electric vehicles by allowing them to plan their charging sessions. As we want to be able to manage the charge of electric vehicles in our micro Smart Grid systems, we decided to implement the protocol defined by this standard. The goal is also to participate actively in the design of the new version of this protocol. During a charging session the charging station provides the vehicle with the status of the electric power grid. The vehicle is then able to plan its sharing session accordingly. It sends back its charge plan to the charging station, so that the Smart Grid is aware of it. The protocol also provides security and authentication features.

This software platform was implemented onto small PCs, and was used to control the charge in a small and portable demonstration platform, to demonstrate how it is possible to interconnect this high level decision and communication software with low level components, such as a Battery Management System (BMS), and a battery charger. In 2016, in the context of the Greenfeed project our software has been demonstrated to control the charge of the electric vehicle during the final demonstration of the project. The integration work has been done in collaboration with VeDeCom [0].

KEYWORDS: Smart Grid - Intelligent Transport System

- Partner: IMT Atlantique
- Contact: Jean-Marie Bonnin

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[0] http://www.vedecom.fr/

EVA Project-Team

6. New Software and Platforms

6.1. OpenWSN

KEYWORDS: Internet of things - 6TiSCH - 6LoWPAN - CoAP

FUNCTIONAL DESCRIPTION: OpenWSN is an open-source implementation of a fully standards-based protocol stack for the Internet of Things. It has become the de-facto implementation of the IEEE802.15.4e TSCH standard, has a vibrant community of academic and industrial users, and is the reference implementation of the work we do in the IETF 6TiSCH standardization working group.

- Partner: University of California Berkeley
- Contact: Thomas Watteyne
- URL: http://www.openwsn.org/

6.2. 6TiSCH Simulator

High-level simulator of a 6TiSCH network

KEYWORDS: Network simulator - 6TiSCH

FUNCTIONAL DESCRIPTION: The simulator is written in Python. While it doesn't provide a cycle-accurate emulation, it does implement the functional behavior of a node running the full 6TiSCH protocol stack. This includes RPL, 6LoWPAN, CoAP and 6P. The implementation work tracks the progress of the standardization process at the IETF.

- Contact: Malisa Vucinic

6.3. Argus

KEYWORDS: Cloud - Low-Power WIreless - Sniffer

FUNCTIONAL DESCRIPTION: There are three piece to the Argus:

The Argus Probe is the program which attaches to your low-power wireless sniffer and forwards its traffic to the Argus Broker.

The Argus Broker sits somewhere in the cloud. Based on MQTT, it connect Argus Probes with Argus Clients based on a pub-sub architecture.

Several Argus Clients can the started at the same time. It is a program which subscribes to the Argus Broker and displays the frames in Wireshark.

- Contact: Remy Leone

6.4. SolSystem

Sensor Object Library System

KEYWORDS: Low-Power WIreless - Back-End System - SmartMesh IP

FUNCTIONAL DESCRIPTION: The source code is composed of the definition of the SOL structure (https://github.com/realms-team/sol), the code that runs on the manager (https://github.com/realms-team/solmanager, written in Python) and the code that runs on the server receiving the data (https://github.com/realms-team/solserver, written in Python)

- Contact: Keoma Brun-Laguna
- URL: http://www.solsystem.io/

6.5. 6TiSCH Wireshark Dissector

KEYWORDS: 6TiSCH - Wireshark

FUNCTIONAL DESCRIPTION: Implementation on the dissectors is done through an open-source repository, stable code is regularly contributed back to the main Wireshark code base.

- Contact: Jonathan Muñoz

6.6. F-Interop

Remote Conformance and Interoperability Tests for the Internet of Thing

KEYWORDS: Interoperability - Iot - Conformance testing - Standardization

- Partners: UPMC - IMEC - ETSI - EANTC - Mandat International - Digital Catapult - University of Luxembourg - Device Gateway
- Contact: Remy Leone

6.7. Mercator

KEYWORDS: Deployment - Low-Power WIreless - Testbeds - Connectivity

FUNCTIONAL DESCRIPTION: The firmware is written as part of the OpenWSN project. Scripts and analysis tools are written in Python.

- Contact: Keoma Brun-Laguna

<p align="center" style="color:red">FOCUS Project-Team</p>

6. New Software and Platforms

6.1. HoCA

Higher-Order Complexity Analysis

KEYWORDS: Ocaml - Verification - Runtime Complexity Analysis

SCIENTIFIC DESCRIPTION: Over the last decade, various tools for the static analysis of resource properties of programs have emerged. In particular, the rewriting community has recently developed several tools for the time complexity analysis of term rewrite systems. These tools have matured and are nowadays able to treat non-trivial programs, in a fully automatic setting. However, none of these automatic complexity analysers can deal with higher-order functions, a pervasive feature of functional programs. HoCA (Higher-Order Complexity Analyser) overcomes this limitation by translating higher-order programs – in the form of side-effect free OCaml programs - into equivalent first-order rewrite systems. At the heart of our tool lies Reynold's defunctionalization technique. Defunctionalization however is not enough. Resulting programs have a recursive structure too complicated to be analysed automatically in all but trivial cases. To overcome this issue, HoCA integrates a handful of well established program transformation techniques, noteworthy dead-code elimination, inlining, instantiation and uncurrying. A complexity bound on the resulting first-order program can be relayed back reliably to the higher-order program of interest. A detailed description of HoCA is available on http://arxiv.org/abs/1506.05043.

FUNCTIONAL DESCRIPTION: HoCA is an abbreviation for Higher-Order Complexity Analysis, and is meant as a laboratory for the automated complexity analysis of higher-order functional programs. Currently, HoCA consists of one executable pcf2trs which translates a pure subset of OCaml to term rewrite systems, in a complexity reflecting manner. As a first step, HoCA desugars the given program to a variation of Plotkin's PCF with data-constructors. Via Reynold's defunctionalization, the PCF program is turned into an applicative term rewrite system (ATRS for short), call-by-value reductions of the PCF program are simulated by the ATRS step-by-step, on the ATRS, and various complexity reflecting transformations are performed: inlining, dead-code-elminiation, instantiation of higher-order variables through a call-flow-analysis and finally uncurrying. This results finally in a first-order rewrite system, whose runtime-complexity reflects the complexity of the initial program, asymptotically.

- Participants: Martin Avanzini and Ugo Dal Lago
- Contact: Ugo Dal Lago
- URL: http://cbr.uibk.ac.at/tools/hoca/

6.2. JOLIE

Java Orchestration Language Interpreter Engine

KEYWORD: Microservices

SCIENTIFIC DESCRIPTION: Jolie enforces a strict separation of concerns between behaviour, describing the logic of the application, and deployment, describing the communication capabilities. The behaviour is defined using the typical constructs of structured sequential programming, communication primitives, and operators to deal with concurrency (parallel composition and input choice). Jolie communication primitives comprise two modalities of interaction typical of Service-Oriented Architectures (SOAs), namely one-way (sends an asynchronous message) and request-response (sends a message and waits for an answer). A main feature of the Jolie language is that it allows one to switch among many communication media and data protocols in a simple, uniform way. Since it targets the field of SOAs, Jolie supports the main communication media (TCP/IP sockets, Bluetooth L2CAP, Java RMI, and Unix local sockets) and data protocols (HTTP, JSON-RPC, XML-RPC, SOAP and their respective SSL versions) from this area.

FUNCTIONAL DESCRIPTION: Jolie is a language for programming service-oriented and microservice applications. It directly supports service-oriented abstractions such as service, port, and session. Jolie allows to program a service behaviour, possibly obtained by composing existing services, and supports the main communication protocols and data formats used in service-oriented architectures. Differently from other service-oriented programming languages such as WS-BPEL, Jolie is based on a user-friendly Java-like syntax (more readable than the verbose XML syntax of WS-BPEL). Moreover, the kernel of Jolie is equipped with a formal operational semantics. Jolie is used to provide proof of concepts around Focus activities.

RELEASE FUNCTIONAL DESCRIPTION: There are many fixes to the HTTP extension, improvements to the embedding engine for Javascript programs, and improvements to the support tools jolie2java and wsdl2jolie.

NEWS OF THE YEAR: During 2019 the Jolie project saw three major actions.

The first action regards the build system used for the development of the language, which has been transitioned to Maven, the main build automation tool used for Java projects. The move to Maven is dictated by two needs. The first is to streamline the development and release processes of Jolie, as Maven greatly helps in obtaining, updating, and managing library dependencies. The second necessity addressed by Maven is helping in partitioning the many sub-projects that constitute the Jolie codebase, reducing development and testing times. Having Jolie as a Maven project also helps in providing Jolie sub-components (as Maven libraries) to other projects. Finally, the move to Maven is set within a larger effort to expedite the inclusion in the main Jolie development branch of contributions by new members of its growing community.

The second action regards the transition to Netty as a common framework to support communication protocols and data formats in Jolie. Netty is a widely-adopted Java framework for the development of network applications, and it was used in 2018 to successfully support several IoT communication protocols and data formats in a Jolie spin-off project, called JIoT. The work in 2019 integrated into the Jolie codebase the protocols and data format developed within the JIoT project and pushed towards the integration of the Netty development branch into the main branch of the Jolie project (i.e., re-implementing using Netty the many protocol and data-formats already supported by Jolie). The Netty development branch is currently in a beta phase and it is subject to thorough in-production tests, to ensure consistent behaviour with the previous implementation.

The third action regards the development and support for a new official IDE for Jolie. Hence, along with the ones already existing for the Atom and Sublime Text text editors, Jolie developers can use the Jolie plugin (based on the Language Server Protocol) for the Visual Studio Code text editor to obtain syntax highlighting, documentation aids, file navigation, syntax checking, semantic checking, and quick-run shortcuts for their Jolie programs.

In addition to the above actions, in 2019 Jolie transitioned through three minor releases and a major one, from 1.7.1 to 1.8.2. The minor releases mainly fixed bugs, improved performance, and included new protocol/data-format functionalities. The major release included a slim-down of the notation for the composition of statements, types definitions, and tree structures, for a terser codebase. Upgrades to 1.8.2 also introduced: timeouts for solicit-response invocations to handle the interruption of long-standing requests, more user-friendly messages from the Jolie interpreter, including easier-to-parse errors and the pretty-printing of data structures, for a more effective development and debugging experience.

In 2019 Jolie also saw the development of a new Jolie library, called TQuery, which is a query framework integrated into the Jolie language for the data handling/querying of Jolie trees. Tquery is based on a tree-based instantiation (language and semantics) of MQuery, a sound variant of the Aggregation Framework, the query language of the most popular document-oriented database: MongoDB. Usage scenarios for Tquery are (but not limited to) eHealth, the Internet-of-Things, and Edge Computing, where data should be handled in an ephemeral way, i.e., in a real-time manner but with the constraint that data shall not persist in the system.

- Participants: Claudio Guidi, Fabrizio Montesi, Maurizio Gabbrielli, Saverio Giallorenzo and Ivan Lanese
- Contact: Fabrizio Montesi
- URL: http://www.jolie-lang.org/

6.3. NightSplitter

KEYWORD: Constraint-based programming

FUNCTIONAL DESCRIPTION: Nightsplitter deals with the group preference optimization problem. We propose to split users into subgroups trying to optimize members' satisfaction as much as possible. In a large city with a huge volume of activity information, designing subgroup activities and avoiding time conflict is a challenging task. Currently, the Demo is available only for restaurant and movie activities in the city of Paris.

- Contact: Tong Liu
- URL: http://cs.unibo.it/t.liu/nightsplitter/

6.4. AIOCJ

Adaptive Interaction-Oriented Choreographies in Jolie

KEYWORD: Dynamic adaptation

SCIENTIFIC DESCRIPTION: AIOCJ is an open-source choreographic programming language for developing adaptive systems. It allows one to describe a full distributed system as a unique choreographic program and to generate code for each role avoiding by construction errors such as deadlocks. Furthermore, it supports dynamic adaptation of the distributed system via adaptation rules.

FUNCTIONAL DESCRIPTION: AIOCJ is a framework for programming adaptive distributed systems based on message passing. AIOCJ comes as a plugin for Eclipse, AIOCJ-ecl, allowing to edit descriptions of distributed systems written as adaptive interaction-oriented choreographies (AIOC). From interaction-oriented choreographies the description of single participants can be automatically derived. Adaptation is specified by rules allowing one to replace predetermined parts of the AIOC with a new behaviour. A suitable protocol ensures that all the participants are updated in a coordinated way. As a result, the distributed system follows the specification given by the AIOC under all changing sets of adaptation rules and environment conditions. In particular, the system is always deadlock free. AIOCJ can interact with external services, seen as functions, by specifying their URL and the protocol they support (HTTP, SOAP, ...). Deadlock-freedom guarantees of the application are preserved provided that those services do not block.

NEWS OF THE YEAR: In 2019 we performed a major upgrade to AIOCJ: the possibility to introduce new roles, absent from a running choreography, within a given adaptation rule. The inclusion of new roles is supported by a slight, incremental change in the AIOCJ syntax and by a new component of the AIOCJ runtime environment.

- Participants: Ivan Lanese, Jacopo Mauro, Maurizio Gabbrielli, Mila Dalla Preda and Saverio Giallorenzo
- Contact: Saverio Giallorenzo
- URL: http://www.cs.unibo.it/projects/jolie/aiocj.html

6.5. CauDEr

Causal-consistent Debugger for Erlang

KEYWORDS: Debug - Reversible computing

SCIENTIFIC DESCRIPTION: The CauDEr reversible debugger is based on the theory of causal-consistent reversibility, which states that any action can be undone provided that its consequences, if any, are undone beforehand. This theory relies on a causal semantic for the target language, and can be used even if different processes have different notions of time

FUNCTIONAL DESCRIPTION: CauDEr is a debugger allowing one to explore the execution of concurrent Erlang programs both forward and backward. Notably, when going backward, any action can be undone provided that its consequences, if any, are undone beforehand. The debugger also provides commands to automatically find relevant past actions (e.g., send of a given message) and undo them, including their consequences. Forward computation can be driven by a log taken from a computation in the standard Erlang/OTP environment. An action in the log can be selected and replayed together with all and only its causes. The debugger enables one to find a bug by following the causality links from the visible misbehaviour to the bug. The debugger takes an Erlang program but debugging is done on its translation into Core Erlang.

NEWS OF THE YEAR: Work in 2019 consisted in maintenance, bug fixing and some minor refinements, in particular on the logging part.

- Partner: Universitat Politècnica de València
- Contact: Ivan Lanese
- URL: https://github.com/mistupv/cauder

6.6. SUNNY-AS

SUNNY FOR ALGORITHM SELECTION

KEYWORDS: Optimisation - Machine learning

FUNCTIONAL DESCRIPTION: SUNNY-AS is a portfolio solver derived from SUNNY-CP for Algorithm Selection Problems (ASLIB). The goal of SUNNY-AS is to provide a flexible, configurable, and usable portfolio solver that can be set up and executed just like a regular individual solver.

- Contact: Tong Liu
- URL: https://github.com/lteu/oasc

6.7. eco-imp

Expected Cost Analysis for Imperative Programs

KEYWORDS: Software Verification - Automation - Runtime Complexity Analysis - Randomized algorithms

FUNCTIONAL DESCRIPTION: Eco-imp is a cost analyser for probabilistic and non-deterministic imperative programs. Particularly, it features dedicated support for sampling from distributions, and can thereby accurately reason about the average case complexity of randomized algorithms, in a fully automatic fashion. The tool is based on an adaption of the ert-calculus of Kaminski et al., extended to the more general setting of cost analysis where the programmer is free to specify a (non-uniform) cost measure on programs. The main distinctive feature of eco-imp, though, is the combination of this calculus with an expected value analysis. This provides the glue to analyse program components in complete independence, that is, the analysis is modular and thus scalable. As a consequence, confirmed by our experiments, eco-imp runs on average orders of magnitude faster than comparable tools: execution times of several seconds become milliseconds.

- Contact: Martin Avanzini
- URL: http://www-sop.inria.fr/members/Martin.Avanzini/software/eco-imp/

<p style="text-align: center; color: red;">**FUN Project-Team**</p>

5. New Software and Platforms

5.1. AspireRFID ALE

FUNCTIONAL DESCRIPTION: AspireRFID middleware is a modular OW2 open source RFID middleware. It is compliant with EPC Global standards. This new module integrates the modifications of the new standard release, including new RP and LLRP definitions and fixing bugs. This module has been implemented in the framework of the MIAOU project.

- Participants: Ibrahim Amadou, Julien Vandaele, Nathalie Mitton and Rim Driss
- Contact: Nathalie Mitton

5.2. ETINODE-CONTIKI-PORT

KEYWORD: Iot

FUNCTIONAL DESCRIPTION: Contiki is an open source embedded OS for Internet of Things (IoT). It is light and portable to different hardware architectures. It embeds communication stacks for IoT. This driver allows the running of Contiki OS over Etinode-MSP430. The code dalso allows the use of radio chip and embedded sensors. This module has been implemented in the framework of the ETIPOPS project.

- Participants: Nathalie Mitton, Roudy Dagher and Salvatore Guzzo Bonifacio
- Contact: Salvatore Guzzo Bonifacio

5.3. ETINODE-DRIVERS

FUNCTIONAL DESCRIPTION: These drivers for Etinode-MSP430 control the different embedded sensors and hardware components available on an Etinode-MSP430 node such as gyroscope, accelerometer and barometric sensor. This module has been implemented in the framework of the ETIPOPS project.

- Participants: Nathalie Mitton, Roudy Dagher and Salvatore Guzzo Bonifacio
- Contact: Salvatore Guzzo Bonifacio

5.4. EVe-TCF

Embedded Verifier for Transitive Control Flow

KEYWORDS: Control Flow - JavaCard - Embedded systems - Embedded - Security - Code analysis

FUNCTIONAL DESCRIPTION: Verification of transitive control flow policies on JavaCard 2.x bytecode. Control flow policies expressed using a DSL language are embedded in JavaCard packages (CAP files) using EVe-TCF convert tool. Control flow policies are then statically verified on-device at loading-time thanks to an embedded verifier (designed for smart cards in EVe-TCF). EVe-TCF (Embedded Verifier for Transitive Control Flow) also contains an off-device (i.e. PC tool) to simulate on-device loading process of JavaCard 2.x platforms with GlobalPlatform 2.x installed.

- Participants: Arnaud Fontaine and Isablle Simplot Ryl
- Contact: Nathalie Mitton

5.5. GOLIATH

Generic Optimized LIghtweight communication stack for Ambient TecHnologies

KEYWORDS: WSN - WSN430

FUNCTIONAL DESCRIPTION: GOLIATH (Generic Optimized LIghtweight communication stack for Ambient TecHnologies) is a full protocol stack for wireless sensor networks. This module has been implemented in the framework of the ETIPOPS project.

- Participants: David Simplot Ryl, Fadila Khadar, Nathalie Mitton and Salvatore Guzzo Bonifacio
- Contact: Nathalie Mitton
- URL: https://gforge.inria.fr/projects/goliath/

5.6. IoT-LAB robots

KEYWORDS: Internet of things - Robotics

FUNCTIONAL DESCRIPTION: IoT-LAB robots is an embedded robot controler on a Turtlebot2 providing the IoT-LAB node mobility functionnality

- Partner: Université de Strasbourg
- Contact: Julien Vandaele
- URL: https://github.com/iot-lab/

5.7. T-SCAN

KEYWORDS: Rfid - RFID Middleware

FUNCTIONAL DESCRIPTION: T-Scan is an interface ensuring the translation from a SGTIN tag format to an ONS hostname format according to the EPCGlobal standards. It allows the sending of a DNS request to look up the EPC-IS aides to which the product belongs in order to access the data relative to that product. This module has been implemented in the framework of the TRACAVERRE project.

- Participants: Gabriele Sabatino and Nathalie Mitton
- Contact: Gabriele Sabatino

5.8. FIT IoT-Lab

Participants: Nathalie Mitton [contact person], Julien Vandaele, Matthieu Berthome.

FIT IoT-LAB (http://www.iot-lab.info) is a very large scale open testbed that features over 2700 wireless sensor nodes and more than 200 robots spread across six different sites in France. Nodes are either fixed or mobile and can be allocated in various topologies throughout all sites. A variety of wireless sensors are available, with different processor architectures (MSP430, STM32 and Cortex-A8) and different wireless chips (802.15.4 PHY at 800 MHz or 2.4 GHz). In addition, "open nodes" can receive custom wireless sensors for inclusion in IoT-LAB testbed. This platform is completely open and can be used by any one wishing to run experiment on wireless sensors and robots.

The Lille site displays 2 subsets of the platforms:

- Haute Borne: this site features 256 M3 sensor nodes operating in the 2.4GHz band and 64 mobile robots (32 turtlebots and 32 wifibots) completely remotely programmable.
- Opennodes: this site features 64 hardware open slots to allow any one to plug his own hardware and benefits from the platform debugging and monitoring tools.

GANG Project-Team

6. New Software and Platforms

6.1. big-graph-tools

KEYWORD: Graph algorithmics

FUNCTIONAL DESCRIPTION: Gang is developping a software for big graph manipulation. A preliminary library offering diameter and skeleton computation. This library was used to compute the diameters of the worldwide road network (200M edges) and the largest strongly connected component of the Twitter follower-followee graph (23G edges).

- Contact: Laurent Viennot
- URL: https://who.rocq.inria.fr/Laurent.Viennot/dev/big-graph-tools/

6.2. GRPH

The high performance graph library for Java

KEYWORDS: Graph - Graph algorithmics - Java

FUNCTIONAL DESCRIPTION: Grph is an open-source Java library for the manipulation of graphs. Its design objectives are to make it portable, simple to use/extend, computationally/memory efficient, and, according to its initial motivation: useful in the context of graph experimentation and network simulation. Grph also has the particularity to come with tools like an evolutionary computation engine, a bridge to linear programming solvers, a framework for distributed computing, etc.

Grph offers a very general model of graphs. Unlike other graph libraries which impose the user to first decide if he wants to deal with directed, undirected, hyper (or not) graphs, the model offered by Grph is unified in a general class that supports mixed graphs made of undirected and directed simple and hyper edges. Grph achieves great efficiency through the use of multiple code optimization techniques such as multi-core parallelism, caching, adequate data structures, use of primitive objects, exploitation of low-level processor caches, on-the-fly compilation of specific C/C++ code, etc. Grph attempts to access the Internet in order to check if a new version is available and to report who is using it (login name and hostname). This has no impact whatsoever on performance and security.

- Participants: Aurélien Lancin, David Coudert, Issam Tahiri, Luc Hogie and Nathann Cohen
- Contact: Luc Hogie
- URL: http://www.i3s.unice.fr/~hogie/grph/

HIEPACS Project-Team

6. New Software and Platforms

6.1. AVCI

Adaptive vibrational configuration interaction

KEYWORDS: Vibrational spectra - Eigen value

FUNCTIONAL DESCRIPTION: A-VCI is a theoretical vibrational spectroscopy algorithm developed to effectively reduce the number of vibrational states used in the configuration-interaction (CI) process. It constructs a nested basis for the discretization of the Hamiltonian operator inside a large CI approximation space and uses an a-posteriori error estimator (residue) to select the most relevant directions to expand the discretization space.

The Hamiltonian operator consists of 3 operators: a harmonic oscillator sum, the potential energy surface operator and the Coriolis operators. In addition, the code can compute the intensity of eigenvectors.

The code can handle molecules up to 10 atoms, which corresponds to solving an eigenvalue problem in a 24-dimensional space.

- Partner: IPREM
- Contact: Olivier Coulaud

6.2. Chameleon

KEYWORDS: Runtime system - Task-based algorithm - Dense linear algebra - HPC - Task scheduling

SCIENTIFIC DESCRIPTION: Chameleon is part of the MORSE (Matrices Over Runtime Systems @ Exascale) project. The overall objective is to develop robust linear algebra libraries relying on innovative runtime systems that can fully benefit from the potential of those future large-scale complex machines.

We expect advances in three directions based first on strong and closed interactions between the runtime and numerical linear algebra communities. This initial activity will then naturally expand to more focused but still joint research in both fields.

1. Fine interaction between linear algebra and runtime systems. On parallel machines, HPC applications need to take care of data movement and consistency, which can be either explicitly managed at the level of the application itself or delegated to a runtime system. We adopt the latter approach in order to better keep up with hardware trends whose complexity is growing exponentially. One major task in this project is to define a proper interface between HPC applications and runtime systems in order to maximize productivity and expressivity. As mentioned in the next section, a widely used approach consists in abstracting the application as a DAG that the runtime system is in charge of scheduling. Scheduling such a DAG over a set of heterogeneous processing units introduces a lot of new challenges, such as predicting accurately the execution time of each type of task over each kind of unit, minimizing data transfers between memory banks, performing data prefetching, etc. Expected advances: In a nutshell, a new runtime system API will be designed to allow applications to provide scheduling hints to the runtime system and to get real-time feedback about the consequences of scheduling decisions.

2. Runtime systems. A runtime environment is an intermediate layer between the system and the application. It provides low-level functionality not provided by the system (such as scheduling or management of the heterogeneity) and high-level features (such as performance portability). In the framework of this proposal, we will work on the scalability of runtime environment. To achieve scalability it is required to avoid all centralization. Here, the main problem is the scheduling of the tasks. In many task-based runtime environments the scheduler is centralized and becomes a bottleneck as soon as too many cores are involved. It is therefore required to distribute the scheduling decision or to compute a data distribution that impose the mapping of task using, for instance the so-called "owner-compute" rule. Expected advances: We will design runtime systems that enable an efficient and scalable use of thousands of distributed multicore nodes enhanced with accelerators.

3. Linear algebra. Because of its central position in HPC and of the well understood structure of its algorithms, dense linear algebra has often pioneered new challenges that HPC had to face. Again, dense linear algebra has been in the vanguard of the new era of petascale computing with the design of new algorithms that can efficiently run on a multicore node with GPU accelerators. These algorithms are called "communication-avoiding" since they have been redesigned to limit the amount of communication between processing units (and between the different levels of memory hierarchy). They are expressed through Direct Acyclic Graphs (DAG) of fine-grained tasks that are dynamically scheduled. Expected advances: First, we plan to investigate the impact of these principles in the case of sparse applications (whose algorithms are slightly more complicated but often rely on dense kernels). Furthermore, both in the dense and sparse cases, the scalability on thousands of nodes is still limited, new numerical approaches need to be found. We will specifically design sparse hybrid direct/iterative methods that represent a promising approach.

Overall end point. The overall goal of the MORSE associate team is to enable advanced numerical algorithms to be executed on a scalable unified runtime system for exploiting the full potential of future exascale machines.

FUNCTIONAL DESCRIPTION: Chameleon is a dense linear algebra software relying on sequential task-based algorithms where sub-tasks of the overall algorithms are submitted to a Runtime system. A Runtime system such as StarPU is able to manage automatically data transfers between not shared memory area (CPUs-GPUs, distributed nodes). This kind of implementation paradigm allows to design high performing linear algebra algorithms on very different type of architecture: laptop, many-core nodes, CPUs-GPUs, multiple nodes. For example, Chameleon is able to perform a Cholesky factorization (double-precision) at 80 TFlop/s on a dense matrix of order 400 000 (i.e. 4 min 30 s).

RELEASE FUNCTIONAL DESCRIPTION: Chameleon includes the following features:

- BLAS 3, LAPACK one-sided and LAPACK norms tile algorithms - Support QUARK and StarPU runtime systems and PaRSEC since 2018 - Exploitation of homogeneous and heterogeneous platforms through the use of BLAS/LAPACK CPU kernels and cuBLAS/MAGMA CUDA kernels - Exploitation of clusters of interconnected nodes with distributed memory (using OpenMPI)

- Participants: Cédric Castagnede, Samuel Thibault, Emmanuel Agullo, Florent Pruvost and Mathieu Faverge
- Partners: Innovative Computing Laboratory (ICL) - King Abdullha University of Science and Technology - University of Colorado Denver
- Contact: Emmanuel Agullo
- URL: https://gitlab.inria.fr/solverstack/chameleon

6.3. Diodon

KEYWORDS: Dimensionality reduction - Data analysis

FUNCTIONAL DESCRIPTION: Most of dimension reduction methods inherited from Multivariate Data Analysis, and currently implemented as element in statistical learning for handling very large datasets (the dimension of spaces is the number of features) rely on a chain of pretreatments, a core with a SVD for low rank approximation of a given matrix, and a post-treatment for interpreting results. The costly part in computations is the SVD, which is in cubic complexity. Diodon is a list of functions and drivers which implement (i) pre-treatments, SVD and post-treatments on a large diversity of methods, (ii) random projection methods for running the SVD which permits to bypass the time limit in computing the SVD, and (iii) an implementation in C++ of the SVD with random projection at prescribed rank or precision, connected to MDS.

- Contact: Alain Franc

6.4. DPLASMA

Distributed Parallel Linear Algebra Software for Multicore Architectures

FUNCTIONAL DESCRIPTION: DPLASMA is the leading implementation of a dense linear algebra package for distributed heterogeneous systems. It is designed to deliver sustained performance for distributed systems where each node featuring multiple sockets of multicore processors, and if available, accelerators like GPUs or Intel Xeon Phi. DPLASMA achieves this objective through the state of the art PaRSEC runtime, porting the PLASMA algorithms to the distributed memory realm.

- Contact: Mathieu Faverge
- URL: http://icl.cs.utk.edu/parsec/index.html

6.5. Fabulous

Fast Accurate Block Linear krylOv Solver

KEYWORDS: Numerical algorithm - Block Krylov solver

SCIENTIFIC DESCRIPTION: Versatile and flexible numerical library that implements Block Krylov iterative schemes for the solution of linear systems of equations with multiple right-hand sides

FUNCTIONAL DESCRIPTION: Versatile and flexible numerical library that implements Block Krylov iterative schemes for the solution of linear systems of equations with multiple right-hand sides. The library implements block variants of minimal norm residual variants with partial convergence management and spectral information recycling. The package already implements regular block-GMRES (BGMRES), Inexact Breakdown BGMRES (IB-BMGRES), Inexact Breakdown BGMRES with Deflated Restarting (IB-BGMRES-DR), Block Generalized Conjugate Residual with partial convergence management. The C++ library relies on callback mechanisms to implement the calculations (matrix-vector, dot-product, ...) that depend on the parallel data distribution selected by the user.

- Participants: Emmanuel Agullo, Luc Giraud, Gilles Marait and Cyrille Piacibello
- Contact: Luc Giraud
- Publication: Block GMRES method with inexact breakdowns and deflated restarting
- URL: https://gitlab.inria.fr/solverstack/fabulous/

6.6. MAPHYS

Massively Parallel Hybrid Solver

KEYWORD: Parallel hybrid direct/iterative solution of large linear systems

FUNCTIONAL DESCRIPTION: MaPHyS is a software package that implements a parallel linear solver coupling direct and iterative approaches. The underlying idea is to apply to general unstructured linear systems domain decomposition ideas developed for the solution of linear systems arising from PDEs. The interface problem, associated with the so called Schur complement system, is solved using a block preconditioner with overlap between the blocks that is referred to as Algebraic Additive Schwarz. A fully algebraic coarse space is available for symmetric positive definite problems, that insures the numerical scalability of the preconditioner.

The parallel implementation is based on MPI+thread. Maphys relies on state-of-the art sparse and dense direct solvers.

MaPHyS is essentially a preconditioner that can be used to speed-up the convergence of any Krylov subspace method and is coupled with the ones implemented in the Fabulous package.

- Participants: Emmanuel Agullo, Luc Giraud, Matthieu Kuhn, Gilles Marait and Louis Poirel
- Contact: Emmanuel Agullo
- Publications: Hierarchical hybrid sparse linear solver for multicore platforms - Robust coarse spaces for Abstract Schwarz preconditioners via generalized eigenproblems
- URL: https://gitlab.inria.fr/solverstack/maphys

6.7. MetaPart

KEYWORDS: High performance computing - HPC - Parallel computing - Graph algorithmics - Graph - Hypergraph

FUNCTIONAL DESCRIPTION: MetaPart is a framework for graph or hypergraph manipulation that addresses different problems, like partitioning, repartitioning, or co-partitioning, ... MetaPart is made up of several projects, such as StarPart, LibGraph or CoPart. StarPart is the core of the MetaPart framework. It offers a wide variety of graph partitioning methods (Metis, Scotch, Zoltan, Patoh, ParMetis, Kahip, ...), which makes it easy to compare these different methods and to better adjust the parameters of these methods. It is built upon the LibGraph library, that provides basic graph and hypergraph routines. The Copart project is a library used on top of StarPart, that provides co-partitioning algorithms for the load-blancing of parallel coupled simulations.

- Participant: Aurélien Esnard
- Contact: Aurélien Esnard
- URL: https://gitlab.inria.fr/metapart

6.8. MPICPL

MPI CouPLing

KEYWORDS: MPI - Coupling software

FUNCTIONAL DESCRIPTION: MPICPL is a software library dedicated to the coupling of parallel legacy codes, that are based on the well-known MPI standard. It proposes a lightweight and comprehensive programing interface that simplifies the coupling of several MPI codes (2, 3 or more). MPICPL facilitates the deployment of these codes thanks to the mpicplrun tool and it interconnects them automatically through standard MPI inter-communicators. Moreover, it generates the universe communicator, that merges the world communicators of all coupled-codes. The coupling infrastructure is described by a simple XML file, that is just loaded by the mpicplrun tool.

- Participant: Aurélien Esnard
- Contact: Aurélien Esnard
- URL: https://gitlab.inria.fr/esnard/mpicpl

6.9. OptiDis

KEYWORDS: Dislocation dynamics simulation - Fast multipole method - Large scale - Collision

FUNCTIONAL DESCRIPTION: OptiDis is a new code for large scale dislocation dynamics simulations. Its purpose is to simulate real life dislocation densities (up to 5.1022 dislocations/m-2) in order to understand plastic deformation and study strain hardening. The main application is to observe and understand plastic deformation of irradiated zirconium. Zirconium alloys are the first containment barrier against the dissemination of radioactive elements. More precisely, with neutron irradiated zirconium alloys we are talking about channeling mechanism, which means to stick with the reality, more than tens of thousands of induced loops, i. e. 100 million degrees of freedom in the simulation. The code is based on Numodis code developed at CEA Saclay and the ScalFMM library developed in HiePACS project. The code is written in C++ language and using the last features of C++11/14. One of the main aspects is the hybrid parallelism MPI/OpenMP that gives the software the ability to scale on large cluster while the computation load rises. In order to achieve that, we use different levels of parallelism. First of all, the simulation box is distributed over MPI processes, then we use a thinner level for threads, dividing the domain by an Octree representation. All theses parts are controlled by the ScalFMM library. On the last level, our data are stored in an adaptive structure that absorbs the dynamics of this type of simulation and manages the parallelism of tasks..

- Participant: Olivier Coulaud
- Contact: Olivier Coulaud
- URL: http://optidis.gforge.inria.fr/

6.10. PaStiX

Parallel Sparse matriX package

KEYWORDS: Linear algebra - High-performance calculation - Sparse Matrices - Linear Systems Solver - Low-Rank compression

SCIENTIFIC DESCRIPTION: PaStiX is based on an efficient static scheduling and memory manager, in order to solve 3D problems with more than 50 million of unknowns. The mapping and scheduling algorithm handle a combination of 1D and 2D block distributions. A dynamic scheduling can also be applied to take care of NUMA architectures while taking into account very precisely the computational costs of the BLAS 3 primitives, the communication costs and the cost of local aggregations.

FUNCTIONAL DESCRIPTION: PaStiX is a scientific library that provides a high performance parallel solver for very large sparse linear systems based on block direct and block ILU(k) methods. It can handle low-rank compression techniques to reduce the computation and the memory complexity. Numerical algorithms are implemented in single or double precision (real or complex) for LLt, LDLt and LU factorization with static pivoting (for non symmetric matrices having a symmetric pattern). The PaStiX library uses the graph partitioning and sparse matrix block ordering packages Scotch or Metis.

The PaStiX solver is suitable for any heterogeneous parallel/distributed architecture when its performance is predictable, such as clusters of multicore nodes with GPU accelerators or KNL processors. In particular, we provide a high-performance version with a low memory overhead for multicore node architectures, which fully exploits the advantage of shared memory by using an hybrid MPI-thread implementation.

The solver also provides some low-rank compression methods to reduce the memory footprint and/or the time-to-solution.

- Participants: Tony Delarue, Grégoire Pichon, Mathieu Faverge, EsragÜl Korkmaz and Pierre Ramet
- Partners: Université Bordeaux 1 - INP Bordeaux
- Contact: Pierre Ramet
- URL: https://gitlab.inria.fr/solverstack/pastix

6.11. pmtool

KEYWORDS: Scheduling - Task scheduling - StarPU - Heterogeneity - GPGPU - Performance analysis

FUNCTIONAL DESCRIPTION: Analyse post-mortem the behavior of StarPU applications. Provide lower bounds on makespan. Study the performance of different schedulers in a simple context. Provide implementations of many scheduling algorithms from the literature

NEWS OF THE YEAR: Included many new algorithms, in particular online algorithms Better integration with StarPU by accepting .rec files as input

- Participant: Lionel Eyraud-Dubois
- Contact: Lionel Eyraud-Dubois
- Publications: Approximation Proofs of a Fast and Efficient List Scheduling Algorithm for Task-Based Runtime Systems on Multicores and GPUs - Fast Approximation Algorithms for Task-Based Runtime Systems
- URL: https://gitlab.inria.fr/eyrauddu/pmtool

6.12. rotor

Re-materializing Optimally with pyTORch

KEYWORDS: Deep learning - Optimization - Python - GPU - Automatic differentiation

FUNCTIONAL DESCRIPTION: Allows to train very large convolutional networks on limited memory by optimally selecting which activations should be kept and which should be recomputed. This code is meant to replace the checkpoint.py utility available in pytorch, by providing more efficient rematerialization strategies. The algorithm is easier to tune: the only required parameter is the available memory, instead of the number of segments.

- Contact: Lionel Eyraud-Dubois

6.13. ScalFMM

Scalable Fast Multipole Method

KEYWORDS: N-body - Fast multipole method - Parallelism - MPI - OpenMP

SCIENTIFIC DESCRIPTION: ScalFMM is a software library to simulate N-body interactions using the Fast Multipole Method. The library offers two methods to compute interactions between bodies when the potential decays like 1/r. The first method is the classical FMM based on spherical harmonic expansions and the second is the Black-Box method which is an independent kernel formulation (introduced by E. Darve @ Stanford). With this method, we can now easily add new non oscillatory kernels in our library. For the classical method, two approaches are used to decrease the complexity of the operators. We consider either matrix formulation that allows us to use BLAS routines or rotation matrix to speed up the M2L operator.

ScalFMM intends to offer all the functionalities needed to perform large parallel simulations while enabling an easy customization of the simulation components: kernels, particles and cells. It works in parallel in a shared/distributed memory model using OpenMP and MPI. The software architecture has been designed with two major objectives: being easy to maintain and easy to understand. There is two main parts:

the management of the octree and the parallelization of the method the kernels. This new architecture allow us to easily add new FMM algorithm or kernels and new paradigm of parallelization.

FUNCTIONAL DESCRIPTION: Compute N-body interactions using the Fast Multipole Method for large number of objects

- Participants: Bramas Bérenger, Olivier Coulaud and Pierre Estérie
- Contact: Olivier Coulaud
- URL: https://gitlab.inria.fr/solverstack/ScalFMM

6.14. VITE

Visual Trace Explorer

KEYWORDS: Visualization - Execution trace

FUNCTIONAL DESCRIPTION: ViTE is a trace explorer. It is a tool made to visualize execution traces of large parallel programs. It supports Pajé, a trace format created by Inria Grenoble, and OTF and OTF2 formats, developed by the University of Dresden and allows the programmer a simpler way to analyse, debug and/or profile large parallel applications.

- Participant: Mathieu Faverge
- Contact: Mathieu Faverge
- URL: http://vite.gforge.inria.fr/

6.15. PlaFRIM

Plateforme Fédérative pour la Recherche en Informatique et Mathématiques

KEYWORDS: High-Performance Computing - Hardware platform

FUNCTIONAL DESCRIPTION: PlaFRIM is an experimental platform for research in modeling, simulations and high performance computing. This platform has been set up from 2009 under the leadership of Inria Bordeaux Sud-Ouest in collaboration with computer science and mathematics laboratories, respectively Labri and IMB with a strong support in the region Aquitaine.

It aggregates different kinds of computational resources for research and development purposes. The latest technologies in terms of processors, memories and architecture are added when they are available on the market. It is now more than 1,000 cores (excluding GPU and Xeon Phi) that are available for all research teams of Inria Bordeaux, Labri and IMB. This computer is in particular used by all the engineers who work in HiePACS and are advised by F. Rue from the SED.

- Contact: Olivier Coulaud
- URL: https://www.plafrim.fr/en/home/

INDES Project-Team

5. New Software and Platforms

5.1. Bigloo

KEYWORD: Compilers

FUNCTIONAL DESCRIPTION: Bigloo is a Scheme implementation devoted to one goal: enabling Scheme based programming style where C(++) is usually required. Bigloo attempts to make Scheme practical by offering features usually presented by traditional programming languages but not offered by Scheme and functional programming. Bigloo compiles Scheme modules. It delivers small and fast stand alone binary executables. Bigloo enables full connections between Scheme and C programs, between Scheme and Java programs.

RELEASE FUNCTIONAL DESCRIPTION: modification of the object system (language design and implementation), new APIs (alsa, flac, mpg123, avahi, csv parsing), new library functions (UDP support), new regular expressions support, new garbage collector (Boehm's collection 7.3alpha1).

- Participant: Manuel Serrano
- Contact: Manuel Serrano
- URL: http://www-sop.inria.fr/teams/indes/fp/Bigloo/

5.2. Hop

KEYWORDS: Programming language - Multimedia - Iot - Web 2.0 - Functional programming

SCIENTIFIC DESCRIPTION: The Hop programming environment consists in a web broker that intuitively combines in a single architecture a web server and a web proxy. The broker embeds a Hop interpreter for executing server-side code and a Hop client-side compiler for generating the code that will get executed by the client.

An important effort is devoted to providing Hop with a realistic and efficient implementation. The Hop implementation is validated against web applications that are used on a daily-basis. In particular, we have developed Hop applications for authoring and projecting slides, editing calendars, reading RSS streams, or managing blogs.

FUNCTIONAL DESCRIPTION: Multitier web programming language and runtime environment.

- Participant: Manuel Serrano
- Contact: Manuel Serrano
- URL: http://hop.inria.fr

5.3. IFJS

Infomation Flow monitor inlining for JavaScript

KEYWORD: Cybersecurity

FUNCTIONAL DESCRIPTION: The IFJS compiler is applied to JavaScript code. The compiler generates JavaScript code instrumented with checks to secure code. The compiler takes into account special features of JavaScript such as implicit type coercions and programs that actively try to bypass the inlined enforcement mechanisms. The compiler guarantees that third-party programs cannot (1) access the compiler internal state by randomizing the names of the resources through which it is accessed and (2) change the behaviour of native functions that are used by the enforcement mechanisms inlined in the compiled code.

- Contact: Tamara Rezk
- URL: http://www-sop.inria.fr/indes/ifJS/

5.4. Hiphop.js

KEYWORDS: Web 2.0 - Synchronous Language - Programming language

FUNCTIONAL DESCRIPTION: HipHop.js is an Hop.js DLS for orchestrating web applications. HipHop.js helps programming and maintaining Web applications where the orchestration of asynchronous tasks is complex.

- Contact: Manuel Serrano
- URL: http://hop-dev.inria.fr/hiphop

5.5. Server-Side Protection against Third Party Web Tracking

KEYWORDS: Privacy - Web Application - Web - Architecture - Security by design - Program rewriting techniques

FUNCTIONAL DESCRIPTION: We present a new web application architecture that allows web developers to gain control over certain types of third party content. In the traditional web application architecture, a web application developer has no control over third party content. This allows the exchange of tracking information between the browser and the third party content provider.

To prevent this, our solution is based on the automatic rewriting of the web application in such a way that the third party requests are redirected to a trusted third party server, called the Middle Party Server. It may be either controlled by a trusted party, or by a main site owner and automatically eliminates third-party tracking cookies and other technologies that may be exchanged by the browser and third party server

- Contact: Francis Doliére Some
- URL: http://www-sop.inria.fr/members/Doliere.Some/essos/

5.6. webstats

Webstats

KEYWORDS: Web Usage Mining - Statistic analysis - Security

FUNCTIONAL DESCRIPTION: The goal of this tool is to perform a large-scale monthly crawl of the top Alexa sites, collecting both inline scripts (written by web developers) and remote scripts, and establishing the popularity of remote scripts (such as Google Analytics and jQuery). With this data, we establish whether the collected scripts are actually written in a subset of JavaScript by analyzing the different constructs used in those scripts. Finally, we collect and analyze the HTTP headers of the different sites visited, and provide statistics about the usage of HTTPOnly and Secure cookies, and the Content Security Policy in top sites.

- Contact: Francis Doliére Some
- URL: https://webstats.inria.fr

5.7. Skini

Platform for creation and execution for audience participative music

KEYWORDS: Music - Interaction - Web Application - Synchronous Language

FUNCTIONAL DESCRIPTION: Skini is a platform form designing et performing collaborative music. It is based on two musical concept: pattern and orchestration. The orchestration is design using HipHop.js.

RELEASE FUNCTIONAL DESCRIPTION: Can be use for performance and création.

- Contact: Bertrand Petit

5.8. Platforms

5.8.1. BehaviorTrack

Keyword: Web tracking detection, Large-scale measurement

Description: In our study, we propose a tracking detection method inspired by analyzing behavior of invisible pixels. By crawling 84,658 webpages from 8,744 domains, we detect that third-party invisible pixels are widely deployed: they are present on more than 94.51% of domains and constitute 35.66% of all third-party images. We propose a fine-grained behavioral classification of tracking based on the analysis of invisible pixels. BehaviorTrack uses this classification to detect new categories of tracking and uncover new collaborations between domains on the full dataset of 4,216,454 third-party requests.

- Contact: Imane Fouad
- URL: http://www-sop.inria.fr/members/Imane.Fouad/pixeltrack

<p align="center" style="color:red">KERDATA Project-Team</p>

6. New Software and Platforms

6.1. Damaris

KEYWORDS: Visualization - I/O - HPC - Exascale - High performance computing

SCIENTIFIC DESCRIPTION: Damaris is a middleware for I/O and data management targeting large-scale, MPI-based HPC simulations. It initially proposed to dedicate cores for asynchronous I/O in multicore nodes of recent HPC platforms, with an emphasis on ease of integration in existing simulations, efficient resource usage (with the use of shared memory) and simplicity of extension through plug-ins. Over the years, Damaris has evolved into a more elaborate system, providing the possibility to use dedicated cores or dedicated nodes to in situ data processing and visualization. It proposes a seamless connection to the VisIt visualization framework to enable in situ visualization with minimum impact on run time. Damaris provides an extremely simple API and can be easily integrated into the existing large-scale simulations.

Damaris was at the core of the PhD thesis of Matthieu Dorier, who received an Accessit to the Gilles Kahn Ph.D. Thesis Award of the SIF and the Academy of Science in 2015. Developed in the framework of our collaboration with the JLESC – Joint Laboratory for Extreme-Scale Computing, Damaris was the first software resulted from this joint lab validated in 2011 for integration to the Blue Waters supercomputer project. It scaled up to 16,000 cores on Oak Ridge's leadership supercomputer Titan (first in the Top500 supercomputer list in 2013) before being validated on other top supercomputers. Active development is currently continuing within the KerData team at Inria, where it is at the center of several collaborations with industry as well as with national and international academic partners.

FUNCTIONAL DESCRIPTION: Damaris is a middleware for data management and in-situ visualization targeting large-scale HPC simulations: - In situ data analysis by some dedicated cores/nodes of the simulation platform - Asynchronous and fast data transfer from HPC simulations to Damaris - Semantic-aware dataset processing through Damaris plug-ins - Writing aggregated data (by hdf5 format) or visualizating them either by VisIt or ParaView

- Participants: Gabriel Antoniu, Lokman Rahmani, Luc Bougé, Matthieu Dorier, Orçun Yildiz and Hadi Salimi
- Partner: ENS Rennes
- Contact: Matthieu Dorier
- URL: https://project.inria.fr/damaris/

6.2. OverFlow

FUNCTIONAL DESCRIPTION: OverFlow is a uniform data management system for scientific workflows running across geographically distributed sites, aiming to reap economic benefits from this geo-diversity. The software is environment-aware, as it monitors and models the global cloud infrastructure, offering high and predictable data handling performance for transfer cost and time, within and across sites. OverFlow proposes a set of pluggable services, grouped in a data-scientist cloud kit. They provide the applications with the possibility to monitor the underlying infrastructure, to exploit smart data compression, deduplication and geo-replication, to evaluate data management costs, to set a tradeoff between money and time, and optimize the transfer strategy accordingly.

Currently, OverFlow is used for data transfers by the Microsoft Research ATLE Munich team as well as for synthetic benchmarks at the Politehnica University of Bucharest.

- Participants: Alexandru Costan, Gabriel Antoniu and Radu Marius Tudoran
- Contact: Alexandru Costan

6.3. Pufferbench

KEYWORDS: Distributed Storage Systems - Elasticity - Benchmarking

SCIENTIFIC DESCRIPTION: Pufferbench is a benchmark for evaluating how fast one can scale up and down a distributed storage system on a given infrastructure and, thereby, how viably can one implement storage malleability on it. Besides, it can serve to quickly prototype and evaluate mechanisms for malleability in existing distributed storage systems.

FUNCTIONAL DESCRIPTION: Pufferbench is a benchmark to designed to evaluate whether to use malleable distributed storage systems on a given platform. - It measures the duration of commission and decommission operations. - Its modularity allows to quickly change and adapt each component to the needs of the user. - It can serve as a baseline when implementing commission and decommission mechanisms in a distributed storage system.

RELEASE FUNCTIONAL DESCRIPTION: This is the first release of Pufferbench.

It includes default components for each of the customisable components: - storage: in memory, on drive with file system cache, and on drive without file system cache - network: MPI network - IODispatcher: basic, and with acknowledgements - DataTransferScheduler: basic - DataDistributionGenerator: uniform, and random - MetadataGenerator: Files of same size The diversity of available components enables Pufferbench to fit to multiple use cases.

- Participants: Nathanaël Cheriere, Matthieu Dorier and Gabriel Antoniu
- Partner: ENS Rennes
- Contact: Nathanaël Cheriere
- Publication: hal-01886351
- URL: https://gitlab.inria.fr/Puffertools/Pufferbench/wikis/home

6.4. Tyr

KEYWORDS: Cloud storage - Distributed Storage Systems - Big data

FUNCTIONAL DESCRIPTION: Tyr is the first blob storage system to provide built-in, multiblob transactions, while retaining sequential consistency and high throughput under heavy access concurrency. Tyr offers fine-grained random write access to data and in-place atomic operations.

- Partner: Universidad Politécnica de Madrid
- Contact: Gabriel Antoniu

6.5. Planner

KEYWORDS: Edge elements - Cloud computing - Scheduling

FUNCTIONAL DESCRIPTION: Planner is a middleware for uniform and transparent stream processing across Edge and Cloud. Planner automatically selects which parts of the executiongraph will be executed at the Edge in order to minimize thenetwork cost.

- Partner: ENS Cachan
- Contact: Gabriel Antoniu
- URL: https://team.inria.fr/kerdata/

6.6. KerA

KerAnalytics

KEYWORD: Distributed Storage Systems

FUNCTIONAL DESCRIPTION: A unified architecture for stream ingestion and storage which can lead to the optimization of the processing of Big Data applications. This approach minimizes data movement within the analytics architecture, finally leading to better utilized resources.

- Contact: Gabriel Antoniu

6.7. TailWind

KEYWORDS: Fault-tolerance - Data management. - Distributed Data Management

FUNCTIONAL DESCRIPTION: Replication is essential for fault-tolerance. However, in in-memory systems, it is a source of high overhead. Remote direct memory access (RDMA) is attractive to create redundant copies of data, since it is low-latency and has no CPU overhead at the target. However, existing approaches still result in redundant data copying and active receivers. To ensure atomic data transfers, receivers check and apply only fully received messages. Tailwind is a zero-copy recovery-log replication protocol for scale-out in-memory databases. Tailwind is the first replication protocol that eliminates *all* CPU-driven data copying and fully bypasses target server CPUs, thus leaving backups idle. Tailwind ensures all writes are atomic by leveraging a protocol that detects incomplete RDMA transfers. Tailwind substantially improves replication throughput and response latency compared with conventional RPC-based replication. In symmetric systems where servers both serve requests and act as replicas, Tailwind also improves normal-case throughput by freeing server CPU resources for request processing. We implemented and evaluated Tailwind on RAMCloud, a low-latency in-memory storage system. Experiments show Tailwind improves RAMCloud's normal-case request processing throughput by $1.7\times$. It also cuts down writes median and 99th percentile latencies by 2x and 3x respectively.

- Contact: Gabriel Antoniu

<p align="center">**MARACAS Team**</p>

6. New Software and Platforms

6.1. cortexlab-fftweb

KEYWORDS: Experimentation - Data visualization - SDR (Software Defined Radio)

FUNCTIONAL DESCRIPTION: fftweb is a real-time spectral (FFT) visualization of one or several signal, embedded in a web page. The FFT is computed in a GNURadio block, then sent to a gateway server, which serves the web page, associated javascripts, and signal websockets. The end user only has to use the GNURadio block and and the web page, and doesn't need to bother about the internal details of the system. fftweb has been developed specially for the CorteXlab testbed but with minor adaptations, it can be used in other contexts, and also can be used to draw more generic real-time graphs, not only FFTs. Technologies: GNURadio, python, python-gevent, Javascript, D3JS

- Contact: Matthieu Imbert

6.2. cortexlab-minus

KEYWORDS: Experimentation - SDR (Software Defined Radio)

FUNCTIONAL DESCRIPTION: Minus is an experiment control system able to control, the whole lifecycle of a radio experiment in CorteXlab or any other testbed inspired by it. Minus controls and automates the whole experiment process starting from node power cycling, experiment deployment, experiment start and stop, and results collection and transfer. Minus is also capable of managing multiple queues of experiments which are executed simultaneously in the testbed.

- Contact: Matthieu Imbert

6.3. cortexlab-webapp

KEYWORDS: Experimentation - SDR (Software Defined Radio)

FUNCTIONAL DESCRIPTION: User management module, which aims at easing platform usage and improving the metadata that we can associate with each experimenter and experiment. This metadata aims at improving the metrics we can gather about the platform's usage

- Partner: Insa de Lyon
- Contact: Pascal Girard

6.4. CorteXlab-IoT Framework

Framework for PHY-MAC layers Prototyping in Dense IoT Networks using CorteXlab Testbed

KEYWORDS: SDR (Software Defined Radio) - Iot - CorteXlab - GNU Radio

FUNCTIONAL DESCRIPTION: This framework was developed in the project "Enhanced Physical Layer for Cellular IoT" (EPHYL). It provides a customizable and open source design for IoT networks prototyping in a massive multi-user, synchronized and reproducible environment thanks to the hardware and software capabilities of the testbed.

- Author: Othmane Oubejja
- Contact: Othmane Oubejja
- Publication: Framework for PHY-MAC layers Prototyping in Dense IoT Networks using FIT/CorteXlab Testbed
- URL: https://github.com/CorteXlab/gr-ephyl

6.5. Platforms

6.5.1. FIT/CorteXlab

FIT (Future Internet of Things) is a french Equipex (Équipement d'excellence) which aims to develop an experimental facility, a federated and competitive infrastructure with international visibility and a broad panel of customers. FIT is be composed of four main parts: a Network Operations Center (FIT NOC), a set of IoT test-beds (FIT IoT-Lab), a set of wireless test-beds (FIT-Wireless) which includes the FIT/CorteXlab platform deployed previoulsy by the Socrate team and now managed by Maracas team in the Citi lab, and finally a set of Cloud test-beds (FIT-Cloud). In 2014 the construction of the room was done and SDR nodes have been installed in the room: 42 industrial PCs (Aplus Nuvo-3000E/P), 22 NI radio boards (usrp) and 18 Nutaq boards (PicoSDR, 2x2 and 4X4) can be programmed remotely, from internet now.

New features are under developments, and the platform is used or has been used by several research groups : i) Nokia Bell Labs - Inria common labs for research in machine learning, ii) ANR projects EPHYL and ARBURST for research on massive access for IoT, iii) ERC of prof. Michele Wigger, IMT Paris, for validating distributed coding strategies, iv) Nokia Bell Labs New Jersey for a proof of concept of wireless caching, Greentouch international consortium to develop a prototype of interference alignment.

Figure 3. FIT/CorteXlab facility

MIMOVE Project-Team

6. New Software and Platforms

6.1. SocialBus

Universal Social Network Bus

KEYWORDS: Middleware - Interoperability - Social networks - Software Oriented Service (SOA)

FUNCTIONAL DESCRIPTION: Online social network services (OSNSs) have become an integral part of our daily lives. At the same time, the aggressive market competition has led to the emergence of multiple competing siloed OSNSs that cannot interoperate. As a consequence, people face the burden of creating and managing multiple OSNS accounts and learning how to use them, to stay connected. The goal of the Universal Social Network Bus (USNB) is to relieve users from such a burden, letting them use their favorite applications to communicate.

- Authors: Rafael Angarita Arocha, Nikolaos Georgantas and Valérie Issarny
- Contact: Valérie Issarny
- URL: https://gitlab.inria.fr/usnb/universal-social-network-bus

6.2. WeBrowse

KEYWORDS: Web Usage Mining - Content analysis - Recommendation systems

FUNCTIONAL DESCRIPTION: The amount of information available on the web today, and the fast rate with which new information appears, overwhelm most users. The goal of our research is to assist Web users in discovering content. One of the most powerful means today to help people discover new web content is sharing between members of online communities. In the case of communities of a place (e.g., people who live, study, or work together) people share common interests, but often fail to actively share content. To address this problem, we have developed WeBrowse, a passive crowdsourced content discovery system for communities of a place.

WeBrowse leverages the passive observation of web-clicks (i.e., the URLs users intentionally visit) as an indication of users' interest in a piece of content. Intuitively, the more users click on a URL, the higher the interest in the content on the corresponding page. Our approach is then to leverage the collective clicks in a community to automatically discover relevant content to promote to users of the community.

To implement passive crowdsourcing, one must be in a position to observe the aggregated web-clicks of the community. Luckily, in many communities of a place, users will connect to the Internet from the same network, such as, e.g., the campus/enterprise network or the network of a residential Internet Service Provider (ISP) in a neighborhood. WeBrowse (i) observes web packets flowing through a network link, (ii) passively extracts HTTP logs (i.e., streams recording the headers of HTTP requests), and (iii) detects and decides on-the-fly the set of URLs to show to users.

- Contact: Renata Cruz Teixeira
- URL: https://team.inria.fr/muse/webrowse-info-page/

6.3. VSB

eVolution Service Bus

KEYWORDS: Service and Thing choreographies - Middleware protocol interoperability - Enterprise service bus

FUNCTIONAL DESCRIPTION: VSB is a development and runtime environment dedicated to complex distributed applications of the Future Internet. Such applications are open, dynamic choreographies of extremely heterogeneous services and Things, including lightweight embedded systems (e.g., sensors, actuators and networks of them), mobile systems (e.g., smartphone applications), and resource-rich IT systems (e.g., systems hosted on enterprise servers and Cloud infrastructures). VSB's objective is to seamlessly interconnect, inside choreographies, services and Things that employ heterogeneous interaction protocols at the middleware level, e.g., SOAP Web services, REST Web services, Things using CoAP. This is based on runtime conversions between such protocols, with respect to their primitives and data type systems, while properly mapping between their semantics. This also includes mapping between the public interfaces of services/Things, regarding their operations and data, from the viewpoint of the middleware: the latter means that operations and data are converted based on their middleware-level semantics, while their business semantics remains transparent to the conversion. VSB follows the well-known Enterprise Service Bus (ESB) paradigm. We propose a generic interface description, which we call GIDL, for application components that employ VSB. Based on GIDL, we enable automated synthesis of binding components for connecting heterogeneous services and Things onto VSB.

- Participants: Georgios Bouloukakis, Nikolaos Georgantas and Patient Ntumba
- Contact: Nikolaos Georgantas
- URL: https://gitlab.ow2.org/chorevolution/evolution-service-bus

6.4. Service traceroute

KEYWORDS: Network monitoring - Network diagnosis

FUNCTIONAL DESCRIPTION: Traceroute is often used to help diagnose when users experience issues with Internet applications or services. Unfortunately, probes issued by classic traceroute tools differ from application traffic and hence can be treated differently by middleboxes within the network. We propose a new traceroute tool, called Service traceroute. Service traceroute leverages the idea from paratrace, which passively listens to application traffic to then issue traceroute probes that pretend to be part of the application flow. We extend this idea to work for modern Internet services with support for identifying the flows to probe automatically, for tracing of multiple concurrent flows, and for UDP flows. We implement command-line and library versions of Service traceroute, which we release as open source.

- Partner: Princeton University
- Contact: Renata Cruz Teixeira
- URL: https://github.com/wontoniii/service-traceroute

6.5. Network Microscope

KEYWORDS: Quality of Experience - Network monitoring - Video analysis

FUNCTIONAL DESCRIPTION: A system that accurately infers video streaming quality metrics in real time, such as startup delay or video resolution, by using just a handful of features extracted from passive traffic measurement. Network Microscope passively collects a corpus of network features about the traffic flows of interest in the network and directs those to a real-time analytics framework that can perform more complex inference tasks. Network Microscope enables network operators to determine degradations in application quality as they happen, even when the traffic is encrypted.

- Participants: Francesco Bronzino and Renata Cruz Teixeira
- Contact: Renata Cruz Teixeira
- URL: https://netmicroscope.com/

6.6. HostView Mobile

KEYWORDS: Quality of Experience - Network monitoring

FUNCTIONAL DESCRIPTION: HostView for mobile runs on Android devices to monitor user system and network performance together with user feedback on Internet experience.

- Contact: Giulio Grassi

6. New Software and Platforms

6.1. PaaSage Adapter

KEYWORDS: Cloud computing - Dynamic adaptation - Cloud applications management

FUNCTIONAL DESCRIPTION: The purpose of the Adapter is to transform the current configuration of a cloud application into a target configuration in an efficient and safe way. The Adapter is part of PaaSage, an open-source platform for modeling, deploying and executing applications on different clouds in an optimal manner. The Adapter has the following responsibilities: (1) validating reconfiguration plans, (2) applying the plans to the running system, and (3) maintaining an up-to-date representation of the current system state.

- Contact: Nikolaos Parlavantzas
- URL: https://team.inria.fr/myriads/software-and-platforms/paasage-adapter/

6.2. SAIDS

self-adaptable intrusion detection system

KEYWORDS: Cloud - Security

FUNCTIONAL DESCRIPTION: SAIDS is a self-adaptable intrusion detection system for IaaS clouds. To maintain an effective level of intrusion detection, SAIDS monitors changes in the virtual infrastructure of a Cloud environment and reconfigures its components (security probes) accordingly. SAIDS can also reconfigure probes in the case of a change in the list of running services.

- Authors: Anna Giannakou and Jean-Léon Cusinato
- Contact: Christine Morin

6.3. SimGrid

KEYWORDS: Large-scale Emulators - Grid Computing - Distributed Applications

SCIENTIFIC DESCRIPTION: SimGrid is a toolkit that provides core functionalities for the simulation of distributed applications in heterogeneous distributed environments. The simulation engine uses algorithmic and implementation techniques toward the fast simulation of large systems on a single machine. The models are theoretically grounded and experimentally validated. The results are reproducible, enabling better scientific practices.

Its models of networks, cpus and disks are adapted to (Data)Grids, P2P, Clouds, Clusters and HPC, allowing multi-domain studies. It can be used either to simulate algorithms and prototypes of applications, or to emulate real MPI applications through the virtualization of their communication, or to formally assess algorithms and applications that can run in the framework.

The formal verification module explores all possible message interleavings in the application, searching for states violating the provided properties. We recently added the ability to assess liveness properties over arbitrary and legacy codes, thanks to a system-level introspection tool that provides a finely detailed view of the running application to the model checker. This can for example be leveraged to verify both safety or liveness properties, on arbitrary MPI code written in C/C++/Fortran.

NEWS OF THE YEAR: There were 3 major releases in 2019: Python bindings were introduced, SMPI now partially supports some of the MPI/IO functions, a new model for Wifi networks was proposed, and the API for the simulation of storage resources was completely revisited. We also pursued our efforts to improve the documentation of the software, simplified the web site, and made a lot of bug fixing and code refactoring.

- Participants: Adrien Lèbre, Arnaud Legrand, Augustin Degomme, Florence Perronnin, Frédéric Suter, Jean-Marc Vincent, Jonathan Pastor, Luka Stanisic and Martin Quinson
- Partners: CNRS - ENS Rennes
- Contact: Martin Quinson
- URL: https://simgrid.org/

6.4. DiFFuSE

Distributed framework for cloud-based epidemic simulations

KEYWORDS: Simulation - Cloud

FUNCTIONAL DESCRIPTION: The DiFFuSE framework enables simulations of epidemics to take full advantage of cloud environments. The framework provides design support, reusable code, and tools for building and executing epidemic simulations. Notably, the framework automatically handles failures and supports elastic allocation of resources from multiple clouds.

- Authors: Yvon Jégou, Manh Linh Pham, Nikolaos Parlavantzas and Christine Morin
- Contact: Nikolaos Parlavantzas
- Publication: hal-01612979/
- URL: https://team.inria.fr/myriads/software-and-platforms/diffuse/

6.5. GinFlow

KEYWORDS: Workflow - Distributed computing - Distributed - Distributed Applications - Dynamic adaptation - Framework

FUNCTIONAL DESCRIPTION: GinFlow decentralizes the coordination of the execution of workflow-based applications. GinFlow relyies on an architecture where multiple service agents (SA) coordinate each others through a shared space containing the workflow description and current status. GinFlow allows the user to define several variants of a workflow and to switch from one to the other during run time.

- Participants: Cédric Tedeschi, Hector Fernandez, Javier Rojas Balderrama, Matthieu Simonin and Thierry Priol
- Partner: Université de Rennes 1
- Contact: Cédric Tedeschi
- URL: http://ginflow.inria.fr

6.6. libcvss

KEYWORD: Cybersecurity

FUNCTIONAL DESCRIPTION: libcvss is a Rust implementation of the CVSS specification. The supported versions of CVSS are 2.0, 3.0 and 3.1.

The official CVSS website describes CVSS this way: "The Common Vulnerability Scoring System (CVSS) provides a way to capture the principal characteristics of a vulnerability and produce a numerical score reflecting its severity. The numerical score can then be translated into a qualitative representation (such as low, medium, high, and critical) to help organizations properly assess and prioritize their vulnerability management processes."

libcvss provides Rust users with a native way to manipulate CVSS-formatted vulnerability data. Rust is leveraged to provide a CVSS implementation focused on both performance and correctness.

- Participant: Clement El Baz
- Contact: Clement El Baz
- URL: https://crates.io/crates/libcvss

NEO Project-Team

6. New Software and Platforms

6.1. marmoteCore

Markov Modeling Tools and Environments - the Core

KEYWORDS: Modeling - Stochastic models - Markov model

FUNCTIONAL DESCRIPTION: marmoteCore is a C++ environment for modeling with Markov chains. It consists in a reduced set of high-level abstractions for constructing state spaces, transition structures and Markov chains (discrete-time and continuous-time). It provides the ability of constructing hierarchies of Markov models, from the most general to the particular, and equip each level with specifically optimized solution methods.

This software is developed within the ANR MARMOTE project: ANR-12-MONU-00019.

- Participants: Alain Jean-Marie, Hlib Mykhailenko, Benjamin Briot, Franck Quessette, Issam Rabhi, Jean-Marc Vincent and Jean-Michel Fourneau
- Partner: UVSQ
- Contact: Alain Jean-Marie
- Publications: marmoteCore: a Markov Modeling Platform - marmoteCore: a software platform for Markov modeling
- URL: http://marmotecore.gforge.inria.fr/

POLARIS Project-Team

6. New Software and Platforms

6.1. Framesoc

FUNCTIONAL DESCRIPTION: Framesoc is the core software infrastructure of the SoC-Trace project. It provides a graphical user environment for execution-trace analysis, featuring interactive analysis views as Gantt charts or statistics views. It provides also a software library to store generic trace data, play with them, and build other analysis tools (e.g., Ocelotl).

- Participants: Arnaud Legrand and Jean-Marc Vincent
- Contact: Guillaume Huard
- URL: http://soctrace-inria.github.io/framesoc/

6.2. GameSeer

FUNCTIONAL DESCRIPTION: GameSeer is a tool for students and researchers in game theory that uses Mathematica to generate phase portraits for normal form games under a variety of (user-customizable) evolutionary dynamics. The whole point behind GameSeer is to provide a dynamic graphical interface that allows the user to employ Mathematica's vast numerical capabilities from a simple and intuitive front-end. So, even if you've never used Mathematica before, you should be able to generate fully editable and customizable portraits quickly and painlessly.

- Contact: Panayotis Mertikopoulos
- URL: http://mescal.imag.fr/membres/panayotis.mertikopoulos/

6.3. marmoteCore

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- Partner: UVSQ
- Contact: Alain Jean-Marie
- Publications: marmoteCore: a Markov Modeling Platform - marmoteCore: a software platform for Markov modeling
- URL: http://marmotecore.gforge.inria.fr/

6.4. Moca

Memory Organisation Cartography and Analysis

KEYWORDS: High-Performance Computing - Performance analysis
- Contact: David Beniamine
- URL: https://github.com/dbeniamine/MOCA

6.5. Ocelotl

Multidimensional Overviews for Huge Trace Analysis

FUNCTIONAL DESCRIPTION: Ocelotl is an innovative visualization tool, which provides overviews for execution trace analysis by using a data aggregation technique. This technique enables to find anomalies in huge traces containing up to several billions of events, while keeping a fast computation time and providing a simple representation that does not overload the user.
- Participants: Arnaud Legrand and Jean-Marc Vincent
- Contact: Jean-Marc Vincent
- URL: http://soctrace-inria.github.io/ocelotl/

6.6. PSI

Perfect Simulator

FUNCTIONAL DESCRIPTION: Perfect simulator is a simulation software of markovian models. It is able to simulate discrete and continuous time models to provide a perfect sampling of the stationary distribution or directly a sampling of functional of this distribution by using coupling from the past. The simulation kernel is based on the CFTP algorithm, and the internal simulation of transitions on the Aliasing method.
- Contact: Jean-Marc Vincent
- URL: http://psi.gforge.inria.fr/

6.7. SimGrid

KEYWORDS: Large-scale Emulators - Grid Computing - Distributed Applications

SCIENTIFIC DESCRIPTION: SimGrid is a toolkit that provides core functionalities for the simulation of distributed applications in heterogeneous distributed environments. The simulation engine uses algorithmic and implementation techniques toward the fast simulation of large systems on a single machine. The models are theoretically grounded and experimentally validated. The results are reproducible, enabling better scientific practices.

Its models of networks, cpus and disks are adapted to (Data)Grids, P2P, Clouds, Clusters and HPC, allowing multi-domain studies. It can be used either to simulate algorithms and prototypes of applications, or to emulate real MPI applications through the virtualization of their communication, or to formally assess algorithms and applications that can run in the framework.

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NEWS OF THE YEAR: There were 3 major releases in 2019: Python bindings were introduced, SMPI now partially supports some of the MPI/IO functions, a new model for Wifi networks was proposed, and the API for the simulation of storage resources was completely revisited. We also pursued our efforts to improve the documentation of the software, simplified the web site, and made a lot of bug fixing and code refactoring.
- Participants: Adrien Lèbre, Arnaud Legrand, Augustin Degomme, Florence Perronnin, Frédéric Suter, Jean-Marc Vincent, Jonathan Pastor, Luka Stanisic and Martin Quinson
- Partners: CNRS - ENS Rennes
- Contact: Martin Quinson
- URL: https://simgrid.org/

6.8. Tabarnac

Tool for Analyzing the Behavior of Applications Running on NUMA ArChitecture

KEYWORDS: High-Performance Computing - Performance analysis - NUMA

- Contact: David Beniamine
- URL: https://dbeniamine.github.io/Tabarnac/

RESIST Team

6. New Software and Platforms

6.1. Distem

KEYWORDS: Large scale - Experimentation - Virtualization - Emulation

FUNCTIONAL DESCRIPTION: Distem is a distributed systems emulator. When conducting research on Cloud, P2P, High Performance Computing or Grid systems, it can be used to transform an homogenenous cluster (composed of identical nodes) into an experimental platform where nodes have different performance, and are linked together through a complex network topology, making it the ideal tool to benchmark applications targetting such environments, or aiming at tolerating performance degradations or variations which are frequent in the Cloud or in other applications distributed at large scale (P2P for example).

RELEASE FUNCTIONAL DESCRIPTION: New features in Distem 1.3 include: (1) New network emulation parameters: loss, duplication, corruption, reordering and jitter, (2) Support for Debian Stretch, (3) Added many tests, (4) Moved project from GForge to GitHub (https://github.com/madynes/distem).

NEWS OF THE YEAR: New version 1.3

- Participants: Luc Sarzyniec, Lucas Nussbaum and Tomasz Buchert
- Partners: CNRS - Université de Lorraine - Loria - Grid'5000 - Inria
- Contact: Lucas Nussbaum
- URL: http://distem.gforge.inria.fr

6.2. Grid'5000

Grid'5000 testbed

KEYWORDS: HPC - Cloud - Big data - Testbeds

FUNCTIONAL DESCRIPTION: The Grid'5000 experimental platform is a scientific instrument to support computer science research related to distributed systems, including parallel processing, high performance computing, cloud computing, operating systems, peer-to-peer systems and networks. It is distributed on 10 sites in France and Luxembourg. Grid'5000 is a unique platform as it offers to researchers many and varied hardware resources and a complete software stack to conduct complex experiments, ensure reproducibility and ease understanding of results.

NEWS OF THE YEAR: This year's highlights include the TILECS workshop, and various improvements (update to Debian 10, several new clusters including the addition of 72 GPUs, etc.). More information on https://www.grid5000.fr/w/News

- Participants: Christian Pérez, David Loup, Frédéric Desprez, Laurent Lefèvre, Laurent Pouilloux, Marc Pinhède, Simon Delamare, Lucas Nussbaum, Teddy Valette and Alexandre Merlin
- Contact: Lucas Nussbaum
- URL: https://www.grid5000.fr/

6.3. SCUBA

A Tool Suite for the automated security assessment of IoT environments

KEYWORDS: Cybersecurity - Internet of things - Machine learning - Artificial intelligence

FUNCTIONAL DESCRIPTION: IoT devices are used in different fields of application, not only for the general public, but also in industrial environments. SCUBA is tool suite for the security assessment of industrial and general public IoT devices. It mainly relies on collected information through passive and active scanning of a running IoT device in its exploitation environment to build its Security Knowledge Base (SKB). The knowledge base contains all relevant information of the device regarding its network communications extracted from PCAP files, the enumeration of its used hardware and software represented in the CPE (Common Platform Enumeration) format, the list of its known vulnerabilities in the CVE (Common Vulnerabilities and Exposures) format associated to their CWE (Common Weakness Enumeration) and CAPEC (Common Attack Pattern Enumeration and Classification) descriptions. The SKB is used by SCUBA to predict the intrusion chains associated to an IoT device and its environment. SCUBA tries to be as automated as possible to face the large scale and the great heterogeneity of IoT networks.

NEWS OF THE YEAR: First release

- Participants: Abdelkader Lahmadi, Frédéric Beck, Thomas Lacour and Jérôme François
- Contact: Abdelkader Lahmadi

6.4. Platforms

6.4.1. *CPS Security Assessment Platform*

NEWS OF THE YEAR :

During 2019, we have extended our IoT (Internet of Things) and CPS (Cyber-Physical Systems) security assessment platform with more IoT devices dedicated to home networks (Alexa and Google Home voice assistants, smart door bell, smart door lock, alarm system). The platform is used for several demonstrations and it is extensively used for the development carried on the SCUBA (see 6.3) tool suite to automate the assessment of the security of IoT and SCADA systems by using ML/AI methods.

- Participants: Abdelkader Lahmadi, Frédéric Beck, Thomas Lacour and Jérôme François
- Contact: Abdelkader Lahmadi

RMOD Project-Team

6. New Software and Platforms

6.1. Moose

Moose: Software and Data Analysis Platform

KEYWORDS: Software engineering - Meta model - Software visualisation

FUNCTIONAL DESCRIPTION: Moose is an extensive platform for software and data analysis. It offers multiple services ranging from importing and parsing data, to modeling, to measuring, querying, mining, and to building interactive and visual analysis tools. The development of Moose has been evaluated to 200 man/year.

Mots-cles : MetaModeling, Program Visualization, Software metrics, Code Duplication, Software analyses, Parsers

- Participants: Anne Etien, Nicolas Anquetil, Olivier Auverlot, Stéphane Ducasse, Julien Delplanque, Guillaume Larcheveque, Cyril Ferlicot-Delbecque and Pavel Krivanek
- Partners: Université de Berne - Sensus - Synectique - Pleiad - USI - Vrije Universiteit Brussel
- Contact: Stéphane Ducasse
- URL: http://www.moosetechnology.org

6.2. Pharo

KEYWORDS: Live programmation objet - Reflective system - Web Application

FUNCTIONAL DESCRIPTION: Pharo is a pure object reflective and dynamic language inspired by Smalltalk. In addition, Pharo comes with a full advanced programming environment developed under the MIT License. It provides a platform for innovative development both in industry and research. By providing a stable and small core system, excellent developer tools, and maintained releases, Pharo's goal is to be a platform to build and deploy mission critical applications, while at the same time continue to evolve. Pharo 60 got 100 contributors world-wide. It is used by around 30 universities, 15 research groups and around 40 companies.

- Participants: Christophe Demarey, Clement Bera, Damien Pollet, Esteban Lorenzano, Marcus Denker, Stéphane Ducasse and Guillermo Polito
- Partners: BetaNine - Reveal - Inceptive - Netstyle - Feenk - ObjectProfile - GemTalk Systems - Greyc Université de Caen - Basse-Normandie - Université de Berne - Yesplan - RMod - Pleiad - Sensus - Université de Bretagne Occidentale - École des Mines de Douai - ENSTA - Uqbar foundation Argentina - LAM Research - ZWEIDENKER - LifeWare - JPMorgan Chase - KnowRoaming - ENIT - Spesenfuchs - FINWorks - Esug - FAST - Ingenieubüro Schmidt - Projector Software - HRWorks - Inspired.org - Palantir Solutions - High Octane - Soops - Osoco - Ta Mère SCRL - University of Yaounde 1 - Software Quality Laboratory, University of Novi Sad - Software Institute Università della Svizzera italiana - Universdad Nacional de Quilmes - UMMISCO IRD - Université technique de Prague
- Contact: Marcus Denker
- URL: http://www.pharo.org

6.3. Pillar

KEYWORDS: HTML - LaTeX - HTML5

FUNCTIONAL DESCRIPTION: Pillar is a markup syntax and associated tools to write and generate documentation and books. Pillar is currently used to write several books and other documentation. It is used in the tools developed by Feenk.com.

- Partner: Feenk
- Contact: Stéphane Ducasse
- URL: https://github.com/Pillar-markup/pillar

ROMA Project-Team

6. New Software and Platforms

6.1. MUMPS

A MUltifrontal Massively Parallel Solver

KEYWORDS: High-Performance Computing - Direct solvers - Finite element modelling

FUNCTIONAL DESCRIPTION: MUMPS is a software library to solve large sparse linear systems (AX=B) on sequential and parallel distributed memory computers. It implements a sparse direct method called the multifrontal method. It is used worldwide in academic and industrial codes, in the context numerical modeling of physical phenomena with finite elements. Its main characteristics are its numerical stability, its large number of features, its high performance and its constant evolution through research and feedback from its community of users. Examples of application fields include structural mechanics, electromagnetism, geophysics, acoustics, computational fluid dynamics. MUMPS has been developed by INPT(ENSEEIHT)-IRIT, Inria, CERFACS, University of Bordeaux, CNRS and ENS Lyon. Since January 2019, it is developed and licensed by Mumps Technologies SAS.

NEWS OF THE YEAR: In June 2019, a new version of MUMPS, MUMPS 5.2.1, was released by Mumps Technologies.

- Participants: Gilles Moreau, Abdou Guermouche, Alfredo Buttari, Aurélia Fevre, Bora Uçar, Chiara Puglisi, Clément Weisbecker, Emmanuel Agullo, François-Henry Rouet, Guillaume Joslin, Jacko Koster, Jean-Yves L'Excellent, Marie Durand, Maurice Brémond, Mohamed Sid-Lakhdar, Patrick Amestoy, Philippe Combes, Stéphane Pralet, Theo Mary and Tzvetomila Slavova
- Partners: Université de Bordeaux - CNRS - CERFACS - ENS Lyon - INPT - IRIT - Université de Lyon - Université de Toulouse - LIP - Mumps Technologies SAS
- Contact: Jean-Yves L'Excellent
- URL: http://mumps-solver.org/

<p align="center" style="color:red">**SOCRATE Project-Team**</p>

4. New Software and Platforms

4.1. FloPoCo

Floating-Point Cores, but not only

KEYWORD: Synthesizable VHDL generator

FUNCTIONAL DESCRIPTION: The purpose of the open-source FloPoCo project is to explore the many ways in which the flexibility of the FPGA target can be exploited in the arithmetic realm.

- Participants: Florent de Dinechin and Luc Forget
- Partners: CNRS - ENS Lyon - UCBL Lyon 1 - UPVD
- Contact: Florent de Dinechin
- URL: http://flopoco.gforge.inria.fr/

4.2. Sytare

KEYWORDS: Embedded systems - Operating system - Non volatile memory

FUNCTIONAL DESCRIPTION: Sytare is an embedded operating system targeting tiny platforms with intermittent power. In order to make power failures transparent for the application, the system detects imminent failures and saves a checkpoint of program state to non-volatile memory. Hardware peripherals are also made persistent without requiring developer attention.

- Authors: Tristan Delizy, Gautier Berthou, Guillaume Salagnac, Kevin Marquet and Tanguy Risset
- Contact: Guillaume Salagnac
- Publication: Peripheral State Persistence For Transiently Powered Systems
- URL: https://hal.inria.fr/hal-01460699

4.3. NanoTracer

KEYWORDS: Embedded systems - Power monitoring - Low power consumption

FUNCTIONAL DESCRIPTION: NanoTracer is a high performance ammeter dedicated to power measurements for small devices. The system measures currents between 100nA and 100mA (gain is audo-adjusted dynamically) with a sampling frequency of 2Msps. Data is streamed to a PC over USB which enables long-running experiments, or just real-time visualization of data.

- Contact: Guillaume Salagnac
- URL: https://gitlab.inria.fr/nanotracer/

4.4. marto

Modern Arithmetic Tools

KEYWORDS: High-level synthesis - Arithmetic - FPGA

FUNCTIONAL DESCRIPTION: Marto provides C++ headers to implement custom sized arithmetic operators such as:

Custom sized posits and their environment (including the quire) Custom sized IEEE-754 numbers Custom sized Kulisch accumulators (and sums of products)

- Participants: Yohann Uguen, Florent de Dinechin and Luc Forget
- Contact: Yohann Uguen
- Publication: hal-02130912v4
- URL: https://gitlab.inria.fr/lforget/marto

4.5. hint

High-level synthesis Integer Library

KEYWORD: High-level synthesis

FUNCTIONAL DESCRIPTION: Hint is an header-only arbitrary size integer API with strong semantics for C++. Multiple backends are provided using various HLS libraries, allowing a user to write one operator and synthetize it using the main vendor tools.

- Participants: Yohann Uguen, Florent de Dinechin and Luc Forget
- Contact: Luc Forget
- Publication: hal-02131798v2
- URL: https://github.com/yuguen/hint

<p style="text-align:center">**SPIRALS Project-Team**</p>

6. New Software and Platforms

6.1. APISENSE

KEYWORDS: Mobile sensing - Crowd-sensing - Mobile application - Crowd-sourcing - Android

FUNCTIONAL DESCRIPTION: APISENSE platform is a software solution to collect various contextual information from Android devices (client application) and automatically upload collected data to a server (deployed as a SaaS). APISENSE is based on a Cloud computing infrastructure to facilitate datasets collection from significant populations of mobile users for research purposes.

- Participants: Antoine Veuiller, Christophe Ribeiro, Julien Duribreux, Nicolas Haderer, Romain Rouvoy, Romain Sommerard and Lakhdar Meftah
- Partner: Université de Lille
- Contact: Romain Rouvoy
- URL: https://apisense.io

6.2. PowerAPI

KEYWORDS: Energy efficiency - Energy management

FUNCTIONAL DESCRIPTION: PowerAPI is a library for monitoring the energy consumption of software systems.

PowerAPI differs from existing energy process-level monitoring tool in its software orientation, with a fully customizable and modular solution that let the user to precisely define what he/she wants to monitor. PowerAPI is based on a modular and asynchronous event-driven architecture using the Akka library. PowerAPI offers an API which can be used to define requests about energy spent by a process, following its hardware resource utilization (in term of CPU, memory, disk, network, etc.).

- Participants: Adel Noureddine, Loïc Huertas, Maxime Colmant, Romain Rouvoy, Mohammed Chakib Belgaid and Arthur D'azemar
- Contact: Romain Rouvoy
- URL: http://powerapi.org

6.3. Saloon

KEYWORDS: Feature Model - Software Product Line - Cloud computing - Model-driven engineering - Ontologies

FUNCTIONAL DESCRIPTION: Saloon is a framework for the selection and configuration of Cloud providers according to application requirements. The framework enables the specification of such requirements by defining ontologies. Each ontology provides a unified vision of provider offers in terms of frameworks, databases, languages, application servers and computational resources (i.e., memory, storage and CPU frequency). Furthermore, each provider is related to a Feature Model (FM) with attributes and cardinalities, which captures its capabilities. By combining the ontology and FMs, the framework is able to match application requirements with provider capabilities and select a suitable one. Specific scripts to the selected provider are generated in order to enable its configuration.

- Participants: Clément Quinton, Daniel Romero Acero, Laurence Duchien, Lionel Seinturier and Romain Rouvoy
- Partner: Université de Lille
- Contact: Clément Quinton
- URL: https://gitlab.irisa.fr/drome00A/saloon

6.4. SPOON

KEYWORDS: Java - Code analysis

FUNCTIONAL DESCRIPTION: Spoon is an open-source library that enables you to transform (see below) and analyze Java source code (see example). Spoon provides a complete and fine-grained Java metamodel where any program element (classes, methods, fields, statements, expressions...) can be accessed both for reading and modification. Spoon takes as input source code and produces transformed source code ready to be compiled.

- Participants: Gérard Paligot, Lionel Seinturier, Martin Monperrus, Nicolas Petitprez and Simon Urli
- Contact: Martin Monperrus
- URL: http://spoon.gforge.inria.fr

<p style="text-align:center">**STACK Project-Team**</p>

6. New Software and Platforms

6.1. MAD

Madeus Application Deployer

KEYWORDS: Automatic deployment - Distributed Software - Component models - Cloud computing

SCIENTIFIC DESCRIPTION: MAD is a Python implementation of the Madeus deployment model for multi-component distributed software. Precisely, it allows to: 1. describe the deployment process and the dependencies of distributed software components in accordance with the Madeus model, 2. describe an assembly of components, resulting in a functional distributed software, 3. automatically deploy the component assembly of distributed software following the operational semantics of Madeus.

RELEASE FUNCTIONAL DESCRIPTION: Initial submission with basic functionalities of MAD

NEWS OF THE YEAR: Operational prototype.

- Participants: Christian Pérez, Dimitri Pertin, Hélène Coullon and Maverick Chardet
- Partners: IMT Atlantique - LS2N - LIP
- Contact: Hélène Coullon
- Publications: Madeus: A formal deployment model - Behavioral interfaces for reconfiguration of component models

6.2. Nitro

KEYWORDS: Cloud storage - Virtual Machine Image - Geo-distribution

SCIENTIFIC DESCRIPTION: Nitro is a storage system that is designed to work in geo-distributed cloud environments (i.e., over WAN) to efficiently manage Virtual Machine Images (VMIs).

Nitro employs fixed-size deduplication to store VMIs. This technique contributes to minimizing the network cost. Also, Nitro incorporates a network-aware scheduling algorithm (based on max flow algorithm) to determine which chunks should be pulled from which site in order to reconstruct the corresponding image on the destination site, with minimal (provisioning) time.

FUNCTIONAL DESCRIPTION: Geo-distributed Storage System to optimize Images (VM, containers, ...) management, in terms of cost and time, in geographically distributed cloud environment (i.e. data centers are connected over WAN).

- Authors: Jad Darrous, Shadi Ibrahim and Christian Pérez
- Contact: Shadi Ibrahim
- URL: https://gitlab.inria.fr/jdarrous/nitro

6.3. VMPlaces

KEYWORDS: Simulation - Virtualization - Scheduling

FUNCTIONAL DESCRIPTION: VMPlaces is a dedicated framework to evaluate and compare VM placement algorithms. This framework is composed of two major components: the injector and the VM placement algorithm. The injector is the generic part of the framework (i.e. the one you can directly use) while the VM placement algorithm is the part you want to study (or compare with available algorithms). Currently, the VMPlaceS is released with three algorithms:

Entropy, a centralized approach using a constraint programming approach to solve the placement/reconfiguration VM problem

Snooze, a hierarchical approach where each manager of a group invokes Entropy to solve the placement/reconfiguration VM problem. Note that in the original implementation of Snooze, it is using a specific heuristic to solve the placement/reconfiguration VM problem. As the sake of simplicity, we have simply reused the entropy scheduling code.

DVMS, a distributed approach that dynamically partitions the system and invokes Entropy on each partition.

- Participants: Adrien Lèbre, Jonathan Pastor and Mario Südholt
- Contact: Adrien Lèbre
- URL: http://beyondtheclouds.github.io/VMPlaceS/

6.4. ENOS

Experimental eNvironment for OpenStack

KEYWORDS: OpenStack - Experimentation - Reproducibility

FUNCTIONAL DESCRIPTION: Enos workflow :

A typical experiment using Enos is the sequence of several phases:

- enos up : Enos will read the configuration file, get machines from the resource provider and will prepare the next phase - enos os : Enos will deploy OpenStack on the machines. This phase rely highly on Kolla deployment. - enos init-os : Enos will bootstrap the OpenStack installation (default quotas, security rules, ...) - enos bench : Enos will run a list of benchmarks. Enos support Rally and Shaker benchmarks. - enos backup : Enos will backup metrics gathered, logs and configuration files from the experiment.

- Partner: Orange Labs
- Contact: Adrien Lèbre
- URL: http://enos.readthedocs.io/en/stable/

6.5. EnOSlib

EnOSlib is a library to help you with your experiments

KEYWORDS: Distributed Applications - Distributed systems - Evaluation - Grid Computing - Cloud computing - Experimentation - Reproducibility - Linux - Virtualization

FUNCTIONAL DESCRIPTION: EnOSlib is a library to help you with your distributed application experiments. The main parts of your experiment logic is made reusable by the following EnOSlib building blocks:

- Reusable infrastructure configuration: The provider abstraction allows you to run your experiment on different environments (locally with Vagrant, Grid'5000, Chameleon and more) - Reusable software provisioning: In order to configure your nodes, EnOSlib exposes different APIs with different level of expressivity - Reusable experiment facilities: Tasks help you to organize your experimentation workflow.

EnOSlib is designed for experimentation purpose: benchmark in a controlled environment, academic validation . . .

- Contact: Matthieu Simonin
- Publications: Toward a Holistic Framework for Conducting Scientific Evaluations of OpenStack - EnosStack: A LAMP-like stack for the experimenter
- URL: https://discovery.gitlabpages.inria.fr/enoslib/

6.6. Concerto

KEYWORDS: Reconfiguration - Distributed Software - Component models - Dynamic software architecture

FUNCTIONAL DESCRIPTION: Concerto is an implementation of the formal model Concerto written in Python. Concerto aloows to : 1. describe the life-cycle and the dependencies of software components, 2. describe a components assembly that forms the overall life-cycle of a distributed software, 3. automatically reconfigure a Concerto assembly of components by using a set of reconfiguration instructions as well as a formal operational semantics.

- Partners: IMT Atlantique - LS2N - LIP
- Contact: Maverick Chardet
- URL: https://gitlab.inria.fr/VeRDi-project/concerto

6.7. Platforms

6.7.1. OpenStack

OpenStack is the de facto open-source management system to operate and use Cloud Computing infrastructures. Started in 2012, the OpenStack foundation gathers 500 organizations including groups such as Intel, AT&T, RedHat, etc. The software platform relies on tens of services with a 6-month development cycle. It is composed of more than 2 millions of lines of code, mainly in Python, just for the core services. While these aspects make the whole ecosystem quite swift, they are also good signs of maturity of this community. We created and animated between 2016 and 2018 the Fog/Edge/Massively Distributed (FEMDC) Special Interest Group[0] and have been contributing to the Performance working group since 2015. The former investigates how OpenStack can address Fog/Edge Computing use cases whereas the latter addresses scalability, reactivity and high-availability challenges. In addition to releasing white papers and guidelines [96], the major result from the academic view point is the aforementioned EnOS solution, a holistic framework to conduct performance evaluations of OpenStack (control and data plane). In May 2018, the FEMDC SiG turned into a larger group under the control of the OpenStack foundation. This group gathers large companies such as Verizon, ATT, etc.

6.7.2. Grid'5000

Grid'5000 is a large-scale and versatile testbed for experiment-driven research in all areas of computer science, with a focus on parallel and distributed computing including Cloud, HPC and Big Data. It provides access to a large amount of resources: 12000 cores, 800 compute-nodes grouped in homogeneous clusters, and featuring various technologies (GPU, SSD, NVMe, 10G and 25G Ethernet, Infiniband, Omni-Path) and advanced monitoring and measurement features for traces collection of networking and power consumption, providing a deep understanding of experiments. It is highly reconfigurable and controllable. Researchers can experiment with a fully customized software stack thanks to bare-metal deployment features, and can isolate their experiment at the networking layer advanced monitoring and measurement features for traces collection of networking and power consumption, providing a deep understanding of experiments designed to support Open Science and reproducible research, with full traceability of infrastructure and software changes on the testbed. STACK members are strongly involved into the management and the supervision of the testbed, notably through the steering committee or the SeDuCe testbed described hereafter.

6.7.3. SeDuCe

The SeDuCe Project aims to deliver a research testbed dedicated to holistic research studies on energetical aspects of datacenters. Part of the Grid'5000 Nantes' site, this infrastructure is composed of probes that measure the power consumption of each server, each switch and each cooling system, and also measure the temperature at the front and the back of each servers. These sensors enable reasearch to cover a full spectrum of the energetical aspect of datacenters, such as cooling and power consumption depending of experimental conditions.

The testbed is connected to renewable energy sources (solar panels). This "green" datacenter will enable researchers to perform real experiment-driven studies on fields such as temperature based scheduling or "green" aware software (*i.e.*, software that take into account renewable energies and weather conditions).

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[0]https://wiki.openstack.org/wiki/Fog_Edge_Massively_Distributed_Clouds

6.7.4. SILECS

STACK Members are involved in the definition and bootstrap of the SILECS infrastructure. This infrastructure can be seen as a merge of the Grid'5000 and FIT testbeds with the goal of providing a common platform for experimental computer Science (Next Generation Internet, Internet of things, clouds, HPC, big data, etc.).

<div align="center">

STORM Project-Team

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6. New Software and Platforms

6.1. Chameleon

KEYWORDS: Runtime system - Task-based algorithm - Dense linear algebra - HPC - Task scheduling

SCIENTIFIC DESCRIPTION: Chameleon is part of the MORSE (Matrices Over Runtime Systems @ Exascale) project. The overall objective is to develop robust linear algebra libraries relying on innovative runtime systems that can fully benefit from the potential of those future large-scale complex machines.

We expect advances in three directions based first on strong and closed interactions between the runtime and numerical linear algebra communities. This initial activity will then naturally expand to more focused but still joint research in both fields.

1. Fine interaction between linear algebra and runtime systems. On parallel machines, HPC applications need to take care of data movement and consistency, which can be either explicitly managed at the level of the application itself or delegated to a runtime system. We adopt the latter approach in order to better keep up with hardware trends whose complexity is growing exponentially. One major task in this project is to define a proper interface between HPC applications and runtime systems in order to maximize productivity and expressivity. As mentioned in the next section, a widely used approach consists in abstracting the application as a DAG that the runtime system is in charge of scheduling. Scheduling such a DAG over a set of heterogeneous processing units introduces a lot of new challenges, such as predicting accurately the execution time of each type of task over each kind of unit, minimizing data transfers between memory banks, performing data prefetching, etc. Expected advances: In a nutshell, a new runtime system API will be designed to allow applications to provide scheduling hints to the runtime system and to get real-time feedback about the consequences of scheduling decisions.

2. Runtime systems. A runtime environment is an intermediate layer between the system and the application. It provides low-level functionality not provided by the system (such as scheduling or management of the heterogeneity) and high-level features (such as performance portability). In the framework of this proposal, we will work on the scalability of runtime environment. To achieve scalability it is required to avoid all centralization. Here, the main problem is the scheduling of the tasks. In many task-based runtime environments the scheduler is centralized and becomes a bottleneck as soon as too many cores are involved. It is therefore required to distribute the scheduling decision or to compute a data distribution that impose the mapping of task using, for instance the so-called "owner-compute" rule. Expected advances: We will design runtime systems that enable an efficient and scalable use of thousands of distributed multicore nodes enhanced with accelerators.

3. Linear algebra. Because of its central position in HPC and of the well understood structure of its algorithms, dense linear algebra has often pioneered new challenges that HPC had to face. Again, dense linear algebra has been in the vanguard of the new era of petascale computing with the design of new algorithms that can efficiently run on a multicore node with GPU accelerators. These algorithms are called "communication-avoiding" since they have been redesigned to limit the amount of communication between processing units (and between the different levels of memory hierarchy). They are expressed through Direct Acyclic Graphs (DAG) of fine-grained tasks that are dynamically scheduled. Expected advances: First, we plan to investigate the impact of these principles in the case of sparse applications (whose algorithms are slightly more complicated but often rely on dense kernels). Furthermore, both in the dense and sparse cases, the scalability on thousands of nodes is still limited, new numerical approaches need to be found. We will specifically design sparse hybrid direct/iterative methods that represent a promising approach.

Overall end point. The overall goal of the MORSE associate team is to enable advanced numerical algorithms to be executed on a scalable unified runtime system for exploiting the full potential of future exascale machines.

FUNCTIONAL DESCRIPTION: Chameleon is a dense linear algebra software relying on sequential task-based algorithms where sub-tasks of the overall algorithms are submitted to a Runtime system. A Runtime system such as StarPU is able to manage automatically data transfers between not shared memory area (CPUs-GPUs, distributed nodes). This kind of implementation paradigm allows to design high performing linear algebra algorithms on very different type of architecture: laptop, many-core nodes, CPUs-GPUs, multiple nodes. For example, Chameleon is able to perform a Cholesky factorization (double-precision) at 80 TFlop/s on a dense matrix of order 400 000 (i.e. 4 min 30 s).

RELEASE FUNCTIONAL DESCRIPTION: Chameleon includes the following features:

- BLAS 3, LAPACK one-sided and LAPACK norms tile algorithms - Support QUARK and StarPU runtime systems and PaRSEC since 2018 - Exploitation of homogeneous and heterogeneous platforms through the use of BLAS/LAPACK CPU kernels and cuBLAS/MAGMA CUDA kernels - Exploitation of clusters of interconnected nodes with distributed memory (using OpenMPI)

- Participants: Cédric Castagnede, Samuel Thibault, Emmanuel Agullo, Florent Pruvost and Mathieu Faverge
- Partners: Innovative Computing Laboratory (ICL) - King Abdullha University of Science and Technology - University of Colorado Denver
- Contact: Emmanuel Agullo
- URL: https://gitlab.inria.fr/solverstack/chameleon

6.2. hwloc

Hardware Locality

KEYWORDS: NUMA - Multicore - GPU - Affinities - Open MPI - Topology - HPC - Locality

FUNCTIONAL DESCRIPTION: Hardware Locality (hwloc) is a library and set of tools aiming at discovering and exposing the topology of machines, including processors, cores, threads, shared caches, NUMA memory nodes and I/O devices. It builds a widely-portable abstraction of these resources and exposes it to applications so as to help them adapt their behavior to the hardware characteristics. They may consult the hierarchy of resources, their attributes, and bind task or memory on them.

hwloc targets many types of high-performance computing applications, from thread scheduling to placement of MPI processes. Most existing MPI implementations, several resource managers and task schedulers, and multiple other parallel libraries already use hwloc.

NEWS OF THE YEAR: hwloc 2.1 brought support for modern multi-die processors and memory-side caches. It also enhanced memory locality in heterogeneous memory architecture (e.g. with non-volatile memory DIMMs). The visualization of many-core platforms was also improved by factorizing objects when many of them are identical.

- Participants: Brice Goglin and Valentin Hoyet
- Partners: Open MPI consortium - Intel - AMD - IBM
- Contact: Brice Goglin
- Publications: hwloc: a Generic Framework for Managing Hardware Affinities in HPC Applications - Managing the Topology of Heterogeneous Cluster Nodes with Hardware Locality (hwloc) - A Topology-Aware Performance Monitoring Tool for Shared Resource Management in Multicore Systems - Exposing the Locality of Heterogeneous Memory Architectures to HPC Applications - Towards the Structural Modeling of the Topology of next-generation heterogeneous cluster Nodes with hwloc - On the Overhead of Topology Discovery for Locality-aware Scheduling in HPC - Memory Footprint of Locality Information on Many-Core Platforms - M&MMs: Navigating Complex Memory Spaces with hwloc
- URL: http://www.open-mpi.org/projects/hwloc/

6.3. KaStORS

The KaStORS OpenMP Benchmark Suite

KEYWORDS: Benchmarking - HPC - Task-based algorithm - Task scheduling - OpenMP - Data parallelism

FUNCTIONAL DESCRIPTION: The KaStORS benchmarks suite has been designed to evaluate implementations of the OpenMP dependent task paradigm, introduced as part of the OpenMP 4.0 specification.

- Participants: François Broquedis, Nathalie Furmento, Olivier Aumage, Philippe Virouleau, Pierrick Brunet, Samuel Thibault and Thierry Gautier
- Contact: Thierry Gautier
- URL: http://kastors.gforge.inria.fr/#!index.md

6.4. KStar

The KStar OpenMP Compiler

KEYWORDS: Source-to-source compiler - OpenMP - Task scheduling - Compilers - Data parallelism

FUNCTIONAL DESCRIPTION: The KStar software is a source-to-source OpenMP compiler for languages C and C++. The KStar compiler translates OpenMP directives and constructs into API calls from the StarPU runtime system or the XKaapi runtime system. The KStar compiler is virtually fully compliant with OpenMP 3.0 constructs. The KStar compiler supports OpenMP 4.0 dependent tasks and accelerated targets.

- Participants: Nathalie Furmento, Olivier Aumage, Philippe Virouleau and Samuel Thibault
- Contact: Olivier Aumage
- Publications: Bridging the gap between OpenMP and task-based runtime systems for the fast multipole method - Bridging the gap between OpenMP 4.0 and native runtime systems for the fast multipole method - Evaluation of OpenMP Dependent Tasks with the KASTORS Benchmark Suite
- URL: http://kstar.gforge.inria.fr/#!index.md

6.5. AFF3CT

A Fast Forward Error Correction Toolbox

KEYWORDS: High-Performance Computing - Signal processing - Error Correction Code

FUNCTIONAL DESCRIPTION: AFF3CT proposes high performance Error Correction algorithms for Polar, Turbo, LDPC, RSC (Recursive Systematic Convolutional), Repetition and RA (Repeat and Accumulate) codes. These signal processing codes can be parameterized in order to optimize some given metrics, such as Bit Error Rate, Bandwidth, Latency, ...using simulation. For the designers of such signal processing chain, AFF3CT proposes also high performance building blocks so to develop new algorithms. AFF3CT compiles with many compilers and runs on Windows, Mac OS X, Linux environments and has been optimized for x86 (SSE, AVX instruction sets) and ARM architectures (NEON instruction set).

- Authors: Adrien Cassagne, Bertrand Le Gal, Camille Leroux, Denis Barthou and Olivier Aumage
- Partner: IMS
- Contact: Adrien Cassagne
- Publications: AFF3CT: A Fast Forward Error Correction Toolbox! - AFF3CT : Un environnement de simulation pour le codage de canal - Toward High-Performance Implementation of 5G SCMA Algorithms - An Efficient, Portable and Generic Library for Successive Cancellation Decoding of Polar Codes - Beyond Gbps Turbo Decoder on Multi-Core CPUs - Energy Consumption Analysis of Software Polar Decoders on Low Power Processors - Fast and Flexible Software Polar List Decoders - Fast Simulation and Prototyping with AFF3CT
- URL: https://aff3ct.github.io/

6.6. MORSE

KEYWORDS: High performance computing - Matrix calculation - Fast multipole method - Runtime system

FUNCTIONAL DESCRIPTION: MORSE (Matrices Over Runtime Systems @ Exascale) is a scientific project, its objectives are to solve matrix problems on complex architectures, using runtime systems. More specifically, the goal is to write codes that reach a high level of performance for all architectures. The algorithms are written independently of the architecture, and the runtime system dispatches the different computational parts to the different computing units. This methodology has been validated on three classes of problems: dense linear algebra, sparse and dense, and fast multipole methods. The corresponding codes have been incorporated into several softwares, MAGMA, Pastix and ScalFMM.

- Contact: Emmanuel Agullo
- URL: http://icl.cs.utk.edu/morse/

6.7. SwLoc

Software Contexts for Locality

KEYWORDS: HPC - Locality - Contexts - Multicore - GPU

FUNCTIONAL DESCRIPTION: SwLoc is a library for flexible and generic partitioning of computing resources (processors, accelerators) to be able to co-excute confined parallel regions which can rely on different runtime systems (e.g. OpenMP, Intel TBB, StarPU, etc.). With all different hypervisor strategies, It is possible to adapt dynamically the computing resources of each context, in order to match each parallel region's need as closely as possible.

- Contact: Corentin Salingue
- URL: http://swloc.gforge.inria.fr/

6.8. VITE

Visual Trace Explorer

KEYWORDS: Visualization - Execution trace

FUNCTIONAL DESCRIPTION: ViTE is a trace explorer. It is a tool made to visualize execution traces of large parallel programs. It supports Pajé, a trace format created by Inria Grenoble, and OTF and OTF2 formats, developed by the University of Dresden and allows the programmer a simpler way to analyse, debug and/or profile large parallel applications.

- Participant: Mathieu Faverge
- Contact: Mathieu Faverge
- URL: http://vite.gforge.inria.fr/

6.9. PARCOACH

PARallel Control flow Anomaly CHecker

KEYWORDS: High-Performance Computing - Program verification - Debug - MPI - OpenMP - Compilation

SCIENTIFIC DESCRIPTION: PARCOACH verifies programs in two steps. First, it statically verifies applications with a data- and control-flow analysis and outlines execution paths leading to potential deadlocks. The code is then instrumented, displaying an error and synchronously interrupting all processes if the actual scheduling leads to a deadlock situation.

FUNCTIONAL DESCRIPTION: Supercomputing plays an important role in several innovative fields, speeding up prototyping or validating scientific theories. However, supercomputers are evolving rapidly with now millions of processing units, posing the questions of their programmability. Despite the emergence of more widespread and functional parallel programming models, developing correct and effective parallel applications still remains a complex task. As current scientific applications mainly rely on the Message Passing Interface (MPI) parallel programming model, new hardwares designed for Exascale with higher node-level parallelism clearly advocate for an MPI+X solutions with X a thread-based model such as OpenMP. But integrating two different programming models inside the same application can be error-prone leading to complex bugs - mostly detected unfortunately at runtime. PARallel COntrol flow Anomaly CHecker aims at helping developers in their debugging phase.

- Participants: Emmanuelle Saillard, Denis Barthou and Pierre Huchant
- Partner: CEA
- Contact: Emmanuelle Saillard
- Publications: Combining Static and Dynamic Validation of MPI Collective Communication - PARCOACH: Combining static and dynamic validation of MPI collective communications - Static Validation of Barriers and Worksharing Constructs in OpenMP Applications - Correctness Analysis of MPI-3 Non-Blocking Communications in PARCOACH - Static/Dynamic Validation of MPI Collective Communications in Multi-threaded Context - MPI Thread-Level Checking for MPI+OpenMP Applications - PARCOACH Extension for Hybrid Applications with Interprocedural Analysis - PARCOACH Extension for a Full-Interprocedural Collectives Verification - Multi-Valued Expression Analysis for Collective Checking
- URL: https://esaillar.github.io/PARCOACH/

6.10. StarPU

The StarPU Runtime System

KEYWORDS: Multicore - GPU - Scheduling - HPC - Performance

SCIENTIFIC DESCRIPTION: Traditional processors have reached architectural limits which heterogeneous multicore designs and hardware specialization (eg. coprocessors, accelerators, ...) intend to address. However, exploiting such machines introduces numerous challenging issues at all levels, ranging from programming models and compilers to the design of scalable hardware solutions. The design of efficient runtime systems for these architectures is a critical issue. StarPU typically makes it much easier for high performance libraries or compiler environments to exploit heterogeneous multicore machines possibly equipped with GPGPUs or Cell processors: rather than handling low-level issues, programmers may concentrate on algorithmic concerns.Portability is obtained by the means of a unified abstraction of the machine. StarPU offers a unified offloadable task abstraction named "codelet". Rather than rewriting the entire code, programmers can encapsulate existing functions within codelets. In case a codelet may run on heterogeneous architectures, it is possible to specify one function for each architectures (eg. one function for CUDA and one function for CPUs). StarPU takes care to schedule and execute those codelets as efficiently as possible over the entire machine. In order to relieve programmers from the burden of explicit data transfers, a high-level data management library enforces memory coherency over the machine: before a codelet starts (eg. on an accelerator), all its data are transparently made available on the compute resource.Given its expressive interface and portable scheduling policies, StarPU obtains portable performances by efficiently (and easily) using all computing resources at the same time. StarPU also takes advantage of the heterogeneous nature of a machine, for instance by using scheduling strategies based on auto-tuned performance models.

StarPU is a task programming library for hybrid architectures

The application provides algorithms and constraints: - CPU/GPU implementations of tasks - A graph of tasks, using either the StarPU's high level GCC plugin pragmas or StarPU's rich C API

StarPU handles run-time concerns - Task dependencies - Optimized heterogeneous scheduling - Optimized data transfers and replication between main memory and discrete memories - Optimized cluster communications

Rather than handling low-level scheduling and optimizing issues, programmers can concentrate on algorithmic concerns!

FUNCTIONAL DESCRIPTION: StarPU is a runtime system that offers support for heterogeneous multicore machines. While many efforts are devoted to design efficient computation kernels for those architectures (e.g. to implement BLAS kernels on GPUs), StarPU not only takes care of offloading such kernels (and implementing data coherency across the machine), but it also makes sure the kernels are executed as efficiently as possible.

- Participants: Corentin Salingue, Andra Hugo, Benoît Lize, Cédric Augonnet, Cyril Roelandt, François Tessier, Jérôme Clet-Ortega, Ludovic Courtès, Ludovic Stordeur, Marc Sergent, Mehdi Juhoor, Nathalie Furmento, Nicolas Collin, Olivier Aumage, Pierre-André Wacrenier, Raymond Namyst, Samuel Thibault, Simon Archipoff, Xavier Lacoste, Terry Cojean, Yanis Khorsi, Philippe Virouleau, LoÏc Jouans and Leo Villeveygoux

- Contact: Olivier Aumage

- Publications: Asynchronous Task-Based Execution of the Reverse Time Migration for the Oil and Gas Industry - A Compiler Algorithm to Guide Runtime Scheduling - Achieving high-performance with a sparse direct solver on Intel KNL - Modeling Irregular Kernels of Task-based codes: Illustration with the Fast Multipole Method - Scheduling of Dense Linear Algebra Kernels on Heterogeneous Resources - Critical resources management and scheduling under StarPU - Achieving High Performance on Supercomputers with a Sequential Task-based Programming Model - Programmation of heterogeneous architectures using moldable tasks - The StarPU Runtime System at Exascale ? : Scheduling and Programming over Upcoming Machines. - A Visual Performance Analysis Framework for Task-based Parallel Applications running on Hybrid Clusters - Analyzing Dynamic Task-Based Applications on Hybrid Platforms: An Agile Scripting Approach - Detecção de Anomalias de Desempenho em Aplicações de Alto Desempenho baseadas em Tarefas em Clusters Híbridos - Resource aggregation for task-based Cholesky Factorization on top of heterogeneous machines - On Runtime Systems for Task-based Programming on Heterogeneous Platforms - Resource aggregation in task-based applications over accelerator-based multicore machines - Controlling the Memory Subscription of Distributed Applications with a Task-Based Runtime System - Exploiting Two-Level Parallelism by Aggregating Computing Resources in Task-Based Applications Over Accelerator-Based Machines - Exploiting Two-Level Parallelism by Aggregating Computing Resources in Task-Based Applications Over Accelerator-Based Machines - Achieving High Performance on Supercomputers with a Sequential Task-based Programming Model - Bridging the gap between OpenMP 4.0 and native runtime systems for the fast multipole method - Scalability of a task-based runtime system for dense linear algebra applications - Faithful Performance Prediction of a Dynamic Task-Based Runtime System for Heterogeneous Multi-Core Architectures - Towards seismic wave modeling on heterogeneous many-core architectures using task-based runtime system - Bridging the Gap between Performance and Bounds of Cholesky Factorization on Heterogeneous Platforms - Composing multiple StarPU applications over heterogeneous machines: A supervised approach - Evaluation of OpenMP Dependent Tasks with the KASTORS Benchmark Suite - A runtime approach to dynamic resource allocation for sparse direct solvers - Modeling and Simulation of a Dynamic Task-Based Runtime System for Heterogeneous Multi-Core Architectures - Toward OpenCL Automatic Multi-Device Support - Harnessing clusters of hybrid nodes with a sequential task-based programming model - Taking advantage of hybrid systems for sparse direct solvers via task-based runtimes - Modulariser les ordonnanceurs de tâches : une approche structurelle - Overview of Distributed Linear Algebra on Hybrid Nodes over the StarPU Runtime - StarPU-MPI: Task Programming over Clusters of Machines Enhanced with Accelerators - Modeling and Simulation of a Dynamic Task-Based Runtime System for Heterogeneous Multi-Core Architectures -

Taking advantage of hybrid systems for sparse direct solvers via task-based runtimes - Adaptive Task Size Control on High Level Programming for GPU/CPU Work Sharing - Composing multiple StarPU applications over heterogeneous machines: a supervised approach - Implementation of FEM Application on GPU with StarPU - Le problème de la composition parallèle : une approche supervisée - Support exécutif scalable pour les architectures hybrides distribuées - SOCL: An OpenCL Implementation with Automatic Multi-Device Adaptation Support - C Language Extensions for Hybrid CPU/GPU Programming with StarPU - Programming Models and Runtime Systems for Heterogeneous Architectures - Programmation unifiée multi-accélérateur OpenCL - StarPU-MPI: Task Programming over Clusters of Machines Enhanced with Accelerators - Parallelization on Heterogeneous Multicore and Multi-GPU Systems of the Fast Multipole Method for the Helmholtz Equation Using a Runtime System - High-Level Support for Pipeline Parallelism on Many-Core Architectures - Programmability and Performance Portability Aspects of Heterogeneous Multi-/Manycore Systems - Programmation des architectures hétérogènes à l'aide de tâches divisibles - StarPU: a unified platform for task scheduling on heterogeneous multicore architectures - PEPPHER: Efficient and Productive Usage of Hybrid Computing Systems - The PEPPHER Approach to Programmability and Performance Portability for Heterogeneous many-core Architectures - Flexible runtime support for efficient skeleton programming on hybrid systems - LU Factorization for Accelerator-based Systems - QR Factorization on a Multicore Node Enhanced with Multiple GPU Accelerators - Programmation multi-accélérateurs unifiée en OpenCL - Détection optimale des coins et contours dans des bases d'images volumineuses sur architectures multicœurs hétérogènes - Association de modèles de programmation pour l'exploitation de clusters de GPUs dans le calcul intensif - Programming heterogeneous, accelerator-based multicore machines:current situation and main challenges - Scheduling Tasks over Multicore machines enhanced with acelerators: a Runtime System's Perspective - Composabilité de codes parallèles sur architectures hétérogènes - Data-Aware Task Scheduling on Multi-Accelerator based Platforms - Dynamically scheduled Cholesky factorization on multicore architectures with GPU accelerators. - StarPU: a Runtime System for Scheduling Tasks over Accelerator-Based Multicore Machines - StarPU : un support exécutif unifié pour les architectures multicoeurs hétérogènes - Automatic Calibration of Performance Models on Heterogeneous Multicore Architectures - StarPU: A Unified Platform for Task Scheduling on Heterogeneous Multicore Architectures - Exploiting the Cell/BE architecture with the StarPU unified runtime system - Bridging the gap between OpenMP and task-based runtime systems for the fast multipole method - Composability of parallel codes on heterogeneous architectures - Are Static Schedules so Bad ? A Case Study on Cholesky Factorization - Scheduling of Linear Algebra Kernels on Multiple Heterogeneous Resources - Approximation Proofs of a Fast and Efficient List Scheduling Algorithm for Task-Based Runtime Systems on Multicores and GPUs - Resource aggregation for task-based Cholesky Factorization on top of modern architectures - Visual Performance Analysis of Memory Behavior in a Task-Based Runtime on Hybrid Platforms - Tolérance aux pannes dans l'exécution distribuée de graphes de tâches

- URL: http://starpu.gforge.inria.fr/

TADAAM Project-Team

6. New Software and Platforms

6.1. Hsplit

Hardware communicators split

KEYWORDS: MPI communication - Topology - Hardware platform

SCIENTIFIC DESCRIPTION: Hsplit is a library that implements an abstraction allowing the programmer using MPI in their parallel applications to access the underlying hardware structure through a hierarchy of communicators. Hsplit is based on the MPI_Comm_split_type routine and provides a new value for the split_type argument that specifically creates a hierarchy a subcommunicators where each new subcommunicator corresponds to a meaningful hardware level. The important point is that only the structure o the hardware is exploited and the number of levels or the levels names are not fixed so as to propose a solution independent from future hardware evolutions (such as new levels for instance). Another flavor of this MPI_Comm_split_type function is provided that creates a roots communicators at the same time a subcommunicator is produced, in order to ease the collective communication and/or synchronization among subcommunicators.

FUNCTIONAL DESCRIPTION: Hsplit implements an abstraction that allows the programmer using MPI in their parallel applications to access the underlying hardware structure through a hierarchy of communicators. Hsplit is based on the MPI_Comm_split_type routine and provides a new value for the split_type argument that specifically creates a hierarchy a subcommunicators where each new subcommunicator corresponds to a meaningful hardware level. The important point is that only the structure o the hardware is exploited and the number of levels or the levels names are not fixed so as to propose a solution independent from future hardware evolutions (such as new levels for instance). Another flavor of this MPI_Comm_split_type function is provided that creates a roots communicators at the same time a subcommunicator is produced, in order to ease the collective communication and/or synchronization among subcommunicators.

NEWS OF THE YEAR: Most of our proposal had been officially read in front of the MPI Forum at the last physical meeting in December at Albuquerque. This concerns hte guided and the unguided mode of the split function. This now has to pass two votes in the next physical meetings in 2020 to be part of the new version of the standard: MPI 4.0 that shall be ratified and released at the end of 2020. Since no other MPI library currently implements the unguided mode, Hsplit will be the only sofware that is currently able to provide it.

- Participants: Guillaume Mercier, Brice Goglin and Emmanuel Jeannot
- Contact: Guillaume Mercier
- Publications: A hierarchical model to manage hardware topology in MPI applications - A Hierarchical Model to Manage Hardware Topology in MPI Applications
- URL: http://mpi-topology.gforge.inria.fr/

6.2. hwloc

Hardware Locality

KEYWORDS: NUMA - Multicore - GPU - Affinities - Open MPI - Topology - HPC - Locality

FUNCTIONAL DESCRIPTION: Hardware Locality (hwloc) is a library and set of tools aiming at discovering and exposing the topology of machines, including processors, cores, threads, shared caches, NUMA memory nodes and I/O devices. It builds a widely-portable abstraction of these resources and exposes it to applications so as to help them adapt their behavior to the hardware characteristics. They may consult the hierarchy of resources, their attributes, and bind task or memory on them.

hwloc targets many types of high-performance computing applications, from thread scheduling to placement of MPI processes. Most existing MPI implementations, several resource managers and task schedulers, and multiple other parallel libraries already use hwloc.

NEWS OF THE YEAR: hwloc 2.1 brought support for modern multi-die processors and memory-side caches. It also enhanced memory locality in heterogeneous memory architecture (e.g. with non-volatile memory DIMMs). The visualization of many-core platforms was also improved by factorizing objects when many of them are identical.

- Participants: Brice Goglin and Valentin Hoyet
- Partners: Open MPI consortium - Intel - AMD - IBM
- Contact: Brice Goglin
- Publications: hwloc: a Generic Framework for Managing Hardware Affinities in HPC Applications - Managing the Topology of Heterogeneous Cluster Nodes with Hardware Locality (hwloc) - A Topology-Aware Performance Monitoring Tool for Shared Resource Management in Multicore Systems - Exposing the Locality of Heterogeneous Memory Architectures to HPC Applications - Towards the Structural Modeling of the Topology of next-generation heterogeneous cluster Nodes with hwloc - On the Overhead of Topology Discovery for Locality-aware Scheduling in HPC - Memory Footprint of Locality Information on Many-Core Platforms - M&MMs: Navigating Complex Memory Spaces with hwloc
- URL: http://www.open-mpi.org/projects/hwloc/

6.3. NetLoc

Network Locality

KEYWORDS: Topology - Locality - Distributed networks - HPC - Parallel computing - MPI communication

FUNCTIONAL DESCRIPTION: netloc (Network Locality) is a library that extends hwloc to network topology information by assembling hwloc knowledge of server internals within graphs of inter-node fabrics such as Infiniband, Intel OmniPath or Cray networks.

Netloc builds a software representation of the entire cluster so as to help applications properly place their tasks on the nodes. It may also help communication libraries optimize their strategies according to the wires and switches.

Netloc targets the same challenges as hwloc but focuses on a wider spectrum by enabling cluster-wide solutions such as process placement. It interoperates with the Scotch graph partitioner to do so.

Netloc is distributed within hwloc releases starting with hwloc 2.0.

- Participants: Brice Goglin, Clément Foyer and Cyril Bordage
- Contact: Brice Goglin
- Publications: netloc: Towards a Comprehensive View of the HPC System Topology - Netloc: a Tool for Topology-Aware Process Mapping
- URL: http://www.open-mpi.org/projects/netloc/

6.4. NewMadeleine

NewMadeleine: An Optimizing Communication Library for High-Performance Networks

KEYWORDS: High-performance calculation - MPI communication

FUNCTIONAL DESCRIPTION: NewMadeleine is the fourth incarnation of the Madeleine communication library. The new architecture aims at enabling the use of a much wider range of communication flow optimization techniques. Its design is entirely modular: drivers and optimization strategies are dynamically loadable software components, allowing experimentations with multiple approaches or on multiple issues with regard to processing communication flows.

The optimizing scheduler SchedOpt targets applications with irregular, multi-flow communication schemes such as found in the increasingly common application conglomerates made of multiple programming environments and coupled pieces of code, for instance. SchedOpt itself is easily extensible through the concepts of optimization strategies (what to optimize for, what the optimization goal is) expressed in terms of tactics (how to optimize to reach the optimization goal). Tactics themselves are made of basic communication flows operations such as packet merging or reordering.

The communication library is fully multi-threaded through its close integration with PIOMan. It manages concurrent communication operations from multiple libraries and from multiple threads. Its MPI implementation MadMPI fully supports the MPI_THREAD_MULTIPLE multi-threading level.

- Participants: Alexandre Denis, Clément Foyer, Nathalie Furmento, Raymond Namyst, Adrien Guilbaud, Florian Reynier and Philippe Swartvagher
- Contact: Alexandre Denis
- Publications: NewMadeleine: a Fast Communication Scheduling Engine for High Performance Networks - Ordonnancement et qualité de service pour réseaux rapides - Improving Reactivity and Communication Overlap in MPI using a Generic I/O Manager - PIOMan : un gestionnaire d'entrées-sorties générique - A multithreaded communication engine for multicore architectures - A multicore-enabled multirail communication engine - About the interactions between communication and thread scheduling in clusters of multicore machines - Scalability of the NewMadeleine Communication Library for Large Numbers of MPI Point-to-Point Requests - An analysis of the impact of multi-threading on communication performance - A scalable and generic task scheduling system for communication libraries - A Generic and High Performance Approach for Fault Tolerance in Communication Library - A High-Performance Superpipeline Protocol for InfiniBand - A sampling-based approach for communication libraries auto-tuning - High performance checksum computation for fault-tolerant MPI over InfiniBand - pioman: a Generic Framework for Asynchronous Progression and Multithreaded Communications - pioman: a pthread-based Multithreaded Communication Engine - Updating MadMPI to MPI-3: Remote Memory Access - Portage de StarPU sur la bibliothèque de communication NewMadeleine
- URL: http://pm2.gforge.inria.fr/newmadeleine/

6.5. PaMPA

Parallel Mesh Partitioning and Adaptation

KEYWORDS: Dynamic load balancing - Unstructured heterogeneous meshes - Parallel remeshing - Subdomain decomposition - Parallel numerical solvers

SCIENTIFIC DESCRIPTION: PaMPA is a parallel library for handling, redistributing and remeshing unstructured meshes on distributed-memory architectures. PaMPA dramatically eases and speeds-up the development of parallel numerical solvers for compact schemes. It provides solver writers with a distributed mesh abstraction and an API to: - describe unstructured and possibly heterogeneous meshes, on the form of a graph of interconnected entities of different kinds (e.g. elements, faces, edges, nodes), - attach values to the mesh entities, - distribute such meshes across processing elements, with an overlap of variable width, - perform synchronous or asynchronous data exchanges of values across processing elements, - describe numerical schemes by means of iterators over mesh entities and their connected neighbors of a given kind, - redistribute meshes so as to balance computational load, - perform parallel dynamic remeshing, by applying adequately a user-provided sequential remesher to relevant areas of the distributed mesh.

PaMPA runs concurrently multiple sequential remeshing tasks to perform dynamic parallel remeshing and redistribution of very large unstructured meshes. E.g., it can remesh a tetrahedral mesh from 43Melements to more than 1Belements on 280 Broadwell processors in 20 minutes.

FUNCTIONAL DESCRIPTION: Parallel library for handling, redistributing and remeshing unstructured, heterogeneous meshes on distributed-memory architectures. PaMPA dramatically eases and speeds-up the development of parallel numerical solvers for compact schemes.

NEWS OF THE YEAR: PaMPA has been used to remesh an industrial mesh of a helicopter turbine combustion chamber, up to more than 1 billion elements.

- Participants: Cécile Dobrzynski, Cedric Lachat and François Pellegrini
- Partners: Université de Bordeaux - CNRS - IPB
- Contact: François Pellegrini
- URL: http://project.inria.fr/pampa/

6.6. TopoMatch

KEYWORDS: Intensive parallel computing - High-Performance Computing - Hierarchical architecture - Placement

SCIENTIFIC DESCRIPTION: TreeMatch embeds a set of algorithms to map processors/cores in order to minimize the communication cost of the application.

Important features are : the number of processors can be greater than the number of applications processes , it assumes that the topology is a tree and does not require valuation of the topology (e.g. communication speeds) , it implements different placement algorithms that are switched according to the input size.

Some core algorithms are parallel to speed-up the execution. Optionally embeds scotch for fix-vertex mapping. enable exhaustive search if required. Several metric mapping are computed. Allow for oversubscribing of ressources. multithreaded.

TreeMatch is integrated into various software such as the Charm++ programming environment as well as in both major open-source MPI implementations: Open MPI and MPICH2.

FUNCTIONAL DESCRIPTION: TreeMatch is a library for performing process placement based on the topology of the machine and the communication pattern of the application.

- Participants: Adele Villiermet, Emmanuel Jeannot, François Tessier, Guillaume Mercier and Pierre Celor
- Partners: Université de Bordeaux - CNRS - IPB
- Contact: Emmanuel Jeannot
- URL: http://treematch.gforge.inria.fr/

6.7. SCOTCH

KEYWORDS: Mesh partitioning - Domain decomposition - Graph algorithmics - High-performance calculation - Sparse matrix ordering - Static mapping

FUNCTIONAL DESCRIPTION: Scotch is a graph partitioner. It helps optimise the division of a problem, by means of a graph, into a set of independent sub-problems of equivalent sizes. These sub-problems can also be solved in parallel.

RELEASE FUNCTIONAL DESCRIPTION: Version 6.0 offers many new features:

sequential graph repartitioning

sequential graph partitioning with fixed vertices

sequential graph repartitioning with fixed vertices

new, fast, direct k-way partitioning and mapping algorithms

multi-threaded, shared memory algorithms in the (formerly) sequential part of the library

exposure in the API of many centralized and distributed graph handling routines

embedded pseudo-random generator for improved reproducibility

and even more...

NEWS OF THE YEAR: In 2019, several versions of Scotch have been released, from v6.0.7 up to v6.0.9. While they are mostly bugfix updates, several new features and API routines have been added, to increase its use by third-party software, notably routines handling target topologies. Also, code quality has been improved by the addition of many tests in the continuous integration process. A new graphical system has been developed by Amaury Jacques (Inria intern, Feb.-May 2019) to display differences in result quality across versions and builds. This system has been adopted by other Inria projects.

- Participants: François Pellegrini, Sébastien Fourestier, Jun-Ho Her, Cédric Chevalier and Amaury Jacques

- Partners: Université de Bordeaux - IPB - CNRS - Region Aquitaine

- Contact: François Pellegrini

- Publications: Process Mapping onto Complex Architectures and Partitions Thereof - Multi-criteria Graph Partitioning with Scotch - Adaptation au repartitionnement de graphes d'une méthode d'optimisation globale par diffusion - Contributions au partitionnement de graphes parallèle multi-niveaux - A parallelisable multi-level banded diffusion scheme for computing balanced partitions with smooth boundaries - PT-Scotch: A tool for efficient parallel graph ordering - Design and implementation of efficient tools for parallel partitioning and distribution of very large numerical problems - Improvement of the Efficiency of Genetic Algorithms for Scalable Parallel Graph Partitioning in a Multi-Level Framework - PT-Scotch : Un outil pour la renumérotation parallèle efficace de grands graphes dans un contexte multi-niveaux - PT-Scotch: A tool for efficient parallel graph ordering

- URL: http://www.labri.fr/~pelegrin/scotch/

6.8. disk-revolve

KEYWORDS: Automatic differentiation - Gradients - Machine learning

FUNCTIONAL DESCRIPTION: This software provides several algorithms (Disk-Revolve, 1D-Revolve, Periodic-Disk-Revolve,...) computing the optimal checkpointing strategy when executing a adjoin chain with limited memory. The considered architecture has a level of limited memory that is free to access (writing and reading costs are negligible) and a level of unlimited memory with non-negligible access costs. The algorithms describe which data should be saved in the memory to minimize the number of re-computation during the execution.

- Authors: Guillaume Aupy and Julien Herrmann

- Contact: Julien Herrmann

- Publications: H-Revolve: A Framework for Adjoint Computation on Synchrone Hierarchical Platforms - Periodicity in optimal hierarchical checkpointing schemes for adjoint computations - Optimal Multistage Algorithm for Adjoint Computation

- URL: https://gitlab.inria.fr/adjoint-computation/disk-revolve-public

<p style="text-align:center; color:red">TRIBE Project-Team</p>

5. New Software and Platforms

5.1. RIOT

KEYWORDS: Internet of things - Operating system - Sensors - Iot - Wireless Sensor Networks - Internet protocols

SCIENTIFIC DESCRIPTION: While requiring as low as 1,5kB of RAM and 5kB or ROM, RIOT offers real time and energy efficiency capabilities, as well as a single API (partially POSIX compliant) across heterogeneous 8-bit, 16-bit and 32-bit low-hardware. This API is developer-friendly in that it enables multi-threading, standard C and C++ application programming and the use of standard debugging tools (which was not possible so far for embedded programming). On top of this, RIOT includes several network stacks, such as a standard IPv6/6LoWPAN stack and a information-centric network stack (based on CCN).

FUNCTIONAL DESCRIPTION: RIOT is an Open Source operating system that provides standard protocols for embedded systems. RIOT allows, for example, the development of applications that collect sensor data and transmit it to a central node (e.g. a server). This data can then be used for smart energy management for instance.

RIOT is specially designed for embedded systems, which are strongly constrained in memory and energy. Further, RIOT can easily be ported to different hardware devices and follows the latest evolution of IP standards.

RIOT applications can readily be tested in the FIT IoT-Lab, which provides a large-scale infrastructure facility with 3000 nodes for testing remotely small wireless devices.

- Participants: Emmanuel Baccelli and Oliver Hahm
- Partners: Freie Universität Berlin - University of Hamburg
- Contact: Emmanuel Baccelli
- URL: http://www.riot-os.org

5.2. openschc

KEYWORDS: Internet of things - Internet protocols - Low-Power WIreless

FUNCTIONAL DESCRIPTION: OpenSCHC is a OpenSource Implementation of SCHC (Static Context Header Compression) currently being standardized by the LPWAN Working Group at the IETF. Oversimplifying, this is essentially IPv6 compression and fragmentation intended for low datarate, long range IoT networks.

The short/medium term goal is to organize SCHC Hackathons that occur at the IETF meetings.

The long term wish is to have a stable, open-source, reference codebase for the SCHC protocol (in Python).

The authors of OpenSCHC are listed here: https://github.com/openschc/openschc/blob/master/AUTHORS.txt

- Partner: OpenSCHC Authors
- Contact: Cédric Adjih
- URL: https://github.com/openschc/openschc

5.3. Gardinet

KEYWORD: Distributed networks

FUNCTIONAL DESCRIPTION: Gardinet (previously DragonNet) is a generic framework for network coding in wireless networks. It is a initially result of the GETRF project of the Hipercom2 team.

It is based on intra-flow coding where the source divides the flow in a sequence of payloads of equal size (padding may be used). The design keys of DragonNet are simplicity and universality, DragonNet does not use explicit or implicit knowledge about the topology (such as the direction or distance to the source, the loss rate of the links, ...). Hence, it is perfectly suited to the most dynamic wireless networks. The protocol is distributed and requires minimal coordination. DragonNet architecture is modular, it is based on 5 building blocks (LIB, SIG, Protocol, SEW and DRAGON). Each block is almost independent. This makes DragonNet generic and hence adaptable to many application scenarios. DragonNet derives from a prior protocol called DRAGONCAST. Indeed, DragonNet shares the same principles and theoretical overview of DRAGONCAST. It enriches DRAGONCAST by the information base and signaling required to perform broadcast in wireless networks and in wireless sensor networks in particular.

- Participants: Antonia Masucci, Cédric Adjih, Hana Baccouch and Ichrak Amdouni
- Contact: Cédric Adjih
- URL: http://gitlab.inria.fr/gardinet

WHISPER Project-Team

6. New Software and Platforms

6.1. Coccinelle

KEYWORDS: Code quality - Evolution - Infrastructure software

FUNCTIONAL DESCRIPTION: Coccinelle is a tool for code search and transformation for C programs. It has been extensively used for bug finding and evolutions in Linux kernel code.

- Participants: Gilles Muller, Julia Lawall, Nicolas Palix, Rene Rydhof Hansen and Thierry Martinez
- Partners: LIP6 - IRILL
- Contact: Julia Lawall
- URL: http://coccinelle.lip6.fr

6.2. Prequel

KEYWORDS: Code search - Git

SCIENTIFIC DESCRIPTION: The commit history of a code base such as the Linux kernel is a gold mine of information on how evolutions should be made, how bugs should be fixed, etc. Nevertheless, the high volume of commits available and the rudimentary filtering tools provided mean that it is often necessary to wade through a lot of irrelevant information before finding example commits that can help with a specific software development problem. To address this issue, we propose Prequel (Patch Query Language), which brings the descriptive power of code matching to the problem of querying a commit history.

FUNCTIONAL DESCRIPTION: Prequel is a tool for searching for complex patterns in the commits of software managed using git.

- Participants: Gilles Muller and Julia Lawall
- Partners: LIP6 - IRILL
- Contact: Julia Lawall
- URL: http://prequel-pql.gforge.inria.fr/

6.3. Usuba

KEYWORDS: Cryptography - Optimizing compiler - Synchronous Language

FUNCTIONAL DESCRIPTION: Usuba is a programming language for specifying block ciphers as well as a bitslicing compiler, for producing high-throughput and secure code.

- Contact: Pierre-Evariste Dagand
- Publication: Usuba, Optimizing & Trustworthy Bitslicing Compiler
- URL: https://github.com/DadaIsCrazy/usuba/

6.4. SchedDisplay

KEYWORDS: Linux kernel - Scheduling - Multicore

FUNCTIONAL DESCRIPTION: SchedDisplay is a visualization tool for SchedLog, a custom ring buffer collecting scheduling events in the Linux kernel. SchedDisplay allows kernel developers to analyze the behavior of the Linux scheduler while running a multicore application.

RELEASE FUNCTIONAL DESCRIPTION: First version released as part of a Demo made during the 10th PLOS workshop: https://ess.cs.uni-osnabrueck.de/workshops/plos/2019/program.php

- Partner: Oracle Labs
- Contact: Gilles Muller
- URL: https://gitlab.inria.fr/gmuller/scheddisplay

WIDE Project-Team

5. New Software and Platforms

5.1. WebGC

Web-based Gossip Communication

KEYWORDS: Epidemic protocols - Gossip protocols - Peer-to-peer - Web - Personalized systems - Decentralized architectures - Recommendation systems - WebRTC - Decentralized web

SCIENTIFIC DESCRIPTION: The library currently includes the implementation of two peer sampling protocols, Cyclon and the generic peer-sampling protocol from, as well as a clustering protocol. All protocols implement a common GossipProtocol "interface"

FUNCTIONAL DESCRIPTION: WebGC consists of a WebRTC-based library that supports gossip-based communication between web browsers and enables them to operate with Node-JS applications. WebGC comprises the implementation of standard gossip protocols such as Peer Sampling or Clustering, and simplifies the development of new protocols. It comprises a decentralized signaling service that makes it easier to build completely decentralized browser-based applications.

- Participants: Anne-Marie Kermarrec, Davide Frey, Matthieu Simonin and Raziel Carvajal Gomez
- Contact: Davide Frey

5.2. YALPS

KEYWORDS: Traffic-shaping - Nat traversal - Experimentation - Peer-to-peer - Simulator - Deployment

FUNCTIONAL DESCRIPTION: YALPS is an open-source Java library designed to facilitate the development, deployment, and testing of distributed applications. Applications written using YALPS can be run both in simulation and in real-world mode without changing a line of code or even recompiling the sources. A simple change in a configuration file will load the application in the proper environment. A number of features make YALPS useful both for the design and evaluation of research prototypes and for the development of applications to be released to the public. Specifically, YALPS makes it possible to run the same application as a simulation or in a real deployment. Applications communicate by means of application-defined messages which are then routed either through UDP/TCP or through YALPS's simulation infrastructure. In both cases, YALPS's communication layer offers features for testing and evaluating distributed protocols and applications. Communication channels can be tuned to incorporate message losses or to constrain their outgoing bandwidth. Finally, YALPS includes facilities to support operation in the presence of NATs and firewalls using relaying and NAT-traversal techniques. The implementation of YALPS includes approximately 16K lines of code, and is used in several projects by ASAP, including HEAP, AllYours-P2P, and Behave.

- Participants: Anne Marie Kermarrec, Arnaud Jegou, Davide Frey, Heverson Borba Ribeiro and Maxime Monod
- Contact: Davide Frey
- URL: http://yalps.gforge.inria.fr/

5.3. KIFF

KIFF: An impressively fast and efficient JAVA library for KNN construction

KEYWORD: KNN

FUNCTIONAL DESCRIPTION: This package implements the KIFF algorithm reported in [1]. KIFF is a generic, fast and scalable K-Nearest-Neighbor graph construction algorithm. This algorithm connects each object to its k most similar counterparts, according to a given similarity metric. In term of comparison, this package implements also HYREC [2] and NN-DESCENT [3]. The standalone program implements cosine similarity only, however this library supports arbitrary similarity measures.

[1] Antoine Boutet, Anne-Marie Kermarrec, Nupur Mittal, Francois Taiani. Being prepared in a sparse world: the case of KNN graph construction. ICDE 2016, Finland.

- Partner: LIRIS
- Contact: Antoine Boutet

ALICE Team

6. New Software and Platforms

6.1. VORPALINE

VORPALINE mesh generator

KEYWORDS: 3D modeling - Unstructured heterogeneous meshes

SCIENTIFIC DESCRIPTION: This software is the result of the team's work on the parameterization of surfaces and volumes, on the generation of Voronoi diagrams and mesh generation.

FUNCTIONAL DESCRIPTION: VORPALINE is a surfacic and volumetric mesh generator, for simplicial meshes (triangles and tetrahedra), for quad-dominant and hex-dominant meshes. It also contains surfacic and volumic parameterization modules.

RELEASE FUNCTIONAL DESCRIPTION: Computer vision algorithms allow us to reconstruct surfaces in a 3d scene. The colours associated with these surfaces can be stored in textures, but these are often incomplete due to a lack of reliable data. For example, some points on the surface are not present in the images, are insufficiently illuminated or, on the contrary, in a reflection that does not give the true color of the object. We have developed in Vorpaline an algorithm capable of generating these missing colors from those present in their vicinity. The originality of our approach is the optimization according to the neighbourhoods defined on the surface and not in the texture space.

- Participants: Bruno Lévy, Dmitry Sokolov and Nicolas Ray
- Contact: Bruno Lévy
- URL: http://alice.loria.fr/index.php/erc-vorpaline.html

ALMANACH Project-Team

6. New Software and Platforms

6.1. Enqi

- Author: Benoît Sagot
- Contact: Benoît Sagot

6.2. SYNTAX

KEYWORD: Parsing

FUNCTIONAL DESCRIPTION: Syntax system includes various deterministic and non-deterministic CFG parser generators. It includes in particular an efficient implementation of the Earley algorithm, with many original optimizations, that is used in several of Alpage's NLP tools, including the pre-processing chain Sx Pipe and the LFG deep parser SxLfg . This implementation of the Earley algorithm has been recently extended to handle probabilistic CFG (PCFG), by taking into account probabilities both during parsing (beam) and after parsing (n-best computation).

- Participants: Benoît Sagot and Pierre Boullier
- Contact: Pierre Boullier
- URL: http://syntax.gforge.inria.fr/

6.3. FRMG

KEYWORDS: Parsing - French

FUNCTIONAL DESCRIPTION: FRMG is a large-coverage linguistic meta-grammar of French. It can be compiled (using MGCOMP) into a Tree Adjoining Grammar, which, in turn, can be compiled (using DyALog) into a parser for French.

- Participant: Eric de La Clergerie
- Contact: Éric De La Clergerie
- URL: http://mgkit.gforge.inria.fr/

6.4. MElt

Maximum-Entropy lexicon-aware tagger

KEYWORD: Part-of-speech tagger

FUNCTIONAL DESCRIPTION: MElt is a freely available (LGPL) state-of-the-art sequence labeller that is meant to be trained on both an annotated corpus and an external lexicon. It was developed by Pascal Denis and Benoît Sagot within the Alpage team, a joint Inria and Université Paris-Diderot team in Paris, France. MElt allows for using multiclass Maximum-Entropy Markov models (MEMMs) or multiclass perceptrons (multitrons) as underlying statistical devices. Its output is in the Brown format (one sentence per line, each sentence being a space-separated sequence of annotated words in the word/tag format).

MElt has been trained on various annotated corpora, using Alexina lexicons as source of lexical information. As a result, models for French, English, Spanish and Italian are included in the MElt package.

MElt also includes a normalization wrapper aimed at helping processing noisy text, such as user-generated data retrieved on the web. This wrapper is only available for French and English. It was used for parsing web data for both English and French, respectively during the SANCL shared task (Google Web Bank) and for developing the French Social Media Bank (Facebook, twitter and blog data).

- Contact: Benoît Sagot
- URL: https://team.inria.fr/almanach/melt/

6.5. dyalog-sr

KEYWORDS: Parsing - Deep learning - Natural language processing

FUNCTIONAL DESCRIPTION: DyALog-SR is a transition-based dependency parser, built on top of DyALog system. Parsing relies on dynamic programming techniques to handle beams. Supervised learning exploit a perceptron and aggressive early updates. DyALog-SR can handle word lattice and produce dependency graphs (instead of basic trees). It was tested during several shared tasks (SPMRL'2013 and SEMEVAL'2014). It achieves very good accuracy on French TreeBank, alone or by coupling with FRMG parser. In 2017, DyALog-SR has been extended into DyALog-SRNN by adding deep neuronal layers implemented with the Dynet library. The new version has participated to the evaluation campaigns CONLL UD 2017 (on more than 50 languages) and EPE 2017.

- Contact: Éric De La Clergerie

6.6. FSMB

French Social Media Bank

KEYWORDS: Treebank - User-generated content

FUNCTIONAL DESCRIPTION: The French Social Media Bank is a treebank of French sentences coming from various social media sources (Twitter(c), Facebook(c)) and web forums (JeuxVidéos.com(c), Doctissimo.fr(c)). It contains different kind of linguistic annotations: - part-of-speech tags - surface syntactic representations (phrase-based representations) as well as normalized form whenever necessary.

- Contact: Djamé Seddah

6.7. DyALog

KEYWORD: Logic programming

FUNCTIONAL DESCRIPTION: DyALog provides an environment to compile and execute grammars and logic programs. It is essentially based on the notion of tabulation, i.e. of sharing computations by tabulating traces of them. DyALog is mainly used to build parsers for Natural Language Processing (NLP). It may nevertheless be used as a replacement for traditional PROLOG systems in the context of highly ambiguous applications where sub-computations can be shared.

- Participant: Eric de La Clergerie
- Contact: Eric de La Clergerie
- URL: http://dyalog.gforge.inria.fr/

6.8. SxPipe

KEYWORD: Surface text processing

SCIENTIFIC DESCRIPTION: Developed for French and for other languages, Sx Pipe includes, among others, various named entities recognition modules in raw text, a sentence segmenter and tokenizer, a spelling corrector and compound words recognizer, and an original context-free patterns recognizer, used by several specialized grammars (numbers, impersonal constructions, quotations...). It can now be augmented with modules developed during the former ANR EDyLex project for analysing unknown words, this involves in particular (i) new tools for the automatic pre-classification of unknown words (acronyms, loan words...) (ii) new morphological analysis tools, most notably automatic tools for constructional morphology (both derivational and compositional), following the results of dedicated corpus-based studies. New local grammars for detecting new types of entities and improvement of existing ones, developed in the context of the PACTE project, will soon be integrated within the standard configuration.

FUNCTIONAL DESCRIPTION: SxPipe is a modular and customizable processing chain dedicated to applying to raw corpora a cascade of surface processing steps (tokenisation, wordform detection, non-deterministic spelling correction. . .). It is used as a preliminary step before ALMAnaCH's parsers (e.g., FRMG) and for surface processing (named entities recognition, text normalization, unknown word extraction and processing...).

- Participants: Benoît Sagot, Djamé Seddah and Eric de La Clergerie
- Contact: Benoît Sagot
- URL: http://lingwb.gforge.inria.fr/

6.9. Mgwiki

KEYWORDS: Parsing - French

FUNCTIONAL DESCRIPTION: Mgwiki is a linguistic wiki that may used to discuss linguistic phenomena with the possibility to add annotated illustrative sentences. The work is essentially devoted to the construction of an instance for documenting and discussing FRMG, with the annotations of the sentences automatically provided by parsing them with FRMG. This instance also offers the possibility to parse small corpora with FRMG and an interface of visualization of the results. Large parsed corpora (like French Wikipedia or Wikisource) are also available. The parsed corpora can also be queried through the use of the DPath language.

- Participant: Eric de La Clergerie
- Contact: Eric de La Clergerie
- URL: http://alpage.inria.fr/frmgwiki/

6.10. WOLF

WOrdnet Libre du Français (Free French Wordnet)

KEYWORDS: WordNet - French - Semantic network - Lexical resource

FUNCTIONAL DESCRIPTION: The WOLF (Wordnet Libre du Français, Free French Wordnet) is a free semantic lexical resource (wordnet) for French.

The WOLF has been built from the Princeton WordNet (PWN) and various multilingual resources.

- Contact: Benoît Sagot
- URL: http://alpage.inria.fr/~sagot/wolf-en.html

6.11. vera

KEYWORD: Text mining

FUNCTIONAL DESCRIPTION: Automatic analysis of answers to open-ended questions based on NLP and statistical analysis and visualisation techniques (vera is currently restricted to employee surveys).

- Participants: Benoît Sagot and Dimitri Tcherniak
- Partner: Verbatim Analysis
- Contact: Benoît Sagot

6.12. Alexina

Atelier pour les LEXiques INformatiques et leur Acquisition

KEYWORD: Lexical resource

FUNCTIONAL DESCRIPTION: Alexina is ALMAnaCH's framework for the acquisition and modeling of morphological and syntactic lexical information. The first and most advanced lexical resource developed in this framework is the Lefff, a morphological and syntactic lexicon for French.

- Participant: Benoît Sagot
- Contact: Benoît Sagot
- URL: http://gforge.inria.fr/projects/alexina/

6.13. FQB

French QuestionBank

KEYWORD: Treebank

FUNCTIONAL DESCRIPTION: The French QuestionBanks is a corpus of around 2000 questions coming from various domains (TREC data set, French governmental organisation, NGOs, etc..) it contains different kind of annotations - morpho-syntactic ones (POS, lemmas) - surface syntaxe (phrase based and dependency structures) with long-distance dependency annotations.

The TREC part is aligned with the English QuestionBank (Judge et al, 2006).

- Contact: Djamé Seddah

6.14. Sequoia corpus

KEYWORD: Treebank

FUNCTIONAL DESCRIPTION: The Sequoia corpus contains French sentences, annotated with various linguistic information: - parts-of-speech - surface syntactic representations (both constituency trees and dependency trees) - deep syntactic representations (which are deep syntactic dependency graphs)

- Contact: Djamé Seddah

Auctus Team

6. New Software and Platforms

6.1. HuMoSoft

Human Motion Analysis Software

KEYWORDS: Movement analysis - 3D movement

FUNCTIONAL DESCRIPTION: HuMoSoft is based on the ROS platform. The acquisition data can come from different depth sensors, for example Kinect, via the Nuitrack JDK. An extended Kalman filter has been implemented, and motion analysis uses the RULA method.

- Authors: Jessica Colombel and David Daney
- Contact: Sylvain Pion
- URL: https://gitlab.inria.fr/auctus/kombos-server

6.2. KCADL

Kinematic Chain Appropriate Design Library

KEYWORDS: Interval analysis - Uncertainty - Kinematics

FUNCTIONAL DESCRIPTION: Software for the modelling and analysis of imprecise serial kinematic chains. Chain objects are built by iteratively adding rigid-body segments with associated joint connections (e.g., fixed, revolute, prismatic). Several standard options are provided to model each segment (e.g., Denavit-Hartenberg parameters, transformation matrices, twists). Each option accepts interval and non-interval arguments, allowing to model the uncertainties and variabilities of imprecise serial kinematic chains and also the conventional precise serial kinematic chains. Forward Kinematic (FK) and Inverse Kinematic (IK) solvers are available for Chain objects. The FK solver computes an outer bound of the set of poses associated with a set of joint configurations. The IK solver computes an outer bound of the set of joint configurations associated with a set of poses.

- Participant: Joshua Pickard
- Contact: Joshua Pickard
- Publication: hal-02367664, version 1
- URL: https://gitlab.inria.fr/auctus/kinematic-chain-appropriate-design-library

6.3. AUCTUS-MOVER

AUCTUS panda MOVER project

KEYWORDS: Automatic control - Variability

FUNCTIONAL DESCRIPTION: Software for controlling the Franka Emika Panda robot to study human motor variabilities. Consists of a torque-based controller for the Franka Emika Panda collaborative robot with the following actuation modes: auto mode - the robot follows a predefined trajectory, manual mode - the robot is in a constrained gravity compensation mode (the constraints may be adapted online). A graphical interface allows the operator to switch between modes. Software for calibrating the robot with respect to the Optitrack motion capture system is also included.

- Contact: Joshua Pickard
- URL: https://gitlab.inria.fr/auctus/auctuspanda/tree/mover_project

6.4. AUCTUS-RT

AUCTUS - Redunancy Tubes

KEYWORD: Variability

FUNCTIONAL DESCRIPTION: Software for modelling and analyzing human motor variabilities along a path. Currently used to study the redundant motions associated with the upper limb. Anatomical constraints for the shoulder, elbow, and wrist may be customized for a human subject using: maximal and minimal bounding regression equations, spherical polygon constraints. A constrained imprecise kinematic model of the subject is obtained and the task redundancies and joint redundancies associated with the constrained imprecise kinematic model are able to be evaluated via branch-and-bound exploration to determine achievable and non-achievable redundant motions of the human. For n redundant degrees-of-freedom, this provides an n-dimensional redundant workspace describing the human's capabilities. Along a path, this provides an (n+1)-dimensional redundant workspace tube.

- Contact: Joshua Pickard
- URL: https://gitlab.inria.fr/auctus/redundancy-tubes

6.5. WoobotSim

KEYWORDS: Robotics - Dynamic Analysis

FUNCTIONAL DESCRIPTION: WoobotSim is a simulator that reports the dynamics of the parties involved in an industrial task implying a strong interaction between a machine tool, an operator and a handled object, it also offers the possibility to add a cobot as an actor. Developed on Matlab, this simulator allows to visualize the efforts exchanged by the participants during the task, as well as the dynamics of the object being manipulated. For the specific case of woodworking shaper. It includes a wood cutting model. A model of task control by the craftsman and a model of the robot.

- Contact: Nassim Benhabib

6.6. Arcol

The Arcol platform provides technical support for the short, medium and long term experimental developments carried out within the framework of Auctus' scientific and dissemination activities.

These technological developments are essentially software related in the context of human motion capture and real-time control of collaborative robots. Arcol aims at easing their implementation, deployment, documentation and support.

Implementations include:

- a software component for online estimation of the state of one or more human "subjects" of a collaborative robotics experiment; ǐsualization tool for replaying a number of simulated experiments;
- an integrating architecture allowing the simple addition of hardware components (sensors, robots,...) and the configuration of an experiment by describing the hardware components included, the nature of the treatments to be performed and the history files (logs) to be constituted.

To date the work done is:

- help and realization of an experimental setup for the study of the motor variability of a user ;
- assistance and realization of an experimental setup for the study of the interaction wrenches during a machining task of a piece of wood in an industrial context ;
- implementation and deployment of a method for using Inria integration tools for the team's code ;
- development of a solution allowing to simply interface the ROS framework with the Unity3D software, in a modular and easily deployable experimentation perspective.

6. New Software and Platforms

6.1. Cartolabe

KEYWORD: Information visualization

FUNCTIONAL DESCRIPTION: The goal of Cartolabe is to build a visual map representing the scientific activity of an institution/university/domain from published articles and reports. Using the HAL Database, Cartolabe provides the user with a map of the thematics, authors and articles . ML techniques are used for dimensionality reduction, cluster and topics identification, visualisation techniques are used for a scalable 2D representation of the results.

NEWS OF THE YEAR: Improvement of the graphical interface

- Participants: Philippe Caillou, Jean-Daniel Fekete, Jonas Renault and Anne-Catherine Letournel
- Partners: LRI - Laboratoire de Recherche en Informatique - CNRS
- Contact: Philippe Caillou
- URL: http://www.cartolabe.fr/

6.2. BitConduite

BitConduite Bitcoin explorer

KEYWORDS: Data visualization - Clustering - Financial analysis - Cryptocurrency

FUNCTIONAL DESCRIPTION: BitConduite is a web-based visual tool that allows for a high level explorative analysis of the Bitcoin blockchain. It offers a data transformation back end that gives us an entity-based access to the blockchain data and a visualization front end that supports a novel high-level view on transactions over time. In particular, it facilitates the exploration of activity through filtering and clustering interactions. This gives analysts a new perspective on the data stored on the blockchain.

- Authors: Jean-Daniel Fekete, Petra Isenberg and Christoph Kinkeldey
- Contact: Petra Isenberg

6.3. PAOHvis

Parallel Aggregated Ordered Hypergraph Visualization

KEYWORDS: Dynamic networks - Hypergraphs

FUNCTIONAL DESCRIPTION: Parallel Aggregated Ordered Hypergraph (PAOH) is a novel technique to visualize dynamic hypergraphs [26]. Hypergraphs are a generalization of graphs where edges can connect more than two vertices. Hypergraphs can be used to model co-authorship networks with multiple authors per article, or networks of business partners. A dynamic hypergraph evolves over discrete time slots. A PAOH display represents vertices as parallel horizontal bars and hyperedges as vertical lines that connect two or more vertices. We believe that PAOH is the first technique with a highly readable representation of dynamic hypergraphs without overlaps. It is easy to learn and is well suited for medium size dynamic hypergraph networks such as those commonly generated by digital humanities projects - our driving application domain (see Fig. 3).

- Contact: Paola Tatiana Llerena Valdivia
- URL: https://aviz.fr/paohvis

6.4. AR Collaborative Visualization

KEYWORDS: Augmented reality - Collaborative science - Android

FUNCTIONAL DESCRIPTION: Allows to look at VTK datasets using AR-HMD (Microsoft HoloLens) in multi-users environments (i.e., one headset per user). A Multi-touch tablet is provided per user to manipulate the environment.

- Contact: Mickael Sereno
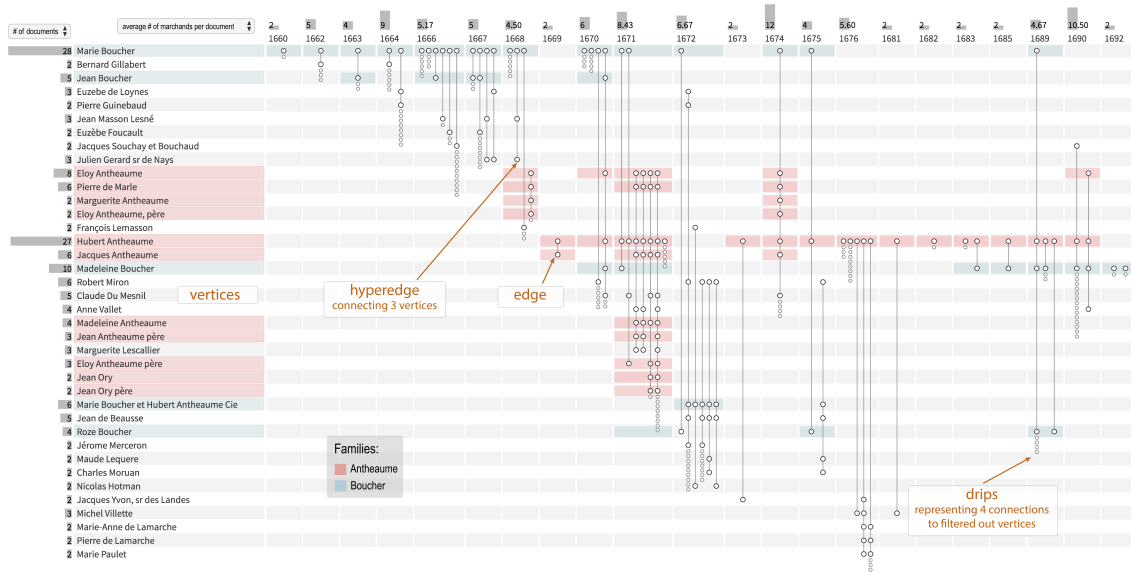
6.5. Platforms

6.5.1. Vispubdata.org

Figure 3. Using Dynamic Hypergraphs to Reveal the Evolution of the Business Network of a 17th Century French Woman Merchant

AVIZ members are making available for research a dataset of IEEE VIS publications at http://vispubdata.org. This dataset is actively being used for research and conference organization.

<div align="center">

CEDAR Project-Team

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6. New Software and Platforms

6.1. Tatooine

KEYWORDS: RDF - JSon - Knowledge database - Databases - Data integration - Polystore

FUNCTIONAL DESCRIPTION: Tatooine allows to jointly query data sources of heterogeneous formats and data models (relations, RDF graphs, JSON documents etc.) under a single interface. It is capable of evaluating conjunctive queries over several such data sources, distributing computations between the underlying single-data model systems and a Java-based integration layer based on nested tuples.

- Participants: François Goasdoué, Ioana Manolescu, Javier Letelier Ruiz, Michaël Thomazo, Oscar Santiago Mendoza Rivera, Raphael Bonaque, Swen Ribeiro, Tien Duc Cao and Xavier Tannier
- Contact: Ioana Manolescu

6.2. AIDES

KEYWORDS: Data Exploration - Active Learning

FUNCTIONAL DESCRIPTION: AIDES is a data exploration software. It allows a user to explore a huge (tabular) dataset and discover tuples matching his or her interest. Our system repeatedly proposes the most informative tuples to the user, who must annotate them as "interesting" / "not-interesting", and as iterations progress an increasingly accurate model of the user's interest region is built. Our system also focuses on supporting low selectivity, high-dimensional interest regions.

- Contact: Yanlei Diao

6.3. OntoSQL

KEYWORDS: RDF - Semantic Web - Querying - Databases

FUNCTIONAL DESCRIPTION: OntoSQL is a tool providing three main functionalities: - Loading RDF graphs (consisting of data triples and possibly a schema or ontology) into a relational database, - Saturating the data based on the ontology. Currently, RDF Schema ontologies are supported. - Querying the loaded data using conjunctive queries. Data can be loaded either from distinct files or from a single file containing them both. The loading process allows to choose between two storage schemas: - One triples table. - One table per role and concept. Querying provides an SQL translation for each conjunctive query according to the storage schema used in the loading process, then the SQL query is evaluated by the underlying relational database.

- Participants: Ioana Manolescu, Michaël Thomazo and Tayeb Merabti
- Partner: Université de Rennes 1
- Contact: Ioana Manolescu
- URL: https://ontosql.inria.fr/

6.4. ConnectionLens

KEYWORDS: Data management - Big data - Information extraction - Semantic Web

FUNCTIONAL DESCRIPTION: ConnectionLens treats a set of heterogeneous, independently authored data sources as a single virtual graph, whereas nodes represent fine-granularity data items (relational tuples, attributes, key-value pairs, RDF, JSON or XML nodes...) and edges correspond either to structural connections (e.g., a tuple is in a database, an attribute is in a tuple, a JSON node has a parent...) or to similarity (sameAs) links. To further enrich the content journalists work with, we also apply entity extraction which enables to detect the people, organizations etc. mentioned in text, whether full-text or text snippets found e.g. in RDF or XML. ConnectionLens is thus capable of finding and exploiting connections present across heterogeneous data sources without requiring the user to specify any join predicate.

- Contact: Manolescu Ioana
- Publication: ConnectionLens: Finding Connections Across Heterogeneous Data Sources
- URL: https://team.inria.fr/cedar/connectionlens/

6.5. INSEE-Extract

Spreadsheets extractor

KEYWORDS: RDF - Data extraction

FUNCTIONAL DESCRIPTION: Extract content of spreadsheets automatically and store it as RDF triples

- Participants: Ioana Manolescu, Xavier Tannier and Tien Duc Cao
- Contact: Tien Duc Cao
- Publication: Extracting Linked Data from statistic spreadsheets
- URL: https://gitlab.inria.fr/cedar/excel-extractor

6.6. INSEE-Search

KEYWORDS: Document ranking - RDF

FUNCTIONAL DESCRIPTION: Searching for relevant data cells (or data row/column) given a query in natural language (French)

- Participants: Ioana Manolescu, Xavier Tannier and Tien Duc Cao
- Contact: Tien Duc Cao
- Publications: Extracting Linked Data from statistic spreadsheets - Searching for Truth in a Database of Statistics

6.7. RDFQuotient

Quotient summaries of RDF graphs

KEYWORDS: RDF - Graph algorithmics - Graph visualization - Graph summaries - Semantic Web

FUNCTIONAL DESCRIPTION: RDF graphs can be large and heterogeneous, making it hard for users to get acquainted with a new graph and understand whether it may have interesting information. To help users figure it out, we have devised novel equivalence relations among RDF nodes, capable of recognizing them as equivalent (and thus, summarize them together) despite the heterogeneity often exhibited by their incoming and outgoing node properties. From these relations, we derive four novel summaries, called Weak, Strong, Typed Weak and Typed Strong, and show how to obtain from them compact and enticing visualizations.

- Participants: Ioana Manolescu, Pawel Guzewicz and François Goasdoué
- Partner: Université de Rennes 1
- Contact: Manolescu Ioana
- Publications: hal-01325900v6 - Structural Summarization of Semantic Graphs

6.8. AIDEme

KEYWORDS: Active Learning - Data Exploration

SCIENTIFIC DESCRIPTION: AIDEme is a large-scale interactive data exploration system that is cast in a principled active learning (AL) framework: in this context, we consider the data content as a large set of records in a data source, and the user is interested in some of them but not all. In the data exploration process, the system allows the user to label a record as "interesting" or "not interesting" in each iteration, so that it can construct an increasingly-more-accurate model of the user interest. Active learning techniques are employed to select a new record from the unlabeled data source in each iteration for the user to label next in order to improve the model accuracy. Upon convergence, the model is run through the entire data source to retrieve all relevant records.

A challenge in building such a system is that existing active learning techniques experience slow convergence in learning the user interest when such exploration is performed on large datasets: for example, hundreds of labeled examples are needed to learn a user interest model over 6 attributes, as we showed using a digital sky survey of 1.9 million records. AIDEme employs a set of novel techniques to overcome the slow convergence problem:

• Factorization: We observe that a user labels a data record, her decision making process often can be broken into a set of smaller questions, and the answers to these questions can be combined to derive the final answer. This insight, formally modeled as a factorization structure, allows us to design new active learning algorithms, e.g., factorized version space algorithms [2], that break the learning problem into subproblems in a set of subspaces and perform active learning in each subspace, thereby significantly expediting convergence.

• Optimization based on class distribution: Another interesting observation is that when projecting the data space for exploration onto a subset of dimensions, the user interest pattern projected onto such a subspace often entails a convex object. When such a subspatial convex property holds, we introduce a new "dual-space model" (DSM) that builds not only a classification model from labeled examples, but also a polytope model of the data space that offers a more direct description of the areas known to be positive, areas known to be negative, and areas with unknown labels. We use both the classification model and the polytope model to predict unlabeled examples and choose the best example to label next. • Formal results on convergence: We further provide theoretical results on the convergence of our proposed techniques. Some of them can be used to detect convergence and terminate the exploration process. • Scaling to large datasets: In many applications the dataset may be too large to fit in memory. In this case, we introduce subsampling procedures and provide provable results that guarantee the performance of the model learned from the sample over the entire data source.

FUNCTIONAL DESCRIPTION: There is an increasing gap between fast growth of data and limited human ability to comprehend data. Consequently, there has been a growing demand for analytics tools that can bridge this gap and help the user retrieve high-value content from data. We introduce AIDEme, a scalable interactive data exploration system for efficiently learning a user interest pattern over a large dataset. The system is cast in a principled active learning (AL) framework, which iteratively presents strategically selected records for user labeling, thereby building an increasingly-more-accurate model of the user interest. However, a challenge in building such a system is that existing active learning techniques experience slow convergence when learning the user interest on large datasets. To overcome the problem, AIDEme explores properties of the user labeling process and the class distribution of observed data to design new active learning algorithms, which come with provable results on model accuracy, convergence, and approximation, and have evaluation results showing much improved convergence over existing AL methods while maintaining interactive speed.

RELEASE FUNCTIONAL DESCRIPTION: Project code can be found over: https://gitlab.inria.fr/ldipalma/aideme

- Participants: Luciano Di Palma and Enhui Huang
- Contact: Yanlei Diao
- URL: http://www.lix.polytechnique.fr/aideme

<h1 style="text-align:center;color:red;">CHORALE Team</h1>

5. New Software and Platforms

5.1. Perception360

Perception360 is an integration software platform for all perception developments in the Inria CHORALE team. All functions have been coded in a modular and scalable ROS environment by including a generic model to take into account the different sensors (monocular perspective vision (RGB), vision stereo perspective (RGB-D), spherical vision (RGB and RGB-D).

The main application concerns representation of the environment (multi-layers topological and spherical representation of the environment), Localization, SLAM and Navigation.

Features

Robot vision (Perspective and Omnidirectional RGB-D sensors)

3D mapping

- Image acquisition
- Registration
- Sensor Calibration
- Visual odometry
- Localization
- Keyframe based mapping
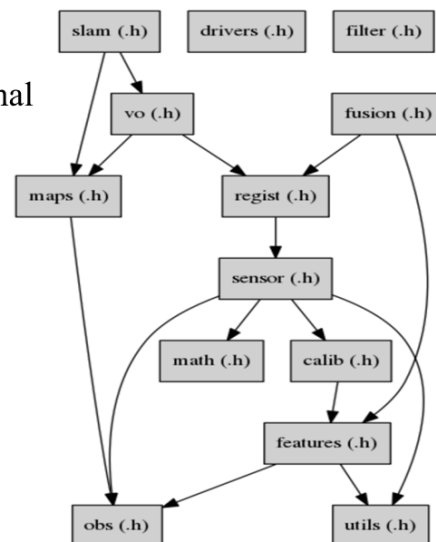
Figure 1. PERCEPTION360

5.2. ICAV

ICAV is an Intelligent and Connected Autonomous Vehicle. It is composed of a Renault ZOE robotized by Ecole Centrale of Nantes (by the team setup by Philippe Martinet in LS2N/ARMEN).

The robotization allows to have access to the control of:

- Steering angle (or steering torque)
- Braking torque
- Acceleration
- Gear box
- Blinking light

Figure 2. ICAV plateform and its web interface

In its original version, it is composed of embedded sensors:

- Car odometry and velocity
- Low cost GPS (Ublox 6)
- Low cost IMU
- Lidar VLP16 from Velodyne
- Two front cameras in the bumper
- One rear camera in the bumper

and one embedded computer, with a web interface connected to a simple tablet. All the equipments are connected to the existing comfort battery. This equipment has been funded by UCA (Digital Reference Centre) and delivered late 2018.

In addition, in the framework of a collaboration between CHORALE and LS2N/ARMEN one global application of Mapping/Localization/Navigation/Parking is installed in the vehicle. This application is using LIDAR VLP16 based mapping algorithm developed in Nantes including the last two years collaboration work between CHORALE and ARMEN. In January 2019, we have done the map of the Inria Sophia Antipolis Center, and other places of Sophia Antipolis. On all places, it is possible to localize the vehicle, register a path and then proceed to autonomous navigation (if we obtain the authorization to make it). Fast prototyping tools environment called ICARS is available for both simulation and development purposes.

In december 2019, we have evaluated the navigation algorithm on the new experimental site made available by CASA.

Figure 3. CASA experimental site in Sophia Antipolis

In the near future, in the framework of the project SPHERE we will integrate a novel 360 degree camera system with the Perception360 platform and embed this system in ICAV. A global 360 degree navigation system will be developed.

5.3. DRONIX

In 2019, we have defined and installed a capture motion system composed of 6 cameras coming from the QUALISYS company. This system allows to track and localize a multi robot system.

Figure 4. DRONIX plateform

In our applications, we will consider the use of UAVs and possibly the collaboration between UAVs and AGV. The DRONIX platform will be used for real time navigation, and as a ground truth system. The system has a central computer and each robots will have possible access to the global information by wifi.

CHROMA Project-Team

6. New Software and Platforms

6.1. Ground Elevation and Occupancy Grid Estimator (GEOG - Estimator)

KEYWORDS: Robotics - Environment perception

FUNCTIONAL DESCRIPTION: GEOG-Estimator is a system of joint estimation of the shape of the ground, in the form of a Bayesian network of constrained elevation nodes, and the ground-obstacle classification of a pointcloud. Starting from an unclassified 3D pointcloud, it consists of a set of expectation-maximization methods computed in parallel on the network of elevation nodes, integrating the constraints of spatial continuity as well as the influence of 3D points, classified as ground-based or obstacles. Once the ground model is generated, the system can then construct a occupation grid, taking into account the classification of 3D points, and the actual height of these impacts. Mainly used with lidars (Velodyne64, Quanergy M8, IBEO Lux), the approach can be generalized to any type of sensor providing 3D pointclouds. On the other hand, in the case of lidars, free space information between the source and the 3D point can be integrated into the construction of the grid, as well as the height at which the laser passes through the area (taking into account the height of the laser in the sensor model). The areas of application of the system spread across all areas of mobile robotics, it is particularly suitable for unknown environments. GEOG-Estimator was originally developed to allow optimal integration of 3D sensors in systems using 2D occupancy grids, taking into account the orientation of sensors, and indefinite forms of grounds. The ground model generated can be used directly, whether for mapping or as a pre-calculation step for methods of obstacle recognition or classification. Designed to be effective (real-time) in the context of embedded applications, the entire system is implemented on Nvidia graphics card (in Cuda), and optimized for Tegra X2 embedded boards. To ease interconnections with the sensor outputs and other perception modules, the system is implemented using ROS (Robot Operating System), a set of opensource tools for robotics.

- Authors: Amaury Nègre, Lukas Rummelhard, Lukas Rummelhard, Jean-Alix David and Christian Laugier
- Contact: Christian Laugier

6.2. CMCDOT

KEYWORDS: Robotics - Environment perception

FUNCTIONAL DESCRIPTION: CMCDOT is a Bayesian filtering system for dynamic occupation grids, allowing parallel estimation of occupation probabilities for each cell of a grid, inference of velocities, prediction of the risk of collision and association of cells belonging to the same dynamic object. Last generation of a suite of Bayesian filtering methods developed in the Inria eMotion team, then in the Inria Chroma team (BOF, HSBOF, ...), it integrates the managment of hybrid sampling methods (classical occupancy grids for static parts, particle sets for parts dynamics) into a Bayesian unified programming formalism , while incorporating elements resembling the Dempster-Shafer theory (state "unknown", allowing a focus of computing resources). It also offers a projection system of the estimated scene in the near future, to reference potential collisions with the ego-vehicle or any other element of the environment, as well as very low cost pre-segmentation of coherent dynamic spaces (taking into account speeds). It takes as input instantaneous occupation grids generated by sensor models for different sources, the system is composed of a ROS package, to manage the connectivity of I / O, which encapsulates the core of the embedded and optimized application on GPU Nvidia (Cuda), allowing real-time analysis of the direct environment on embedded boards (Tegra X1, X2). ROS (Robot Operating System) is a set of open source tools to develop software for robotics. Developed in an automotive setting, these techniques can be exploited in all areas of mobile robotics, and are particularly suited to highly dynamic and uncertain environment management (eg urban scenario, with pedestrians, cyclists, cars, buses, etc.).

- Authors: Amaury Nègre, Lukas Rummelhard, Jean-Alix David and Christian Laugier
- Partners: CEA - CNRS
- Contact: Christian Laugier

6.3. cuda_grid_fusion

KEYWORDS: Robotics - Environment perception

FUNCTIONAL DESCRIPTION: This module, directly implemented in ROS / Cuda, performs the merge of occupancy grids, defined in the format proposed in CMCDOT (probabilities integrating the "visibility" information of the cell, via the coefficients "unknown") thanks to an original method, allowing not only consistency with the rest of the system, but also a nuanced consideration of confidence criteria towards the various sources of information.

- Authors: Lukas Rummelhard and Jean-Alix David
- Contact: Lukas Rummelhard

6.4. cuda_laser_grid

KEYWORDS: Robotics - Environment perception

FUNCTIONAL DESCRIPTION: This module generates occupation grids from "almost" planar lidar. The sensor model, as well as the outputs, have been modified, in order to be fully consistent with the CMCDOT and grid fusion module formats.

- Authors: Amaury Nègre, Lukas Rummelhard and Jean-Alix David
- Contact: Lukas Rummelhard

6.5. Zoe Simulation

Simulation of Inria's Renault Zoe in Gazebo environment

KEYWORD: Simulation

FUNCTIONAL DESCRIPTION: This simulation represents the Renault Zoe vehicle considering the realistic physical phenomena (friction, sliding, inertia, ...). The simulated vehicle embeds sensors similar to the ones of the actual vehicle. They provide measurement data under the same format. Moreover the software input/output are identical to the vehicle's. Therefoe any program executed on the vehicle can be used with the simulation and reciprocally.

- Authors: Christian Laugier, Nicolas Turro and Thomas Genevois
- Contact: Christian Laugier

6.6. EKF Odom

EKF based localisation for vehicles

KEYWORDS: Localization - Autonomous Cars

FUNCTIONAL DESCRIPTION: This software fuses IMU data with wheel rotation or speed measurement inside an Extended Kalman Filter. It estimates the state position, orientation, speed, angular speed, acceleration.

- Authors: Thomas Genevois and Christian Laugier
- Contact: Christian Laugier
- URL: https://team.inria.fr/chroma/en/

6.7. Light Vehicle Simulation

Simulation of a light vehicle in Gazebo environment

KEYWORD: Simulation

FUNCTIONAL DESCRIPTION: This simulation represents a light vehicle considering the realistic physical phenomena (friction, sliding, inertia, ...). The simulated vehicle embeds sensors similar to the ones of the actual vehicle. They provide measurement data under the same format. Moreover the software input/output are identical to the vehicle's. Therefore any program executed on the vehicle can be used with the simulation and reciprocally.

- Authors: Thomas Genevois and Christian Laugier
- Contact: Christian Laugier
- URL: https://team.inria.fr/chroma/en/

6.8. CarHybridSim

Hybrid simulation for autonomous cars with high traffic

KEYWORDS: Simulation - Autonomous Cars

FUNCTIONAL DESCRIPTION: Open source tool for simulating autonomous vehicles in complex, high traffic, scenarios. The hybrid simulation fully integrates and synchronizes a microscopic, multi-modal traffic simulator and a complex 3D simulator.

- Contact: Mario Garzon Oviedo
- URL: https://github.com/marioney/hybrid_simulation

6.9. SimuDronesGR

Simultion of UAV fleets with Gazebo/ROS

KEYWORDS: Robotics - Simulation

FUNCTIONAL DESCRIPTION: The simulator includes the following functionality : 1) Simulation of the mechanical behavior of an Unmanned Aerial Vehicle : * Modeling of the body's aerodynamics with lift, drag and moment * Modeling of rotors' aerodynamics using the forces and moments' expressions from Philppe Martin's and Erwan Salaün's 2010 IEEE Conference on Robotics and Automation paper "The True Role of Accelerometer Feedback in Quadrotor Control". 2) Gives groundtruth informations : * Positions in East-North-Up reference frame * Linear velocity in East-North-Up and Front-Left-Up reference frames * Linear acceleration in East-North-Up and Front-Left-Up reference frames * Orientation from East-North-Up reference frame to Front-Left-Up reference frame (Quaternions) * Angular velocity of Front-Left-Up reference frame expressed in Front-Left-Up reference frame. 3) Simulation of the following sensors : * Inertial Measurement Unit with 9DoF (Accelerometer + Gyroscope + Orientation) * Barometer using an ISA model for the troposphere (valid up to 11km above Mean Sea Level) * Magnetometer with the earth magnetic field declination * GPS Antenna with a geodesic map projection.

RELEASE FUNCTIONAL DESCRIPTION: Initial version

- Author: Vincent Le Doze
- Partner: Insa de Lyon
- Contact: Vincent Le Doze

6.10. cuda_US_grid

KEYWORDS: Robotics - Environment perception

FUNCTIONAL DESCRIPTION: This module generates occupation grids from data generated by an ultrasonic range sensor. The sensor model, as well as the outputs, have been modified, in order to be fully consistent with the CMCDOT and grid fusion module formats.

- Authors: Christian Laugier and Thomas Genevois
- Partner: CEA
- Contact: Christian Laugier

6.11. Embedded Perception

FUNCTIONAL DESCRIPTION: The method for computing occupancy grids from a stereoscopic sensor, developped in the e-motion team, has been implemented on GPU, using NVIDIA CUDA. This allows a real time implementation and an online processing within the Lexus experimental platform.

- Participants: Amaury Nègre, Christian Laugier and Mathias Perrollaz
- Contact: Christian Laugier

6.12. spank

Swarm Protocol And Navigation Kontrol

KEYWORD: Protocoles

FUNCTIONAL DESCRIPTION: Communication and distance measurement in an uav swarm

- Contact: Stéphane d'Alu
- URL: https://gitlab.inria.fr/dalu/spank

6.13. S-NAMO-SIM

S-NAMO Simulator

KEYWORDS: Simulation - Navigation - Robotics - Planning

FUNCTIONAL DESCRIPTION: 2D Simulator of NAMO algorithms (Navigation Among Movable Obstacles) ROS compatible

RELEASE FUNCTIONAL DESCRIPTION: Creation

- Contact: Benoit Renault

COML Team

5. New Software and Platforms

5.1. intphys

IntPhys: A Benchmark for Visual Intuitive Physics Reasoning

KEYWORDS: Competition - Physical simulation - Artificial intelligence - Video Game

FUNCTIONAL DESCRIPTION: The intphys benchmark can be applied to any vision system, engineered, or trained, provided it can output a scalar when presented with a video clip, which should correspond to how physically plausible the video clip is. Our test set contains well matched videos of possible versus impossible events, and the metric consists in measuring how well the vision system can tell apart the possible from the impossible events..

- Contact: Mathieu Bernard
- URL: http://www.intphys.com

5.2. shennong

KEYWORDS: Speech processing - Python - Information extraction - Audio signal processing

FUNCTIONAL DESCRIPTION: Shennong is a Python library which implement the most used methods for speech features extraction. Features extraction is the first step of every speech processing pipeline.

Shennong provides the following functionalities: - implementation of the main methods from state of the art (including pre and post processing) - exhaustive documentation and tests - usage from a Python API or a command line tool - simple and coherent interface

- Contact: Mathieu Bernard
- URL: https://coml.lscp.ens.fr/docs/shennong

5.3. Seshat

Seshat Audio Annotation Platform

KEYWORDS: Audio - Speech - Web Application - Speech-text alignment

FUNCTIONAL DESCRIPTION: A web application to ease audio annotation campaigns, while also enabling the campaign manager to ensure that all annotations stick to a predefined format.

- Partner: ENS Paris
- Contact: Hadrien Titeux
- URL: https://github.com/bootphon/seshat

5.4. pyGammaAgreement

KEYWORDS: Reliability - Measures

FUNCTIONAL DESCRIPTION: Python library for measuring inter and intra annotator reliability for annotation sequences

- Contact: Emmanuel Dupoux

5.5. phonemizer

KEYWORD: Text

FUNCTIONAL DESCRIPTION:

- Conversion of a text into its phonemic representation
- Wrapper on speech synthesis programs espeak and festival
- Contact: Mathieu Bernard
- URL: https://github.com/bootphon/phonemizer

DEFROST Project-Team

6. New Software and Platforms

6.1. SOFA

Simulation Open Framework Architecture

KEYWORDS: Real time - Multi-physics simulation - Medical applications

FUNCTIONAL DESCRIPTION: SOFA is an Open Source framework primarily targeted at real-time simulation, with an emphasis on medical simulation. It is mostly intended for the research community to help develop new algorithms, but can also be used as an efficient prototyping tool. Based on an advanced software architecture, it allows : the creation of complex and evolving simulations by combining new algorithms with algorithms already included in SOFA, the modification of most parameters of the simulation (deformable behavior, surface representation, solver, constraints, collision algorithm, etc.) by simply editing an XML file, the building of complex models from simpler ones using a scene-graph description, the efficient simulation of the dynamics of interacting objects using abstract equation solvers, the reuse and easy comparison of a variety of available methods.

- Participants: Christian Duriez, François Faure, Hervé Delingette and Stéphane Cotin
- Partner: IGG
- Contact: Hugo Talbot
- URL: http://www.sofa-framework.org

6.2. SoftRobots

SoftRobots plugin for Sofa

KEYWORDS: Numerical simulations - Problem inverse - Soft robotics

FUNCTIONAL DESCRIPTION: This plugin allows the modeling of deformable robots in the Sofa platform. It allows the modeling of different actuators, such as cable, pneumatic pressure, hydraulics and other simpler types of actuation. It also contains useful tools for animation design or communication with the robot. Coupled with the SoftRobots.Inverse plugin, it also allows the control of these robots. More information can be found on the dedicated website.

- Participants: Christian Duriez, Olivier Goury, Jérémie Dequidt, Damien Marchal, Eulalie Coevoet and Félix Vanneste
- Contact: Christian Duriez
- URL: https://project.inria.fr/softrobot/

6.3. Model Order Reduction Plugin for SOFA

KEYWORDS: Model Order Reduction - Sofa - Finite element modelling

SCIENTIFIC DESCRIPTION: This plugin allows speed-up of SOFA simulations by providing tools to create a reduced version of the SOFA simulation that runs at much higher rates but remains accurate. Starting with a snapshot of the object deformations on a high-dimensional Finite Element mesh, Proper Orthogonal Decomposition (POD) is used to compute a reduced basis of small dimension representing correctly all the possible deformations of the object. The original system describing the object motion is then greatly reduced. To keep numerical efficiency, a hyper-reduction method is used to speed-up the construction of the reduced system.

FUNCTIONAL DESCRIPTION: This plugin allows to dramatically reduce computational time in mechanical simulation in the SOFA framework. A reduced simulation, of much smaller dimension but still accurate is created in an automatic way by the plugin. Building the reduced model may take time, but this operation is made once only. The user can then benefit from a reduced and interactive version of his/her simulation without significant loss of accuracy.

RELEASE FUNCTIONAL DESCRIPTION: This is the first version of the plugin.

NEWS OF THE YEAR: Publication using this plugin accepted dans IEEE Transactions on Robotics

- Participants: Olivier Goury, Félix Vanneste, Christian Duriez and Eulalie Coevoet
- Contact: Olivier Goury
- Publication: Fast, generic and reliable control and simulation of soft robots using model order reduction
- URL: https://project.inria.fr/modelorderreduction/

6.4. SoftRobots.Inverse

KEYWORDS: Sofa - SoftRobots

FUNCTIONAL DESCRIPTION: This plugin builds on the plugin SoftRobots. Inside the plugin, there is some constraint components that are used to describe the robot (effectors, actuators, sensors). An optimisation algorithm is provided to find the efforts to put on actuators in order to place the robot in a the closest possible configuration than the one described by "effectors", or to a state described by "sensors". This method used to control the soft-robots in the task space is patented.

- Partners: CNRS - Université de Lille - Ecole Centrale de Lille
- Contact: Christian Duriez
- URL: https://project.inria.fr/softrobot.inverse

6.5. SofaPython3

KEYWORDS: Python - Numerical simulations - Sofa

FUNCTIONAL DESCRIPTION: This plugin allows to use Sofa as a library from any python3 program. It also allows to write new mechanical component for a Sofa simulation in python3.

- Contact: Christian Duriez
- URL: https://github.com/SofaDefrost/plugin.SofaPython3/

6.6. SofaQtQuick

runSofa2

KEYWORDS: Sofa - GUI (Graphical User Interface) - Modeling - Physical simulation

FUNCTIONAL DESCRIPTION: Smooth the user experience with Sofa By integrating authoring features into runSofa so we can design simulation in an integrated environment. We should be able to model scenes, simulate & debug them.

This tool replaces the old "runSofa" interface, today deprecated but still in use by most SOFA users.

SofaQtQuick provides a fluid and dynamic user experience for SOFA, thanks to the integration of authoring tools to design complex simulations directly in the 3D environment, rather that scripting them as it is done today.

FEATURES:

*Scene graph editing

*Interactive modeling

*Project oriented approach

*Prefab as reusable and parametric object

*2D Canvas

*Custom widgets per component

*Live coding

*Node base interface for data link debugging

*Everything with a non-linear workflow

Based on a code gift from Anatoscope, stringly inspired by Blender & Unity's workflow.

RELEASE FUNCTIONAL DESCRIPTION: 1st Beta version, unstable, but testable.

- Contact: Christian Duriez
- URL: http://github.com/SofaDefrost/SofaQtQuick

EX-SITU Project-Team

6. New Software and Platforms

6.1. Digiscape

KEYWORDS: 2D - 3D - Node.js - Unity 3D - Video stream

FUNCTIONAL DESCRIPTION: Through the Digiscape application, the users can connect to a remote workspace and share files, video and audio streams with other users. Application running on complex visualization platforms can be easily launched and synchronized.

- Partners: Maison de la simulation - UVSQ - CEA - ENS Cachan - LIMSI - LRI - Laboratoire de Recherche en Informatique - CentraleSupélec - Telecom Paris
- Contact: Olivier Gladin
- URL: http://www.digiscope.fr

6.2. Touchstone2

KEYWORD: Experimental design

FUNCTIONAL DESCRIPTION: Touchstone2 is a graphical user interface to create and compare experimental designs. It is based on a visual language: Each experiment consists of nested bricks that represent the overall design, blocking levels, independent variables, and their levels. Parameters such as variable names, counterbalancing strategy and trial duration are specified in the bricks and used to compute the minimum number of participants for a balanced design, account for learning effects, and estimate session length. An experiment summary appears below each brick assembly, documenting the design. Manipulating bricks immediately generates a corresponding trial table that shows the distribution of experiment conditions across participants. Trial tables are faceted by participant. Using brushing and fish-eye views, users can easily compare among participants and among designs on one screen, and examine their trade-offs.

Touchstone2 plots a power chart for each experiment in the workspace. Each power curve is a function of the number of participants, and thus increases monotonically. Dots on the curves denote numbers of participants for a balanced design. The pink area corresponds to a power less than the 0.8 criterion: the first dot above it indicates the minimum number of participants. To refine this estimate, users can choose among Cohen's three conventional effect sizes, directly enter a numerical effect size, or use a calculator to enter mean values for each treatment of the dependent variable (often from a pilot study).

Touchstone2 can export a design in a variety of formats, including JSON and XML for the trial table, and TSL, a language we have created to describe experimental designs. A command-line tool is provided to generate a trial table from a TSL description.

Touchstone2 runs in any modern Web browser and is also available as a standalone tool. It is used at ExSitu for the design of our experiments, and by other Universities and research centers worldwide. It is available under an Open Source licence at https://touchstone2.org.

- Partner: University of Zurich
- Contact: Wendy Mackay
- URL: https://touchstone2.org

6.3. UnityCluster

KEYWORDS: 3D - Virtual reality - 3D interaction

FUNCTIONAL DESCRIPTION: UnityCluster is middleware to distribute any Unity 3D (https://unity3d.com/) application on a cluster of computers that run in interactive rooms, such as our WILD and WILDER rooms, or immersive CAVES (Computer-Augmented Virtual Environments). Users can interact the the application with various interaction resources.

UnityCluster provides an easy solution for running existing Unity 3D applications on any display that requires a rendering cluster with several computers. UnityCluster is based on a master-slave architecture: The master computer runs the main application and the physical simulation as well as manages the input, the slave computers receive updates from the master and render small parts of the 3D scene. UnityCluster manages data distribution and synchronization among the computers to obtain a consistent image on the entire wall-sized display surface.

UnityCluster can also deform the displayed images according to the user's position in order to match the viewing frustum defined by the user's head and the four corners of the screens. This respects the motion parallax of the 3D scene, giving users a better sense of depth.

UnityCluster is composed of a set of C Sharp scripts that manage the network connection, data distribution, and the deformation of the viewing frustum. In order to distribute an existing application on the rendering cluster, all scripts must be embedded into a Unity package that is included in an existing Unity project.

- Partner: Inria
- Contact: Cédric Fleury

6.4. VideoClipper

KEYWORD: Video recording

FUNCTIONAL DESCRIPTION: VideoClipper is an IOS app for Apple Ipad, designed to guide the capture of video during a variety of prototyping activities, including video brainstorming, interviews, video prototyping and participatory design workshops. It relies heavily on Apple's AVFoundation, a framework that provides essential services for working with time-based audiovisual media on iOS (https://developer.apple.com/av-foundation/). Key uses include: transforming still images (title cards) into video tracks, composing video and audio tracks in memory to create a preview of the resulting video project and saving video files into the default Photo Album outside the application.

VideoClipper consists of four main screens: project list, project, capture and import. The project list screen shows a list with the most recent projects at the top and allows the user to quickly add, remove or clone (copy and paste) projects. The project screen includes a storyboard composed of storylines that can be added, cloned or deleted. Each storyline is composed of a single title card, followed by one or more video clips. Users can reorder storylines within the storyboard, and the elements within each storyline through direct manipulation. Users can preview the complete storyboard, including all titlecards and videos, by pressing the play button, or export it to the Ipad's Photo Album by pressing the action button.

VideoClipper offers multiple tools for editing titlecards and storylines. Tapping on the title card lets the user edit the foreground text, including font, size and color, change background color, add or edit text labels, including size, position, color, and add or edit images, both new pictures and existing ones. Users can also delete text labels and images with the trash button. Video clips are presented via a standard video player, with standard interaction. Users can tap on any clip in a storyline to: trim the clip with a non-destructive trimming tool, delete it with a trash button, open a capture screen by clicking on the camera icon, label the clip by clicking a colored label button, and display or hide the selected clip by toggling the eye icon.

VideoClipper is currently in beta test, and is used by students in two HCI classes at the Université Paris-Saclay, researchers in ExSitu as well as external researchers who use it for both teaching and research work. A beta test version is available on demand under the Apple testflight online service.

- Contact: Wendy Mackay

6.5. WildOS

KEYWORDS: Human Computer Interaction - Wall displays

FUNCTIONAL DESCRIPTION: WildOS is middleware to support applications running in an interactive room featuring various interaction resources, such as our WILD and WILDER rooms: a tiled wall display, a motion tracking system, tablets and smartphones, etc. The conceptual model of WildOS is a platform, such as the WILD or WILDER room, described as a set of devices and on which one or more applications can be run.

WildOS consists of a server running on a machine that has network access to all the machines involved in the platform, and a set of clients running on the various interaction resources, such as a display cluster or a tablet. Once WildOS is running, applications can be started and stopped and devices can be added to or removed from the platform.

WildOS relies on Web technologies, most notably Javascript and node.js, as well as node-webkit and HTML5. This makes it inherently portable (it is currently tested on Mac OS X and Linux). While applications can be developed only with these Web technologies, it is also possible to bridge to existing applications developed in other environments if they provide sufficient access for remote control. Sample applications include a web browser, an image viewer, a window manager, and the BrainTwister application developed in collaboration with neuroanatomists at NeuroSpin.

WildOS is used for several research projects at ExSitu and by other partners of the Digiscope project. It was also deployed on several of Google's interactive rooms in Mountain View, Dublin and Paris. It is available under an Open Source licence at https://bitbucket.org/mblinsitu/wildos.

- Contact: Michel Beaudouin-Lafon
- URL: https://bitbucket.org/mblinsitu/wildos

6.6. Platforms

6.6.1. WILDER

Participants: Michel Beaudouin-Lafon [correspondant], Cédric Fleury, Olivier Gladin.

WILDER (Figure 1) is our second experimental ultra-high-resolution interactive environment, which follows the WILD platform developed in 2009. It features a wall-sized display with seventy-five 20" LCD screens, i.e. a 5m50 x 1m80 (18' x 6') wall displaying 14 400 x 4 800 = 69 million pixels, powered by a 10-computer cluster and two front-end computers. The platform also features a camera-based motion tracking system that lets users interact with the wall, as well as the surrounding space, with various mobile devices. The display uses a multitouch frame (the largest of its kind in the world) to make the entire wall touch sensitive.

WILDER was inaugurated in June, 2015. It is one of the ten platforms of the Digiscope Equipment of Excellence and, in combination with WILD and the other Digiscope rooms, provides a unique experimental environment for collaborative interaction.

In addition to using WILD and WILDER for our research, we have also developed software architectures and toolkits, such as WildOS and Unity Cluster, that enable developers to run applications on these multi-device, cluster-based systems.
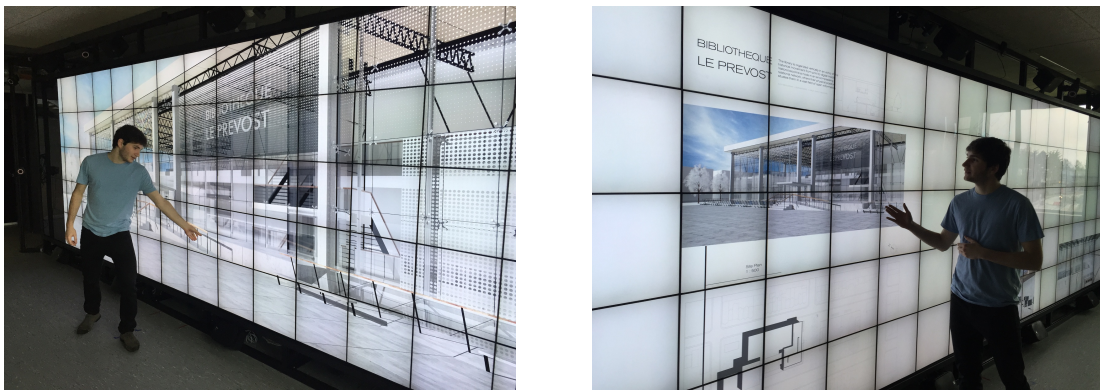
Figure 1. The WILDER platform.

FLOWERS Project-Team

6. New Software and Platforms

6.1. Explauto

an autonomous exploration library

KEYWORD: Exploration

SCIENTIFIC DESCRIPTION: An important challenge in developmental robotics is how robots can be intrinsically motivated to learn efficiently parametrized policies to solve parametrized multi-task reinforcement learning problems, i.e. learn the mappings between the actions and the problem they solve, or sensory effects they produce. This can be a robot learning how arm movements make physical objects move, or how movements of a virtual vocal tract modulates vocalization sounds. The way the robot will collects its own sensorimotor experience have a strong impact on learning efficiency because for most robotic systems the involved spaces are high dimensional, the mapping between them is non-linear and redundant, and there is limited time allowed for learning. If robots explore the world in an unorganized manner, e.g. randomly, learning algorithms will be often ineffective because very sparse data points will be collected. Data are precious due to the high dimensionality and the limited time, whereas data are not equally useful due to non-linearity and redundancy. This is why learning has to be guided using efficient exploration strategies, allowing the robot to actively drive its own interaction with the environment in order to gather maximally informative data to optimize the parametrized policies. In the recent year, work in developmental learning has explored various families of algorithmic principles which allow the efficient guiding of learning and exploration.

Explauto is a framework developed to study, model and simulate curiosity-driven learning and exploration in real and simulated robotic agents. Explauto's scientific roots trace back from Intelligent Adaptive Curiosity algorithmic architecture [127], which has been extended to a more general family of autonomous exploration architectures by [1] and recently expressed as a compact and unified formalism [119]. The library is detailed in [120]. In Explauto, interest models are implementing the strategies of active selection of particular problems / goals in a parametrized multi-task reinforcement learning setup to efficiently learn parametrized policies. The agent can have different available strategies, parametrized problems, models, sources of information, or learning mechanisms (for instance imitate by mimicking vs by emulation, or asking help to one teacher or to another), and chooses between them in order to optimize learning (a processus called strategic learning [124]). Given a set of parametrized problems, a particular exploration strategy is to randomly draw goals/ RL problems to solve in the motor or problem space. More efficient strategies are based on the active choice of learning experiments that maximize learning progress using bandit algorithms, e.g. maximizing improvement of predictions or of competences to solve RL problems [127]. This automatically drives the system to explore and learn first easy skills, and then explore skills of progressively increasing complexity. Both random and learning progress strategies can act either on the motor or on the problem space, resulting in motor babbling or goal babbling strategies.

- Motor babbling consists in sampling commands in the motor space according to a given strategy (random or learning progress), predicting the expected effect, executing the command through the environment and observing the actual effect. Both the parametrized policies and interest models are finally updated according to this experience.

- Goal babbling consists in sampling goals in the problem space and to use the current policies to infer a motor action supposed to solve the problem (inverse prediction). The robot/agent then executes the command through the environment and observes the actual effect. Both the parametrized policies and interest models are finally updated according to this experience.It has been shown that this second strategy allows a progressive solving of problems much more uniformly in the problem space than with a motor babbling strategy, where the agent samples directly in the motor space [1].
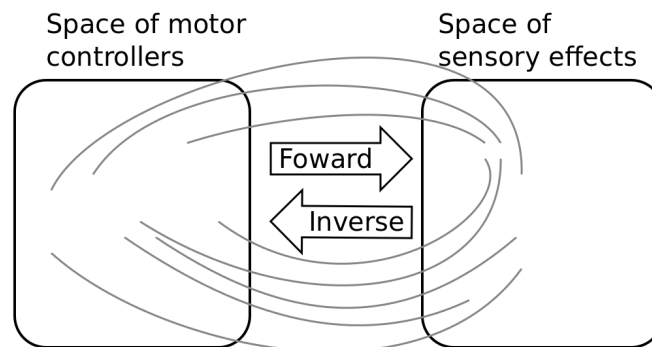
Figure 1. Complex parametrized policies involve high dimensional action and effect spaces. For the sake of visualization, the motor M and sensory S spaces are only 2D each in this example. The relationship between M and S is non-linear, dividing the sensorimotor space into regions of unequal stability: small regions of S can be reached very precisely by large regions of M, or large regions in S can be very sensitive to variations in M.: s as well as a non-linear and redundant relationship. This non-linearity can imply redundancy, where the same sensory effect can be attained using distinct regions in M.

FUNCTIONAL DESCRIPTION: This library provides high-level API for an easy definition of:

- Real and simulated robotic setups (Environment level),
- Incremental learning of parametrized policies (Sensorimotor level),
- Active selection of parametrized RL problems (Interest level).

The library comes with several built-in environments. Two of them corresponds to simulated environments: a multi-DoF arm acting on a 2D plan, and an under-actuated torque-controlled pendulum. The third one allows to control real robots based on Dynamixel actuators using the Pypot library. Learning parametrized policies involves machine learning algorithms, which are typically regression algorithms to learn forward models, from motor controllers to sensory effects, and optimization algorithms to learn inverse models, from sensory effects, or problems, to the motor programs allowing to reach them. We call these sensorimotor learning algorithms sensorimotor models. The library comes with several built-in sensorimotor models: simple nearest-neighbor look-up, non-parametric models combining classical regressions and optimization algorithms, online mixtures of Gaussians, and discrete Lidstone distributions. Explauto sensorimotor models are online learning algorithms, i.e. they are trained iteratively during the interaction of the robot in theenvironment in which it evolves. Explauto provides also a unified interface to define exploration strategies using the InterestModel class. The library comes with two built-in interest models: random sampling as well as sampling maximizing the learning progress in forward or inverse predictions.

Explauto environments now handle actions depending on a current context, as for instance in an environment where a robotic arm is trying to catch a ball: the arm trajectories will depend on the current position of the ball (context). Also, if the dynamic of the environment is changing over time, a new sensorimotor model (Non-Stationary Nearest Neighbor) is able to cope with those changes by taking more into account recent experiences. Those new features are explained in Jupyter notebooks.

This library has been used in many experiments including:

- the control of a 2D simulated arm,
- the exploration of the inverse kinematics of a poppy humanoid (both on the real robot and on the simulated version),
- acoustic model of a vocal tract.

Explauto is crossed-platform and has been tested on Linux, Windows and Mac OS. It has been released under the GPLv3 license.

- Contact: Sebastien Forestier
- URL: https://github.com/flowersteam/explauto

6.2. KidBreath

KEYWORD: Machine learning

FUNCTIONAL DESCRIPTION: KidBreath is a web responsive application composed by several interactive contents linked to asthma and displayed to different forms: learning activities with quiz, short games and videos. There are profil creation and personalization, and a part which describes historic and scoring of learning activities, to see evolution of Kidreath use. To test Kidlearn algorithm, it is iadapted and integrated on this platform. Development in PHP, HTML-5, CSS, MySQL, JQuery, Javascript. Hosting in APACHE, LINUX, PHP 5.5, MySQL, OVH.

- Partner: ItWell SAS
- Contact: Alexandra Delmas
- URL: http://www.kidbreath.fr

6.3. Kidlearn: money game application

FUNCTIONAL DESCRIPTION: The games is instantiated in a browser environment where students are proposed exercises in the form of money/token games (see Figure 2). For an exercise type, one object is presented with a given tagged price and the learner has to choose which combination of bank notes, coins or abstract tokens need to be taken from the wallet to buy the object, with various constraints depending on exercises parameters. The games have been developed using web technologies, HTML5, javascript and Django.
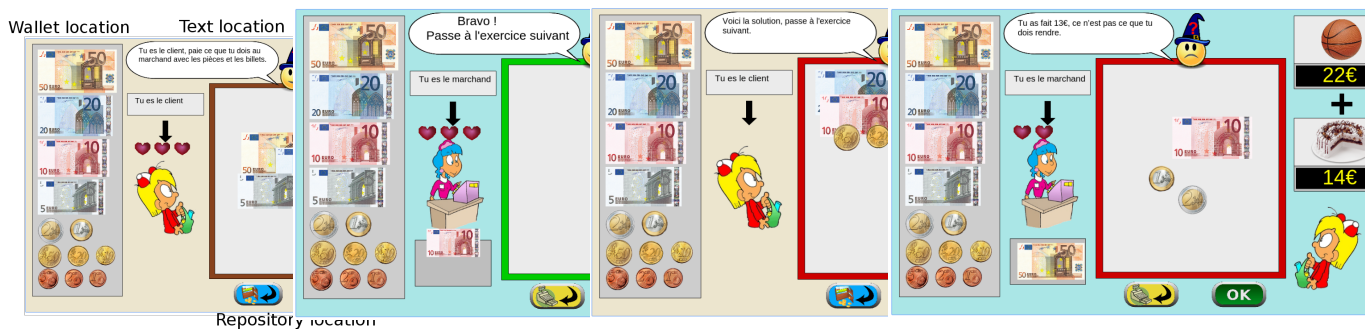
Figure 2. Four principal regions are defined in the graphical interface. The first is the wallet location where users can pick and drag the money items and drop them on the repository location to compose the correct price. The object and the price are present in the object location. Four different types of exercises exist: M : customer/one object, R : merchant/one object, MM : customer/two objects, RM : merchant/two objects.

- Contact: Benjamin Clement
- URL: https://flowers.inria.fr/research/kidlearn/

6.4. Kidlearn: script for Kidbreath use

KEYWORD: PHP

FUNCTIONAL DESCRIPTION: A new way to test Kidlearn algorithms is to use them on Kidbreath Plateform. The Kidbreath Plateform use apache/PHP server, so to facilitate the integration of our algorithm, a python script have been made to allow PHP code to use easily the python library already made which include our algorithms.

- Contact: Benjamin Clement
- URL: https://flowers.inria.fr/research/kidlearn/

6.5. KidLearn

KEYWORD: Automatic Learning

FUNCTIONAL DESCRIPTION: KidLearn is a software which adaptively personalize sequences of learning activities to the particularities of each individual student. It aims at proposing to the student the right activity at the right time, maximizing concurrently his learning progress and its motivation.

- Participants: Benjamin Clement, Didier Roy, Manuel Lopes and Pierre Yves Oudeyer
- Contact: Pierre-Yves Oudeyer
- URL: https://flowers.inria.fr/research/kidlearn/

6.6. Poppy

KEYWORDS: Robotics - Education

FUNCTIONAL DESCRIPTION: The Poppy Project team develops open-source 3D printed robots platforms based on robust, flexible, easy-to-use and reproduce hardware and software. In particular, the use of 3D printing and rapid prototyping technologies is a central aspect of this project, and makes it easy and fast not only to reproduce the platform, but also to explore morphological variants. Poppy targets three domains of use: science, education and art.

In the Poppy project we are working on the Poppy System which is a new modular and open-source robotic architecture. It is designed to help people create and build custom robots. It permits, in a similar approach as Lego, building robots or smart objects using standardized elements.

Poppy System is a unified system in which essential robotic components (actuators, sensors...) are independent modules connected with other modules through standardized interfaces:

- Unified mechanical interfaces, simplifying the assembly process and the design of 3D printable parts.
- Unified communication between elements using the same connector and bus for each module.
- Unified software, making it easy to program each module independently.

Our ambition is to create an ecosystem around this system so communities can develop custom modules, following the Poppy System standards, which can be compatible with all other Poppy robots.

- Participants: Jonathan Grizou, Matthieu Lapeyre, Pierre Rouanet and Pierre-Yves Oudeyer
- Contact: Pierre-Yves Oudeyer
- URL: https://www.poppy-project.org/

6.7. Poppy Ergo Jr

KEYWORDS: Robotics - Education

FUNCTIONAL DESCRIPTION: Poppy Ergo Jr is an open hardware robot developed by the Poppy Project to explore the use of robots in classrooms for learning robotic and computer science.

It is available as a 6 or 4 degrees of freedom arm designed to be both expressive and low-cost. This is achieved by the use of FDM 3D printing and low cost Robotis XL-320 actuators. A Raspberry Pi camera is attached to the robot so it can detect object, faces or QR codes.
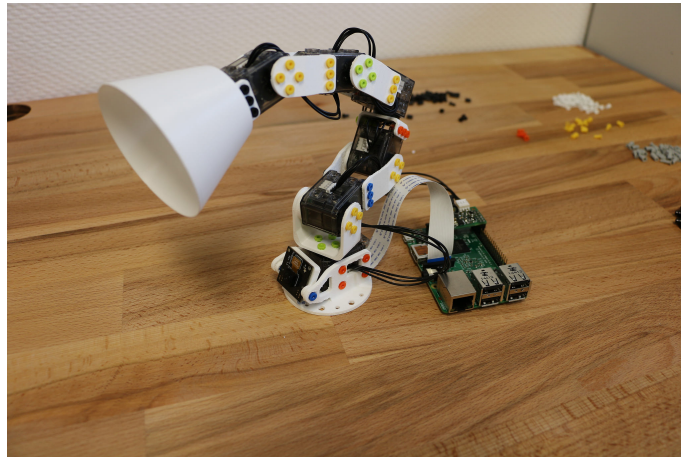
Figure 3. Poppy Ergo Jr, 6-DoFs arm robot for education

The Ergo Jr is controlled by the Pypot library and runs on a Raspberry pi 2 or 3 board. Communication between the Raspberry Pi and the actuators is made possible by the Pixl board we have designed.

The Poppy Ergo Jr robot has several 3D printed tools extending its capabilities. There are currently the lampshade, the gripper and a pen holder.
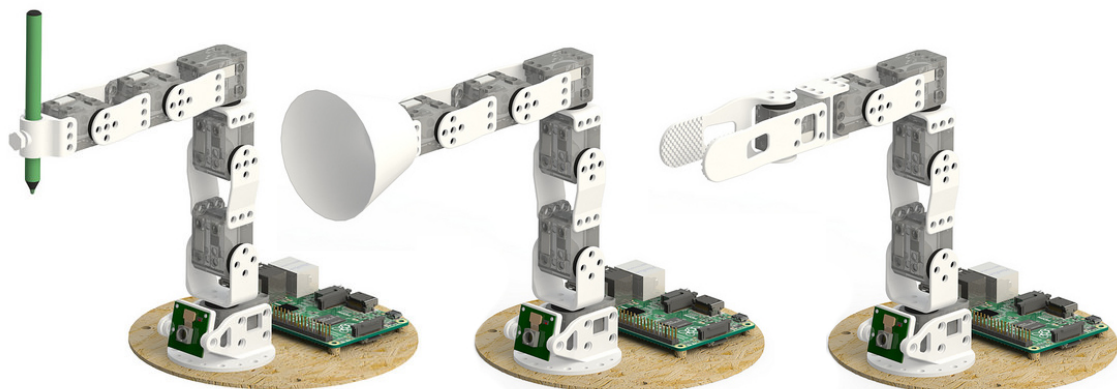
Figure 4. The available Ergo Jr tools: a pen holder, a lampshade and a gripper

With the release of a new Raspberry Pi board early 2016, the Poppy Ergo Jr disk image was updated to support Raspberry Pi 2 and 3 boards. The disk image can be used seamlessly with a board or the other.

- Contact: Theo Segonds
- URL: https://github.com/poppy-project/poppy-ergo-jr

6.8. S-RL Toolbox

Reinforcement Learning (RL) and State Representation Learning (SRL) for Robotics

KEYWORDS: Machine learning - Robotics

FUNCTIONAL DESCRIPTION: This repository was made to evaluate State Representation Learning methods using Reinforcement Learning. It integrates (automatic logging, plotting, saving, loading of trained agent) various RL algorithms (PPO, A2C, ARS, ACKTR, DDPG, DQN, ACER, CMA-ES, SAC, TRPO) along with different SRL methods (see SRL Repo) in an efficient way (1 Million steps in 1 Hour with 8-core cpu and 1 Titan X GPU).

- Partner: ENSTA
- Contact: David Filliat
- URL: https://github.com/araffin/robotics-rl-srl

6.9. Deep-Explauto

KEYWORDS: Deep learning - Unsupervised learning - Learning - Experimentation

FUNCTIONAL DESCRIPTION: Until recently, curiosity driven exploration algorithms were based on classic learning algorithms, unable to handle large dimensional problems (see explauto). Recent advances in the field of deep learning offer new algorithms able to handle such situations.

Deep explauto is an experimental library, containing reference implementations of curiosity driven exploration algorithms. Given the experimental aspect of exploration algorithms, and the low maturity of the libraries and algorithms using deep learning, proposing black-box implementations of those algorithms, enabling a blind use of those, seem unrealistic.

Nevertheless, in order to quickly launch new experiments, this library offers an set of objects, functions and examples, allowing to kickstart new experiments.

- Contact: Alexandre Pere

6.10. Orchestra

KEYWORD: Experimental mechanics

FUNCTIONAL DESCRIPTION: Ochestra is a set of tools meant to help in performing experimental campaigns in computer science. It provides you with simple tools to:

+ Organize a manual experimental workflow, leveraging git and lfs through a simple interface. + Collaborate with other peoples on a single experimental campaign. + Execute pieces of code on remote hosts such as clusters or clouds, in one line. + Automate the execution of batches of experiments and the presentation of the results through a clean web ui.

A lot of advanced tools exists on the net to handle similar situations. Most of them target very complicated workflows, e.g. DAGs of tasks. Those tools are very powerful but lack the simplicity needed by newcomers. Here, we propose a limited but very simple tool to handle one of the most common situation of experimental campaigns: the repeated execution of an experiment on variations of parameters.

In particular, we include three tools: + expegit: a tool to organize your experimental campaign results in a git repository using git-lfs (large file storage). + runaway: a tool to execute code on distant hosts parameterized with easy to use file templates. + orchestra: a tool to automate the use of the two previous tools on large campaigns.

- Contact: Alexandre Pere

6.11. Curious

Curious: Intrinsically Motivated Modular Multi-Goal Reinforcement Learning

KEYWORDS: Exploration - Reinforcement learning - Artificial intelligence

FUNCTIONAL DESCRIPTION: This is an algorithm enabling to learn a controller for an agent in a modular multi-goal environment. In these types of environments, the agent faces multiple goals classified in different types (e.g. reaching goals, grasping goals for a manipulation robot).

- Contact: Cedric Colas

6.12. teachDeepRL

Teacher algorithms for curriculum learning of Deep RL in continuously parameterized environments

KEYWORDS: Machine learning - Git

FUNCTIONAL DESCRIPTION: Codebase from our CoRL2019 paper https://arxiv.org/abs/1910.07224

This github repository provides implementations for the following teacher algorithms: - Absolute Learning Progress-Gaussian Mixture Model (ALP-GMM), our proposed teacher algorithm - Robust Intelligent Adaptive Curiosity (RIAC), from Baranes and Oudeyer, R-IAC: robust intrinsically motivated exploration and active learning. - Covar-GMM, from Moulin-Frier et al., Self-organization of early vocal development in infants and machines: The role of intrinsic motivation.

- Contact: Remy Portelas
- URL: https://github.com/flowersteam/teachDeepRL

6.13. Automated Discovery of Lenia Patterns

KEYWORDS: Exploration - Cellular automaton - Deep learning - Unsupervised learning

SCIENTIFIC DESCRIPTION: In many complex dynamical systems, artificial or natural, one can observe selforganization of patterns emerging from local rules. Cellular automata, like the Game of Life (GOL), have been widely used as abstract models enabling the study of various aspects of self-organization and morphogenesis, such as the emergence of spatially localized patterns. However, findings of self-organized patterns in such models have so far relied on manual tuning of parameters and initial states, and on the human eye to identify "interesting" patterns. In this paper, we formulate the problem of automated discovery of diverse self-organized patterns in such high-dimensional complex dynamical systems, as well as a framework for experimentation and evaluation. Using a continuous GOL as a testbed, we show that recent intrinsically-motivated machine learning algorithms (POP-IMGEPs), initially developed for learning of inverse models in robotics, can be transposed and used in this novel application area. These algorithms combine intrinsically motivated goal exploration and unsupervised learning of goal space representations. Goal space representations describe the "interesting" features of patterns for which diverse variations should be discovered. In particular, we compare various approaches to define and learn goal space representations from the perspective of discovering diverse spatially localized patterns. Moreover, we introduce an extension of a state-of-the-art POP-IMGEP algorithm which incrementally learns a goal representation using a deep auto-encoder, and the use of CPPN primitives for generating initialization parameters. We show that it is more efficient than several baselines and equally efficient as a system pre-trained on a hand-made database of patterns identified by human experts.

FUNCTIONAL DESCRIPTION: Python source code of experiments and data analysis for the paper " Intrinsically Motivated Discovery of Diverse Patterns in Self-Organizing Systems" (Chris Reinke, Mayalen Echeverry, Pierre-Yves Oudeyer in Submitted to ICLR 2020). The software includes: Lenia environment, exploration algorithms (IMGEPs, random search), deep learning algorithms for unsupervised learning of goal spaces, tools and configurations to run experiments, and data analysis tools.

- Contact: Chris Reinke
- URL: https://github.com/flowersteam/automated_discovery_of_lenia_patterns

6.14. ZPDES_ts

ZPDES in typescript

KEYWORDS: Machine learning - Education

FUNCTIONAL DESCRIPTION: ZPDES is a machine learning-based algorithm that allows you to customize the content of training courses for each learner's level. It has already been implemented in the Kidlern software in python with other algorithms. Here, ZPDES is implemented in typescript.

- Authors: Benjamin Clement, Pierre-Yves Oudeyer, Didier Roy and Manuel Lopes
- Contact: Benjamin Clement
- URL: https://flowers.inria.fr/research/kidlearn/

6.15. GEP-PG

Goal Exploration Process - Policy Gradient

KEYWORDS: Machine learning - Deep learning

FUNCTIONAL DESCRIPTION: Reinforcement Learning algorithm working with OpenAI Gym environments. A first phase implements exploration using a Goal Exploration Process (GEP). Samples collected during exploration are then transferred to the memory of a deep reinforcement learning algorithm (deep deterministic policy gradient or DDPG). DDPG then starts learning from a pre-initialized memory so as to maximize the sum of discounted rewards given by the environment.

- Contact: Cedric Colas

<p style="text-align:center">**GRAPHDECO Project-Team**</p>

5. New Software and Platforms

5.1. SynDraw

KEYWORDS: Non-photorealistic rendering - Vector-based drawing - Geometry Processing

FUNCTIONAL DESCRIPTION: The SynDraw library extracts occluding contours and sharp features over a 3D shape, computes all their intersections using a binary space partitioning algorithm, and finally performs a raycast to determine each sub-contour visibility. The resulting lines can then be exported as an SVG file for subsequent processing, for instance to stylize the drawing with different brush strokes. The library can also export various attributes for each line, such as its visibility and type. Finally, the library embeds tools allowing one to add noise into an SVG drawing, in order to generate multiple images from a single sketch. SynthDraw is based on the geometry processing library libIGL.

RELEASE FUNCTIONAL DESCRIPTION: This first version extracts occluding contours, boundaries, creases, ridges, valleys, suggestive contours and demarcating curves. Visibility is computed with a view graph structure. Lines can be aggregated and/or filtered. Labels and outputs include: line type, visibility, depth and aligned normal map.

- Authors: Adrien Bousseau, Bastien Wailly and Adele Saint-Denis
- Contact: Bastien Wailly

5.2. DeepSketch

KEYWORDS: 3D modeling - Sketching - Deep learning

FUNCTIONAL DESCRIPTION: DeepSketch is a sketch-based modeling system that runs in a web browser. It relies on deep learning to recognize geometric shapes in line drawings. The system follows a client/server architecture, based on the Node.js and WebGL technology. The application's main targets are iPads or Android tablets equipped with a digital pen, but it can also be used on desktop computers.

RELEASE FUNCTIONAL DESCRIPTION: This first version is built around a client/server Node.js application whose job is to transmit a drawing from the client's interface to the server where the deep networks are deployed, then transmit the results back to the client where the final shape is created and rendered in a WebGL 3D scene thanks to the THREE.js JavaScript framework. Moreover, the client is able to perform various camera transformations before drawing an object (change position, rotate in place, scale on place) by interacting with the touch screen. The user also has the ability to draw the shape's shadow to disambiguate depth/height. The deep networks are created, trained and deployed with the Caffe framework.

- Authors: Adrien Bousseau and Bastien Wailly
- Contact: Adrien Bousseau

5.3. DPP

Delaunay Point Process for image analysis

KEYWORDS: Computer vision - Shape recognition - Delaunay triangulation - Stochastic process

FUNCTIONAL DESCRIPTION: The software extract 2D geometric structures (planar graphs, polygons...) from images

- Participants: Jean-Dominique Favreau, Florent Lafarge and Adrien Bousseau
- Contact: Florent Lafarge
- Publication: Extracting Geometric Structures in Images with Delaunay Point Processes

5.4. sibr-core

System for Image-Based Rendering

KEYWORD: Graphics

SCIENTIFIC DESCRIPTION: Core functionality to support Image-Based Rendering research. The core provides basic support for camera calibration, multi-view stereo meshes and basic image-based rendering functionality. Separate dependent repositories interface with the core for each research project. This library is an evolution of the previous SIBR software, but now is much more modular.

We plan to release the core module, as well as the code for several of our research papers, as well as papers from other authors for comparisons and benchmark purposes.

FUNCTIONAL DESCRIPTION: sibr-core is a framework containing libraries and tools used internally for research projects based on Image-Base Rendering. It includes both preprocessing tools (computing data used for rendering) and rendering utilities and serves as the basis for many research projects in the group.

- Authors: Sebastien Bonopera, Jérôme Esnault, Siddhant Prakash, Simon Rodriguez, Théo Thonat, Gaurav Chaurasia, Julien Philip and George Drettakis
- Contact: George Drettakis

5.5. SGTDGP

Synthetic Ground Truth Data Generation Platform

KEYWORD: Graphics

FUNCTIONAL DESCRIPTION: The goal of this platform is to render large numbers of realistic synthetic images for use as ground truth to compare and validate image-based rendering algorithms and also to train deep neural networks developed in our team.

This pipeline consists of tree major elements that are:

- Scene exporter
- Assisted point of view generation
- Distributed rendering on Inria's high performance computing cluster

The scene exporter is able to export scenes created in the widely-used commercial modeler 3DSMAX to the Mitsuba opensource renderer format. It handles the conversion of complex materials and shade trees from 3DSMAX including materials made for VRay. The overall quality of the produced images with exported scenes have been improved thanks to a more accurate material conversion. The initial version of the exporter was extended and improved to provide better stability and to avoid any manual intervention.

From each scene we can generate a large number of images by placing multiple cameras. Most of the time those points of view has to be placed with a certain coherency. This task could be long and tedious. In the context of image-based rendering, cameras have to be placed in a row with a specific spacing. To simplify this process we have developed a set of tools to assist the placement of hundreds of cameras along a path.

The rendering is made with the open source renderer Mitsuba. The rendering pipeline is optimised to render a large number of point of view for single scene. We use a path tracing algorithm to simulate the light interaction in the scene and produce hight dynamic range images. It produces realistic images but it is computationally demanding. To speed up the process we setup an architecture that takes advantage of the Inria cluster to distribute the rendering on hundreds of CPUs cores.

The scene data (geometry, textures, materials) and the cameras are automatically transfered to remote workers and HDR images are returned to the user.

We already use this pipeline to export tens of scenes and to generate several thousands of images, which have been used for machine learning and for ground-truth image production.

We have recently integrated the platform with the sibr-core software library, allowing us to read mitsuba scenes. We have written a tool to allow camera placement to be used for rendering and for reconstruction of synthetic scenes, including alignment of the exact and reconstructed version of the scenes. This dual-representation scenes can be used for learning and as ground truth. We can also perform various operations on the ground truth data within sibr-core, e.g., compute shadow maps of both exact and reconstructed representations etc.

- Authors: Laurent Boiron, Sébastien Morgenthaler, Georgios Kopanas, Julien Philip and George Drettakis
- Contact: George Drettakis

5.6. Unity IBR

KEYWORD: Graphics

FUNCTIONAL DESCRIPTION: Unity IBR (for Image-Based Rendering in Unity) This is a software module that proceeds the development of IBR algorithms in Unity. In this case, algorithms are developed for the context of EMOTIVE EU project. The rendering technique was changed during the year to evaluate and compare which one produces better results suitable for Game Development with Unity (improvement of image quality and faster rendering). New features were also added such as rendering of bigger datasets and some debugging utilities. Software was also updated to keep compatibility with new released versions of Unity game engine. In addition, in order to develop a demo showcasing the technology, a multiplayer VR scene was created proving the integration of IBR with the rest of the engine.

- Authors: Sebastian Vizcay and George Drettakis
- Contact: George Drettakis

5.7. DeepRelighting

Deep Geometry-Aware Multi-View Relighting

KEYWORD: Graphics

SCIENTIFIC DESCRIPTION: Implementation of the paper: Multi-view Relighting using a Geometry-Aware Network (https://hal.inria.fr/hal-02125095), based on the sibr-core library.

- Participants: Julien Philip and George Drettakis
- Contact: George Drettakis
- Publication: https://hal.inria.fr/hal-02125095

5.8. SingleDeepMat

Single-image deep material acquisition

KEYWORDS: Materials - 3D - Realistic rendering - Deep learning

SCIENTIFIC DESCRIPTION: Cook-Torrance SVBRDF parameter acquisition from a single Image using Deep learning

FUNCTIONAL DESCRIPTION: Allows material acquisition from a single picture, to then be rendered in a virtual environment. Implementation of the paper https://hal.inria.fr/hal-01793826/

RELEASE FUNCTIONAL DESCRIPTION: Based on Pix2Pix implementation by AffineLayer (Github)

- Participants: Valentin Deschaintre, Miika Aittala, Frédo Durand, George Drettakis and Adrien Bousseau
- Partner: CSAIL, MIT
- Contact: Adrien Bousseau
- Publication: Single-Image SVBRDF Capture with a Rendering-Aware Deep Network
- URL: https://team.inria.fr/graphdeco/projects/deep-materials/

5.9. MultiDeepMat

Multi-image deep material acquisition

KEYWORDS: 3D - Materials - Deep learning

SCIENTIFIC DESCRIPTION: Allows material acquisition from multiple pictures, to then be rendered in a virtual environment. Implementation of the paper https://hal.inria.fr/hal-02164993

RELEASE FUNCTIONAL DESCRIPTION: Code fully rewritten since the SingleDeepMat project, but some function are imported from it.

- Participants: Valentin Deschaintre, Miika Aittala, Frédo Durand, George Drettakis and Adrien Bousseau
- Contact: Adrien Bousseau
- Publication: Flexible SVBRDF Capture with a Multi-Image Deep Network
- URL: https://team.inria.fr/graphdeco/projects/multi-materials/

5.10. GuidedDeepMat

Guided deep material acquisition

KEYWORDS: Materials - 3D - Deep learning

SCIENTIFIC DESCRIPTION: Deep large scale HD material acquisition guided by an example small scale SVBRDF

RELEASE FUNCTIONAL DESCRIPTION: Code based on the MultiDeepMat project code.

- Participants: Valentin Deschaintre, George Drettakis and Adrien Bousseau
- Contact: Adrien Bousseau

GRAPHIK Project-Team

6. New Software and Platforms

6.1. Docamex

KEYWORD: Ontologies

SCIENTIFIC DESCRIPTION: In many agri-food companies, food quality is often managed using expertise gained through experience. Overall quality enhancement may come from sharing collective expertise. In this paper, we describe the design and implementation of a complete methodology allowing an expert knowledge base to be created and used to recommend the technical action to take to maintain food quality. We present its functional specifications, defined in cooperation with several industrial partners and technical centres over the course of several projects carried out in recent years. We propose a systematic methodology for collecting the knowledge on a given food process, from the design of a questionnaire to the synthesis of the information from completed questionnaires using a mind map approach. We then propose an original core ontology for structuring knowledge as possible causal relationships between situations of interest. We describe how mind map files generated by mind map tools are automatically imported into a conceptual graph knowledge base, before being validated and finally automatically processed in a graph-based visual tool. A specific end-user interface has been designed to ensure that end-user experts in agri-food companies can use the tool in a convenient way. Finally, our approach is compared with current research.

FUNCTIONAL DESCRIPTION: Docamex is a software dedicated to expert knowledge capitalization and visualization.

NEWS OF THE YEAR: Reliability score implemented.
- Participants: Jérôme Fortin and Patrice Buche
- Contact: Jérôme Fortin
- Publication: Expertise-based decision support for managing food quality in agri-food companies

6.2. Cogui

KEYWORDS: Knowledge database - Ontologies - GUI (Graphical User Interface)

SCIENTIFIC DESCRIPTION: Cogui is a visual tool for building and verifying graphical knowledge bases (KB). Knowledge bases are represented under graphical form (close to conceptual graphs). There is a complete correspondence with the logical existential rule (or Datalog+) framework.

FUNCTIONAL DESCRIPTION: Cogui is a freeware written in Java. It allows to graphically create a KB, to handle its structure and content, and to control it. Currently, it supports Conceptual Graphs and import/export in RDFS and Datalog+. Wizards allow to analyze and check facts with respect to some constraints, as well as to query them while taking into account inferences enabled by the ontology.

RELEASE FUNCTIONAL DESCRIPTION: Plugin-extensible architecture, multi-project management, automatic construction of a web documentation of the ontology, adoption of semantic web conventions (IRIs and namespaces), integration of some Graal functionalities (homomorphisms and OWL 2 import), improvement of the import/export between Cogui knowledge bases and Graal dlgp format.

NEWS OF THE YEAR: 2019: new website and completely revised user documentation, following the release of version V3 (in 2018), which required heavy refactoring to benefit from NetBeans plugin-extensible platform architecture and graphical libraries (total replacement of the graphical editors).
- Participants: Alain Gutierrez, Michel Chein, Marie-Laure Mugnier, Michel Leclère and Madalina Croitoru
- Partner: LIRMM
- Contact: Michel Chein
- URL: http://www.lirmm.fr/cogui/

6.3. Damn

Defeasible reasoning tool for multi-agent collaboration

KEYWORDS: Knowledge representation - Logic programming

FUNCTIONAL DESCRIPTION: Damn is an open source defeasible reasoning tool that allows the use of different semantics (ambiguity blocking/propagating with or without team defeat) in order to reason with incoherent or inconsistent knowledge. It allows the reasoning about preferences and their justification between different agents with a final aim of producing justified preferences on different outcomes (alternatives). These preferences are then used with a voting module (given certain voting strategy) to break ties and establish the chosen alternative. It is applied within the GLOPACK and NOAW projects.

NEWS OF THE YEAR: The HCI has been finalised: multi-users functionalities have been added (login, agents added, etc.).

- Contact: Madalina Croitoru
- URL: https://hamhec.github.io/damn/home

<p align="center">**HEPHAISTOS Project-Team**</p>

5. New Software and Platforms

5.1. ALIAS

Algorithms Library of Interval Analysis for Systems

FUNCTIONAL DESCRIPTION: The ALIAS library whose development started in 1998, is a collection of procedures based on interval analysis for systems solving and optimization.

ALIAS is made of two parts:

ALIAS-C++ : the C++ library (87 000 code lines) which is the core of the algorithms

ALIAS-Maple : the Maple interface for ALIAS-C++ (55 000 code lines). This interface allows one to specify a solving problem within Maple and get the results within the same Maple session. The role of this interface is not only to generate the C++ code automatically, but also to perform an analysis of the problem in order to improve the efficiency of the solver. Furthermore, a distributed implementation of the algorithms is available directly within the interface.

- Participants: Jean-Pierre Merlet and Odile Pourtallier
- Contact: Jean-Pierre Merlet

5.2. PALGate

KEYWORDS: Health - Home care - Handicap
- Contact: David Daney

5.3. Platforms

5.3.1. *ALIAS, Algorithms Library of Interval Analysis for Systems*

Participants: Hiparco Lins Vieira, Jean-Pierre Merlet [correspondant], Yves Papegay.

URL: http://www-sop.inria.fr/hephaistos/developpements/main.html

The ALIAS library whose development started in 1998, is a collection of procedures based on interval analysis for systems solving and optimization.

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ALIAS-C++ : the C++ library (87 000 code lines) which is the core of the algorithms

ALIAS-Maple : the Maple interface for ALIAS-C++ (55 000 code lines). This interface allows one to specify a solving problem within Maple and get the results within the same Maple session. The role of this interface is not only to generate the C++ code automatically, but also to perform an analysis of the problem in order to improve the efficiency of the solver. Furthermore, a distributed implementation of the algorithms is available directly within the interface.

ALIAS is a core element for solving the usually complex equations we have to manage our robotics problems. We may mention as example our work on cable-driven parallel robot (see section 6.1.1) involves non-algebraic models whose exact solving is required while the unknowns of our system are physical entities that may usually be bounded (meaning that we are not interested in all solutions of the system but only in the one that make physical sense) and therefore interval analysis is appropriate (and quite often the only one that may manage to get exactly all solutions). This year we have also used ALIAS to provide certified solutions of the kinematics of a flexible parallel robots [17]. We have confirmed the solutions that has been provided by a computer intensive iterative methods and have shown that the interval analysis method was able to manage a more complex case for which the iterative method cannot be reasonably used. In a third example we combine interval analysis and Monte-Carlo method for developing a reliable motion planning for parallel manipulators [15] while interval analysis has been used for the design of parallel robot [14].

5.3.2. Hardware platforms

We describe here only the new platforms that have been developed or improved in 2019 while we maintain a very large number of platforms (e.g. the cable-driven parallel robots of the MARIONET family, the ANG family of walking aids,r our experimental flat and the activities detection platform implemented in the day hospital Institut Claude Pompidou and EHPAD Valrose, Nice). Among the MARIONET family we have reactivated and adapted the MARIONET-CRANE prototype for the experiment described in section 6.1.2 . We have also updated our parallel $6 - \underline{P}US$ prototype for the medical application mentioned in section 6.3 .

5.3.2.1. REVMED: virtual reality and rehabilitation

Inria and Université Côte d'Azur have agreed to fund us for developing the platform REVMED whose purpose is to introduce end-user motion and their analysis in a virtual reality environment in order to make rehabilitation exercises more attractive and more appropriate for the rehabilitation process. The main idea is to have a modular rehabilitation station allowing to manage various exercise devices with a very low set-up time (typically 10 mn), that will be actuated in order to allow ergotherapists to favor the work of various muscles groups and the difficulty of the exercise, while monitoring the rehabilitation process with various external sensors, providing an objectification of the evaluation. Version 2 has been completed this year and we will proceed in 2020 to the first trials. These trials will consist in establishing walking patterns for non-pathological people in various conditions that will be created by a walk in a mountainous environment.

<h1 style="text-align:center; color:red;">HYBRID Project-Team</h1>

6. New Software and Platforms

6.1. #FIVE

Framework for Interactive Virtual Environments

KEYWORDS: Virtual reality - 3D - 3D interaction - Behavior modeling

SCIENTIFIC DESCRIPTION: #FIVE (Framework for Interactive Virtual Environments) is a framework for the development of interactive and collaborative virtual environments. #FIVE was developed to answer the need for an easier and a faster design and development of virtual reality applications. #FIVE provides a toolkit that simplifies the declaration of possible actions and behaviours of objects in a VE. It also provides a toolkit that facilitates the setting and the management of collaborative interactions in a VE. It is compliant with a distribution of the VE on different setups. It also proposes guidelines to efficiently create a collaborative and interactive VE. The current implementation is in C# and comes with a Unity3D engine integration, compatible with MiddleVR framework.

FUNCTIONAL DESCRIPTION: #FIVE contains software modules that can be interconnected and helps in building interactive and collaborative virtual environments. The user can focus on domain-specific aspects for his/her application (industrial training, medical training, etc) thanks to #FIVE's modules. These modules can be used in a vast range of domains using virtual reality applications and requiring interactive environments and collaboration, such as in training for example.

- Participants: Florian Nouviale, Valérie Gouranton, Bruno Arnaldi, Vincent Goupil, Carl-Johan Jorgensen, Emeric Goga, Adrien Reuzeau and Alexandre Audinot
- Contact: Valérie Gouranton
- Publication: #FIVE : High-Level Components for Developing Collaborative and Interactive Virtual Environments
- URL: https://bil.inria.fr/fr/software/view/2527/tab

6.2. #SEVEN

Sensor Effector Based Scenarios Model for Driving Collaborative Virtual Environments

KEYWORDS: Virtual reality - Interactive Scenarios - 3D interaction

SCIENTIFIC DESCRIPTION: #SEVEN (Sensor Effector Based Scenarios Model for Driving Collaborative Virtual Environments) is a model and an engine based on petri nets extended with sensors and effectors, enabling the description and execution of complex and interactive scenarios

FUNCTIONAL DESCRIPTION: #SEVEN enables the execution of complex scenarios for driving Virtual Reality applications. #SEVEN's scenarios are based on enhanced Petri net and state machine models which is able to describe and solve intricate event sequences. #SEVEN comes with an editor for creating, editing and remotely controlling and running scenarios. #SEVEN is implemented in C# and can be used as a stand-alone application or as a library. An integration to the Unity3D engine, compatible with MiddleVR, also exists.

RELEASE FUNCTIONAL DESCRIPTION: Adding state machine handling for scenario description in addition to the already existing petri net format. Improved scenario editor

- Participants: Florian Nouviale, Valérie Gouranton, Bruno Arnaldi, Vincent Goupil, Emeric Goga, Carl-Johan Jorgensen, Adrien Reuzeau and Alexandre Audinot
- Contact: Valérie Gouranton
- Publications: Versatile Scenario Guidance for Collaborative Virtual Environments - Roles in Collaborative Virtual Environments for Training - Actions sequencing incollaborative virtual environment - Short Paper: #SEVEN, a Sensor Effector Based Scenarios Model for Driving Collaborative Virtual Environment
- URL: https://bil.inria.fr/fr/software/view/2528/tab

6.3. OpenVIBE

KEYWORDS: Neurosciences - Interaction - Virtual reality - Health - Real time - Neurofeedback - Brain-Computer Interface - EEG - 3D interaction

FUNCTIONAL DESCRIPTION: OpenViBE is a free and open-source software platform devoted to the design, test and use of Brain-Computer Interfaces (BCI). The platform consists of a set of software modules that can be integrated easily and efficiently to design BCI applications. The key features of OpenViBE software are its modularity, its high-performance, its portability, its multiple-users facilities and its connection with high-end/VR displays. The designer of the platform enables to build complete scenarios based on existing software modules using a dedicated graphical language and a simple Graphical User Interface (GUI). This software is available on the Inria Forge under the terms of the AGPL licence, and it was officially released in June 2009. Since then, the OpenViBE software has already been downloaded more than 60000 times, and it is used by numerous laboratories, projects, or individuals worldwide. More information, downloads, tutorials, videos, documentations are available on the OpenViBE website.

- Participants: Cedric Riou, Thierry Gaugry, Anatole Lécuyer, Fabien Lotte, Jussi Tapio Lindgren, Laurent Bougrain, Maureen Clerc and Théodore Papadopoulo
- Partners: INSERM - GIPSA-Lab
- Contact: Anatole Lécuyer
- URL: http://openvibe.inria.fr

6.4. Platforms

6.4.1. Immerstar

- Participants: Florian Nouviale, Ronan Gaugne
- URL: http://www.irisa.fr/immersia/

With the two virtual reality technological platforms Immersia and Immermove, grouped under the name Immerstar, the team has access to high-level scientific facilities. This equipment benefits the research teams of the center and has allowed them to extend their local, national and international collaborations. The Immerstar platform was granted by an Inria funding for the 2015-2019 period which had enabled several important evolutions. In particular, in 2018, a haptic system covering the entire volume of the Immersia platform was installed, allowing various configurations from single haptic device usage to dual haptic devices usage with either one or two users. In addition, a motion platform designed to introduce motion feedback for powered wheelchair simulations has also been incorporated (see Figure 2).

We celebrated the twentieth anniversary of the Immersia platform in November 2019 by inaugurating the new haptic equipment. We proposed scientific presentations and received 150 participants, and visits for the support services in which we received 50 persons.

Immersia hosted and supported several projects and experiments during the year such as the Adapt [34], Sunset [2] or Introspect ([19], [29]) projects. Moreover, the platform was involved in the multidisciplinary project LSI led by the invited professor Franz Fischnaller from the Academy of Fine Arts of Torino. The project was implemented in Immersia with the support of the Immersia staff and deployed in the Ars Electronica center 3 .
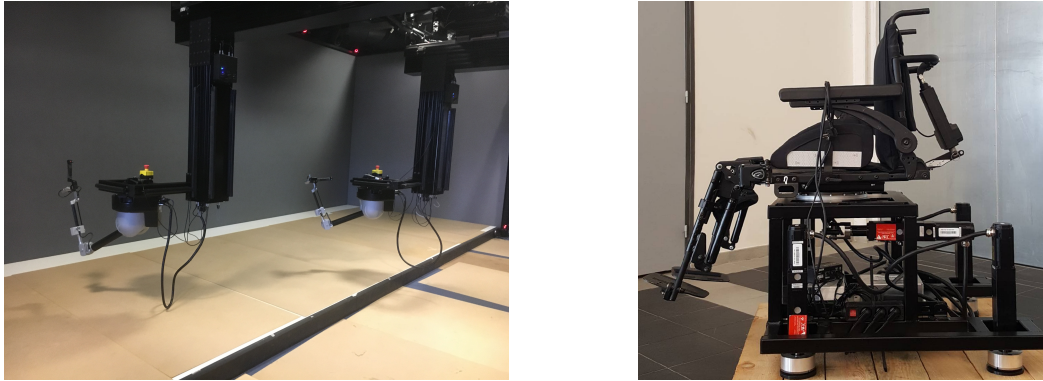
Figure 2. Immersia platform: (Left) "Scale-One" Haptic system for one or two users. (Right) Motion platform for a powered wheelchair simulation.

Figure 3. (Left) The LSI project in Immersia. (Right) The LSI project in Ars Electronica.

<p style="text-align: center; color: red;">**ILDA Project-Team**</p>

6. New Software and Platforms

6.1. Smarties

FUNCTIONAL DESCRIPTION: The Smarties system provides an easy way to add mobile interactive support to collaborative applications for wall displays.

It consists of (i) a mobile interface that runs on mobile devices for input, (ii) a communication protocol between the mobiles and the wall application, and (iii) libraries that implement the protocol and handle synchronization, locking and input conflicts. The library presents the input as an event loop with callback functions and handles all communication between mobiles and wall application. Developpers can customize the mobile interface from the wall application without modifying the mobile interface code.

On each mobile we find a set of cursor controllers associated with keyboards, widgets and clipboards. These controllers (pucks) can be shared by multiple collaborating users. They can control simple cursors on the wall application, or specific content (objects or groups of them). The developper can decide the types of widgets associated to pucks from the wall application side.

- Contact: Olivier Chapuis
- URL: http://smarties.lri.fr/

6.2. ZVTM

Zoomable Visual Transformation Machine

KEYWORDS: Big data - Visualization - Data visualization - Information visualization - Graph visualization

FUNCTIONAL DESCRIPTION: ZVTM is a toolkit enabling the implementation of multi-scale interfaces for interactively navigating in large datasets displayed as 2D graphics.

ZVTM is used for browsing large databases in multiple domains: geographical information systems, control rooms of complex facilitites, astronomy, power distribution systems.

The toolkit also enables the development of applications running on ultra-high-resolution wall-sized displays.

- Participants: Caroline Appert, Olivier Chapuis and Emmanuel Pietriga
- Contact: Emmanuel Pietriga
- Publications: Rapid Development of User Interfaces on Cluster-Driven Wall Displays with jBricks - A Toolkit for Addressing HCI Issues in Visual Language Environments
- URL: http://zvtm.sf.net

6.3. MapMosaic

KEYWORDS: Geo-visualization - Data visualization

SCIENTIFIC DESCRIPTION: GIS software applications and other mapping tools enable users to correlate data from multiple layers and gain insight from the resulting visualizations. However, most of these applications only feature basic, monolithic layer compositing techniques. These techniques do not always support users effectively in their tasks, as we observed during interviews with GIS experts. MapMosaic is a novel approach based on dynamic visual compositing that enables users to interactively create and manipulate local composites of multiple vector and raster map layers, taking into account the semantics and attribute values of objects and fields in the composit-ing process. We evaluated MapMosaic's interaction model against that of QGIS (a widely-used desktop GIS) and MAPublisher (a professional cartography tool) using the "Cognitive Dimensions" framework and through an analytical comparison, showing that MapMosaic's model is more flexible and can support users more effectively in their tasks.

FUNCTIONAL DESCRIPTION: MapMosaic is a novel approach to combine geographical layers based on dynamic visual compositing that enables users to interactively create and manipulate local composites of multiple vector and raster map layers. It takes into account the semantics and attribute values of objects and fields in the compositing process. MapMosaic aims at better supporting GIS users in their tasks such as correlating data from multiple layers and gaining insight from the resulting visualizations.

RELEASE FUNCTIONAL DESCRIPTION: First public release.

- Participants: Maria Jesus Lobo, Caroline Appert and Emmanuel Pietriga
- Contact: Emmanuel Pietriga
- Publications: MapMosaic: Dynamic Layer Compositing for Interactive Geovisualization - An Evaluation of Interactive Map Comparison Techniques
- URL: http://ilda.saclay.inria.fr/mapmuxing/mapmosaic/index.html

6.4. Baia

Before-and-after satellite image animation

KEYWORDS: Geo-visualization - 2D animation

SCIENTIFIC DESCRIPTION: Before-and-after image pairs show how entities in a given region have evolved over a specific period of time. Satellite images are a major source of such data, that capture how natural phenomena or human activity impact a geographical area. These images are used both for data analysis and to illustrate the resulting findings to diverse audiences. The simple techniques used to display them, including juxtaposing, swapping and monolithic blending, often fail to convey the underlying phenomenon in a meaningful manner. Baia is a framework to create advanced animated transitions, called animation plans, between before-and-after images. Baia relies on a pixel-based transition model that gives authors much expressive power, while keeping animations for common types of changes easy to create thanks to predefined animation primitives.

FUNCTIONAL DESCRIPTION: Baia is a framework to create advanced animated transitions, called animation plans, between before-and-after satellite images.

Before-and-after image pairs show how entities in a given region have evolved over a specific period of time. Satellite images are a major source of such data, that capture how natural phenomena or human activity impact a geographical area. These images are used both for data analysis and to illustrate the resulting findings to diverse audiences. The simple techniques used to display them, including juxtaposing, swapping and monolithic blending, often fail to convey the underlying phenomenon in a meaningful manner.

Baia relies on a pixel-based transition model that gives authors much expressive power. The animation editor enables authors to easily represent common types of changes thanks to predefined animation primitives and to sequence different changes across time.

RELEASE FUNCTIONAL DESCRIPTION: First public release

- Participants: Maria Jesus Lobo, Caroline Appert and Emmanuel Pietriga
- Contact: Emmanuel Pietriga
- Publication: Animation Plans for Before-and-After Satellite Images
- URL: http://ilda.saclay.inria.fr/mapmuxing/baia/index.html

6.5. LODAtlas

KEYWORDS: LOD - Linked open data - Semantic Web

SCIENTIFIC DESCRIPTION: The Web of Data is growing fast, as exemplified by the evolution of the Linked Open Data (LOD) cloud over the last ten years. One of the consequences of this growth is that it is becoming increasingly difficult for application developers and end-users to find the datasets that would be relevant to them. Semantic Web search engines, open data catalogs , datasets and frameworks such as LODStats and LOD Laundromat, are all useful but only give partial, even if complementary, views on what datasets are available on the Web. LODAtlas is a portal that enables users to find datasets of interest. Users can make different types of queries about both the datasets' metadata and contents, aggregated from multiple sources. They can then quickly evaluate the matching datasets' relevance, thanks to LODAtlas' summary visualizations of their general metadata, connections and contents.

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- Participants: Caroline Appert, Marie Destandau, Ioana Manolescu, François Goasdoué, Sejla Cebiric, Hande Ozaygen and Emmanuel Pietriga
- Contact: Emmanuel Pietriga
- Publication: Browsing Linked Data Catalogs with LODAtlas
- URL: http://lodatlas.lri.fr

6.6. TouchTokens

KEYWORDS: Tangible interface - HCI

SCIENTIFIC DESCRIPTION: TouchTokens make it possible to easily build interfaces that combine tangible and gestural input using passive tokens and a regular multi-touch surface. The tokens constrain users' grasp, and thus, the relative spatial configuration of fingers on the surface, theoretically making it possible to design algorithms that can recognize the resulting touch patterns. See associated scientific articles below.

FUNCTIONAL DESCRIPTION: TouchTokens allow interface designers to build low-cost tangible interfaces. The technique consists in recognizing multi-touch patterns that are associated with specific passive tokens. Those physical tokens can be made out of any material to get tracked on any touch-sensitive surface. Implementations of the recognizer (in both TUIO and Android) and vector descriptions of the tokens ready for 3D-printing or laser-cutting are available

- Participants: Caroline Appert, Rafael Morales Gonzalez, Emmanuel Pietriga and Gilles Bailly
- Contact: Caroline Appert
- Publications: TouchTokens: Guiding Touch Patterns with Passive Tokens - Passive yet Expressive TouchTokens - Custom-made Tangible Interfaces with TouchTokens
- URL: https://www.lri.fr/~appert/touchtokens/

6.7. Platforms
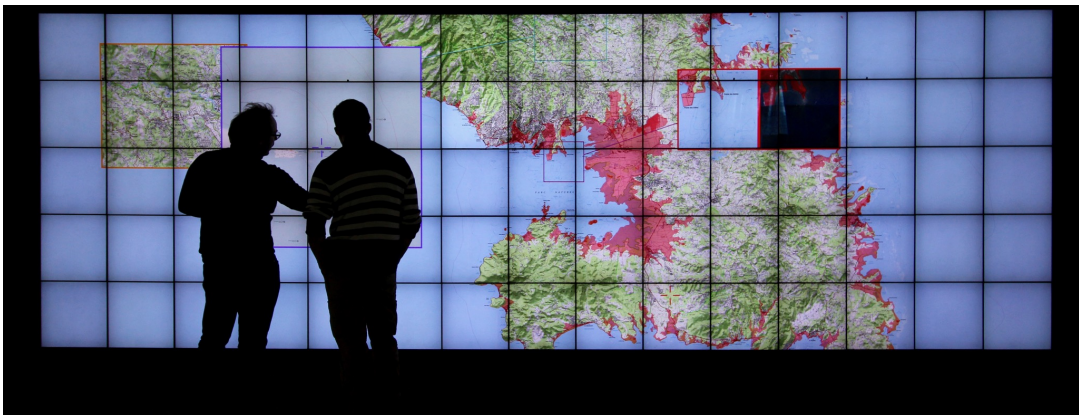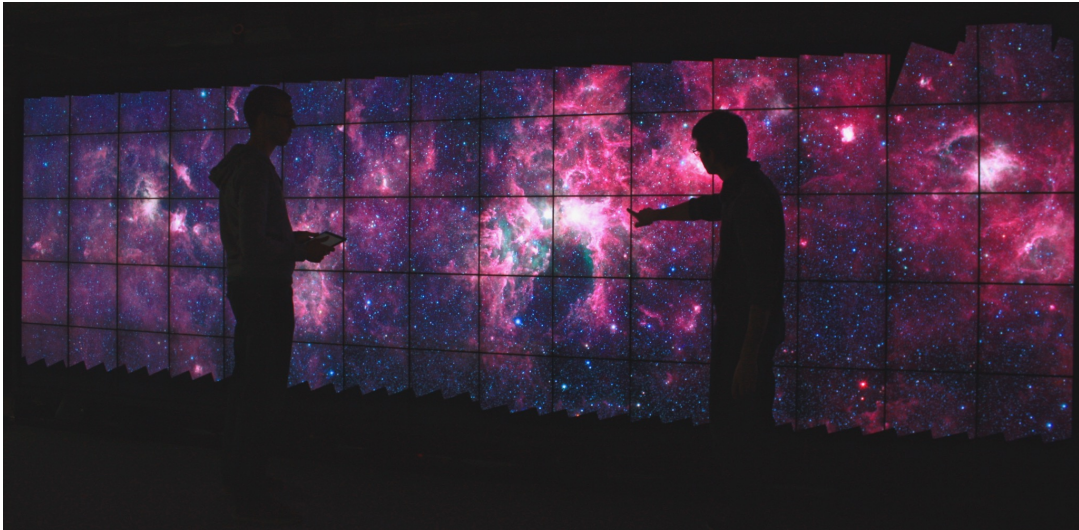
6.7.1. Platform: WILDER

Figure 2. Example application area for ultra-high-resolution wall-sized displays: geographical information systems, and astronomical data analysis.

Ultra-high-resolution wall-sized displays [31] feature a very high pixel density over a large physical surface. Such platforms have properties that make them well-suited to the visualization of very large datasets. They can represent the data with a high level of detail while at the same time retaining context: users can transition from an overview of the data to a detailed view simply by physically moving in front of the wall display. Wall displays also offer good support for collaborative work, enabling multiple users to simultaneously visualize and interact with the displayed data. To make them interactive, wall-sized displays are increasingly coupled with input devices such as touch frames, motion-tracking systems and wireless multitouch devices, in order to enable multi-device and multi-user interaction with the displayed data. Application areas for such visualization platforms range from the monitoring of complex infrastructures and crisis management situations to tools for the exploratory visualization of scientific data.

WILDER is the latest ultra-high-resolution wall-sized display set up at Inria Saclay, and is one of the nodes of the Digiscope EquipEx. We use this platform for multiple projects, both fundamental HCI research, and research and development activities for specific application areas such as geographical informations systems and astronomy (Figure 2).

<p style="text-align:center">**IMAGINE Project-Team**</p>

6. New Software and Platforms

6.1. MyCF

My Corporis Fabrica

KEYWORDS: 3D modeling - Simulation - Health - Ontologies - Anatomy - Patientspecific - Medical imaging

FUNCTIONAL DESCRIPTION: Knowledge-based 3D anatomical modeling using MyCF The MyCF software eases the creation of 3D anatomical models for visualization and mechanical simulation. As input, the user provides a list of anatomical entities or functions to simulate, using keywords or navigating in reference 3D model. As output, she gets a 3D model ready to visualize, or to simulate.

- Participants: Ali Hamadi Dicko, Federico Ulliana, François Faure and Olivier Palombi
- Partner: Université Joseph-Fourier
- Contact: Olivier Palombi

6.2. Kino AI

Artificial intelligence for cinematography

KEYWORDS: Video analysis - Post-production

FUNCTIONAL DESCRIPTION: Kino AI is an implementation of the method described in our patent "automatic generation of cinematographic rushes using video processing". Starting from a single ultra high definitiion (UltraHD) recording of a live performance, we track and recognize all actors present on stage and generate one or more rushes suitable for cinematographic editing of a movie.

- Partner: IIIT Hyderabad
- Contact: Rémi Ronfard
- Publications: Multi-Clip Video Editing from a Single Viewpoint - Zooming On All Actors: Automatic Focus+Context Split Screen Video Generation

6.3. Platforms

6.3.1. RUMBA

RUMBA is a next-generation 3D animation software targeted to professional animation studios, developed jointly by Mercenaries Engineering, TEAMTO and IMAGINE. Development was funded in part by FUI projects COLLODI 1 and COLLODI 2. RUMBA has been used in production by TEAMTO since 2017. We are using RUMBA as a platform for developing new algorithms in sketch-based animation, based on our previous work during Martin Guay's PhD thesis. This includes many improvements to allow those methods to work in a professional workflow.

6.3.2. Sky Engine

Sky Engine is a realtime game engine developped by Maxime Garcia as part of his PhD thesis, which incorporates several shape modleing and animation tools developed within the team. It is hoped that it will supersede Expressive as a platform for future integration of research results of the team involving real-time, story-driven shape modeling, animation and cinematography.

<p align="center" style="color:red">**LACODAM Project-Team**</p>

6. New Software and Platforms

6.1. REMI

Mining Intuitive Referring Expressions in Knowledge Bases

KEYWORDS: RDF - Knowledge database - Referring expression

FUNCTIONAL DESCRIPTION: REMI takes an RDF knowledge base stored as an HDT file, and a set of target entities and returns a referring expression that is intuitive, i.e., the user is likely to understand it.

- Contact: Luis Galarraga Del Prado
- URL: http://gitlab.inria.fr/lgalarra/remi

6.2. HIPAR

Hierarchical Interpretable Pattern-aided Regression

KEYWORDS: Regression - Pattern extraction

FUNCTIONAL DESCRIPTION: Given a (tabular) dataset with categorical and numerical attributes, HIPAR is a Python library that can extract accurate hybrid rules that offer a trade-off between (a) interpretability, (b) accuracy, and (c) data coverage.

- Contact: Luis Galarraga Del Prado
- URL: https://gitlab.inria.fr/opelgrin/hipar

6.3. PyChronicle

KEYWORDS: Sequence - Sequential patterns - Pattern matching

FUNCTIONAL DESCRIPTION: Python library containing classes for representing sequences and chronicles, ie a representation of a temporal pattern. It implements efficient recognition algorithms to match chronicles in a long sequence.

- Participant: Thomas Guyet
- Contact: Thomas Guyet
- Publication: Énumération des occurrences d'une chronique
- URL: https://gitlab.inria.fr/tguyet/pychronicles

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LARSEN Project-Team

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6. New Software and Platforms

6.1. ROS Qt Control

KEYWORDS: Control - Robot Operating System (ROS) - 2D

SCIENTIFIC DESCRIPTION: This ROS module allows to easily develop different controllers for wheeled mobile robots: Controller class just has to be inherited, the new class only needing a constructor and a chooseVelocities method. A graphical user interface using Qt makes it easy to choose a controller and to set its parameters, and it displays odometric data sent by ROS and the velocities sent to ROS by the controller.

NEWS OF THE YEAR: The code structure has been modified in order to propose a class hierarchy, with controllers aiming to reach a given state and others built to follow a selected trajectory.

- Participant: Alexis Scheuer
- Contact: Alexis Scheuer

6.2. ISeeML

Introducing a Smooth, Efficient and Easy-to-use Motion Library

KEYWORDS: Mobile Computing, Transportation - Optimal control - Planning

SCIENTIFIC DESCRIPTION: The main interest of this library is to offer smooth (continuous-curvature) efficient (close to the optimal) motions for mobile robots. Obtained paths correspond to locally optimal motions with constant velocity for wheeled mobile robots, either car-like or with differential-wheels (e.g. Thymio or Turtlebot). Classical paths (with a discontinuous curvature profile) are also provided. Both paths can also be used for aerial robots, as the motion constraints of those are similar to those of wheeled mobile robots.

RELEASE FUNCTIONAL DESCRIPTION: Additionnal functionnalities for optimal control using ROS.

NEWS OF THE YEAR: Additionnal functionnalities for optimal control using ROS.

- Participant: Alexis Scheuer
- Contact: Alexis Scheuer
- Publication: inria-00527913v1
- URL: http://iseeml.loria.fr

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LINKMEDIA Project-Team

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6. New Software and Platforms

6.1. Lookinlabs-Global

KEYWORD: Search Engine

FUNCTIONAL DESCRIPTION: Lookinlabs allows you to find, among teams/individuals/publications, those best matching your query.

- Authors: William Kokou Dedzoe and Jean Hany
- Contact: Vincent Claveau

6.2. TagEx

Yet another Part-of-Speech Tagger for French

KEYWORD: Natural language processing

FUNCTIONAL DESCRIPTION: TagEx is available as a web-service on https://allgo.inria.fr . Refer to Allgo for its usage.

- Contact: Vincent Claveau
- URL: https://allgo.inria.fr/app/tagex

6.3. NegDetect

Negation Detection

KEYWORD: Natural language processing

FUNCTIONAL DESCRIPTION: NegDetect relies on several layers of machine learning techniques (CRF, neural networks).

- Contact: Vincent Claveau

LINKS Project-Team

6. New Software and Platforms

6.1. ShEx validator

Validation of Shape Expression schemas

KEYWORDS: Data management - RDF

FUNCTIONAL DESCRIPTION: Shape Expression schemas is a formalism for defining constraints on RDF graphs. This software allows to check whether a graph satisfies a Shape Expressions schema.

RELEASE FUNCTIONAL DESCRIPTION: ShExJava now uses the Commons RDF API and so support RDF4J, Jena, JSON-LD-Java, OWL API and Apache Clerezza. It can parse ShEx schema in the ShEcC, ShEJ, ShExR formats and can serialize a schema in ShExJ.

To validate data against a ShExSchema using ShExJava, you have two different algorithms: - the refine algorithm: compute once and for all the typing for the whole graph - the recursive algorithm: compute only the typing required to answer a validate(node,ShapeLabel) call and forget the results.

- Contact: Iovka Boneva
- URL: http://shexjava.lille.inria.fr/

6.2. gMark

gMark: schema-driven graph and query generation

KEYWORDS: Semantic Web - Data base

FUNCTIONAL DESCRIPTION: gMark allow the generation of graph databases and an associated set of query from a schema of the graph.gMark is based on the following principles: - great flexibility in the schema definition - ability to generate big size graphs - ability to generate recursive queries - ability to generate queries with a desired selectivity

- Contact: Aurélien Lemay
- URL: https://github.com/graphMark/gmark

6.3. SmartHal

KEYWORD: Bibliography

FUNCTIONAL DESCRIPTION: SmartHal is a better tool for querying the HAL bibliography database, while is based on Haltool queries. The idea is that a Haltool query returns an XML document that can be queried further. In order to do so, SmartHal provides a new query language. Its queries are conjunctions of Haltool queries (for a list of laboratories or authors) with expressive Boolean queries by which answers of Haltool queries can be refined. These Boolean refinement queries are automatically translated to XQuery and executed by Saxon. A java application for extraction from the command line is available. On top of this, we have build a tool for producing the citation lists for the evaluation report of the LIFL, which can be easily adapter to other Labs.

- Contact: Joachim Niehren
- URL: http://smarthal.lille.inria.fr/

6.4. QuiXPath

KEYWORDS: XML - NoSQL - Data stream

SCIENTIFIC DESCRIPTION: The QuiXPath tools supports a very large fragment of XPath 3.0. The QuiXPath library provides a compiler from QuiXPath to FXP, which is a library for querying XML streams with a fragment of temporal logic.

FUNCTIONAL DESCRIPTION: QuiXPath is a streaming implementation of XPath 3.0. It can query large XML files without loading the entire file in main memory, while selecting nodes as early as possible.

- Contact: Joachim Niehren
- URL: https://project.inria.fr/quix-tool-suite/

6.5. X-FUN

KEYWORDS: Programming language - Compilers - Functional programming - Transformation - XML

FUNCTIONAL DESCRIPTION: X-FUN is a core language for implementing various XML, standards in a uniform manner. X-Fun is a higher-order functional programming language for transforming data trees based on node selection queries.

- Participants: Joachim Niehren and Pavel Labath
- Contact: Joachim Niehren

6.6. ShapeDesigner

KEYWORDS: Validation - Data Exploration - Verification

FUNCTIONAL DESCRIPTION: ShapeDesigner allows construct a ShEx or SHACL schema for an existing dataset. It combines algorithms to analyse the data and automatically extract shape constraints, and to edit and validate shape schemas.

- Contact: Jeremie Dusart
- URL: https://gitlab.inria.fr/jdusart/shexjapp

LOKI Project-Team

6. New Software and Platforms

6.1. Polyphony

KEYWORDS: Human Computer Interaction - Toolkit - Engineering of Interactive Systems

FUNCTIONAL DESCRIPTION: Polyphony is an experimental toolkit demonstrating the use of Entity-Component-System (ECS) to design Graphical User Interfaces (GUI). It also extends the original ECS model to support advanced interfaces.

NEWS OF THE YEAR: Design and implementation of a first version of the toolkit and associated examples as a proof of concept.

- Participants: Thibault Raffaillac and Stéphane Huot
- Contact: Stéphane Huot
- Publications: Applying the Entity-Component-System Model to Interaction Programming - Polyphony: Programming Interfaces and Interactions with the Entity-Component-System Model
- URL: https://gitlab.inria.fr/Loki/PolyphonyECS

6.2. Esquisse

KEYWORDS: Vector graphics - 3D interaction - Human Computer Interaction

SCIENTIFIC DESCRIPTION: Trace figures are contour drawings of people and objects that capture the essence of scenes without the visual noise of photos or other visual representations. Their focus and clarity make them ideal representations to illustrate designs or interaction techniques. In practice, creating those figures is a tedious task requiring advanced skills, even when creating the figures by tracing outlines based on photos. To mediate the process of creating trace figures, we introduce the open-source tool Esquisse. Informed by our taxonomy of 124 trace figures, Esquisse provides an innovative 3D model staging workflow, with specific interaction techniques that facilitate 3D staging through kinematic manipulation, anchor points and posture tracking. Our rendering algorithm (including stroboscopic rendering effects) creates vector-based trace figures of 3D scenes. We validated Esquisse with an experiment where participants created trace figures illustrating interaction techniques, and results show that participants quickly managed to use and appropriate the tool.

FUNCTIONAL DESCRIPTION: Esquisse is an add-on for Blender that can be used to rapidly produce trace figures. It relies on a 3D model staging workflow, with specific interaction techniques that facilitate the staging through kinematic manipulation, anchor points and posture tracking. Staged 3D scenes can be exported to SVG thanks to Esquisse's dedicated rendering algorithm.

NEWS OF THE YEAR: First version of Esquisse, implementing both staging and vector rendering.

- Contact: Sylvain Malacria
- Publication: Esquisse: Using 3D Models Staging to Facilitate the Creation of Vector-based Trace Figures
- URL: https://github.com/LokiResearch/Esquisse

6.3. RayCursor

Source code for the pointing technique RayCursor

KEYWORDS: Virtual reality - Interaction technique

FUNCTIONAL DESCRIPTION: This is a Unity Project containing the source code and prefab for the pointing technique RayCursor to be easily integrated in other Unity Projects.

- Contact: Géry Casiez
- Publications: RayCursor: a 3D Pointing Facilitation Technique based on Raycasting - Improving Raycasting using Proximity Selection and Filtering
- URL: http://ns.inria.fr/loki/raycursor/

MAGNET Project-Team

6. New Software and Platforms

6.1. CoRTeX

Python library for noun phrase COreference Resolution in natural language TEXts

KEYWORD: Natural language processing

FUNCTIONAL DESCRIPTION: CoRTex is a LGPL-licensed Python library for Noun Phrase coreference resolution in natural language texts. This library contains implementations of various state-of-the-art coreference resolution algorithms, including those developed in our research. In addition, it provides a set of APIs and utilities for text pre-processing, reading the CONLL2012 and CONLLU annotation formats, and performing evaluation, notably based on the main evaluation metrics (MUC, B-CUBED, and CEAF). As such, CoRTex provides benchmarks for researchers working on coreference resolution, but it is also of interest for developers who want to integrate a coreference resolution within a larger platform. It currently supports use of the English or French language.

- Participant: Pascal Denis
- Partner: Orange Labs
- Contact: Pascal Denis
- URL: https://gitlab.inria.fr/magnet/CoRTeX

6.2. Mangoes

MAgnet liNGuistic wOrd vEctorS

KEYWORDS: Word embeddings - NLP

FUNCTIONAL DESCRIPTION: Process textual data and compute vocabularies and co-occurrence matrices. Input data should be raw text or annotated text. Compute word embeddings with different state-of-the art unsupervised methods. Propose statistical and intrinsic evaluation methods, as well as some visualization tools.

- Contact: Nathalie Vauquier
- URL: https://gitlab.inria.fr/magnet/mangoes

6.3. metric-learn

KEYWORDS: Machine learning - Python - Metric learning

FUNCTIONAL DESCRIPTION: Distance metrics are widely used in the machine learning literature. Traditionally, practicioners would choose a standard distance metric (Euclidean, City-Block, Cosine, etc.) using a priori knowledge of the domain. Distance metric learning (or simply, metric learning) is the sub-field of machine learning dedicated to automatically constructing optimal distance metrics.

This package contains efficient Python implementations of several popular metric learning algorithms.

- Partner: Parietal
- Contact: Aurélien Bellet
- URL: https://github.com/scikit-learn-contrib/metric-learn

6.4. MyLocalInfo

KEYWORDS: Privacy - Machine learning - Statistics

FUNCTIONAL DESCRIPTION: Decentralized algorithms for machine learning and inference tasks which (1) perform as much computation as possible locally and (2) ensure privacy and security by avoiding personal data leaves devices.

- Contact: Nathalie Vauquier
- URL: https://gitlab.inria.fr/magnet/mylocalinfo

MAGRIT Team

6. New Software and Platforms

6.1. PoLAR

Portable Library for Augmented Reality

FUNCTIONAL DESCRIPTION: PoLAR (Portable Library for Augmented Reality) is a framework which aims to help creating graphical applications for augmented reality, image visualization and medical imaging. PoLAR was designed to offer powerful visualization functionalities without the need to be a specialist in Computer Graphics. The framework provides an API to state-of-the-art libraries: Qt to build GUIs and OpenSceneGraph for high-end visualization, for researchers and engineers with a background in Computer Vision to be able to create beautiful AR applications, with little programming effort. The framework is written in C++ and published under the GNU GPL license

- Contact: Erwan Kerrien
- URL: http://polar.inria.fr

6.2. Fast>VP

KEYWORDS: Vanishing points - Image rectification

FUNCTIONAL DESCRIPTION: Fast>VP is a fast and effective tool to detect vanishing points in uncalibrated images of urban or indoor scenes.

This tool also allows automatic rectification of the vertical planes in the scene, namely generating images where these planes appear as if they were observed from a fronto-parallel view.

It is the Matlab implementation of the algorithm described in [5].

- Contact: Gilles Simon
- URL: https://members.loria.fr/GSimon/fastvp/

6.3. NoLoDuDoCT

A non-local dual-domain cartoon and texture decomposition

KEYWORDS: Image analysis - Cartoon and texture decomposition

FUNCTIONAL DESCRIPTION: This is an algorithm decomposing images into cartoon and texture components. Spectrum components of textures are detected on the basis of a statistical hypothesis test, the null hypothesis modeling a purely cartoon patch. Statistics are estimated in a non-local way.

- Contact: Frédéric Sur
- Publication: A non-local dual-domain approach to cartoon and texture decomposition
- URL: https://members.loria.fr/FSur/software/NoLoDuDoCT/

6.4. TheGridMethod

The grid method toolbox

KEYWORD: Experimental mechanics

FUNCTIONAL DESCRIPTION: This Matlab toolbox implements several efficient and state-of-the art algorithms to estimate displacement and strain fields from grid images deposited on the surface of a specimen submitted to mechanical testing.

NEWS OF THE YEAR: Informal contacts told us that this library is used in academia and industry.

- Contact: Frédéric Sur
- Publication: The grid method for in-plane displacement and strain measurement: a review and analysis
- URL: http://www.thegridmethod.net/

6.5. BSpeckleRender

A Boolean model for deformed speckle rendering

KEYWORDS: Boolean model - Monte Carlo estimation - Experimental mechanics - Displacement fields

FUNCTIONAL DESCRIPTION: This library implements a new method for synthesizing speckle images deformed by an arbitrary deformation field set by the user. Such images are very useful for assessing the different methods based on digital image correlation (DIC) for estimating displacement fields in experimental mechanics. Since the deformations are very small, it is necessary to ensure that no additional bias is introduced by the image synthesis algorithm. The proposed method is based on the Monte Carlo evaluation of images generated by a Boolean model.

- Contact: Frédéric Sur
- Publication: Rendering Deformed Speckle Images with a Boolean Model
- URL: https://members.loria.fr/FSur/software/BSpeckleRender/

<p align="center" style="color:red">MANAO Project-Team</p>

6. New Software and Platforms

6.1. Eigen

KEYWORD: Linear algebra

FUNCTIONAL DESCRIPTION: Eigen is an efficient and versatile C++ mathematical template library for linear algebra and related algorithms. In particular it provides fixed and dynamic size matrices and vectors, matrix decompositions (LU, LLT, LDLT, QR, eigenvalues, etc.), sparse matrices with iterative and direct solvers, some basic geometry features (transformations, quaternions, axis-angles, Euler angles, hyperplanes, lines, etc.), some non-linear solvers, automatic differentiations, etc. Thanks to expression templates, Eigen provides a very powerful and easy to use API. Explicit vectorization is performed for the SSE, AltiVec and ARM NEON instruction sets, with graceful fallback to non-vectorized code. Expression templates allow to perform global expression optimizations, and to remove unnecessary temporary objects.

RELEASE FUNCTIONAL DESCRIPTION: In 2017, we released three revisions of the 3.3 branch with few fixes of compilation and performance regressions, some doxygen documentation improvements, and the addition of transpose, adjoint, conjugate methods to SelfAdjointView to ease writing generic code.

- Participant: Gaël Guennebaud
- Contact: Gaël Guennebaud
- URL: http://eigen.tuxfamily.org/

6.2. Spectral Viewer

KEYWORD: Image

FUNCTIONAL DESCRIPTION: An open-source (spectral) image viewer that supports several images formats: ENVI (spectral), exr, png, jpg.

- Partner: LP2N (CNRS - UMR 5298)
- Contact: Romain Pacanowski
- URL: https://adufay.gitlabpages.inria.fr/SpectralViewer/index.html

6.3. otmap

C++ optimal transport solver on 2D grids

KEYWORDS: Optimal transportation - Eigen - C++ - Image processing - Numerical solver

FUNCTIONAL DESCRIPTION: This is a lightweight implementation of "Instant Transport Maps on 2D Grids".

It currently supports L2-optimal maps from an arbitrary density defined on a uniform 2D grid (aka an image) to a square with uniform density. Inverse maps and maps between pairs of arbitrary images are then recovered through numerical inversion and composition resulting in density preserving but approximately optimal maps.

This code also includes with 3 mini applications:

- otmap: computes the forward and backward maps between one image and a uniform square or between a pair of images. The maps are exported as .off quad meshes. - stippling: adapt a uniformly distributed point cloud to a given image. - barycenters: computes linear (resp. bilinear) approximate Wasserstein barycenters between a pair (resp. four) images.

- Contact: Gaël Guennebaud

MAVERICK Project-Team

5. New Software and Platforms

5.1. GRATIN

FUNCTIONAL DESCRIPTION: Gratin is a node-based compositing software for creating, manipulating and animating 2D and 3D data. It uses an internal direct acyclic multi-graph and provides an intuitive user interface that allows to quickly design complex prototypes. Gratin has several properties that make it useful for researchers and students. (1) it works in real-time: everything is executed on the GPU, using OpenGL, GLSL and/or Cuda. (2) it is easily programmable: users can directly write GLSL scripts inside the interface, or create new C++ plugins that will be loaded as new nodes in the software. (3) all the parameters can be animated using keyframe curves to generate videos and demos. (4) the system allows to easily exchange nodes, group of nodes or full pipelines between people.

- Participants: Pascal Barla and Romain Vergne
- Partner: UJF
- Contact: Romain Vergne
- URL: http://gratin.gforge.inria.fr/

5.2. HQR

High Quality Renderer

KEYWORDS: Lighting simulation - Materials - Plug-in

FUNCTIONAL DESCRIPTION: HQR is a global lighting simulation platform. HQR software is based on the photon mapping method which is capable of solving the light balance equation and of giving a high quality solution. Through a graphical user interface, it reads X3D scenes using the X3DToolKit package developed at Maverick, it allows the user to tune several parameters, computes photon maps, and reconstructs information to obtain a high quality solution. HQR also accepts plugins which considerably eases the developpement of new algorithms for global illumination, those benefiting from the existing algorithms for handling materials, geometry and light sources.

- Participant: Cyril Soler
- Contact: Cyril Soler
- URL: http://artis.imag.fr/~Cyril.Soler/HQR

5.3. libylm

LibYLM

KEYWORD: Spherical harmonics

FUNCTIONAL DESCRIPTION: This library implements spherical and zonal harmonics. It provides the means to perform decompositions, manipulate spherical harmonic distributions and provides its own viewer to visualize spherical harmonic distributions.

- Author: Cyril Soler
- Contact: Cyril Soler
- URL: https://launchpad.net/~csoler-users/+archive/ubuntu/ylm

5.4. ShwarpIt

KEYWORD: Warping

FUNCTIONAL DESCRIPTION: ShwarpIt is a simple mobile app that allows you to manipulate the perception of shapes in images. Slide the ShwarpIt slider to the right to make shapes appear rounder. Slide it to the left to make shapes appear more flat. The Scale slider gives you control on the scale of the warping deformation.

- Contact: Georges-Pierre Bonneau
- URL: http://bonneau.meylan.free.fr/ShwarpIt/ShwarpIt.html

5.5. Vrender

KEYWORDS: 3D - Vector graphics

FUNCTIONAL DESCRIPTION: The VRender library is a simple tool to render the content of an OpenGL window to a vectorial device such as Postscript, XFig, and soon SVG. The main usage of such a library is to make clean vectorial drawings for publications, books, etc.

In practice, VRender replaces the z-buffer based hidden surface removal of OpenGL by sorting the geometric primitives so that they can be rendered in a back-to-front order, possibly cutting them into pieces to solve cycles.

VRender is also responsible for the vectorial snapshot feature of the QGLViewer library.

- Participant: Cyril Soler
- Contact: Cyril Soler
- URL: http://maverick.inria.fr/Software/VRender/

5.6. X3D TOOLKIT

X3D Development pateform

KEYWORDS: X3D - Geometric modeling

FUNCTIONAL DESCRIPTION: X3DToolkit is a library to parse and write X3D files, that supports plugins and extensions.

- Participants: Gilles Debunne and Yannick Le Goc
- Contact: Cyril Soler
- URL: http://maverick.inria.fr/Software/X3D/

5.7. PLANTRAD

KEYWORDS: Bioinformatics - Biology

FUNCTIONAL DESCRIPTION: PlantRad is a software program for computing solutions to the equation of light equilibrium in a complex scene including vegetation. The technology used is hierarchical radiosity with clustering and instantiation. Thanks to the latter, PlantRad is capable of treating scenes with a very high geometric complexity (up to millions of polygons) such as plants or any kind of vegetation scene where a high degree of approximate self-similarity permits a significant gain in memory requirements.

- Participants: Cyril Soler, François Sillion and George Drettakis
- Contact: Cyril Soler

MFX Project-Team

6. New Software and Platforms

6.1. Chill

Chill, node-based graphical interface for IceSL

KEYWORDS: 3D - Additive manufacturing

SCIENTIFIC DESCRIPTION: ChiLL is an effort to explore visual modeling tools for IceSL. The core idea behind Chill is to propose a node-based modeling interface, which is a popular way to facilitate the design of 3D objects without going directly through code. Our approach creates a bridge between nodes-based editing and scripting, as the syntax for creating a new node is identical to the scripting language used in IceSL.

FUNCTIONAL DESCRIPTION: In Chill a user creates 3D shapes by connecting various nodes arranged in a directed graph. The shape visualization is updated instantly as the graph is modified.

NEWS OF THE YEAR: Chill was publicly released during the summer of 2019. We will broadly communicate about it in 2020.

- Participants: Jimmy Etienne, Pierre Bedell, Thibault Tricard, Yamil Salim Perchy and Sylvain Lefebvre
- Contact: Sylvain Lefebvre

6.2. IceSL

KEYWORD: Additive manufacturing

SCIENTIFIC DESCRIPTION: IceSL is the software developed within MFX, that serves as a research platform, a showcase of our research results, a test bed for comparisons and a vector of collaborations with both academic and industry partners. The software is freely available both as a desktop (Windows/Linux) and an online version.

FUNCTIONAL DESCRIPTION: IceSL allows users to model complex shapes through CSG boolean operations. Objects can be directly prepared and sent to a 3d printer for fabrication, without the need to compute an intermediate 3D mesh.

NEWS OF THE YEAR: In 2019, IceSL has been featured in news, exhibitions and fairs as a well-established tool for 3D printing. Additionally, since its inception, IceSL's community has grown significantly together with the number of new features included in it for slicing and modeling.

Regarding new features and additions to the software in 2019, IceSL has gone through many changes, primarily focused on improving the user experience and scalability/stability of algorithms. The most visible change is the complete rework of the slicing parameters GUI, with the addition of category-icons to allow for a quick access to settings. We can also note the upgrade of the renderer to support wide and high resolution screens, and the possibility to choose an experimental renderer (based on HCSG, published last year).

On the slicing front, we added new features, long requested, from the community: ironing, automatic spiralization, selection of different nozzle diameters, minimum time per layer, etc. A new GUI to customize the supports points was also added to help with the generation of supports.

The social community of IceSL has been growing steadily. Our twitter account has around 338 followers, 187 users frequently interacting in its Google forum (respectively, a progress of 69% and 25% since last year). Downloads have increased by 78% from last year (55K downloads total). In addition, Slicecrafter, the online version, has a cumulative of around 15K sliced objects.

- Participants: Frédéric Claux, Jean Hergel, Jérémie Dumas, Jonas Martinez-Bayona, Samuel Hornus, Sylvain Lefebvre, Pierre Bedell, Cédric Zanni, Noemie Vennin, Thibault Tricard, Jimmy Etienne, Yamil Salim Perchy and Pierre-Alexandre Hugron
- Contact: Sylvain Lefebvre
- URL: https://icesl.loria.fr

6.3. Platforms

Participants: Pierre Bedell, Noémie Vennin, Pierre-Alexandre Hugron.

We continued our active participation within the Creativ'Lab, a common experimental platform funded by Inria, Loria, CNRS and Région Grand Est. We added novel machines (DLP resin printers and large format printers) to explore new problems related to the specificity of each technology. We are also in the process of revisiting some of our techniques in the context of resin 3D printing.

This year we kept developing our custom-made hardware, in particular our color filament 3D printers. In this context we also elaborated our own colored PLA filament (using a filament extrusion device, PLA pellets and pigments). This was instrumental to the success of the corresponding research [15]. Finally, we started the assembly of a 3D printer based on a robotic arm, in the context of our research on curved 3D printing.

We are making these installations available to industrial partners and other research teams.

MIMETIC Project-Team

6. New Software and Platforms

6.1. AsymGait

Asymmetry index for clinical gait analysis based on depth images

KEYWORDS: Motion analysis - Kinect - Clinical analysis

SCIENTIFIC DESCRIPTION: The system uses depth images delivered by the Microsoft Kinect to retrieve the gait cycles first. To this end it is based on a analyzing the knees trajectories instead of the feet to obtain more robust gait event detection. Based on these cycles, the system computes a mean gait cycle model to decrease the effect of noise of the system. Asymmetry is then computed at each frame of the gait cycle as the spatial difference between the left and right parts of the body. This information is computed for each frame of the cycle.

FUNCTIONAL DESCRIPTION: AsymGait is a software package that works with Microsoft Kinect data, especially depth images, in order to carry-out clinical gait analysis. First it identifies the main gait events using the depth information (footstrike, toe-off) to isolate gait cycles. Then it computes a continuous asymmetry index within the gait cycle. Asymmetry is viewed as a spatial difference between the two sides of the body.

- Participants: Edouard Auvinet and Franck Multon
- Contact: Franck Multon

6.2. Cinematic Viewpoint Generator

KEYWORD: 3D animation

FUNCTIONAL DESCRIPTION: The software, developed as an API, provides a mean to automatically compute a collection of viewpoints over one or two specified geometric entities, in a given 3D scene, at a given time. These viewpoints satisfy classical cinematographic framing conventions and guidelines including different shot scales (from extreme long shot to extreme close-up), different shot angles (internal, external, parallel, apex), and different screen compositions (thirds,fifths, symmetric of di-symmetric). The viewpoints allow to cover the range of possible framings for the specified entities. The computation of such viewpoints relies on a database of framings that are dynamically adapted to the 3D scene by using a manifold parametric representation and guarantee the visibility of the specified entities. The set of viewpoints is also automatically annotated with cinematographic tags such as shot scales, angles, compositions, relative placement of entities, line of interest.

- Participants: Christophe Lino, Emmanuel Badier and Marc Christie
- Partners: Université d'Udine - Université de Nantes
- Contact: Marc Christie

6.3. Directors Lens Motion Builder

KEYWORDS: Previzualisation - Virtual camera - 3D animation

FUNCTIONAL DESCRIPTION: Directors Lens Motion Builder is a software plugin for Autodesk's Motion Builder animation tool. This plugin features a novel workflow to rapidly prototype cinematographic sequences in a 3D scene, and is dedicated to the 3D animation and movie previsualization industries. The workflow integrates the automated computation of viewpoints (using the Cinematic Viewpoint Generator) to interactively explore different framings of the scene, proposes means to interactively control framings in the image space, and proposes a technique to automatically retarget a camera trajectory from one scene to another while enforcing visual properties. The tool also proposes to edit the cinematographic sequence and export the animation. The software can be linked to different virtual camera systems available on the market.

- Participants: Christophe Lino, Emmanuel Badier and Marc Christie
- Partner: Université de Rennes 1
- Contact: Marc Christie

6.4. Kimea

Kinect IMprovement for Egronomics Assessment

KEYWORDS: Biomechanics - Motion analysis - Kinect

SCIENTIFIC DESCRIPTION: Kimea consists in correcting skeleton data delivered by a Microsoft Kinect in an ergonomics purpose. Kimea is able to manage most of the occlultations that can occur in real working situation, on workstations. To this end, Kimea relies on a database of examples/poses organized as a graph, in order to replace unreliable body segments reconstruction by poses that have already been measured on real subject. The potential pose candidates are used in an optimization framework.

FUNCTIONAL DESCRIPTION: Kimea gets Kinect data as input data (skeleton data) and correct most of measurement errors to carry-out ergonomic assessment at workstation.

- Participants: Franck Multon, Hubert Shum and Pierre Plantard
- Partner: Faurecia
- Contact: Franck Multon
- Publications: hal-01612939v1 - hal-01393066v1 - hal-01332716v1 - hal-01332711v2 - hal-01095084v1

6.5. Populate

KEYWORDS: Behavior modeling - Agent - Scheduling

SCIENTIFIC DESCRIPTION: The software provides the following functionalities:

- A high level XML dialect that is dedicated to the description of agents activities in terms of tasks and sub activities that can be combined with different kind of operators: sequential, without order, interlaced. This dialect also enables the description of time and location constraints associated to tasks.

- An XML dialect that enables the description of agent's personal characteristics.

- An informed graph describes the topology of the environment as well as the locations where tasks can be performed. A bridge between TopoPlan and Populate has also been designed. It provides an automatic analysis of an informed 3D environment that is used to generate an informed graph compatible with Populate.

- The generation of a valid task schedule based on the previously mentioned descriptions.

With a good configuration of agents characteristics (based on statistics), we demonstrated that tasks schedules produced by Populate are representative of human ones. In conjunction with TopoPlan, it has been used to populate a district of Paris as well as imaginary cities with several thousands of pedestrians navigating in real time.

FUNCTIONAL DESCRIPTION: Populate is a toolkit dedicated to task scheduling under time and space constraints in the field of behavioral animation. It is currently used to populate virtual cities with pedestrian performing different kind of activities implying travels between different locations. However the generic aspect of the algorithm and underlying representations enable its use in a wide range of applications that need to link activity, time and space. The main scheduling algorithm relies on the following inputs: an informed environment description, an activity an agent needs to perform and individual characteristics of this agent. The algorithm produces a valid task schedule compatible with time and spatial constraints imposed by the activity description and the environment. In this task schedule, time intervals relating to travel and task fulfillment are identified and locations where tasks should be performed are automatically selected.

- Participants: Carl-Johan Jorgensen and Fabrice Lamarche
- Contact: Fabrice Lamarche

6.6. The Theater

KEYWORDS: 3D animation - Interactive Scenarios

FUNCTIONAL DESCRIPTION: The Theater is a software framework to develop interactive scenarios in virtual 3D environements. The framework provides means to author and orchestrate 3D character behaviors and simulate them in real-time. The tools provides a basis to build a range of 3D applications, from simple simulations with reactive behaviors, to complex storytelling applications including narrative mechanisms such as flashbacks.

- Participant: Marc Christie
- Contact: Marc Christie

6.7. CusToM

Customizable Toolbox for Musculoskeletal simulation

KEYWORDS: Biomechanics - Dynamic Analysis - Kinematics - Simulation - Mechanical multi-body systems

SCIENTIFIC DESCRIPTION: The present toolbox aims at performing a motion analysis thanks to an inverse dynamics method.

Before performing motion analysis steps, a musculoskeletal model is generated. Its consists of, first, generating the desire anthropometric model thanks to models libraries. The generated model is then kinematical calibrated by using data of a motion capture. The inverse kinematics step, the inverse dynamics step and the muscle forces estimation step are then successively performed from motion capture and external forces data. Two folders and one script are available on the toolbox root. The Main script collects all the different functions of the motion analysis pipeline. The Functions folder contains all functions used in the toolbox. It is necessary to add this folder and all the subfolders to the Matlab path. The Problems folder is used to contain the different study. The user has to create one subfolder for each new study. Once a new musculoskeletal model is used, a new study is necessary. Different files will be automaticaly generated and saved in this folder. All files located on its root are related to the model and are valuable whatever the motion considered. A new folder will be added for each new motion capture. All files located on a folder are only related to this considered motion.

FUNCTIONAL DESCRIPTION: Inverse kinematics Inverse dynamics Muscle forces estimation External forces prediction

- Participants: Antoine Muller, Charles Pontonnier, Georges Dumont, Pierre Puchaud, Anthony Sorel, Claire Livet and Louise Demestre
- Contact: Charles Pontonnier
- Publications: Motion-based prediction of external forces and moments and back loading during manual material handling tasks - A case study with custom : a comparison of normal and altered gait with an ankle brace - Motion-based prediction of hands and feet contact efforts during asymmetric handling tasks - MusIC method enhancement by a sensitivity study of its performance: application to a lower limbs musculoskeletal model - Ground Reaction Forces and Moments Prediction of Challenging Motions: Fencing Lunges - CusToM: a Matlab toolbox for musculoskeletal simulation - The MusIC method: a fast and quasi-optimal solution to the muscle forces estimation problem

6.8. Immerstar Platform

Participants: Georges Dumont [contact], Ronan Gaugne, Anthony Sorel, Richard Kulpa.

With the two platforms of virtual reality, Immersia (http://www.irisa.fr/immersia/) and Immermove (http://m2slab.com/index.php/facilities-4/), grouped under the name Immerstar, the team has access to high level scientific facilities. This equipment benefits the research teams of the center and has allowed them to extend their local, national and international collaborations. The Immerstar platform is granted by a Inria CPER funding for 2015-2019 that enables important evolutions of the equipment. In 2016, the first technical evolutions have been decided and, in 2017, these evolutions have been implemented. On one side, for Immermove, the addition of a third face to the immersive space, and the extension of the Vicon tracking system have been realized and continued this year with 23 new cameras. And, on the second side, for Immersia, the installation of WQXGA laser projectors with augmented global resolution, of a new tracking system with

higher frequency and of new computers for simulation and image generation in 2017. In 2018, a Scale One haptic device has been installed. It allows, as in the CPER proposal, one or two handed haptic feedback in the full space covered by Immersia and possibility of carrying the user.

We celebrated the twentieth anniversary of the Immersia platform in November 2019 by inaugurating the new haptic equipment. We proposed scientific presentations and received 150 participants, and visits for support services where we received 50 persons.

MOEX Project-Team

5. New Software and Platforms

5.1. Lazylav

Lazy lavender

KEYWORDS: Reproducibility - Multi-agent - Simulation

SCIENTIFIC DESCRIPTION: Lazy lavender aims at supporting mOeX's research on simulating knowledge evolution. It is not a general purpose simulator. However, it features some methodological innovations in term of facilitating publication, recording, and replaying of experiments.

FUNCTIONAL DESCRIPTION: Lazy Lavender is a simulation environment for cultural knowledge evolution, i.e. running randomised experiments with agent adjusting their knowledge while attempting to communicate. It can generate detailed report and data from the experiments and directions to repeat them.

NEWS OF THE YEAR: In 2019, we implemented facilities for dealing with population of agents and designed several synchronisation approaches. This led to seriously refactor the code.
- Participant: Jérôme Euzenat
- Contact: Jérôme Euzenat
- Publications: Crafting ontology alignments from scratch through agent communication - Interaction-based ontology alignment repair with expansion and relaxation - First experiments in cultural alignment repair (extended version)
- URL: http://lazylav.gforge.inria.fr

5.2. Alignment API

KEYWORDS: Ontologies - Alignment - Ontology engineering - Knowledge representation

SCIENTIFIC DESCRIPTION: The api itself is a Java description of tools for accessing the common format. It defines five main interfaces (OntologyNetwork, Alignment, Cell, Relation and Evaluator).

We provide an implementation for this api which can be used for producing transformations, rules or bridge axioms independently from the algorithm that produced the alignment. The proposed implementation features: - a base implementation of the interfaces with all useful facilities, - a library of sample matchers, - a library of renderers (XSLT, RDF, SKOS, SWRL, OWL, C-OWL, SPARQL), - a library of evaluators (various generalisation of precision/recall, precision/recall graphs), - a flexible test generation framework that allows for generating evaluation data sets, - a library of wrappers for several ontology APIs , - a parser for the format.

To instanciate the API , it is sufficient to refine the base implementation by implementing the align() method. Doing so, the new implementation will benefit from all the services already implemented in the base implementation.

FUNCTIONAL DESCRIPTION: Using ontologies is the privileged way to achieve interoperability among heterogeneous systems within the Semantic web. However, as the ontologies underlying two systems are not necessarily compatible, they may in turn need to be reconciled. Ontology reconciliation requires most of the time to find the correspondences between entities (e.g. classes, objects, properties) occurring in the ontologies. We call a set of such correspondences an alignment.

NEWS OF THE YEAR: Link keys are fully supported by the EDOAL language. In particular it can transform them into SPARQL queries.
- Participants: Armen Inants, Chan Le Duc, Jérôme David, Jérôme Euzenat, Jérôme Pierson, Luz Maria Priego-Roche and Nicolas Guillouet
- Contact: Jérôme Euzenat
- Publications: An API for ontology alignment - The Alignment API 4.0
- URL: http://alignapi.gforge.inria.fr/

<p style="text-align:center">**MORPHEO Project-Team**</p>

6. New Software and Platforms

6.1. Lucy Viewer

KEYWORDS: Data visualization - 4D - Multi-Cameras

SCIENTIFIC DESCRIPTION: Lucy Viewer is an interactive viewing software for 4D models, i.e, dynamic three-dimensional scenes that evolve over time. Each 4D model is a sequence of meshes with associated texture information, in terms of images captured from multiple cameras at each frame. Such data is available from the 4D repository website hosted by Inria Grenoble.

With Lucy Viewer, the user can use the mouse to zoom in onto the 4D models, zoom out, rotate, translate and view from an arbitrary angle as the 4D sequence is being played. The texture information is read from the images at each frame in the sequence and applied onto the meshes. This helps the user visualize the 3D scene in a realistic manner. The user can also freeze the motion at a particular frame and inspect a mesh in detail. Lucy Viewer lets the user to also select a subset of cameras from which to apply texture information onto the meshes. The supported formats are meshes in .OFF format and associated images in .PNG or .JPG format.

FUNCTIONAL DESCRIPTION: Lucy Viewer is an interactive viewing software for 4D models, i.e, dynamic three-dimensional scenes that evolve over time. Each 4D model is a sequence of meshes with associated texture information, in terms of images captured from multiple cameras at each frame.

- Participants: Edmond Boyer, Jean-Sébastien Franco, Matthieu Armando and Eymeric Amselem
- Contact: Edmond Boyer
- URL: https://kinovis.inria.fr/lucyviewer/

6.2. Shape Tracking

FUNCTIONAL DESCRIPTION: We are developing a software suite to track shapes over temporal sequences. The motivation is to provide temporally coherent 4D Models, i.e. 3D models and their evolutions over time , as required by motion related applications such as motion analysis. This software takes as input a temporal sequence of 3D models in addition to a template and estimate the template deformations over the sequence that fit the observed 3D models.

- Contact: Edmond Boyer

6.3. QuickCSG V2

KEYWORDS: 3D modeling - CAD - 3D reconstruction - Geometric algorithms

SCIENTIFIC DESCRIPTION: See the technical report "QuickCSG: Arbitrary and Faster Boolean Combinations of N Solids", Douze, Franco, Raffin.

The extension of the algorithm to self-intersecting meshes is described in "QuickCSG with self-intersections", a document inside the package.

FUNCTIONAL DESCRIPTION: QuickCSG is a library and command-line application that computes Boolean operations between polyhedra. The basic algorithm is described in the research report "QuickCSG: Arbitrary and Faster Boolean Combinations of N Solids", Douze, Franco, Raffin. The input and output polyhedra are defined as indexed meshes. In version 2, that was developed in the context of a software transfer contract, the meshes can be self-intersecting, in which case the inside and outside are defined by the non-zero winding rule. The operation can be any arbitrary Boolean function, including one that is defined as a CSG tree. The focus of QuickCSG is speed. Robustness to degeneracies is obtained by carefully applied random perturbations.

- Authors: Matthys Douze, Jean-Sébastien Franco and Bruno Raffin
- Contact: Jean-Sébastien Franco
- URL: https://kinovis.inria.fr/quickcsg/

6.4. CVTGenerator

KEYWORDS: Mesh - Centroidal Voronoi tessellation - Implicit surface

FUNCTIONAL DESCRIPTION: CVTGenerator is a program to build Centroidal Voronoi Tessellations of any 3D meshes and implicit surfaces.

- Partner: INP Grenoble
- Contact: Li WANG
- URL: http://cvt.gforge.inria.fr/

6.5. Adaptive mesh texture

KEYWORDS: 3D - Geometry Processing - Texturing

FUNCTIONAL DESCRIPTION: Tool for computing appearance information on a 3D scene acquired with a multi-view stereo (MVS) pipeline. Appearance information is sampled in an adaptive way so as to maximize the entropy of stored information. This is made possible through a homemade representation of appearance, different from the more traditional texture maps. This tool laso includes a compression module, so as to optimize disk space.

RELEASE FUNCTIONAL DESCRIPTION: 1st version

- Authors: Matthieu Armando, Edmond Bover, Jean-Sébastien Franco and Vincent Leroy
- Partner: Microsoft
- Contact: Matthieu Armando
- URL: https://gitlab.inria.fr/marmando/adaptive-mesh-texture

MULTISPEECH Project-Team

6. New Software and Platforms

6.1. dnnsep

Multichannel audio source separation with deep neural networks

KEYWORDS: Audio - Source Separation - Deep learning

SCIENTIFIC DESCRIPTION: dnnsep is the only source separation software relying on multichannel Wiener filtering based on deep learning. Deep neural networks are used to initialize and reestimate the power spectrum of the sources at every iteration of an expectation-maximization (EM) algorithm.

FUNCTIONAL DESCRIPTION: Combines deep neural networks and multichannel signal processing for speech enhancement and separation of musical recordings.

NEWS OF THE YEAR: Version 1.1 was slightly modified in order to issue a test license to the French Ministry of Interior.

- Participants: Aditya Nugraha, Emmanuel Vincent and Antoine Liutkus
- Contact: Emmanuel Vincent

6.2. KATS

Kaldi-based Automatic Transcription System

KEYWORD: Speech recognition

FUNCTIONAL DESCRIPTION: KATS is a multipass system for transcribing audio data, and in particular radio or TV shows in French, English or Arabic. It is based on the Kaldi speech recognition tools. It relies on Deep Neural Network (DNN) modeling for speech detection and acoustic modeling of the phones (speech sounds). Higher order statistical language models and recurrent neural network language models can be used for improving performance through rescoring of multiple hypotheses.

NEWS OF THE YEAR: New models have been trained for German, as well as two bilingual models: one combining French and German phones, and one combining French and English phones. Also, a web server has been set up for on line real-time speech recognition.

- Participants: Dominique Fohr, Odile Mella, Mathieu Hu, Denis Jouvet and Irina Illina
- Contact: Dominique Fohr

6.3. SOJA

Speech Synthesis platform in JAva

KEYWORDS: Speech Synthesis - Audio

SCIENTIFIC DESCRIPTION: SOJA relies on a non-uniform unit selection algorithm. Phonetic and linguistic features are extracted and computed from the text to drive the selection of speech units in a recorded corpus. The selected units are concatenated to obtain the speech signal corresponding to the input text.

FUNCTIONAL DESCRIPTION: SOJA is a software for Text-To-Speech synthesis (TTS). It performs all steps from text input to speech signal output. A set of associated tools is available for elaborating a corpus for a TTS system (transcription, alignment, etc.). Currently, the corpus contains about 3 hours of speech recorded by a female speaker. Most of the modules are in Java, some are in C. The SOJA software runs under Windows and Linux. It can be launched with a graphical user interface or directly integrated in a Java code or by following the client-server paradigm.

RELEASE FUNCTIONAL DESCRIPTION: Version 3.0 integrates a phonetization based on a deep learning algorithm. In addition, the phonetization step is managed by API REST (client/server mode). The NLP part provides an output of descriptors in the format that can be used by HTS and Merlin systems.

NEWS OF THE YEAR: The latest version can use the LORIA-PHON deep learning based grapheme-to-phoneme converter through a web API.

- Participants: Alexandre Lafosse and Vincent Colotte
- Contact: Vincent Colotte

6.4. LORIA-PHON

LORIA grapheme-to-phoneme converter

KEYWORDS: Grapheme-to-phoneme converter - Neural networks

FUNCTIONAL DESCRIPTION: LORIA-PHON is a deep-learning based software for grapheme-to-phoneme conversion. It currently works for French. A web API is available for using it in a client/server mode. It properly interfaces with the SOJA software used for speech synthesis.

NEWS OF THE YEAR: new software

- Participants: Mathieu Hu, Denis Jouvet, Vincent Colotte and Louis Delebecque
- Contact: Vincent Colotte

6.5. Dynalips-Player

High realistic lip synchronization for 3d animated characters

KEYWORDS: 3D animation - Graphics - Speech Synthesis

FUNCTIONAL DESCRIPTION: Dynalips provides a solution to synchronize precisely and automatically the movements of the lips of a 3D character with speech (we address 3D animation movies and video games). We have developed a demonstrator that illustrates the whole process: from audio + text to the generation of the animation trajectory, and controlling the animation of a 3D model (e.g. an avatar). The demonstrator is composed mainly by the player developed in Unity 3D (but can be used with any other system) and plays the animation synchronously with speech in realtime. It is possible to generate an animation for Autodesk Maya 3D.

NEWS OF THE YEAR: The player has been extended to be multilingual thanks to two developments within two projects. In fact, within the METAL project, a lipsync for German has been developed. In addition, within the ATT Dynalips, we have built a lipsync for English.

- Partners: Université de Lorraine - Sayens (SATT Grand Est)
- Contact: Slim Ouni
- URL: http://www.dynalips.com

6.6. VisArtico

Visualization of multimodal speech data

KEYWORDS: Data visualization - 3D movement - Speech processing - Videos

SCIENTIFIC DESCRIPTION: VisArtico is a visualization software of multimodal data. It is possible to visualize the positions of real or virtual sensors and to animate them simultaneously with acoustics. This software can be useful for researchers in speech production, audiovisual speech synthesis or articulatory speech analysis.

FUNCTIONAL DESCRIPTION: VisArtico is a user-friendly software which allows visualizing multimodal data acquired by several systems: an articulograph, motion capture system, depth camera. This visualization software has been designed so that it can directly use the data provided by the different systems to display the spatial and temporal positions of the sensors (real and virtual). Moreover, VisArtico allows viewing the sensors augmented with visual information by indicating graphically the data for the tongue, lips and jaw.

RELEASE FUNCTIONAL DESCRIPTION: The current version allows the user to manage different modalities (articulatory, gestural, acoustic and video). It is possible to do automatic alignment, or even speech recognition. Several spatial data processing tools have been added (referential change, head movement suppression, merging data from multiple sources, ...).

NEWS OF THE YEAR: The software has undergone several improvements. Mainly, several branches have been merged in order to have as many features as possible available within the master branch.

- Participants: Ilef Ben Farhat, Loïc Mangeonjean, Slim Ouni and Louis Abel
- Partners: CNRS - Université de Lorraine
- Contact: Slim Ouni
- Publication: VisArtico: a visualization tool for articulatory data
- URL: http://visartico.loria.fr

6.7. Xarticulators

KEYWORDS: Medical imaging - Natural language processing

FUNCTIONAL DESCRIPTION: The Xarticulators software is intended to delineate contours of speech articulators in X-ray and MR images, construct articulatory models and synthesize speech from X-ray films. This software provides tools to track contours automatically, semi-automatically or by hand, to make the visibility of contours easier, to add anatomical landmarks to speech articulators and to synchronize images with the sound. In addition we also added the possibility of processing digitized manual delineation results made on sheets of papers when no software is available. Xarticulators also enables the construction of adaptable linear articulatory models from the X-ray or MR images and incorporates acoustic simulation tools to synthesize speech signals from the vocal tract shape. Recent work was on the possibility of synthesizing speech from 2D-MRI films, and on the construction of better articulatory models for the velum, lips and epiglottis.

RELEASE FUNCTIONAL DESCRIPTION: The new version allows MRI films to be processed and, above all, it offers a better transition from the shape of the vocal tract to the area function, which corresponds to an approximation of the vocal tract using a series of elementary tubes from the glottis to the lips.

NEWS OF THE YEAR: This year we completed the software to evaluate the articulatory model built from static images on dynamic images and we added a module to monitor the contour of the language using deep learning.

- Contact: Yves Laprie
- Publication: Articulatory model of the epiglottis

6.8. DCASE 2019 baseline

Baseline system for the task 4 of DCASE 2019 Challenge

KEYWORDS: Audio signal processing - Audio source classification - Machine learning - Smart home

FUNCTIONAL DESCRIPTION: This is the baseline system for the task 4 of the challenge on Detection and Classification of Acoustic Scenes and Events (DCASE) 2019. The algorithm performs sound events detection and classification. From an audio recording, the target of the system is to provide not only the event class but also the event time boundaries given that multiple events can be present in an audio recording. The baseline approach relies on convolutionnal and recurrent neural networks (CRNN) and a mean-teacher model to exploit a large amount of unbalanced and unlabeled training data together with a small weakly annotated (without timestamps) training set and a strongly annotated (with timestamps) synthetic set to improve system performance.

RELEASE FUNCTIONAL DESCRIPTION: This version includes a mean teacher model to exploit the various training sets with that have different levels of annotations, as provided in the task 4 of the DCASE 2019 challenge.

- Participants: Nicolas Turpault and Romain Serizel
- Contact: Nicolas Turpault
- Publication: Sound event detection in domestic environments with weakly labeled data and soundscape synthesis
- URL: https://github.com/turpaultn/DCASE2019_task4/tree/public/baseline

<p style="text-align:center">**ORPAILLEUR Project-Team**</p>

6. New Software and Platforms

6.1. ARPEnTAge

Analyse de Régularités dans les Paysages : Environnement, Territoires, Agronomie

KEYWORDS: Stochastic process - Hidden Markov Models

FUNCTIONAL DESCRIPTION: ARPEnTAge is a software based on stochastic models (HMM2 and Markov Field) for analyzing spatio-temporal data-bases. ARPEnTAge is built on top of the CarottAge system to fully take into account the spatial dimension of input sequences. It takes as input an array of discrete data in which the columns contain the annual land-uses and the rows are regularly spaced locations of the studied landscape. It performs a Time-Space clustering of a landscape based on its time dynamic Land Uses (LUS). Displaying tools and the generation of Time-dominant shape files have also been defined.

- Partner: INRA
- Contact: Jean-François Mari
- URL: http://carottage.loria.fr/index_in_english.html

6.2. CarottAge

KEYWORDS: Stochastic process - Hidden Markov Models

FUNCTIONAL DESCRIPTION: The system CarottAge is based on Hidden Markov Models of second order and provides a non supervised temporal clustering algorithm for data mining and a synthetic representation of temporal and spatial data. CarottAge is currently used by INRA researchers interested in mining the changes in territories related to the loss of biodiversity (projects ANR BiodivAgrim and ACI Ecoger) and/or water contamination. CarottAge is also used for mining hydromorphological data. Actually a comparison was performed with three other algorithms classically used for the delineation of river continuum and CarottAge proved to give very interesting results for that purpose.

- Participants: Florence Le Ber and Jean-François Mari
- Partner: INRA
- Contact: Jean-François Mari
- URL: http://carottage.loria.fr/index_in_english.html

6.3. CORON

KEYWORDS: Data mining - Closed itemset - Frequent itemset - Generator - Association rule - Rare itemset

FUNCTIONAL DESCRIPTION: The Coron platform is a KDD toolkit organized around three main components: (1) Coron-base, (2) AssRuleX, and (3) pre- and post-processing modules.

The Coron-base component includes a complete collection of data mining algorithms for extracting itemsets such as frequent itemsets, closed itemsets, generators and rare itemsets. In this collection we can find APriori, Close, Pascal, Eclat, Charm, and, as well, original algorithms such as ZART, Snow, Touch, and Talky-G. AssRuleX generates different sets of association rules (from itemsets), such as minimal non-redundant association rules, generic basis, and informative basis. In addition, the Coron system supports the whole life-cycle of a data mining task and proposes modules for cleaning the input dataset, and for reducing its size if necessary.

- Participants: Adrien Coulet, Aleksey Buzmakov, Amedeo Napoli, Florent Marcuola, Jérémie Bourseau, Laszlo Szathmary, Mehdi Kaytoue, Victor Codocedo and Yannick Toussaint
- Contact: Amedeo Napoli
- URL: http://coron.loria.fr/site/index.php

6.4. LatViz: Visualization of Concept Lattices

- Contact: Amedeo Napoli
- URL: http://latviz.loria.fr/
- KEYWORDS: Formal Concept Analysis, Pattern Structures, Concept Lattice, Implications, Visualization

FUNCTIONAL DESCRIPTION.

LatViz is a tool allowing the construction, the display and the exploration of concept lattices. LatViz proposes some noticeable improvements over existing tools and introduces various functionalities focusing on interaction with experts, such as visualization of pattern structures for dealing with complex non-binary data, AOC-poset which is composed of the core elements of the lattice, concept annotations, filtering based on various criteria and a visualization of implications [75]. This way the user can effectively perform interactive exploratory knowledge discovery as often needed in knowledge engineering.

The LatViz platform can be associated with the Coron platform and extends its visualization capabilities (see http://coron.loria.fr). Recall that the Coron platform includes a complete collection of data mining algorithms for extracting itemsets and association rules.

6.5. OrphaMine: Data Mining Platform for Orphan Diseases

- Contact: Laureline Nevin
- URL: http://orphamine.inria.fr/
- KEYWORDS: Bioinformatics, data mining, biology, health, data visualization, drug development.

FUNCTIONAL DESCRIPTION.

The OrphaMine platform enables visualization, data integration and in-depth analytics in the domain of "orphan diseases", where data is extracted from the OrphaData ontology (http://www.orpha.net/consor/cgi-bin/index.php). At present, we aim at building a true collaborative portal that will serve different actors: (i) a general visualization of OrphaData data for physicians working, maintaining and developing this knowledge database about orphan diseases, (ii) the integration of analytics (data mining) algorithms developed by the different academic actors, (iii) the use of these algorithms to improve our general knowledge of rare diseases.

6.6. Siren: Interactive and Visual Redescription Mining

- Contact: Esther Catherine Galbrun
- URL: http://siren.gforge.inria.fr/main/
- KEYWORDS: Redescription mining, Interactivity, Visualization.

FUNCTIONAL DESCRIPTION.

Siren is a tool for interactive mining and visualization of redescriptions. Redescription mining aims to find distinct common characterizations of the same objects and, vice versa, to identify sets of objects that admit multiple shared descriptions. The goal is to provide domain experts with a tool allowing them to tackle their research questions using redescription mining. Merely being able to find redescriptions is not enough. The expert must also be able to understand the redescriptions found, adjust them to better match his domain knowledge and test alternative hypotheses with them, for instance. Thus, Siren allows mining redescriptions in an anytime fashion through efficient, distributed mining, to examine the results in various linked visualizations, to interact with the results either directly or via the visualizations, and to guide the mining algorithm toward specific redescriptions.

New features, such as a visualization of the contribution of individual literals in the queries and the simplification of queries as a post-processing, have been added to the tool.

<p align="center" style="color:red">PANAMA Project-Team</p>

6. New Software and Platforms

6.1. FAuST

KEYWORDS: Learning - Sparsity - Fast transform - Multilayer sparse factorisation

SCIENTIFIC DESCRIPTION: FAuST allows to approximate a given dense matrix by a product of sparse matrices, with considerable potential gains in terms of storage and speedup for matrix-vector multiplications.

FUNCTIONAL DESCRIPTION: Faust 1.x contains Matlab routines to reproduce experiments of the PANAMA team on learned fast transforms.

Faust 2.x contains a C++ implementation with Matlab / Python wrappers (work in progress).

NEWS OF THE YEAR: A Software Development Initiative (ADT REVELATION) started in April 2018 for the maturation of FAuST. A first step achieved this year was to complete and robustify Matlab wrappers, to code Python wrappers with the same functionality, and to setup a continuous integration process. A second step was to simplify the parameterization of the main algorithms. The roadmap for next year includes showcasing examples and optimizing computational efficiency. – In 2017, new Matlab code for fast approximate Fourier Graph Transforms have been included. based on the approach described in the papers:

-Luc Le Magoarou, Rémi Gribonval, "Are There Approximate Fast Fourier Transforms On Graphs?", ICASSP 2016 .

-Luc Le Magoarou, Rémi Gribonval, Nicolas Tremblay, "Approximate fast graph Fourier transforms via multi-layer sparse approximations", IEEE Transactions on Signal and Information Processing over Networks,2017.

- Participants: Luc Le Magoarou, Nicolas Tremblay, Rémi Gribonval, Nicolas Bellot, Adrien Leman and Hakim Hadj-Djilani
- Contact: Rémi Gribonval
- Publications: Approximate fast graph Fourier transforms via multi-layer sparse approximations - Analyzing the Approximation Error of the Fast Graph Fourier Transform - Flexible Multi-layer Sparse Approximations of Matrices and Applications - Are There Approximate Fast Fourier Transforms On Graphs? - Efficient matrices for signal processing and machine learning - FAμST: speeding up linear transforms for tractable inverse problems - Chasing butterflies: In search of efficient dictionaries - Multi-layer Sparse Matrix Factorization
- URL: http://faust.inria.fr/

6.2. SPADE

Sparse Audio Declipper

KEYWORDS: Audio - Sparse regularization - Declipping

SCIENTIFIC DESCRIPTION: SPADE (the Sparse Audio Declipper) allows to reproduce audio declipping experiments from the papers:

- Srdan Kitic, Nancy Bertin, Remi Gribonval. Audio Declipping by Cosparse Hard Thresholding. iTwist - 2nd international - Traveling Workshop on Interactions between Sparse models and Technology, Aug 2014, Namur, Belgium.

- Srdan Kitic, Nancy Bertin, Remi Gribonval. Sparsity and cosparsity for audio declipping: a flexible non-convex approach. LVA/ICA 2015 - The 12th International Conference on Latent Variable Analysis and Signal Separation, Aug 2015, Liberec, Czech Republic.

FUNCTIONAL DESCRIPTION: SPADE is a declipping algorithm developed by the PANAMA project-team. To the best of our knowledge SPADE achieves state-of-the-art audio declipping quality. Real-time processing of audio streams is possible.

The web site http://spade.inria.fr provides example audio files and allows users to test SPADE on their own files, either by downloading Matlab routines or using Inria's software demonstration platform, Al|go, to test it on the web.

NEWS OF THE YEAR: In 2018, the code has been robustified with the help of InriaTech for a potential industrial transfer. – In 2017, a web interface to demonstrate the potential of SPADE has been setup using the Al|go platform.

- Participants: Nancy Bertin, Clement Gaultier, Ewen Camberlein, Romain Lebarbenchon, Alexandre Sanchez, Rémi Gribonval and Srdan Kitic
- Contact: Rémi Gribonval
- Publications: Audio Declipping by Cosparse Hard Thresholding - Sparsity and cosparsity for audio declipping: a flexible non-convex approach
- URL: http://spade.inria.fr/

6.3. FASST

Flexible Audio Source Separation Toolbox

KEYWORD: Audio signal processing

SCIENTIFIC DESCRIPTION: FASST is a Flexible Audio Source Separation Toolbox, designed to speed up the conception and automate the implementation of new model-based audio source separation algorithms.

FASST 1.0 development was achieved by the METISS team in Rennes and is now deprecated.

FASST 2.1 development was jointly achieved by the PAROLE team in Nancy and the (former) TEXMEX team in Rennes through an Inria funded ADT (Action de Développement Technologique). PANAMA contributed to the development by coordinating and performing user tests, and to the dissemination in a Show-and-Tell ICASSP poster [58]. While the first implementation was in Matlab, the new implementation is in C++ (for core functions), with Matlab and Python user scripts. Version 2, including speedup and new features was released in 2014 and can be downloaded from http://bass-db.gforge.inria.fr/fasst/ .

Version 2.2.2 (current version) has been released in May 2018. This version was developed in the PANAMA team through the Inria funded ADT "FFWD" (FASST For Wider Dissemination). A version 3.0 is currently under development and will be released in 2019.

FUNCTIONAL DESCRIPTION: FASST is a Flexible Audio Source Separation Toolbox designed to speed up the conception and automate the implementation of new model-based audio source separation algorithms. It is the only audio source separation software available to the public (QPL licence) which simultaneously exploits spatial and spectral cues on the sources to separate.

NEWS OF THE YEAR: Version 2.2.2 (current version) has been released in May 2018. This version was developed in the PANAMA team through the Inria funded ADT FFWD (FASST For Wider Dissemination). A version 3.0 is currently under development and will be released in 2019.

- Participants: Alexey Ozerov, Nancy Bertin, Ewen Camberlein, Romain Lebarbenchon, Emmanuel Vincent, Frédéric Bimbot and Yann Salaun
- Contact: Emmanuel Vincent
- URL: http://bass-db.gforge.inria.fr/fasst/

6.4. Multi-channel BSS Locate Basic

KEYWORDS: Audio - Localization - Signal processing - Multichannel signal

SCIENTIFIC DESCRIPTION: Multi-Channel BSS Locate is a Matlab toolbox to estimate Direction Of Arrival (expressed both in azimuth and elevation) of multiple sources in a multi-channel audio signal recorded by an array of microphones. This toolbox implements the previous 8 angular spectrum methods presented in BSS Locate (GCC-PHAT, GCC-NONLIN, MUSIC and several SNR-based spectra).

NEWS OF THE YEAR: In 2018, with the help of InriaTech, selected parts of Multi-channel BSS Locate were ported to C++ in the perspective of a transfer

- Authors: Charles Blandin, Ewen Camberlein, Romain Lebarbenchon, Emmanuel Vincent, Alexey Ozerov and Nancy Bertin

- Contact: Emmanuel Vincent

- URL: http://bass-db.gforge.inria.fr/bss_locate/

6.5. VoiceHome-2

KEYWORDS: Speech processing - Audio signal processing - Source Separation - Source localization

SCIENTIFIC DESCRIPTION: New, extended version of the voiceHome corpus for distant-microphone speech processing in domestic environments. This 5-hour corpus includes short reverberated, noisy utterances (smart home commands) spoken in French by 12 native French talkers in diverse realistic acoustic conditions and recorded by an 8-microphone device at various angles and distances and in various noise conditions. Noise-only segments before and after each utterance are included in the recordings. Clean speech and spontaneous speech recorded in 12 real rooms distributed in 4 different homes are also available. All data have been fully annotated.

- Participants: Nancy Bertin, Ewen Camberlein, Romain Lebarbenchon, Emmanuel Vincent, Sunit Sivasankaran, Irina Illina and Frédéric Bimbot

- Contact: Nancy Bertin

- Publication: VoiceHome-2, an extended corpus for multichannel speech processing in real homes

<h1 style="text-align:center;color:red">PERCEPTION Project-Team</h1>

5. New Software and Platforms

5.1. NaoLab

Distributed middleware architecture for interacting with NAO

FUNCTIONAL DESCRIPTION: This software provides a set of librairies and tools to simply the control of NAO robot from a remote machine. The main challenge is to make easy prototuping applications for NAO ising C++ and Matlab programming environments. Thus NaoLab provides a prototyping-friendly interface to retrieve sensor date (video and sound streams, odometric data...) and to control the robot actuators (head, arms, legs...) from a remote machine.This interface is available on Naoqi SDK, developed by Aldebarab company, Naoqi SDK is needed as it provides the tools to acess the embedded NAO services (low-level motor command, sensor data access...)

- Authors: Fabien Badeig, Quentin Pelorson and Radu Horaud
- Contact: Radu Horaud
- URL: https://team.inria.fr/perception/research/naolab/

5.2. Associations of Audio Cues with 3D locations library

FUNCTIONAL DESCRIPTION: Library to associate some auditory cues with 3D locations (points). It provides an estimation of the emitting state of each of the input locations. There are two main assumptions : 1 - The 3D locations are valid during the acquisition interval related to the audio cues 2 - The 3D locations are the only possible locations for the sound sources, no new locations will be created in this module

The software provides also a multimodal fusion library

- Participants: Antoine Deleforge, Jordi Sanchez-Riera, Radu Horaud and Xavier Alameda-pineda
- Contact: Radu Horaud

5.3. Audio Cue Extractor Library

FUNCTIONAL DESCRIPTION: This module extracts auditory cues from the raw audio streams. The interaural time difference (ITD) is estimated using cross-correlation methods.

- Participants: Antoine Deleforge, Radu Horaud and Soraya Arias
- Contact: Soraya Arias

5.4. Audiovisual Robots and Heads

FUNCTIONAL DESCRIPTION: The team has developed two audiovisual (AV) robot heads: the POPEYE head and the NAO stereo head. Both are equipped with a binocular vision system and with four microphones. The software modules comprise stereo matching and reconstruction, sound-source localization and audio-visual fusion. POPEYE has been developed within the European project POP in collaboration with the project-team MISTIS and with two other POP partners: the Speech and Hearing group of the University of Sheffield and the Institute for Systems and Robotics of the University of Coimbra. The NAO stereo head was developed under the European project HUMAVIPS in collaboration with Aldebaran Robotics (which manufactures the humanoid robot NAO) and with the University of Bielefeld, the Czech Technical Institute, and IDIAP. The software modules that we develop are compatible with both these robot heads.

- Contact: Radu Horaud
- URL: https://team.inria.fr/perception/popeye/

5.5. GLLiM

Gaussian Locally Linear Mapping

KEYWORDS: Regression - Machine learning - Gaussian mixture

SCIENTIFIC DESCRIPTION: GLLiM is a flexible tool for probabilistic non-linear regression using Gaussian mixtures. Using an inverse regression strategy with a reduced number of parameters, it is particularly suited for high- to low-dimensional regression tasks. It also enables the modeling of additional unobserved non-linear effects on input data. The method was published in [Deleforge et al., IJNS 2015]. The toolbox include an example of application to head pose estimation from synthetic images.

- Participant: Antoine Deleforge
- Contact: Antoine Deleforge
- Publication: hal-00863468, version 3
- URL: https://team.inria.fr/perception/gllim_toolbox/

5.6. Litbot

Live together with robots

KEYWORDS: Speaker Localization - Audio tracking - Visual tracking - NAO Robot - Computer vision - Signal processing

SCIENTIFIC DESCRIPTION: Litbot stands for "Live together with robots". This library aims to provide algorithms and associated software packages to perform audio-visual speaker localization and tracking with a consumer robot (in particular a NAO robot). The scope of this project is two-fold. The first is to develop the robust speaker localization and tracking algorithm in the presence of other audio-visual sources like TV. The second is to modify or optimize the original algorithm to be fit into real-time system. This library benefits from the work done with Online Multiple Sound-Source Localization package developed by X. Li.

FUNCTIONAL DESCRIPTION: This project develops algorithms and associated software packages to perform audio-visual speaker localization and tracking with a consumer robot. This version of the litbot library provides new functions to integrate the Samsung robotic platform to handle ROS middleware (robotic defacto standard) and modifies and optimizes tracking and audio localization processes (better handling of the residual noise signals, performance improved to match real time).

- Participants: Xiaofei Li, Yutong Ban, Soraya Arias, Radu Horaud, Guillaume Sarrazin and Bastien Mourgue
- Contact: Radu Horaud

5.7. Online Multiple Sound-Source Localization

KEYWORDS: Audio signal processing - Multiple sound-source localization - Matlab - Direct-path RTF

FUNCTIONAL DESCRIPTION: This project tackles multiple sound-source localization in noisy and reverberant environments, using binaural recordings of an acoustic scene. It provides Matlab routines to estimate multiple sound source (such as speakers) locations based on direct-path relative transfer function (DP-RTF) estimation.

- Participants: Xiaofei Li and Radu Horaud
- Contact: Radu Horaud
- Publications: Multiple-Speaker Localization Based on Direct-Path Features and Likelihood Maximization with Spatial Sparsity Regularization - Estimation of the Direct-Path Relative Transfer Function for Supervised Sound-Source Localization

5.8. RMP

RoMPers

KEYWORDS: Middleware - Robotics - NAO Robot

SCIENTIFIC DESCRIPTION: Robot Middleware developed by Perception. It follows the development done on RobotHandler and NAOLab. Its goal is to provide an abstraction which allows an easy access to robot sensors. In the same time, this high level access is independant of the robot.

FUNCTIONAL DESCRIPTION: Robot Middleware developed by Perception. It follows the development done on RobotHandler and NAOLab. Its goal is to provide an abstraction which allows an easy access to robot sensors. In the same time, this high level access is independant of the robot. And it also provides tools for sensor calibration (audio, video), video annotation, etc

- Participant: Guillaume Sarrazin
- Contact: Soraya Arias

5.9. SE-VAE-alpha-stable

KEYWORDS: Audio signal processing - Speech processing - Deep learning - Neural networks

FUNCTIONAL DESCRIPTION: This software provides an iterative algorithm for enhancing a speech signal in a noisy monophonic recording. The algorithm is detailed in the following paper: "Speech enhancement with variational autoencoders and alpha-stable distributions" Simon Leglaive, Umut Simsekli, Antoine Liutkus, Laurent Girin, Radu Horaud IEEE International Conference on Acoustics Speech and Signal Processing (ICASSP), Brighton, UK, May 2019

- Contact: Simon Leglaive

5.10. Sound recognition library

FUNCTIONAL DESCRIPTION: This recognition module is based on supervised learning.

- Participants: Maxime Janvier and Radu Horaud
- Contact: Radu Horaud

5.11. SE-VAE-NMF

KEYWORDS: Audio signal processing - Speech processing - Deep learning - Neural networks

FUNCTIONAL DESCRIPTION: This software provides an iterative algorithm for enhancing a speech signal in a noisy monophonic recording. The algorithm is detailed in the following paper: "A variance modeling framework based on variational autoencoders for speech enhancement" Simon Leglaive, Laurent Girin, Radu Horaud Proc. of the IEEE International Workshop on Machine Learning for Signal Processing (MLSP), Aalborg, Denmark, September 2018

- Contact: Simon Leglaive
- Publication: hal-01832826v1

PERVASIVE Project-Team (section vide)

PETRUS Project-Team

5. New Software and Platforms

5.1. PLUG-DB ENGINE

KEYWORDS: Databases - Personal information - Privacy - Hardware and Software Platform

FUNCTIONAL DESCRIPTION: en PlugDB is a complete platform dedicated to a secure and ubiquitous management of personal data. It aims at providing an alternative to a systematic centralization of personal data. The PlugDB engine is a personal database server capable of storing data (tuples and documents) in tables and BLOBs, indexing them, querying them in SQL, sharing them through assertional access control policies and enforcing transactional properties (atomicity, integrity, durability).

The PlugDB engine is embedded in a tamper-resistant hardware device combining the security of smartcard with the storage capacity of NAND Flash. The personal database is hosted encrypted in NAND Flash and the PlugDB engine code runs in the microcontroller. Complementary modules allow to pre-compile SQL queries for the applications, communicate with the DBMS from a remote Java program, synchronize local data with remote servers (typically used for recovering the database in the case of a broken or lost devices) and participate in distributed computation (e.g., global queries). PlugDB runs both on secure devices provided by Gemalto and on specific secure devices designed by PETRUS and assembled by electronic SMEs. Mastering the hardware platform opens up new research and experiment opportunities (e.g., support for wireless communication, secure authentication, sensing capabilities, battery powered ...). PlugDB engine has been registered first at APP (Agence de Protection des Programmes) in 2009 - a new version being registered every two years - and the hardware datasheets in 2015.

PlugDB has been experimented in the field, notably in the healthcare domain. We also recently set up an educational platform on top of PlugDB, named SIPD (Système d'Information Privacy-by-Design) and used at ENSIIE, INSA CVL and UVSQ through the Versailles Sciences Lab fablab, to raise students awareness of privacy protection problems and embedded programming. As a conclusion, PlugDB combines several research contributions from the team, at the crossroads of flash data management, embedded data processing and secure distributed computations. It then strongly federates all members of our team (permanent members, PhD students and engineers). It is also a vector of visibility, technological transfer and dissemination and gives us the opportunity to collaborate with researchers from other disciplines around a concrete privacy-enhancing platform.

PlugDB is now being industrialized in the context of the OwnCare Inria Innovation Lab (II-Lab). In OwnCare, PlugDB acts as a secure personal cloud to manage medical/social data for people receiving care at home. It should be deployed over 10.000 patient in the Yvelines district. The industrialization process covers the development of a complete testing environment, the writing of a detailed documentation and the development of additional features (e.g., embedded ODBC driver, TPM support, flexible access control model and embedded code upgrade notably). It has also required the design of a new hardware platform equipped with a battery power supply, introducing new energy consumption issues for the embedded software.

- Participants: Aydogan Ersoz, Laurent Schneider, Luc Bouganim, Nicolas Anciaux and Philippe Pucheral
- Contact: Nicolas Anciaux
- URL: https://project.inria.fr/plugdb/

<p align="center">**POTIOC Project-Team**</p>

6. New Software and Platforms

6.1. Aïana

KEYWORD: Multimedia player

FUNCTIONAL DESCRIPTION: This software aims to make accessible the playing of a MOOC composed of various information flows (boards, videos, subtitles ...). It is not intended to be "reserved" for people with disabilities but rather to be open to as many as possible by allowing each user to adapt the interface, and therefore the use, to its users own capabilities and needs.

- Authors: Damien Caselli, Pierre-Antoine Cinquin, Pascal Guitton and Hélène Sauzéon
- Partner: Université de Bordeaux
- Contact: Pascal Guitton
- Publications: Towards Truly Accessible MOOCs for Persons with Cognitive Disabilities: Design and Field Assessment - Online e-learning and cognitive disabilities: A systematic review

6.2. HybridOptics : Hybrid Optical Platform

KEYWORDS: Augmented reality - Education - Tangible interface

FUNCTIONAL DESCRIPTION: The software platform - gets the values of the sensors - computes in real-time the result of the simulation - generates pedagogical supports that are directly linked to the simulation (projected on the work table) - allows the user to control several parameters from a dedicated application on a tablet

- Participants: Benoit Coulais, Lionel Canioni, Bruno Bousquet, Martin Hachet and Jean-Paul Guillet
- Contact: Martin Hachet
- URL: https://project.inria.fr/hobit/

6.3. Platforms

6.3.1. HOBIT

In 2019, we have continued working on the HOBIT platform dedicated to teaching and training of Optics at University. This has led to a version that we are able to export. A first system has been installed at University of Jena (Germany). We are currently finilizing a licensing contract to export the technology worldwide.

6.3.2. CARDS

Part of the e-Tac project, we have conceived a system composed of hardware and software components that allows us to augment pieces of papers in an interactive way (see Figure 3). 12 copies of this platform have been deployed at school. See also 7.1 .

6.3.3. OpenVIBE

We have continued developing and extending the OpenViBE open-source BCI platform. As new functionalities, we have notably added the use of Riemmannian geometry for EEG classification, which includes computation of covariance matrices and covariance matrix means, projection to tangent space and various covariance matrices classifiers, both with or without supervised or unsupervised adaptation. We have also added a new visualization module which can display any number of BCI commands and associate real-time feedback. In addition to these new functionalities, we have carefully improved and clean OpenViBE code, in order to standardize / clarify / simplify / modernize it and to secure and reduce memory allocations, to reduce unnecessary function calls, type changes and casts. This aimed at facilitating the handling of the code by new contributors and to update the different dependencies of OpenViBE, thus improving its compatibility, security and stability.

<h1 style="text-align:center; color:red;">RAINBOW Project-Team</h1>

5. New Software and Platforms

5.1. HandiViz

Driving assistance of a wheelchair

KEYWORDS: Health - Persons attendant - Handicap

FUNCTIONAL DESCRIPTION: The HandiViz software proposes a semi-autonomous navigation framework of a wheelchair relying on visual servoing.

It has been registered to the APP ("Agence de Protection des Programmes") as an INSA software (IDDN.FR.001.440021.000.S.P.2013.000.10000) and is under GPL license.

- Participants: François Pasteau and Marie Babel
- Partner: INSA Rennes
- Contact: Marie Babel

5.2. UsTk

Ultrasound toolkit for medical robotics applications guided from ultrasound images

KEYWORDS: Echographic imagery - Image reconstruction - Medical robotics - Visual tracking - Visual servoing (VS) - Needle insertion

FUNCTIONAL DESCRIPTION: UsTK, standing for Ultrasound Toolkit, is a cross-platform extension of ViSP software dedicated to 2D and 3D ultrasound image processing and visual servoing based on ultrasound images. Written in C++, UsTK architecture provides a core module that implements all the data structures at the heart of UsTK, a grabber module that allows acquiring ultrasound images from an Ultrasonix or a Sonosite device, a GUI module to display data, an IO module for providing functionalities to read/write data from a storage device, and a set of image processing modules to compute the confidence map of ultrasound images, generate elastography images, track a flexible needle in sequences of 2D and 3D ultrasound images and track a target image template in sequences of 2D ultrasound images. All these modules were implemented on several robotic demonstrators to control the motion of an ultrasound probe or a flexible needle by ultrasound visual servoing.

- Participants: Alexandre Krupa and Fabien Spindler
- Partners: Inria - Université de Rennes 1
- Contact: Alexandre Krupa
- URL: https://ustk.inria.fr

5.3. ViSP

Visual servoing platform

KEYWORDS: Augmented reality - Computer vision - Robotics - Visual servoing (VS) - Visual tracking

SCIENTIFIC DESCRIPTION: Since 2005, we develop and release ViSP [1], an open source library available from https://visp.inria.fr. ViSP standing for Visual Servoing Platform allows prototyping and developing applications using visual tracking and visual servoing techniques at the heart of the Rainbow research. ViSP was designed to be independent from the hardware, to be simple to use, expandable and cross-platform. ViSP allows designing vision-based tasks for eye-in-hand and eye-to-hand systems from the most classical visual features that are used in practice. It involves a large set of elementary positioning tasks with respect to various visual features (points, segments, straight lines, circles, spheres, cylinders, image moments, pose...) that can be combined together, and image processing algorithms that allow tracking of visual cues (dots, segments, ellipses...), or 3D model-based tracking of known objects or template tracking. Simulation capabilities are also available.

[1] E. Marchand, F. Spindler, F. Chaumette. ViSP for visual servoing: a generic software platform with a wide class of robot control skills. IEEE Robotics and Automation Magazine, Special Issue on "Software Packages for Vision-Based Control of Motion", P. Oh, D. Burschka (Eds.), 12(4):40-52, December 2005.

FUNCTIONAL DESCRIPTION: ViSP provides simple ways to integrate and validate new algorithms with already existing tools. It follows a module-based software engineering design where data types, algorithms, sensors, viewers and user interaction are made available. Written in C++, ViSP is based on open-source cross-platform libraries (such as OpenCV) and builds with CMake. Several platforms are supported, including OSX, iOS, Windows and Linux. ViSP online documentation allows to ease learning. More than 300 fully documented classes organized in 17 different modules, with more than 408 examples and 88 tutorials are proposed to the user. ViSP is released under a dual licensing model. It is open-source with a GNU GPLv2 or GPLv3 license. A professional edition license that replaces GNU GPL is also available.

- Participants: Éric Marchand, Fabien Spindler and François Chaumette
- Partners: Inria - Université de Rennes 1
- Contact: Fabien Spindler
- URL: http://visp.inria.fr

5.4. Platforms

5.4.1. *Robot Vision Platform*

Participants: François Chaumette, Alexandre Krupa, Eric Marchand, Fabien Spindler [contact].

We exploit two industrial robotic systems built by Afma Robots in the nineties to validate our research in visual servoing and active vision. The first one is a 6 DoF Gantry robot, the other one is a 4 DoF cylindrical robot (see Fig. 2). These robots are equipped with monocular RGB cameras. The Gantry robot also allows mounting grippers on its end-effector. Attached to this platform, we can also find a collection of various RGB and RGB-D cameras used to validate vision-based real-time tracking algorithms (see Sections 6.1.1 and 6.1.2). Note that four papers [32], [14], [52], [53] published by Rainbow in 2019 include results validated on this platform.
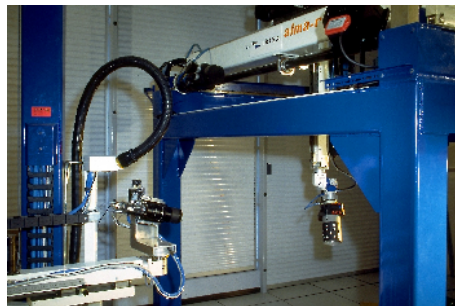

Figure 2. Rainbow robotics platform for vision-based manipulation

5.4.2. *Mobile Robots*

Participants: Marie Babel, Solenne Fortun, François Pasteau, Julien Pettré, Quentin Delamare, Fabien Spindler [contact].

For fast prototyping of algorithms in perception, control and autonomous navigation, the team uses a Pioneer 3DX from Adept (see Fig. 3 .a). This platform is equipped with various sensors needed for autonomous navigation and sensor-based control.

Moreover, to validate our research in personally assisted living topic (see Section 6.4.4), we have three electric wheelchairs, one from Permobil, one from Sunrise and the last from YouQ (see Fig. 3 .b). The control of the wheelchair is performed using a plug and play system between the joystick and the low level control of the wheelchair. Such a system lets us acquire the user intention through the joystick position and control the wheelchair by applying corrections to its motion. The wheelchairs have been fitted with cameras, ultrasound and time of flight sensors to perform the required servoing for assisting handicapped people. This year we also bought a wheelchair haptic simulator to develop new human interaction strategies in a virtual reality environment (see Fig. 3 (c)).

Pepper, a human-shaped robot designed by SoftBank Robotics to be a genuine day-to-day companion (see Fig. 3 .d) is also part of this platform. It has 17 DoF mounted on a wheeled holonomic base and a set of sensors (cameras, laser, ultrasound, inertial, microphone) that makes this platform interesting for robot-human interactions during locomotion (see Section 6.2.6).

Note that 2 papers and 1 PhD Thesis exploiting the mobile robots were published this year [42], [54], [1].

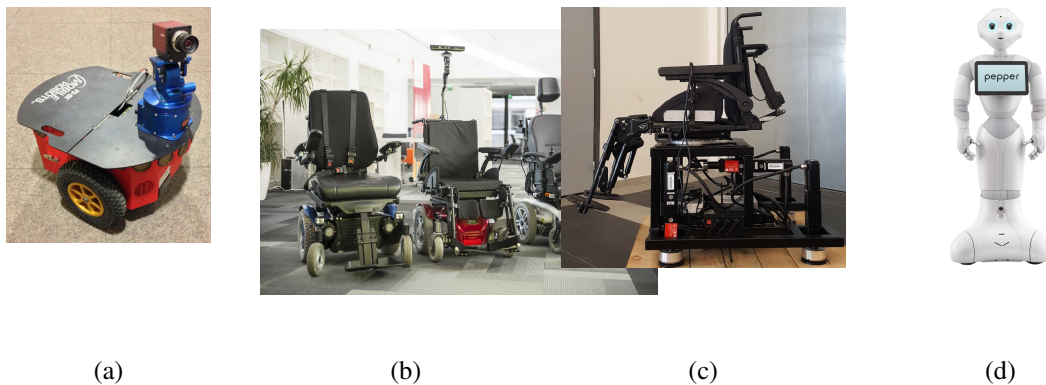| (a) | (b) | (c) | (d) |

Figure 3. Mobile Robot Platform. a) Pioneer P3-DX robot, b) wheelchairs from Permobil, Sunrise and YouQ, c) Wheelchair haptic simulator, d) Pepper human-shaped robot

5.4.3. Medical Robotic Platform

Participants: Alexandre Krupa, Fabien Spindler [contact].

This platform is composed of two 6 DoF Adept Viper arms (see Figs. 4 .a–b). Ultrasound probes connected either to a SonoSite 180 Plus or an Ultrasonix SonixTouch 2D and 3D imaging system can be mounted on a force torque sensor attached to each robot end-effector. The haptic Virtuose 6D or Omega 6 device (see Fig. 7 .a) can also be used within this platform.

This year this platform was extended with a new ATI Nano43 force/torque sensor dedicated to needle insertion applications.

This testbed is of primary interest for researches and experiments concerning ultrasound visual servoing applied to probe positioning, soft tissue tracking, elastography or robotic needle insertion tasks (see Sect. 6.4.3 and Sect. 6.4.2).

This platform was used to obtain experimental results presented in 4 new papers [6], [23], [38], [51].

5.4.4. Advanced Manipulation Platform

Participants: François Chaumette, Claudio Pacchierotti, Paolo Robuffo Giordano, Fabien Spindler [contact].
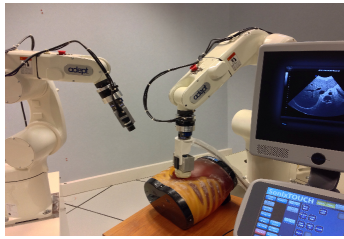
(a)   (b)

Figure 4. Rainbow medical robotic platforms. a) On the right Viper S850 robot arm equipped with a SonixTouch 3D ultrasound probe. On the left Viper S650 equipped with a tool changer that allows to attach a classical camera or biopsy needles. b) Robotic setup for autonomous needle insertion by visual servoing.

This new platform is composed by 2 Panda lightweight arms from Franka Emika equipped with torque sensors in all seven axes. An electric gripper, a camera or a soft hand from qbrobotics can be mounted on the robot end-effector (see Fig. 5 .a) to validate our researches in coupling force and vision for controlling robot manipulators (see Section 6.2.12) and in shared control for remote manipulation (see Section 6.4.1). Other haptic devices (see Section 5.4.6) can also be coupled to this platform.

This year this platform was extended with a new Reflex TakkTile 2 gripper from RightHand Labs (see Fig. 5 .b). A new force/torque sensor from Alberobotics that can be mounted on the robot end-effector to get more precision during torque control was also bought.

Two new papers published this year include experimental results obtained with this platform [50], [66].

Figure 5. Rainbow advanced manipulation platform. a) One of the two Panda lightweight arms from Franka Emika, with mounted the Pisa SoftHand, b) the Reflex TakkTile 2 gripper that could be mounted on the Panda robot end-effector.

5.4.5. Unmanned Aerial Vehicles (UAVs)

Participants: Joudy Nader, Paolo Robuffo Giordano, Claudio Pacchierotti, Fabien Spindler [contact].

Rainbow is involved in several activities involving perception and control for single and multiple quadrotor UAVs. To this end, we purchased four quadrotors from Mikrokopter Gmbh, Germany (see Fig. 6 .a), and one quadrotor from 3DRobotics, USA (see Fig. 6 .b). The Mikrokopter quadrotors have been heavily customized by: (i) reprogramming from scratch the low-level attitude controller onboard the microcontroller of the

quadrotors, (ii) equipping each quadrotor with a NVIDIA Jetson TX2 board running Linux Ubuntu and the TeleKyb-3 software based on genom3 framework developed at LAAS in Toulouse (the middleware used for managing the experiment flows and the communication among the UAVs and the base station), and (iii) purchasing the Flea Color USB3 cameras together with the gimbal needed to mount them on the UAVs. The quadrotor group is used as robotic platforms for testing a number of single and multiple flight control schemes with a special attention on the use of onboard vision as main sensory modality.

This year 2 papers [20], [25] and 2 PhD Theses [3] contain simulative and experimental results obtained with this platform [1].
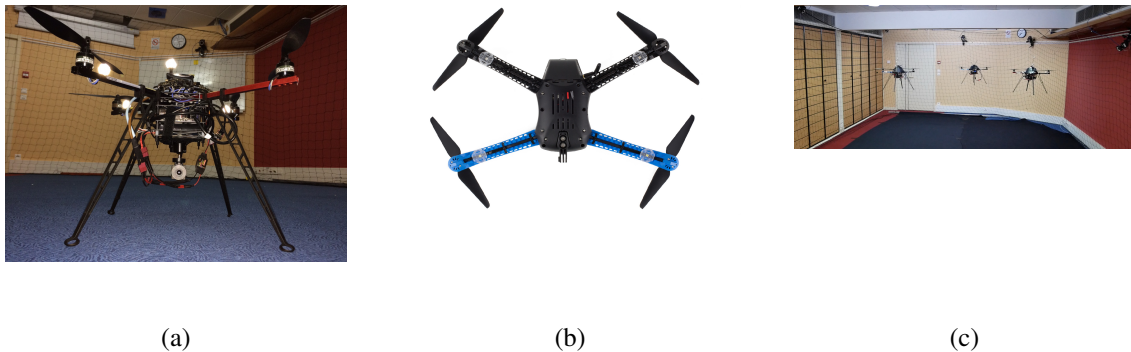

(a) (b) (c)

Figure 6. Unmanned Aerial Vehicles Platform. a) Quadrotor XL1 from Mikrokopter, b) Quadrotor Iris from 3DRobotics, c) Formation control with 3 XL1 from Mikrokopter.

5.4.6. Haptics and Shared Control Platform

Participants: Claudio Pacchierotti, Paolo Robuffo Giordano, Fabien Spindler [contact].

Various haptic devices are used to validate our research in shared control. We have a Virtuose 6D device from Haption (see Fig. 7 .a). This device is used as master device in many of our shared control activities (see Sections 6.4.2 and 6.4.3). It could also be coupled to the Haption haptic glove in loan from the University of Birmingham. An Omega 6 (see Fig. 7 .b) from Force Dimension and devices in loan from Ultrahaptics complete this platform that could be coupled to the other robotic platforms.

This platform was used to obtain experimental results presented in 9 papers [6], [50], [43], [44], [38], [45], [11], [51], [5] published this year.

(a)   (b)

Figure 7. Haptics and Shared Control Platform. a) Virtuose 6D and b) Omega 6 haptic devices

RITS Project-Team

5. New Software and Platforms

5.1. PML-SLAM

KEYWORD: Localization

SCIENTIFIC DESCRIPTION: Simultaneous Localization and Mapping method based on 2D laser data.

- Participants: Fawzi Nashashibi and Zayed Alsayed
- Contact: Fawzi Nashashibi

5.2. V2Provue

Vehicle-to-Pedestrian

FUNCTIONAL DESCRIPTION: It is a software developed for the Vehicle-to-Pedestrian (V2P) communications, risk calculation, and alarming pedestrians of collision risk. This software is made of an Android application dedicated to pedestrians and RtMaps modules for the vehicles.

On the pedestrian side, the application is relying on GPS data to localize the user and Wi-Fi communications are used to receive messages about close vehicles and send information about the pedestrian positioning. Besides, a service has been developed to evaluate the collision risk with the vehicles near the pedestrian and an HMI based on OpenStreetMap displays all the useful information such as pedestrian and vehicles localization and, collision risk.

On the vehicle side, RtMaps modules allowing V2X communications have been developed. These modules contain features such as TCP/UDP socket transmissions, broadcast, multicast, unicast communications, routing, forwarding algorithms, and application specific modules. In the V2ProVu software, a particular application module has been implemented to create data packets containing information about the vehicle state (position, speed, yaw rate,...) and the V2X communication stack is used to broadcast these packets towards pedestrians. Moreover, the V2proVu application can also receive data from pedestrians and create objects structures that can be shared with the vehicle perception tools.

- Contact: Fawzi Nashashibi

5.3. SimConVA

Connected Autonomous Vehicles Simulator

FUNCTIONAL DESCRIPTION: The software provides an interface between the network simulator ns-3 (https://www.nsnam.org/) and the modular prototyping framework RTMaps (https://intempora.com/).

This code allows to create an RTMaps component which activates and controls the ns-3 simulator. The component handles the sending and reception of data packets between ns-3 and RTMaps for each vehicle. It also handles the mobility of vehicles in ns-3 using their known position in RTMaps.

- Authors: Pierre Merdrignac, Oyunchimeg Shagdar and Jean-Marc Lasgouttes
- Contact: Jean-Marc Lasgouttes

SEMAGRAMME Project-Team

5. New Software and Platforms

5.1. ACGtk

Abstract Categorial Grammar Development Toolkit

KEYWORDS: Natural language processing - NLP - Syntactic analysis - Semantics

SCIENTIFIC DESCRIPTION: Abstract Categorial Grammars (ACG) are a grammatical formalism in which grammars are based on typed lambda-calculus. A grammar generates two languages: the abstract language (the language of parse structures), and the object language (the language of the surface forms, e.g., strings, or higher-order logical formulas), which is the realization of the abstract language.

ACGtk provides two software tools to develop and to use ACGs: acgc, which is a grammar compiler, and acg, which is an interpreter of a command language that allows one, in particular, to parse and realize terms.

FUNCTIONAL DESCRIPTION: ACGtk provides softwares for developing and using Abstract Categorial Grammars (ACG).

RELEASE FUNCTIONAL DESCRIPTION: This version removes the dependency to obsolete packages. It also provides a better handling of the command line interface.

NEWS OF THE YEAR: The new version removes dependencies to obsolete libraries. It improves the command line interface and prepares the integration of new functionalities and optimizations.

- Participants: Philippe de Groote, Jiri Marsik, Sylvain Pogodalla and Sylvain Salvati
- Contact: Sylvain Pogodalla
- Publications: A syntax-semantics interface for Tree-Adjoining Grammars through Abstract Categorial Grammars - ACGTK: un outil de développement et de test pour les grammaires catégorielles abstraites - Discourse Modeling with Abstract Categorial Grammars - On the expressive power of Abstract Categorial Grammars: Representing context-free formalisms - Towards abstract categorial grammars
- URL: http://acg.loria.fr/

5.2. Dep2pict

KEYWORDS: Syntactic analysis - Semantics

FUNCTIONAL DESCRIPTION: Dep2pict is a program for drawing graphical representation of dependency structures of natural language sentences. Dep2pict takes into account the modified format mixing surface and deep syntactic information used in deep-sequoia.

- Contact: Bruno Guillaume
- URL: http://dep2pict.loria.fr/

5.3. Grew

Graph Rewriting

KEYWORDS: Semantics - Syntactic analysis - Natural language processing - Graph rewriting

FUNCTIONAL DESCRIPTION: Grew is a Graph Rewriting tool dedicated to applications in NLP. Grew takes into account confluent and non-confluent graph rewriting and it includes several mechanisms that help to use graph rewriting in the context of NLP applications (built-in notion of feature structures, parametrization of rules with lexical information).

NEWS OF THE YEAR: In 2019, the Grew software was enriched with a new syntax for edges (it is now possible to use feature structures as edge labels).

The Grew-match tool (http://match.grew.fr) is an online service available where a user can query different corpora with graph matching requests. All UD corpora (157 in 90 different languages in v2.5) are available and data from several other projects can also be queried. In the last 12 months (December 2018 to November 2019), 32,465 requests were received on the Grew-match server. The number of requests has increased in the last months (7,948 in November 2019).

An experiment was conducted to test the usage of the matching part of Grew on larger graphs. In the internship of Axel Didier, we experiment graph query on the French lexical network, RL-Fr.

- Participants: Bruno Guillaume, Guy Perrier and Guillaume Bonfante
- Contact: Bruno Guillaume
- Publications: Application de la réécriture de graphes au traitement automatique des langues - Application of Graph Rewriting to Natural Language Processing
- URL: http://grew.fr/

5.4. ZombiLingo

KEYWORDS: Syntactic analysis - Natural language processing - Lexical resource - Collaborative science

FUNCTIONAL DESCRIPTION: ZombiLingo is a prototype of a GWAP (Game With A Purpose) where gamers have to give linguistic information about the syntax of natural language sentences, currently in French, and later to other languages.

NEWS OF THE YEAR: Karën Fort and Bruno Guillaume proposed a new version of ZombiLingo this year. It is named ZombiLudik (https://zombiludik.org) and the main difference is that the linguistic data used are now based on the Universal Dependencies (UD) framework. Due to the recent success of the UD project, this format is now used for data in 90 different languages and we hope to find new collaborations to work on a similar games for some foreign languages. A first demonstration version was built on English data (https://en.zombiludik.org). Karën Fort and Bruno Guillaume presented the English version of the game in June during the NIEUW consortium meeting in London.

- Authors: Bruno Guillaume, Karën Fort, Nicolas Lefebvre and Valentin Stern
- Contact: Karën Fort
- URL: http://zombilingo.org/

<p style="text-align:center">**SIROCCO Project-Team**</p>

6. New Software and Platforms

6.1. M360CT

Multi-360 Calibration Toolkit

KEYWORDS: Omnidirectional camera - Calibration - FTV - 6DoF

FUNCTIONAL DESCRIPTION: Based on multiple synchronized sequences of a chessboard pattern moving in the scene, the algorithm computes the internal and external camera parameters of the different cameras under the unified spherical model. This software is composed of two executables, the first one for the individual calibration of each camera, the second one for the fusion of all the outputs of the first executable. The work has been submitted at APP with the number IDNN.FR.001.510008.S.P.2018.000.10800.

- Participants: Cédric Le Cam, Thomas Maugey and Laurent Guillo
- Contact: Thomas Maugey
- URL: http://project.inria.fr/ftv360

6.2. Context-adaptive neural network based prediction for image compression

KEYWORDS: Deep learning - Image compression - Intra prediction - Neural networks

FUNCTIONAL DESCRIPTION: This code implements (i) the learning of deep neural networks for intra-prediction of video compression and (ii) a video coder/decoder integrating the learned deep neural networks. This code allows to reproduce the results of the paper "Thierry Dumas, Aline Roumy and Christine Guillemot. Context-adaptive neural network based prediction for image compression, IEEE Transactions on Image Processing, 2019." To this end, the code implements the pre-processing of an image database (i.e. extraction of a set of pairs containing a block to be predicted and its context) to yield a training set. Then, from this learning set, the code implements the learning of one deep neural network per block size (fully-connected network at size 8x8 and smaller, and convolutional network at bigger size). The code contains the parameters of all deep networks learned from the preprocessed ILSVRC2012 training database. Then, the code contains a modified version of the HEVC video compression test model (HM 16.9), which integrates the learned prediction functions and the signalling of the intra prediction mode (for both classical HEVC intra prediction modes and the learned neural networks).

- Contact: Aline Roumy
- URL: https://github.com/thierrydumas/context_adaptive_neural_network_based_prediction

6.3. LFDE-FLEX

LFDE-FLEX: A Framework for Learning Based Depth from a Flexible Subset of Dense and Sparse Light Field Views

KEYWORDS: Light fields - Depth estimation - Deep learning

FUNCTIONAL DESCRIPTION: The code implements a learning based depth estimation framework suitable for both densely and sparsely sampled light fields. The proposed framework consists of three processing steps: initial depth estimation, fusion with occlusion handling, and refinement. The estimation can be performed from a flexible subset of input views. The fusion of initial disparity estimates, relying on two warping error measures, allows us to have an accurate estimation in occluded regions and along the contours. In contrast with methods relying on the computation of cost volumes, the proposed approach does not need any prior information on the disparity range.

- Participants: Jinglei Shi, Xiaoran Jiang and Christine Guillemot
- Contact: Jinglei Shi

6.4. EPI-SENet

EPI-based light field view extrapolation network

KEYWORDS: Light fields - Deep learning - View synthesis

FUNCTIONAL DESCRIPTION: This code implements a learning based algorithm for light field view extrapolation from axial volumes of sheared epipolar plane images (EPIs). The learned SENet network is based on tensorflow backend. The inputs of this network are multiple views in a row of a structured dense light field. The network predicts novel views in order to extend the light field baseline by a factor which can go up to 4 times the initial baseline. The code also performs digital refocusing with the original and extrapolated views. As with extended numerical aperture in classical imaging, the extrapolated light field gives refocused images with a shallower depth of field (DOF), leading to more accurate refocusing results.

- Participants: Zhaolin Xiao, Jinglei Shi, Xiaoran Jiang and Christine Guillemot
- Contact: Xiaoran Jiang

6.5. 4D-SFE

4D-SFE: 4D Scene Flow Estimator from Light Fields

KEYWORDS: Light fields - Scene Flow - Motion analysis - Depth estimation

FUNCTIONAL DESCRIPTION: This software implements a method for scene flow estimation from light fields by computing an optical flow, a disparity map and a disparity variation map for the whole light field. It takes as inputs two consecutive frames from a light field video, as well as optical flow and disparity maps estimated for each view of the light field (e.g. with a deep model like PWC-Net) and saved as .flo files. First the light field is divided into 4D clusters called superrays, then a neighboring weighted graph is built between the different clusters and finally a 4D affine model is fitted for every cluster, using the initial estimations from the optical flow and disparity estimations that are contained in the cluster and in the neighboring clusters.

- Participants: Pierre David and Christine Guillemot
- Contact: Christine Guillemot

6.6. LMVS-Net

LMVS-Net: Lightweight Neural Network for Monocular View Synthesis with Occlusion Handling

KEYWORDS: Light fields - View synthesis - Deep learning

FUNCTIONAL DESCRIPTION: This code implements the method described in A Lightweight Neural Network for Monocular View Synthesis with Occlusion Handling, allowing to perform monocular view synthesis in a stereo setting. From one input image, it computes a view laterally located, left-side or right-side, and with the required disparity range depending on user input. It is also able to retrieve a disparity map from the input image, as well as a confidence map to distinguish the occluded regions, as well as to evaluate the pixelwise accuracy of the prediction. The code was developed using Keras and TensorFlow.

- Participants: Simon Evain and Christine Guillemot
- Contact: Simon Evain

6.7. 4D-LFDE

KEYWORDS: Light fields - Depth estimation

FUNCTIONAL DESCRIPTION: This code implements a learning based solution for disparity estimation for either densely or sparsely sampled light fields from 4 corner input views. The code contains two parts "DispEstim" and "DispPropa". The DispEstim module (implemented in tensorflow) takes the 4 corner views of a light field, and estimates the disparity information for these input view positions. The DispPropa module (implemented in Matlab) then generates one disparity map per target view position by propagating corner disparity maps and by applying an occlusion-aware soft 3D reconstruction method. The final output is a .mat file which contains disparity maps for every view positions of a light field.

- Participants: Xiaoran Jiang, Christine Guillemot and Jinglei Shi
- Contact: Xiaoran Jiang

6.8. Compression of omnidirectional images on the sphere

KEYWORDS: Image compression - Omnidirectional image

FUNCTIONAL DESCRIPTION: This code implements a compression scheme of omnidirectional images. The approach operates directly on the sphere, without the need to project the data on a 2D image. More specifically, from the sphere pixelization, called healpix, the code implements the partition of the set of pixels into blocks, a block scanning order, an intra prediction between blocks, and a Graph Fourier Transform for each block residual. Finally, the image to be displayed in the viewport is generated.

- Contact: Aline Roumy

6.9. Performance evaluation of interactive video compression schemes and navigation model for omnidirectional images

KEYWORDS: Image compression - Omnidirectional image

FUNCTIONAL DESCRIPTION: This code consists of two parts. First, the code generates typical navigation paths of users viewing omnidirectional images. This generation relies on Markov modeling of the user behavior (probability to choose a first viewing direction to start the navigation, probability to choose a head motion direction, probability of continuing the head motion in the same direction, probability to stop the head motion). The second part of the code implements various criteria to evaluate the compression performance. Three criteria are computed: the distortion averaged along a set of typical navigation paths, the transmission rate related to these navigation paths, and also the storage cost of the compressed image to be able to serve any possible image request. From these 3 criteria, weighted Bjontegaard metric, and iso values are computed.

- Contact: Aline Roumy

6.10. Interactive compression for omnidirectional images and texture maps of 3D models

KEYWORDS: Image compression - Random access

FUNCTIONAL DESCRIPTION: This code implements a new image compression algorithm that allows to navigate within a static scene. To do so, the code provides access in the compressed domain to any block and therefore allows extraction of any subpart of the image. This codec implements this interactive compression for two image modalities: omnidirectional images and texture maps of 3D models. For omnidirectional images the input is a 2D equirectangular projection of the 360 image. The output is the image seen in the viewport. For 3D models, the input is a texture map and the 3D mesh. The output is also the image seen in the viewport.

The code consists of three parts: (A) an offline encoder (B) an online bit extractor and (C) a decoder. The offline encoder (i) partitions the image into blocks, (ii) optimizes the positions of the access blocks, (iii) computes a set of geometry aware predictions for each block (to cover all possible navigation paths), (iv) implements transform quantization for all blocks and their predictions, and finally (v) evaluates the encoding rates. The online bit extractor (Part B) first computes the optimal and geometry aware scanning order. Then it extracts in the bitstream, the sufficient amount of information to allow the decoding of the requested blocks. The last part of the code is the decoder (Part C). The decoder reconstructs the same scanning order as the one computed at the online bit extractor. Then, the blocks are decoded (inverse transform, geometry aware predictions, ...) and reconstructed. Finally the image in the viewport is generated.

- Contact: Aline Roumy

6.11. Platforms

6.11.1. *Acquisition of multi-view sequences for Free viewpoint Television*

Participants: Laurent Guillo, Thomas Maugey.

The scientific and industrial community is nowadays exploring new multimedia applications using 3D data (beyond stereoscopy). In particular, Free Viewpoint Television (FTV) has attracted much attention in the recent years. In those systems, user can choose in real time its view angle from which he wants to observe the scene. Despite the great interest for FTV, the lack of realistic and ambitious datasets penalizes the research effort. The acquisition of such sequences is very costly in terms of hardware and working effort, which explains why no multi-view videos suitable for FTV has been proposed yet.

In the context of the project ADT ATeP 2016-2018 (funded by Inria), such datasets were acquired and some calibration tools have been developed. First 40 omnidirectional cameras and their associated equipments have been acquired by the team (thanks to Rennes Metropole funding). We have first focused on the calibration of this camera, *i.e.,* the development of the relationship between a 3D point and its projection in the omnidirectional image. In particular, we have shown that the unified spherical model fits the acquired omnidirectional cameras. Second, we have developed tools to calibrate the cameras in relation to each other. Finally, we have made a capture of 3 multiview sequences that have been made available to the community via a public web site. In 2019, we have published and presented our dataset at the ACM MMSys conference [28].

6.11.2. *CLIM processing toolbox*

Participants: Pierre Allain, Christine Guillemot, Laurent Guillo.

As part of the ERC Clim project, the EPI Sirocco is developing a light field processing toolbox. The toolbox and libraries are developed in C++ and the graphical user interface relies on Qt. As input data, this tool accepts both sparse light fields acquired with High Density Camera Arrays (HDCA) and denser light fields captured with plenoptic cameras using microlens arrays (MLA). At the time of writing, in addition to some simple functionalities, such as re-focusing, change of viewpoints, with different forms of visualization, the toolbox integrates more advanced tools for scene depth estimation from sparse and dense light fields, for super-ray segmentation and scene flow estimation, and for light field denoising and angular interpolation using anisotropic diffusion in the 4D ray space. The toolbox is now being interfaced with the C/C++ API of the tensorflow platform, in order to execute deep models developed in the team for scene depth and scene flow estimation, view synthesis, and axial super-resolution.

Stars Project-Team

5. New Software and Platforms

5.1. SUP

Scene Understanding Platform

KEYWORDS: Activity recognition - 3D - Dynamic scene

FUNCTIONAL DESCRIPTION: SUP is a software platform for perceiving, analyzing and interpreting a 3D dynamic scene observed through a network of sensors. It encompasses algorithms allowing for the modeling of interesting activities for users to enable their recognition in real-world applications requiring high-throughput.

- Participants: Etienne Corvée, François Brémond, Hung Nguyen and Vasanth Bathrinarayanan
- Partners: CEA - CHU Nice - USC Californie - Université de Hamburg - I2R
- Contact: François Brémond
- URL: https://team.inria.fr/stars/software

5.2. VISEVAL

FUNCTIONAL DESCRIPTION: ViSEval is a software dedicated to the evaluation and visualization of video processing algorithm outputs. The evaluation of video processing algorithm results is an important step in video analysis research. In video processing, we identify 4 different tasks to evaluate: detection, classification and tracking of physical objects of interest and event recognition.

- Participants: Bernard Boulay and François Brémond
- Contact: François Brémond
- URL: http://www-sop.inria.fr/teams/pulsar/EvaluationTool/ViSEvAl_Description.html

THOTH Project-Team

6. New Software and Platforms

6.1. LCR-Net

Localization-Classification-Regression Network for Human Pose

KEYWORDS: Object detection - Recognition of human movement

FUNCTIONAL DESCRIPTION: We propose an end-to-end architecture for joint 2D and 3D human pose estimation in natural images. Key to our approach is the generation and scoring of a number of pose proposals per image, which allows us to predict 2D and 3D pose of multiple people simultaneously. Our architecture contains 3 main components: 1) the pose proposal generator that suggests potential poses at different locations in the image, 2) a classifier that scores the different pose proposals , and 3) a regressor that refines pose proposals both in 2D and 3D.

- Participants: Grégory Rogez, Philippe Weinzaepfel and Cordelia Schmid
- Partner: Naver Labs Europe
- Contact: Nicolas Jourdan
- Publication: LCR-Net: Localization-Classification-Regression for Human Pose
- URL: https://thoth.inrialpes.fr/src/LCR-Net/

6.2. CKN-seq

Convolutional Kernel Networks for Biological Sequences

KEYWORD: Bioinformatics

SCIENTIFIC DESCRIPTION: The growing amount of biological sequences available makes it possible to learn genotype-phenotype relationships from data with increasingly high accuracy. By exploiting large sets of sequences with known phenotypes, machine learning methods can be used to build functions that predict the phenotype of new, unannotated sequences. In particular, deep neural networks have recently obtained good performances on such prediction tasks, but are notoriously difficult to analyze or interpret. Here, we introduce a hybrid approach between kernel methods and convolutional neural networks for sequences, which retains the ability of neural networks to learn good representations for a learning problem at hand, while defining a well characterized Hilbert space to describe prediction functions. Our method outperforms state-of-the-art convolutional neural networks on a transcription factor binding prediction task while being much faster to train and yielding more stable and interpretable results.

FUNCTIONAL DESCRIPTION: D. Chen, L. Jacob, and J. Mairal. Biological Sequence Modeling with Convolutional Kernel Networks. Bioinformatics, volume 35, issue 18, pages 3294-3302, 2019.

- Participants: Laurent Jacob, Dexiong Chen and Julien Mairal
- Partners: CNRS - UGA
- Contact: Julien Mairal
- Publication: Biological Sequence Modeling with Convolutional Kernel Networks
- URL: https://gitlab.inria.fr/dchen/CKN-seq

6.3. LVO

Learning Video Object Segmentation with Visual Memory

KEYWORD: Video analysis

FUNCTIONAL DESCRIPTION: This is a public implementation of the method described in the following paper: Learning Video Object Segmentation with Visual Memory [ICCV 2017] (https://hal.archives-ouvertes.fr/hal-01511145v2/document).

This paper addresses the task of segmenting moving objects in unconstrained videos. We introduce a novel two-stream neural network with an explicit memory module to achieve this. The two streams of the network encode spatial and temporal features in a video sequence respectively, while the memory module captures the evolution of objects over time. The module to build a "visual memory" in video, i.e., a joint representation of all the video frames, is realized with a convolutional recurrent unit learned from a small number of training video sequences. Given a video frame as input, our approach assigns each pixel an object or background label based on the learned spatio-temporal features as well as the "visual memory" specific to the video, acquired automatically without any manually-annotated frames. The visual memory is implemented with convolutional gated recurrent units, which allows to propagate spatial information over time. We evaluate our method extensively on two benchmarks, DAVIS and Freiburg-Berkeley motion segmentation datasets, and show state-of-the-art results. For example, our approach outperforms the top method on the DAVIS dataset by nearly 6%. We also provide an extensive ablative analysis to investigate the influence of each component in the proposed framework.

- Participants: Karteek Alahari, Cordelia Schmid and Pavel Tokmakov
- Contact: Pavel Tokmakov
- Publication: hal-01511145v2
- URL: http://lear.inrialpes.fr/research/lvo/

6.4. SURREAL

Learning from Synthetic Humans

KEYWORDS: Synthetic human - Segmentation - Neural networks

FUNCTIONAL DESCRIPTION: The SURREAL dataset consisting of synthetic videos of humans, and models trained on this dataset are released in this package. The code for rendering synthetic images of people and for training models is also included in the release.

- Participants: Gül Varol, Xavier Martin, Ivan Laptev and Cordelia Schmid
- Contact: Gül Varol
- Publication: Learning from Synthetic Humans
- URL: http://www.di.ens.fr/willow/research/surreal/

6.5. attn2d

Pervasive Attention

KEYWORDS: NLP - Deep learning - Machine translation

SCIENTIFIC DESCRIPTION: Pervasive attention : 2D Convolutional Networks for Sequence-to-Sequence Prediction

FUNCTIONAL DESCRIPTION: An open source PyTorch implementation of the pervasive attention model described in: Maha Elbayad, Laurent Besacier, and Jakob Verbeek. 2018. Pervasive Attention: 2D Convolutional Networks for Sequence-to-Sequence Prediction. In Proceedings of the 22nd Conference on Computational Natural Language Learning (CoNLL 2018)

- Participants: Maha Elbayad and Jakob Verbeek
- Contact: Maha Elbayad
- Publication: Pervasive Attention: 2D Convolutional Neural Networks for Sequence-to-Sequence Prediction
- URL: https://github.com/elbayadm/attn2d

6.6. Cyanure

Cyanure: An Open-Source Toolbox for Empirical Risk Minimization

KEYWORD: Machine learning

FUNCTIONAL DESCRIPTION: Cyanure is an open-source C++ software package with a Python interface. The goal of Arsenic is to provide state-of-the-art solvers for learning linear models, based on stochastic variance-reduced stochastic optimization with acceleration mechanisms and Quasi-Newton principles. Arsenic can handle a large variety of loss functions (logistic, square, squared hinge, multinomial logistic) and regularization functions (l2, l1, elastic-net, fused Lasso, multi-task group Lasso). It provides a simple Python API, which is very close to that of scikit-learn, which should be extended to other languages such as R or Matlab in a near future.

RELEASE FUNCTIONAL DESCRIPTION: version initiale

- Participant: Julien Mairal
- Contact: Julien Mairal
- URL: http://thoth.inrialpes.fr/people/mairal/arsenic/welcome.html

TITANE Project-Team

6. New Software and Platforms

6.1. CGAL Barycentric_coordinates_2

Module CGAL : Barycentric coordinates 2D

KEYWORD: Computational geometry

FUNCTIONAL DESCRIPTION: This package offers an efficient and robust implementation of two-dimensional closed-form generalized barycentric coordinates defined for simple two-dimensional polygons.

- Participants: Dmitry Anisimov and Pierre Alliez
- Contact: Pierre Alliez

6.2. dtk-nurbs-probing

KEYWORDS: Algorithm - CAD - Numerical algorithm - Geometric algorithms

FUNCTIONAL DESCRIPTION: This library offers tools for computing intersection between linear primitives and the constitutive elements of CAD objects (curves and surfaces). It is thus possible to compute intersections between a linear primitive with a trimmed or untrimmed NURBS surface, as well with Bezier surfaces. It is also possible, in the xy plane, to compute the intersections between linear primitives and NURBS curves as well as Bezier curves.

- Participants: Come Le Breton, Laurent Busé and Pierre Alliez
- Contact: Come Le Breton

6.3. Module CGAL : Point Set Processing

KEYWORD: Geometry Processing

FUNCTIONAL DESCRIPTION: This CGAL component implements methods to analyze and process unorganized point sets. The input is an unorganized point set, possibly with normal attributes (unoriented or oriented). The point set can be analyzed to measure its average spacing, and processed through functions devoted to the simplification, outlier removal, smoothing, normal estimation, normal orientation and feature edges estimation.

- Participants: Clément Jamin, Laurent Saboret and Pierre Alliez
- Contact: Pierre Alliez
- URL: http://doc.cgal.org/latest/Point_set_processing_3/index.html#Chapter_Point_Set_Processing

6.4. Module CGAL : Scale space surface reconstruction

KEYWORD: Geometric algorithms

SCIENTIFIC DESCRIPTION: This CGAL package implements a surface reconstruction method which takes as input an unordered point set and computes a triangulated surface mesh interpolating the point set. We assume that the input points were sampled from the surface of an object. The method can also process point sets sampled from the interior of the object, although we cannot provide guarantees on the output. This method can handle a decent amount of noise and outliers. The point set may greatly undersample the object in occluded regions, although no surface will be reconstructed to fill these regions.

FUNCTIONAL DESCRIPTION: This method allows to reconstruct a surface that interpolates a set of 3D points. This method provides an efficient alternative to the Poisson surface reconstruction method. The main difference in output is that this method reconstructs a surface that interpolates the point set (as opposed to approximating the point set). How the surface connects the points depends on a scale variable, which can be estimated semi-automatically.

- Participants: Pierre Alliez and Thijs Van Lankveld
- Contact: Pierre Alliez

6.5. Module Gudhi : Skeleton-Blockers

Skeleton-Blockers data-structure

KEYWORDS: C++ - Mesh - Triangulation - Topology - 3D

FUNCTIONAL DESCRIPTION: Skeleton-Blockers is a compact, efficient and generic data-structure that can represent any simplicial complex. The implementation is in C++11.

- Participant: David Salinas
- Contact: David Salinas
- URL: https://project.inria.fr/gudhi/software/

6.6. DPP

Delaunay Point Process for image analysis

KEYWORDS: Computer vision - Shape recognition - Delaunay triangulation - Stochastic process

FUNCTIONAL DESCRIPTION: The software extract 2D geometric structures (planar graphs, polygons...) from images

- Participants: Jean-Dominique Favreau, Florent Lafarge and Adrien Bousseau
- Contact: Florent Lafarge
- Publication: Extracting Geometric Structures in Images with Delaunay Point Processes

6.7. KIPPI

KInetic Polygonal Partitioning of Images

KEYWORDS: Computer vision - Computational geometry - Image segmentation

SCIENTIFIC DESCRIPTION: The scientific description of the algorithm is detailed in [Bauchet and Lafarge, KIPPI: KInetic Polygonal Partitioning of Images, CVPR 2018]

FUNCTIONAL DESCRIPTION: KIPPI decompose an image, or a bounded 2D space, into convex polygons. The method exploits a kinetic framework for propagating and colliding line-segments until forming convex polygons.

- Participants: Jean-Philippe Bauchet and Florent Lafarge
- Contact: Florent Lafarge

6.8. Module CGAL: 3D Point-Set Shape Detection

KEYWORD: CGAL

FUNCTIONAL DESCRIPTION: This package implements the efficient RANSAC method for shape detection, contributed by Schnabel et al. From an unstructured point set with unoriented normals, the algorithm detects a set of shapes. Five types of primitive shapes are provided by this package: plane, sphere, cylinder, cone and torus. Detecting other types of shapes is possible by implementing a class derived from a base shape.

- Participants: Clément Jamin, Pierre Alliez and Sven Oesau
- Contact: Pierre Alliez

6.9. CGAL module: Classification

KEYWORDS: Classification - Point cloud - Mesh

FUNCTIONAL DESCRIPTION: This CGAL module aims at classifying 3D data, typically point clouds, into arbitrary classes of interest. The module offers the user the possibility to segment data i) locally or globally, and ii) in an supervised or unsupervised way.

- Authors: Florent Lafarge and Simon Giraudot
- Contact: Florent Lafarge

6.10. SMICER

KEYWORDS: Geometric modeling - Computational geometry - Polyhedral meshes

FUNCTIONAL DESCRIPTION: The software allows the decomposition of a 3D domain into a polyhedra from a set of planar shapes

- Participants: Florent Lafarge and Pierre Alliez
- Contact: Florent Lafarge

6.11. Stochastic Vectorization

KEYWORDS: Vector graphics - Stochastic models

FUNCTIONAL DESCRIPTION: The software converts a line-drawing image into Bezier curves.

- Participants: Jean-Dominique Favreau, Florent Lafarge and Adrien Bousseau
- Contact: Florent Lafarge
- Publication: 01309271

<p align="center" style="color:red;">TYREX Project-Team</p>

5. New Software and Platforms

5.1. SPARQLGX

KEYWORDS: RDF - SPARQL - Distributed computing

SCIENTIFIC DESCRIPTION: SPARQL is the W3C standard query language for querying data expressed in RDF (Resource Description Framework). The increasing amounts of RDF data available raise a major need and research interest in building efficient and scalable distributed SPARQL query evaluators.

In this context, we propose and share SPARQLGX: our implementation of a distributed RDF datastore based on Apache Spark. SPARQLGX is designed to leverage existing Hadoop infrastructures for evaluating SPARQL queries. SPARQLGX relies on a translation of SPARQL queries into executable Spark code that adopts evaluation strategies according to (1) the storage method used and (2) statistics on data. Using a simple design, SPARQLGX already represents an interesting alternative in several scenarios.

FUNCTIONAL DESCRIPTION: This software system is an implementation of a distributed evaluator of SPARQL queries. It makes it possible to evaluate SPARQL queries on billions of triples distributed across multiple nodes in a cluster, while providing attractive performance figures.

RELEASE FUNCTIONAL DESCRIPTION: - Faster load routine which widely improves this phase perfomances by reading once the initial triple file and by partitioning data in the same time into the correct predicate files. - Improving the generated Scala-code of the translation process with mapValues. This technic allows not to break the partitioning of KeyValueRDD while applying transformations to the values instead of the traditional map that was done prior. - Merging and cleaning several scripts in bin/ such as for example sgx-eval.sh and sde-eval.sh - Improving the compilation process of compile.sh - Cleaner test scripts in tests/ - Offering the possibility of an easier deployment using Docker.

- Participants: Damien Graux, Thomas Calmant, Louis Jachiet, Nabil Layaïda and Pierre Genevès
- Contact: Pierre Genevès
- Publications: Optimizing SPARQL query evaluation with a worst-case cardinality estimation based on statistics on the data - The SPARQLGX System for Distributed Evaluation of SPARQL Queries
- URL: https://github.com/tyrex-team/sparqlgx

5.2. musparql

KEYWORDS: SPARQL - RDF - Property paths

FUNCTIONAL DESCRIPTION: reads a SPARQL request and translates it into an internal algebra. Rewrites the resulting term into many equivalent versions, then choses one of them and executes it on a graph.

- Participant: Louis Jachiet
- Contact: Nabil Layaïda
- Publication: Extending the SPARQL Algebra for the optimization of Property Paths
- URL: https://gitlab.inria.fr/tyrex/musparql

5.3. MRB

Mixed Reality Browser

KEYWORDS: Augmented reality - Geolocation - Indoor geolocalisation - Smartphone

FUNCTIONAL DESCRIPTION: MRB displays PoI (Point of Interest) content remotely through panoramics with spatialized audio, or on-site by walking to the corresponding place, it can be used for indoor-outdoor navigation, with assistive audio technology for the visually impaired. It is the only browser of geolocalized data to use XML as a native format for PoIs, panoramics, 3D audio and to rely on HTML5 both for the iconic and full information content of PoIs. Positioning in MRB is based on a PDR library, written in C++ and Java and developed by the team, which provides the user's location in real time based on the interpretation of sensors. Three main modules have been designed to build this positioning system: (i) a pedometer that estimates the distance the user has walked and his speed, (ii) a motion manager that enables data set recording and simulation but also the creation of virtual sensors or filters (e.g gyroscope drift compensation, linear acceleration, altimeter), and (iii) a map-matching algorithm that provides a new location based on a given OpenStreetMap file description and the current user's trajectory.

- Participant: Thibaud Michel
- Contact: Nabil Layaïda
- Publications: On Mobile Augmented Reality Applications based on Geolocation - Attitude Estimation for Indoor Navigation and Augmented Reality with Smartphones
- URL: http://tyrex.inria.fr/projects/mrb.html

5.4. Benchmarks Attitude Smartphones

KEYWORDS: Experimentation - Motion analysis - Sensors - Performance analysis - Smartphone

SCIENTIFIC DESCRIPTION: We investigate the precision of attitude estimation algorithms in the particular context of pedestrian navigation with commodity smartphones and their inertial/magnetic sensors. We report on an extensive comparison and experimental analysis of existing algorithms. We focus on typical motions of smartphones when carried by pedestrians. We use a precise ground truth obtained from a motion capture system. We test state-of-the-art attitude estimation techniques with several smartphones, in the presence of magnetic perturbations typically found in buildings. We discuss the obtained results, analyze advantages and limits of current technologies for attitude estimation in this context. Furthermore, we propose a new technique for limiting the impact of magnetic perturbations with any attitude estimation algorithm used in this context. We show how our technique compares and improves over previous works.

- Participants: Hassen Fourati, Nabil Layaïda, Pierre Genevès and Thibaud Michel
- Partner: GIPSA-Lab
- Contact: Pierre Genevès
- URL: http://tyrex.inria.fr/mobile/benchmarks-attitude/

5.5. MedAnalytics

KEYWORDS: Big data - Predictive analytics - Distributed systems

FUNCTIONAL DESCRIPTION: We implemented a method for the automatic detection of at-risk profiles based on a fine-grained analysis of prescription data at the time of admission. The system relies on an optimized distributed architecture adapted for processing very large volumes of medical records and clinical data. We conducted practical experiments with real data of millions of patients and hundreds of hospitals. We demonstrated how the various perspectives of big data improve the detection of at-risk patients, making it possible to construct predictive models that benefit from volume and variety. This prototype implementation is described in the 2017 preprint available at: https://hal.inria.fr/hal-01517087/document.

- Participants: Pierre Genevès and Thomas Calmant
- Partner: CHU Grenoble
- Contact: Pierre Genevès
- Publication: Scalable Machine Learning for Predicting At-Risk Profiles Upon Hospital Admission

5.6. MuIR

Mu Intermediate Representation

KEYWORDS: Optimizing compiler - Querying

FUNCTIONAL DESCRIPTION: This is a prototype of an intermediate language representation, i.e. an implementation of algebraic terms, rewrite rules, query plans, cost model, query optimizer, and query evaluators (including a distributed evaluator of algebraic terms using Apache Spark).

- Contact: Pierre Genevès

VALDA Project-Team

6. New Software and Platforms

6.1. ProvSQL

KEYWORDS: Databases - Provenance - Probability

FUNCTIONAL DESCRIPTION: The goal of the ProvSQL project is to add support for (m-)semiring provenance and uncertainty management to PostgreSQL databases, in the form of a PostgreSQL extension/module/plugin.

NEWS OF THE YEAR: Miscellaneous enhancements and bug fixes. Addition of a tutorial.

- Participants: Pierre Senellart and Yann Ramusat
- Contact: Pierre Senellart
- Publications: Provenance and Probabilities in Relational Databases: From Theory to Practice - ProvSQL: Provenance and Probability Management in PostgreSQL
- URL: https://github.com/PierreSenellart/provsql

6.2. apxproof

KEYWORD: LaTeX

FUNCTIONAL DESCRIPTION: apxproof is a LaTeX package facilitating the typesetting of research articles with proofs in appendix, a common practice in database theory and theoretical computer science in general. The appendix material is written in the LaTeX code along with the main text which it naturally complements, and it is automatically deferred. The package can automatically send proofs to the appendix, can repeat in the appendix the theorem environments stated in the main text, can section the appendix automatically based on the sectioning of the main text, and supports a separate bibliography for the appendix material.

RELEASE FUNCTIONAL DESCRIPTION: Fix formatting of theorems (and proof sketches) to be faithful to the way they are formatted in the base document class (this will change some difference in the appearance of documents typset with earlier versions of apxproof), Configurable mainbodyrepeatedtheorem command to add some styling to repeated theorems, Allow using apxproof without bibunits (e.g., for biblatex compatibility), Restore predefined theorem counters, allowing more robust use of apxproof when the base document class predefines theorems.

NEWS OF THE YEAR: Major 1.2.0 release with a much more faithful rendering of theorems compared to the original base classes, bug fixes, compatibility enhancements (in particular, with respect to the use of biblatex or of fancyvrb).

- Participant: Pierre Senellart
- Contact: Pierre Senellart
- URL: https://github.com/PierreSenellart/apxproof

WILLOW Team

6. New Software and Platforms

6.1. Pinocchio

KEYWORDS: Robotics - Biomechanics - Mechanical multi-body systems

FUNCTIONAL DESCRIPTION: Pinocchio instantiates state-of-the-art Rigid Body Algorithms for poly-articulated systems based on revisited Roy Featherstone's algorithms. In addition, Pinocchio instantiates analytical derivatives of the main Rigid-Body Algorithms like the Recursive Newton-Euler Algorithms or the Articulated-Body Algorithm. Pinocchio is first tailored for legged robotics applications, but it can be used in extra contexts. It is built upon Eigen for linear algebra and FCL for collision detection. Pinocchio comes with a Python interface for fast code prototyping.

- Partner: CNRS
- Contact: Justin Carpentier
- URL: https://github.com/stack-of-tasks/pinocchio

6.2. VRAnalogy

Visual Relations detector using Analogy

KEYWORDS: Computer vision - Machine learning

FUNCTIONAL DESCRIPTION: Implementation of the paper "Detecting Unseen Visual Relations Using Analogies", Peyre et al', ICCV19

- Contact: Julia Peyre

6.3. d2-net

D2-Net: A Trainable CNN for Joint Description and Detection of Local Features

KEYWORD: Feature points

FUNCTIONAL DESCRIPTION: This repository contains the implementation of the following paper:

"D2-Net: A Trainable CNN for Joint Detection and Description of Local Features". M. Dusmanu, I. Rocco, T. Pajdla, M. Pollefeys, J. Sivic, A. Torii, and T. Sattler. CVPR 2019.

- Participants: Mihai Dusmanu, Ignacio Rocco Spremolla, Tomas Pajdla, Marc Pollefeys, Josef Sivic, Akihiko Torii and Torsten Sattler
- Contact: Ignacio Rocco Spremolla
- Publication: D2-Net: A Trainable CNN for Joint Detection and Description of Local Features
- URL: https://github.com/mihaidusmanu/d2-net

6.4. CrossTask

Cross-task weakly supervised learning from instructional videos

KEYWORDS: Videos - Machine learning

FUNCTIONAL DESCRIPTION: Open source release of the software package for the CVPR'19 paper "Cross-task weakly supervised learning from instructional videos" by D. Zhukov, J.-B. Alayrac, R. G. Cinbis, D. Fouhey, I. Laptev and J. Sivic

- Participants: Dimitri Zhukov, Jean-Baptiste Alayrac, Cinbis Gokberk, David Fouhey, Ivan Laptev and Josef Sivic
- Contact: Dimitri Zhukov
- URL: https://github.com/DmZhukov/CrossTask

6.5. MImE

Manipulation Imitation Environments

KEYWORDS: Robotics - Simulator - Computer vision

FUNCTIONAL DESCRIPTION: Simulation environment for learning robotics manipulation policies.

- Contact: Igor Kalevatykh
- URL: https://github.com/ikalevatykh/mime/

6.6. iReal

iReal: Implementing interactive scene understanding for a mixed reality device

KEYWORDS: Computer vision - Augmented reality - Demonstration

FUNCTIONAL DESCRIPTION: The goal of this project is to build a demonstration prototype of a smart personal assistant that sees and understands its surroundings to help the user navigate in unfamiliar environments, recognize new people and operate never seen before devices. The assistant will be implemented on the Microsoft HoloLens mixed reality device and will integrate the latest research software for automatic visual recognition and scene understanding developed in the Inria Willow team

- Contact: Mauricio Diaz

6.7. Sim2RealAugment

Learning to Augment Synthetic Images for Sim2Real Policy Transfer

KEYWORDS: Robotics - Computer vision

FUNCTIONAL DESCRIPTION: Implements the method described in Learning to Augment Synthetic Images for Sim2Real Policy Transfer (2019), A. Pashevich, R. Strudel, I. Kalevatykh, I. Laptev and C. Schmid, in Proc. IROS'19, Macau, China.

- Contact: Ivan Laptev
- URL: http://pascal.inrialpes.fr/data2/sim2real/

6.8. HowTo100M

HowTo100M: Learning a Text-Video Embedding by Watching Hundred Million Narrated Video Clips

KEYWORDS: Computer vision - Video analysis

FUNCTIONAL DESCRIPTION: Implements the method provides the dataset used in the paper HowTo100M: Learning a Text-Video Embedding by Watching Hundred Million Narrated Video Clips (2019), A. Miech, D. Zhukov, J.-B. Alayrac, M. Tapaswi, I. Laptev and J. Sivic, in Proc. ICCV'19, Seoul, South Korea.

- Contact: Ivan Laptev
- URL: https://www.di.ens.fr/willow/research/howto100m/

6.9. ObMan

Learning joint reconstruction of hands and manipulated objects

KEYWORDS: Computer vision - 3D reconstruction

FUNCTIONAL DESCRIPTION: Implements the method and provides dataset used in the paper Learning joint reconstruction of hands and manipulated objects (2019), Y. Hasson, G. Varol, D. Tzionas, I. Kalevatykh, M. Black, I. Laptev and C. Schmid, in Proc. CVPR'19, Long Beach, CA, USA.

- Contact: Yana Hasson
- URL: https://hassony2.github.io/obman.html

<p align="center" style="color:red">**WIMMICS Project-Team**</p>

6. New Software and Platforms

6.1. CORESE

COnceptual REsource Search Engine

KEYWORDS: Semantic Web - Search Engine - RDF - SPARQL

FUNCTIONAL DESCRIPTION: Corese is a Semantic Web Factory, it implements W3C RDF, RDFS, OWL RL, SHACL, SPARQL 1 .1 Query and Update as well as RDF Inference Rules.

Furthermore, Corese query language integrates original features such as approximate search and extended Property Path. It provides STTL: SPARQL Template Transformation Language for RDF graphs. It also provides LDScript: a Script Language for Linked Data. Corese provides distributed federated query processing.

- Participants: Erwan Demairy, Fabien Gandon, Fuqi Song, Olivier Corby, Olivier Savoie and Virginie Bottollier
- Partners: I3S - Mnemotix
- Contact: Olivier Corby
- URL: http://wimmics.inria.fr/corese

6.2. DBpedia

KEYWORDS: RDF - SPARQL

FUNCTIONAL DESCRIPTION: DBpedia is an international crowd-sourced community effort to extract structured information from Wikipedia and make this information available on the semantic Web as linked open data. The DBpedia triple stores then allow anyone to solve sophisticated queries against Wikipedia extracted data, and to link the different data sets on these data. The French chapter of DBpedia was created and deployed by Wimmics and is now an online running platform providing data to several projects such as: QAKIS, Izipedia, zone47, Sépage, HdA Lab., JocondeLab, etc.

RELEASE FUNCTIONAL DESCRIPTION: The new release is based on updated Wikipedia dumps and the inclusion of the DBpedia history extraction of the pages.

- Participants: Fabien Gandon and Elmahdi Korfed
- Contact: Fabien Gandon
- URL: http://wiki.dbpedia.org/

6.3. Discovery Hub

Discovery Hub Exploratory Search Engine

KEYWORD: Search Engine

FUNCTIONAL DESCRIPTION: Recommandation system on top of DBpedia

- Participants: Alain Giboin, Emilie Palagi, Fabien Gandon and Nicolas Marie
- Partner: Alcatel-Lucent
- Contact: Fabien Gandon
- URL: http://discoveryhub.co/

6.4. Fuzzy labelling argumentation module

Fuzzy labelling algorithm for abstract argumentation

KEYWORDS: Artificial intelligence - Multi-agent - Knowledge representation - Algorithm

FUNCTIONAL DESCRIPTION: The goal of the algorithm is to compute the fuzzy acceptability degree of a set of arguments in an abstract argumentation framework. The acceptability degree is computed from the trustworthiness associated with the sources of the arguments.

- Participant: Serena Villata
- Contact: Serena Villata

6.5. Qakis

Question-Answering wiki framework based system

KEYWORD: Natural language

FUNCTIONAL DESCRIPTION: The QAKiS system implements question answering over DBpedia. QAKiS allows end users to submit a query to an RDF triple store in English and to obtain the answer in the same language, hiding the complexity of the non-intuitive formal query languages involved in the resolution process. At the same time, the expressiveness of these standards is exploited to scale to the huge amounts of available semantic data. Its major novelty is to implement a relation-based match for question interpretation, to convert the user question into a query language (e.g. SPARQL). English, French and German DBpedia chapters are the RDF data sets to be queried using a natural language interface.

- Participants: Alessio Palmero Aprosio, Amine Hallili, Elena Cabrio, Fabien Gandon, Julien Cojan and Serena Villata
- Contact: Elena Cabrio
- URL: http://www.qakis.org/

<p style="text-align:center;color:red;font-weight:bold;font-size:larger;">ZENITH Project-Team</p>

6. New Software and Platforms

6.1. Pl@ntNet

KEYWORDS: Plant identification - Deep learning - Citizen science

FUNCTIONAL DESCRIPTION: Pl@ntNet is a participatory platform and information system dedicated to the production of botanical data through deep learning-based plant identification. It includes 3 main front-ends, an Android app (the most advanced and the most used one), an iOs app (being currently re-developed) and a web version. The main feature of the application is to return the ranked list of the most likely species providing an image or an image set of an individual plant. In addition, Pl@ntNet's search engine returns the images of the dataset that are the most similar to the queried observation allowing interactive validation by the users. The back-office running on the server side of the platform is based on Snoop visual search engine (a software developed by ZENITH) and on NewSQL technologies for the data management. The application is distributed in more than 180 countries (10M downloads) and allows identifying about 20K plant species at present time.

- Participants: Antoine Affouard, Jean-Christophe Lombardo, Pierre Bonnet, Hervé Goëau, Mathias Chouet and Julien Champ
- Contact: Alexis Joly
- Publication: Pl@ntNet app in the era of deep learning

6.2. ThePlantGame

KEYWORD: Crowd-sourcing

FUNCTIONAL DESCRIPTION: ThePlantGame is a participatory game whose purpose is the production of big taxonomic data to improve our knowledge of biodiversity. One major contribution is the active training of the users based on innovative sub-task creation and assignment processes that are adaptive to the increasing skills of the user. Thousands of players are registered and produce on average about tens new validated plant observations per day. The accuracy of the produced taxonnomic tags is very high (about 95%), which is quite impressive considering the fact that a majority of users are beginners when they start playing.

- Participants: Maximilien Servajean and Alexis Joly
- Contact: Alexis Joly
- Publication: Crowdsourcing Thousands of Specialized Labels: A Bayesian Active Training Approach

6.3. Chiaroscuro

KEYWORDS: Privacy - P2P - Data mining

FUNCTIONAL DESCRIPTION: Chiaroscuro is a complete solution for clustering personal data with strong privacy guarantees. The execution sequence produced by Chiaroscuro is massively distributed on personal devices, coping with arbitrary connections and disconnections. Chiaroscuro builds on our novel data structure, called Diptych, which allows the participating devices to collaborate privately by combining encryption with differential privacy. Our solution yields a high clustering quality while minimizing the impact of the differentially private perturbation.

- Participants: Tristan Allard, Georges Hebrail, Florent Masseglia and Esther Pacitti
- Contact: Florent Masseglia
- Publication: Chiaroscuro: Transparency and Privacy for Massive Personal Time-Series Clustering

6.4. DfAnalyzer

Dataflow Analysis

KEYWORDS: Data management - Monitoring - Runtime Analysis

FUNCTIONAL DESCRIPTION: DfAnalyzer is a tool for monitoring, debugging, steering, and analysis of dataflows while being generated by scientific applications. It works by capturing strategic domain data, registering provenance and execution data to enable queries at runtime. DfAnalyzer provides lightweight dataflow monitoring components to be invoked by high performance applications. It can be plugged in scripts, or Spark applications, in the same way users already plug visualization library components.

- Participants: Vitor Sousa Silva, Daniel De Oliveira, Marta Mattoso and Patrick Valduriez
- Partners: COPPE/UFRJ - Uff
- Contact: Patrick Valduriez
- Publication: DfAnalyzer: Runtime Dataflow Analysis of Scientific Applications using Provenance
- URL: https://github.com/vssousa/dfanalyzer-spark

6.5. CloudMdsQL Compiler

KEYWORDS: Optimizing compiler - NoSQL - Data integration

FUNCTIONAL DESCRIPTION: The CloudMdsQL (Cloud Multi-datastore Query Language) polystore transforms queries expressed in a common SQL-like query language into an optimized query execution plan to be executed over multiple cloud data stores (SQL, NoSQL, HDFS, etc.) through a query engine. The compiler/optimizer is implemented in C++ and uses the Boost.Spirit framework for parsing context-free grammars. CloudMdsQL has been validated on relational, document and graph data stores in the context of the CoherentPaaS European project.

- Participants: Boyan Kolev, Oleksandra Levchenko and Patrick Valduriez
- Contact: Patrick Valduriez
- Publication: CloudMdsQL: Querying Heterogeneous Cloud Data Stores with a Common Language

6.6. Savime

Simulation And Visualization IN-Memory

KEYWORDS: Data management. - Distributed Data Management

FUNCTIONAL DESCRIPTION: SAVIME is a multi-dimensional array DBMS for scientific applications. It supports a novel data model called TARS (Typed ARray Schema), which extends the basic array data model with typed arrays. In TARS, the support of application dependent data characteristics is provided through the definition of TAR objects, ready to be manipulated by TAR operators. This approach provides much flexibility for capturing internal data layouts through mapping functions, which makes data ingestion independent of how simulation data has been produced, thus minimizing ingestion time.

- Participants: Hermano Lustosa, Fabio Porto and Patrick Valduriez
- Partner: LNCC - Laboratório Nacional de Computação Científica
- Contact: Patrick Valduriez
- Publication: TARS: An Array Model with Rich Semantics for Multidimensional Data

6.7. OpenAlea

KEYWORDS: Bioinformatics - Biology

FUNCTIONAL DESCRIPTION: OpenAlea is an open source project primarily aimed at the plant research community. It is a distributed collaborative effort to develop Python libraries and tools that address the needs of current and future works in Plant Architecture modeling. It includes modules to analyze, visualize and model the functioning and growth of plant architecture. It was formally developed in the Inria VirtualPlants team.

RELEASE FUNCTIONAL DESCRIPTION: OpenAlea 2.0 adds to OpenAlea 1.0 a high-level formalism dedicated to the modeling of morphogenesis that makes it possible to use several modeling paradigms (Blackboard, L-systems, Agents, Branching processes, Cellular Automata) expressed with different languages (Python, L-Py, R, Visual Programming, ...) to analyse and simulate shapes and their development.

- Participants: Christian Fournier, Christophe Godin, Christophe Pradal, Frédéric Boudon, Patrick Valduriez, Esther Pacitti and Yann Guédon
- Partners: CIRAD - INRA
- Contact: Christophe Pradal
- Publications: OpenAlea: Scientific Workflows Combining Data Analysis and Simulation - OpenAlea: A visual programming and component-based software platform for plant modeling

6.8. Triton Server

End-to-end Graph Mapper

KEYWORD: Web Application

FUNCTIONAL DESCRIPTION: A server for managing graph data and applications for mobile social networks. The server is built on top of the OrientDB graph database system and a distributed middleware. It provides an End-to-end Graph Mapper (EGM) for modeling the whole application as (i) a set of graphs representing the business data, the in-memory data structure maintained by the application and the user interface (tree of graphical components), and (ii) a set of standardized mapping operators that maps these graphs with each other.

- Participants: Didier Parigot, Patrick Valduriez and Benjamin Billet
- Contact: Didier Parigot
- Publication: End-to-end Graph Mapper

6.9. museval

KEYWORDS: Source Separation - Metric

SCIENTIFIC DESCRIPTION: museval is a Python package aimed at evaluating audio source separation algorithm on the musdb corpus.

It as a scientific tool of high impact, but of limited transfer importance, since it is only (but widely) used by the community to evaluate performance in scientific publications.

FUNCTIONAL DESCRIPTION: The BSSEval metrics, as implemented in the [MATLAB toolboxes](http://bass-db.gforge.inria.fr/bss_eval/) and their re-implementation in [mir_eval](http://craffel.github.io/mir_eval/#module-mir_eval.separation) are widely used in the audio separation literature. One particularity of BSSEval is to compute the metrics after optimally matching the estimates to the true sources through linear distortion filters. This allows the criteria to be robust to some linear mismatches. Apart from the optional evaluation for all possible permutations of the sources, this matching is the reason for most of the computation cost of BSSEval, especially considering it is done for each evaluation window when the metrics are computed on a framewise basis.

For this package, we enabled the option of having _time invariant_ distortion filters, instead of necessarily taking them as varying over time as done in the previous versions of BSS eval. First, enabling this option _significantly reduces_ the computational cost for evaluation because matching needs to be done only once for the whole signal. Second, it introduces much more dynamics in the evaluation, because time-varying matching filters turn out to over-estimate performance. Third, this makes matching more robust, because true sources are not silent throughout the whole recording, while they often were for short windows.

RELEASE FUNCTIONAL DESCRIPTION: This version makes museval compatible with the latest MUSDB package version

- Participant: Antoine Liutkus
- Contact: Antoine Liutkus
- Publication: The 2018 Signal Separation Evaluation Campaign

6.10. Imitates

Indexing and mining Massive Time Series

KEYWORDS: Time Series - Indexing - Nearest Neighbors

FUNCTIONAL DESCRIPTION: Time series indexing is at the center of many scientific works or business needs. The number and size of the series may well explode depending on the concerned domain. These data are still very difficult to handle and, often, a necessary step to handling them is in their indexing. Imitates is a Spark Library that implements two algorithms developed by Zenith. Both algorithms allow indexing massive amounts of time series (billions of series, several terabytes of data).

- Partners: New York University - Université Paris-Descartes
- Contact: Florent Masseglia
- Publication: ParCorr: efficient parallel methods to identify similar time series pairs across sliding windows

6.11. VersionClimber

KEYWORDS: Software engineering - Deployment - Versionning

FUNCTIONAL DESCRIPTION: VersionClimber is an automated system to help update the package and data infrastructure of a software application based on priorities that the user has indicated (e.g. I care more about having a recent version of this package than that one). The system does a systematic and heuristically efficient exploration (using bounded upward compatibility) of a version search space in a sandbox environment (Virtual Env or conda env), finally delivering a lexicographically maximum configuration based on the user-specified priority order. It works for Linux and Mac OS on the cloud.

- Participants: Christophe Pradal, Dennis Shasha, Sarah Cohen-Boulakia and Patrick Valduriez
- Partners: CIRAD - New York University
- Contact: Christophe Pradal
- Publication: VersionClimber: version upgrades without tears
- URL: https://versionclimber.readthedocs.io/

6.12. UMX

open-unmix

KEYWORDS: Source Separation - Audio

SCIENTIFIC DESCRIPTION: Implements state of the art audio/music source separation with DNNs.

This software is intended to serve as a reference in the domain. It has notably been the object of several scientific communications: 1. An Overview of Lead and Accompaniment Separation in Music https://hal-lirmm.ccsd.cnrs.fr/lirmm-01766781/ 2. Music separation with DNNs: making it work (ISMIR 2018 Tutorial) https://sigsep.github.io/ismir2018_tutorial/index.html#/cover

FUNCTIONAL DESCRIPTION: This software implements audio source separation with deep learning, using pytorch and tensorflow frameworks.

It comprises the code for both training and testing the separation networks, in a flexible manner.

Pre and post-processing around the actual deep neural nets include sophisticated specific multichannel filtering operations.

- Authors: Antoine Liutkus, Fabian Robert Stoter and Emmanuel Vincent
- Contact: Antoine Liutkus
- Publication: An Overview of Lead and Accompaniment Separation in Music