RESEARCH CENTER
Grenoble - Rhône-Alpes

FIELD

Activity Report 2013

Section Software

Edition: 2014-03-19

ARIC Project-Team

5. Software and Platforms

5.1. Overview

AriC software and hardware realizations are accessible from the web page http://www.ens-lyon.fr/LIP/AriC/ware.html. We describe below only those which progressed in 2013.

5.2. FloPoCo

Participants: Florent de Dinechin [correspondant], Matei Istoan.

The purpose of the FloPoCo project is to explore the many ways in which the flexibility of the FPGA target can be exploited in the arithmetic realm [32]. FloPoCo is a generator of operators written in C++ and outputting synthesizable VHDL automatically pipelined to an arbitrary frequency.

2013 saw more work on the *bit-heap* framework [28], [18]. In addition, several new operators were added, in particular for fixed-point sine, cosine [21] and arctangent.

Version 2.5.0 was released in 2013.

Among the known users of FloPoCo are U. Cape Town, U.T. Cluj-Napoca, Imperial College, U. Essex, U. Madrid, U. P. Milano, T.U. Muenchen, T. U. Kaiserslautern, U. Paderborn, CalTech, U. Pernambuco, U. Perpignan, U. Tohoku, U. Tokyo, Virginia Tech U. and several companies.

URL: http://flopoco.gforge.inria.fr/

- Version: 2.5.0 (June 2013)
- APP: IDDN.FR.001.400014.000.S.C.2010.000.20600 (version 2.0.0)
- License: pending, should be GPL-like.
- Type of human computer interaction: command-line interface, synthesizable VHDL output.
- OS/Middleware: Linux, Windows/Cygwin.
- Required library or software: MPFR, flex, Sollya.
- Programming language: C++.
- Documentation: online and command-line help, API in doxygen format, articles.

5.3. GNU MPFR

Participants: Vincent Lefèvre [correspondant], Paul Zimmermann [Caramel, Inria Nancy - Grand Est].

GNU MPFR is an efficient multiple-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. GNU MPFR 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.

MPFR was one of the main pieces of software developed by the old SPACES team at Loria. Since late 2006, with the departure of Vincent Lefèvre to Lyon, it has become a joint project between the Caramel (formerly SPACES then CACAO) and the AriC (formerly Arénaire) project-teams. MPFR has been a GNU package since 26 January 2009.

GNU MPFR 3.1.2 was released on 13 March 2013.

The main work done in the AriC project-team:

- Bug fixes and improved portability.
- Complete revision of the behavior on special values (signed zeros and infinities) and consistency with standards (IEEE 754-2008, ISO C, POSIX) checked. Thanks to this work, several problems in MPFR and the POSIX specification have been detected and the MPFR manual has been completed: https://sympa.inria.fr/sympa/arc/mpfr/2013-12/msg00001.html

URL: http://www.mpfr.org/

GNU MPFR is now on the Ohloh community platform for free and open source software: https://www.ohloh.net/p/gnu-mpfr

- ACM: D.2.2 (Software libraries), G.1.0 (Multiple precision arithmetic), G.4 (Mathematical software).
- AMS: 26-04 Real Numbers, Explicit machine computation and programs.
- APP: no longer applicable (copyright transferred to the Free Software Foundation).
- License: LGPL version 3 or later.
- Type of human computer interaction: C library, callable from C or other languages via third-party interfaces.
- OS/Middleware: any OS, as long as a C compiler is available.
- Required library or software: GMP.
- Programming language: C.
- Documentation: API in texinfo format (and other formats via conversion); algorithms are also described in a separate document.

5.4. Exhaustive Tests for the Correct Rounding of Mathematical Functions

Participant: Vincent Lefèvre.

The search for the worst cases for the correct rounding (hardest-to-round cases) of mathematical functions (exp, log, sin, cos, etc.) in a fixed precision (mainly double precision) using Lefèvre's algorithm is implemented by a set of utilities written in Perl, with calls to Maple/intpakX for computations on intervals and with C code generation for fast computations. It also includes a client-server system for the distribution of intervals to be tested and for tracking the status of intervals (fully tested, being tested, aborted).

The Perl scripts have been improved and some minor bugs have been fixed.

5.5. FPLLL: A Lattice Reduction Library

Participant: Damien Stehlé [correspondant].

fplll contains several algorithms on lattices that rely on floating-point computations. This includes implementations of the floating-point LLL reduction algorithm, 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 also includes a rigorous floating-point implementation of the Kannan-Fincke-Pohst algorithm that finds a shortest non-zero lattice vector, and the BKZ reduction algorithm.

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.

Versions 4.0.4 was released in 2013, fixing a number of user-interface bugs.

URL: http://perso.ens-lyon.fr/damien.stehle/fplll/

- ACM: D.2.2 (Software libraries), G.4 (Mathematical software)
- APP: Procedure started
- License: LGPL v2.1
- Type of human computer interaction: C++ library callable, from any C++ program.
- OS/Middleware: any, as long as a C++ compiler is available.
- Required library or software: MPFR and GMP.
- Programming language: C++.
- Documentation: available in html format on **URL:**http://perso.ens-lyon.fr/damien.stehle/fplll/fplll-doc.html

5.6. Sipe

Participant: Vincent Lefèvre.

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; see [25], [39].

New in 2013:

- the floating-point implementation;
- rounding toward zero (only with the integer implementation).
- ACM: D.2.2 (Software libraries), G.4 (Mathematical software).
- AMS: 26-04 Real Numbers, Explicit machine computation and programs.
- License: LGPL version 2.1 or later.
- Type of human computer interaction: C header file.
- OS/Middleware: any OS.
- Required library or software: GCC compiler.
- Programming language: C.
- Documentation: comment at the beginning of the code and Research report Inria RR-7832.
- URL: https://www.vinc17.net/research/sipe/

COMPSYS Project-Team

5. Software and Platforms

5.1. Introduction

This section lists and briefly describes the software developments conducted within Compsys. Most are tools that we extend and maintain over the years. They mainly concern three activities: a) the development of research tools, in general available on demand, linked to polyhedra and loop/array transformations, b) the development of tools linked to the start-up Zettice, in general not available, c) the development of algorithms within the back-end compilers of STMicroelectronics and/or Kalray.

Many tools based on the polyhedral representation of codes with nested loops are now available. They have been developed and maintained over the years by different teams, after the introduction of Paul Feautrier's Pip, a tool for parametric integer linear programming. This "polytope model" view of codes is now widely accepted: it used by Inria projects-teams Cairn and Alchemy/Parkas, PIPS at École des Mines de Paris, Suif from Stanford University, Compaan at Berkeley and Leiden, PiCo from the HP-Labs (continued as PicoExpress by Synfora and now Synopsis), the DTSE methodology at Imec, Sadayappan's group at Ohio State University, Rajopadhye's group at Colorado State's University, etc. More recently, several compiler groups have shown their interest in polyhedral methods, e.g., the Gcc group, IBM, and Reservoir Labs, a company that develops a compiler fully based on the polytope model and on the techniques that we (the french community) introduced for loop and array transformations. Polyhedra are also used in test and certification projects (Verimag, Lande, Vertecs). Now that these techniques are well-established and disseminated in and by other groups, we prefer to focus on the development of new techniques and tools, which are described here. Some of these tools can be used through a web interface on the Compsys tool demonstrator web page http://compsys-tools.ens-lyon.fr/.

The other activity concerns the developments within the compilers of industrial partners such as STMicroelectronics and Kalray. These are not stand-alone tools, which could be used externally, but algorithms and data structures implemented inside the LAO back-end compiler or other compiler branches, year after year, with the help of STMicroelectronics or Kalray colleagues. They are also completed by important efforts for integration and evaluation within the complete compiler toolchains. They concern exact (ILP-based) methods, algorithms for aggressive optimizations, techniques for just-in-time compilation, code representations, and for improving the design of the compiler.

More recently, an important development activity has been started in the context of the Zettice start-up project (see Section 7.3). An important effort of applied research and software development has been achieved since, which results, in particular, in two major software developments: Dcc (DPN C Compiler) and IceGEN. These tools are outlined in Sections 5.8 and 5.9 .

5.2. Pip

Participants: Cédric Bastoul [professor, Strasbourg University and Inria/CAMUS], Paul Feautrier.

Paul Feautrier is the main developer of Pip (Parametric Integer Programming) since its inception in 1988. Basically, Pip is an "all integer" implementation of the Simplex, augmented for solving integer programming problems (the Gomory cuts method), which also accepts parameters in the non-homogeneous term. Pip is freely available under the GPL at http://www.piplib.org. It is widely used in the automatic parallelization community for testing dependences, scheduling, several kind of optimizations, code generation, and others. Beside being used in several parallelizing compilers, Pip has found applications in some unconnected domains, as for instance in the search for optimal polynomial approximations of elementary functions (see the Inria project Arénaire).

5.3. Syntol

Participant: Paul Feautrier.

Syntol is a modular process network scheduler. The source language is C augmented with specific constructs for representing communicating regular process (CRP) systems. The present version features a syntax analyzer, a semantic analyzer to identify DO loops in C code, a dependence computer, a modular scheduler, and interfaces for CLooG (loop generator developed by C. Bastoul) and Cl@k (see Sections 5.4 and 5.6). The dependence computer now handles casts, records (`structures`), and the modulo operator in subscripts and conditional expressions. The latest developments are, firstly, a new code generator, and secondly, several experimental tools for the construction of bounded parallelism programs.

- The new code generator, based on the ideas of Boulet and Feautrier [16], generates a counter automaton that can be presented as a C program, as a rudimentary VHDL program at the RTL level, as an automaton in the Aspic input format, or as a drawing specification for the DOT tool.
- Hardware synthesis can only be applied to bounded parallelism programs. Our present aim is to construct threads with the objective of minimizing communications and simplifying synchronization. The distribution of operations among threads is specified using a placement function, which is found using techniques of linear algebra and combinatorial optimization.

5.4. Cl@k

Participants: Christophe Alias, Fabrice Baray [Mentor, Former post-doc in Compsys], Alain Darte.

Cl@k (Critical LAttice Kernel) is a stand-alone optimization tool useful for the automatic derivation of array mappings that enable memory reuse, based on the notions of admissible lattice and of modular allocation (linear mapping plus modulo operations). It has been developed in 2005-2006 by Fabrice Baray, former post-doc Inria under Alain Darte's supervision. It computes or approximates the critical lattice for a given 0-symmetric polytope. (An admissible lattice is a lattice whose intersection with the polytope is reduced to 0; a critical lattice is an admissible lattice with minimal determinant.)

Its application to array contraction has been implemented by Christophe Alias in a tool called Bee (see Section 5.6). Bee uses Rose as a parser, analyzes the lifetimes of the elements of the arrays to be compressed, and builds the necessary input for Cl@k, i.e., the 0-symmetric polytope of conflicting differences. Then, Bee computes the array contraction mapping from the lattice provided by Cl@k and generates the final program with contracted arrays. More details on the underlying theory are available in previous reports. Cl@k can be viewed as a complement to the Polylib suite, enabling yet another kind of optimizations on polyhedra. Initially, Bee was the complement of Cl@k in terms of its application to memory reuse. Now, Bee is a stand-alone tool that contains more and more features for program analysis and loop transformations.

5.5. PoCo

Participant: Christophe Alias.

PoCo is a polyhedral compilation framework providing many features to quickly prototype program analysis and optimizations in the polyhedral model. Essentially, PoCo provides:

- A C front-end extracting the polyhedral representation of the input program. The parser itself is based on EDG (*via* Rose), an industrial C/C++ parser from Edison group used in Intel compilers.
- An extended language of pragmas to feed the source code with compilation directives (a schedule, for example).
- A symbolic layer on polyhedral libraries Polylib (set operations on polyhedra) and Piplib (parameterized ILP, see Section 5.2). This feature simplifies drastically the developer task.
- Some dependence analysis (polyhedral dependence graph, array dataflow analysis), array region analysis, array liveness analysis.
- A C and VHDL code generation based on the ideas of P. Boulet and P. Feautrier [16].

The array dataflow analysis (ADA) of PoCo has been extended to a FADA (Fuzzy ADA) by M. Belaoucha, former PhD student at Université de Versailles. FADALib is available at https://bitbucket.org/mbelaoucha/fadalib. PoCo has been developed by Christophe Alias. It represents more than 19000 lines of C++ code. The tools Bee, Chuba, and RanK presented thereafter make an extensive use of PoCo abstractions.

5.6. Bee

Participants: Christophe Alias, Alain Darte.

Bee is a source-to-source optimizer that contracts the temporary arrays of a program under scheduling constraints. Bee bridges the gap between the mathematical optimization framework described in [17] and implemented in Cl@k (Section 5.4), and effective source-to-source array contraction. Bee applies a precise lifetime analysis for arrays to build the mathematical input of Cl@k. Then, Bee derives the array allocations from the basis found by Cl@k and generates the C code accordingly. Bee is – to our knowledge – the only complete array contraction tool.

Bee is sensitive to the program schedule. This latter feature enlarges the application field of array contraction to parallel programs. For instance, it is possible to mark a loop to be software-pipelined (with an affine schedule) and to let Bee find an optimized array contraction. But the most important application is the ability to optimize communicating regular processes (CRP). Given a schedule for every process, Bee can compute an optimized size for the channels, together with their access functions (the corresponding allocations). We currently use this feature in source-to-source transformations for high-level synthesis (see Section 3.3).

- Bee was made available to STMicroelectronics as a binary.
- Bee has been transferred to the (incubated) start-up Zettice, initiated by Alexandru Plesco.
- Bee has been used as an external tool by the compiler Gecos developed in the Cairn team at Irisa.

Bee has been implemented by Christophe Alias, using the compiler infrastructure PoCo (see Section 5.5). It represents more than 2400 lines of C++ code.

5.7. Chuba

Participants: Christophe Alias, Alain Darte, Alexandru Plesco [Compsys/Zettice].

Chuba is a source-level optimizer that improves a C program in the context of the high-level synthesis (HLS) of hardware. Chuba is an implementation of the work described in the PhD thesis of Alexandru Plesco. The optimized program specifies a system of multiple communicating accelerators, which optimize the data transfers with the external DDR memory. The program is divided into blocks of computations obtained thanks to tiling techniques, and, in each block, data are fetched by block to reduce the penalty due to line changes in the DDR accesses. Four accelerators achieve data transfers in a macro-pipeline fashion so that data transfers and computations (performed by a fifth accelerator) are overlapped.

So far, the back-end of Chuba is specific to the HLS tool C2H but the analysis is quite general and adapting Chuba to other HLS tools should be possible. Besides, it is interesting to mention that the program analysis and optimizations implemented in Chuba address a problem that is also very relevant in the context of GPGPUs. The underlying theory and corresponding experiments are described in [4].

Chuba has been implemented by Christophe Alias, using the compiler infrastructure PoCo (see Section 5.5). It represents more than 900 lines of C++. The reduced size of Chuba is mainly due to the high-level abstractions provided by PoCo.

5.8. Dcc

Participants: Christophe Alias, Alexandru Plesco [Compsys/Zettice].

Dcc (DPN C Compiler) is the *front-end* of the HLS tool transferred to the start-up Zettice (see Section 7.3). Dcc takes as input a C program annotated with pragmas and produces an optimized data-aware process network (DPN). A DPN is a regular process network that makes explicit the I/O transfers and the synchronizations. Dcc features throughput optimization, communication vectorization, and automatic parallelization. Furthermore, Dcc applies analysis to build the DPN circuitry: multiplexing, channels sizing and allocation, FSM generation. To do so, Dcc uses extensively the analysis implemented in PoCo (Section 5.5), in particular dataflow analysis and control generation, and Bee (Section 5.6 for buffer sizing. The DPN specific analysis of Dcc is currently under patent deposit.

Dcc represents more than 3000 lines of C++ code.

5.9. IceGEN

Participants: Christophe Alias, Alexandru Plesco [Compsys/Zettice].

IceGEN (Integrated Circuit Generator) is the *back-end* of the HLS tool transferred to the start-up Zettice (see Section 7.3). IceGEN takes as input the DPN produced by Dcc (see Section 5.8) and generates:

- a SystemC description relevant for fast and accurate circuit simulation.
- a VHDL description of the circuit, which can be mapped efficiently to an FPGA.

IceGEN makes an extensive use of the pipelined arithmetic operators of the tool FloPoCo [18] developed by Florent De Dinechin, formerly from Inria ARIC team.

IceGEN represents more than 6000 lines of C++ code.

5.10. C2fsm

Participant: Paul Feautrier.

C2fsm is a general tool that converts an arbitrary C program into a counter automaton. This tool reuses the parser and pre-processor of Syntol (see Section 5.3), which has been greatly extended to handle `while` and `do while` loops, `goto`, `break`, and `continue` statements. C2fsm reuses also part of the code generator of Syntol and has several output formats, including FAST (the input format of Aspic, see Section 5.11), a rudimentary VHDL generator, and a DOT generator which draws the output automaton. C2fsm is also able to do elementary transformations on the automaton, such as eliminating useless states, transitions and variables, simplifying guards, or selecting cut-points, i.e., program points on loops that can be used by RanK (see Section 5.12) to prove program termination.

5.11. Aspic

Participant: Laure Gonnord.

Aspic is an invariant generator for general counter automata. Used with C2fsm (see Section 5.10), it can be used to derivate invariant for numerical C programs, and also prove safety. It is also part of the WTC toolsuite (see http://compsys-tools.ens-lyon.fr/wtc/index.html), a set of examples to demonstrate the capability of the RanK tool (see Section 5.12) for evaluating worse-case time complexity (number of transitions when executing an automaton).

Aspic implements the theoretical results of Laure Gonnord's PhD thesis on acceleration techniques and has been maintained since 2007.

5.12. RanK

Participants: Christophe Alias, Alain Darte, Paul Feautrier, Laure Gonnord [Compsys].

RanK is a software tool that can prove the termination of a program (in some cases) by computing a *ranking function*, i.e., a mapping from the operations of the program to a well-founded set that *decreases* as the computation advances. In case of success, RanK can also provide an upper bound of the worst-case time complexity of the program as a symbolic affine expression involving the input variables of the program (parameters), when it exists. In case of failure, RanK tries to prove the non-termination of the program and then to exhibit a counter-example input. This last feature is of great help for program understanding and debugging, and has already been experimented. The theory underlying RanK was presented at SAS'10 [14].

The input of RanK is an integer automaton, computed by C2fsm (see Section 5.10), representing the control structure of the program to be analyzed. RanK uses the Aspic tool (see Section 5.11), developed by Laure Gonnord during her PhD thesis, to compute automaton invariants. RanK has been used to discover successfully the worst-case time complexity of many benchmarks programs of the community (see the WTC benchmark suite http://compsys-tools.ens-lyon.fr/wtc/index.html). It uses the libraries Piplib (Section 5.2) and Polylib.

RanK has been implemented by Christophe Alias, using the compiler infrastructure PoCo (Section 5.5). It represents more than 3000 lines of C++. The tool has been presented at the CSTVA'13 workshop [11].

5.13. SToP

Participants: Christophe Alias, Guillaume Andrieu [University of Lille], Laure Gonnord [Compsys].

SToP (Scalable Termination of Programs) is the implementation of the modular termination technique presented at the TAPAS'12 workshop [15]. It takes as input a large irregular C program and conservatively checks its termination. To do so, SToP generates a set of small programs whose termination implies the termination of the whole input program. Then, the termination of each small program is checked thanks to RanK (see Section 5.12). In case of success, SToP infers a ranking (schedule) for the whole program. This schedule can be used in a subsequent analysis to optimize the program.

SToP represents more than 2000 lines of C++.

5.14. Simplifiers

Participant: Paul Feautrier.

The aim of the `simple` library is to simplify Boolean formulas on affine inequalities. It works by detecting redundant inequalities in the representation of the subject formula as an ordered binary decision diagram (OBDD), see details in [22]. It uses PIP (see Section 5.2) for testing the feasibility – or unfeasibility – of a conjunction of affine inequalities.

The library is written in Java and is presented as a collection of class files. For experimentation, several front-ends have been written. They differ mainly in their input syntax, among which are a C like syntax, the Mathematica and SMTLib syntaxes, and an ad hoc Quast (quasi-affine syntax tree) syntax.

5.15. LAO Developments in Aggressive Compilation

Participants: Benoit Boissinot, Florent Bouchez, Florian Brandner, Quentin Colombet, Alain Darte, Benoît Dupont de Dinechin [Kalray], Christophe Guillon [STMicroelectronics], Sebastian Hack [Former post-doc in Compsys], Fabrice Rastello, Cédric Vincent [Former student in Compsys].

Our past aggressive optimization techniques are all implemented in stand-alone experimental tools (as for example for register coalescing algorithms) or within LAO, the back-end compiler of STMicroelectronics, or both. They concern SSA construction and destruction, instruction-cache optimizations, register allocation. Here, we report only our activities related to register allocation.

Our developments on register allocation within the STMicroelectronics compiler started when Cédric Vincent (bachelor degree, under Alain Darte supervision) developed a complete register allocator in LAO, the assembly-code optimizer of STMicroelectronics. This was the first time a complete implementation was done with success, outside the MCDT (now CEC) team, in their optimizer. This continued with developments made during the master internships and PhD theses of Florent Bouchez, Benoit Boissinot, and Quentin Colombet, and post-doctoral works of Sebastian Hack and Florian Brandner. In 2009, Quentin Colombet started to develop and integrate into the main trunk of LAO a full implementation of a two-phases register allocation. This implementation now includes two different decoupled spilling phases, the first one as described in Sebastian Hack's PhD thesis and a second ILP-based solution. It also includes an up-to-date graph-based register coalescing. Finally, since all these optimizations take place under SSA form, it includes also a mechanism for going out of colored-SSA (register-allocated SSA) form that can handle critical edges and does further optimizations. See details in the "new results" presented in previous Compsys activity reports.

5.16. LAO Developments in JIT Compilation

Participants: Benoit Boissinot, Florian Brandner, Quentin Colombet, Alain Darte, Benoît Dupont de Dinechin [Kalray], Christophe Guillon [STMicroelectronics], Fabrice Rastello.

The other side of our work in the STMicroelectronics compiler LAO has been to adapt the compiler to make it more suitable for JIT compilation. This means lowering the time and space complexity of several algorithms. In particular we implemented our fast out-of-SSA translation method, and we programmed and tested various ways to compute the liveness information. Recent efforts also focused on developing a tree-scan register allocator for the JIT part of the compiler, in particular a JIT conservative coalescing. The technique is to bias the tree-scan coalescing, taking into account register constraints, with the result of a JIT aggressive coalescing. See details in the "new results" presented in previous Compsys activity reports.

5.17. Low-Level Exchange Format (TireX) and Minimalist Intermediate Representation (MinIR)

Participants: Christophe Guillon [STMicroelectronics], Fabrice Rastello, Benoît Dupont de Dinechin [Kalray].

Most compilers define their own intermediate representation (IR) to be able to work on a program. Sometimes, they even use a different representation for each representation level, from source code parsing to the final object code generation. MinIR (Minimalist Intermediate Representation) is a new intermediate representation, designed to ease the interconnection of compilers, static analyzers, code generators, and other tools. In addition to the specification of MinIR, generic core tools have been developed to offer a basic toolkit and to help the connection of client tools. MinIR generators exist for several compilers, and different analyzers are developed as a testbed to rapidly prototype different static analyses over SSA code. This new common format enables the comparison of the code generator of several production compilers, and simplifies the connection of external tools to existing compilers.

MinIR has been extended into TireX, a Textual Intermediate Representation for EXchanging target-level information between compiler optimizers and whole or parts of code generators (a.k.a., compiler back-end). The first motivation for this intermediate representation is to factor target-specific compiler optimizations into a single component, in case several compilers need to be maintained for a particular target (e.g., operating system compiler and application code compiler). Another motivation is to reduce the run-time cost of JIT compilation and of mixed mode execution, since the program to compile is already in a representation lowered to the level of the target processor. Beside the lowering at the target level, the extensions of MinIR include the program data stream and loop scoped information. TireX is currently produced by the Open64/Path64 and the LLVM compilers, with a GCC producer under work. It is used by the LAO code generator.

Detailed information, generic core tools, and LLVM IR based generator for MinIR are available at http://www.assembla.com/spaces/minir-dev/wiki. MinIR was presented at WIR'11 [29].

CONVECS Project-Team

5. Software and Platforms

5.1. The CADP Toolbox

Participants: Hubert Garavel [correspondent], Frédéric Lang, Radu Mateescu, Wendelin Serwe.

We maintain and enhance CADP (*Construction and Analysis of Distributed Processes* – formerly known as *CAESAR/ALDEBARAN Development Package*) [4], a toolbox for protocols and distributed systems engineering [1]. In this toolbox, we develop and maintain the following tools:

- CAESAR.ADT [41] 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 [47], [46] 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 [42] 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,

[1] http://cadp.inria.fr

  - 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 [51], CTL [36], ACTL [37], etc.) to be defined in XTL.
- PBG (*Partitioned BCG Graph*) is a file format implementing the theoretical concept of *Partitioned LTS* [45] 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 [57] 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 the VERTECS project-team at Inria Rennes – Bretagne-Atlantique.

The CADP tools are well-integrated and can be accessed easily using either the EUCALYPTUS graphical interface or the SVL [43] 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.

5.2. The TRAIAN Compiler

Participants: Hubert Garavel [correspondent], Frédéric Lang, Wendelin Serwe.

We develop a compiler named TRAIAN 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 [44], being used in all recent compilers developed by CONVECS.

The TRAIAN compiler can be freely downloaded from the CONVECS Web site [2].

5.3. The PIC2LNT Translator

Participants: Radu Mateescu, Gwen Salaün [correspondent].

We develop a translator named PIC2LNT from an applied π-calculus (see § 6.1) to LNT, which enables the analysis of concurrent value-passing mobile systems using CADP.

PIC2LNT is developed by using the SYNTAX tool (developed at Inria Paris-Rocquencourt) for lexical and syntactic analysis together with LOTOS NT for semantical aspects, in particular the definition, construction, and traversal of abstract trees.

The PIC2LNT translator can be freely downloaded from the CONVECS Web site [3].

5.4. The PMC Partial Model Checker

Participants: Radu Mateescu, Frédéric Lang.

We develop a tool named PMC (*Partial Model Checker*, see § 6.4), which performs the compositional model checking of dataless MCL formulas on networks of communicating automata described in the EXP language.

PMC can be freely downloaded from the CONVECS Web site [4].

[2] http://convecs.inria.fr/software/traian
[3] http://convecs.inria.fr/software/pic2lnt
[4] http://convecs.inria.fr/software/pmc

DICE Team

5. Software and Platforms

5.1. GPeer: a peer-to-peer javascript communication library

Our software development has been oriented towards systems working in browsers, with the support of an Inria ADT project in cooperation with the ASAP team. To answer our technological objectives, we are working on decentralized architectures, browser to browser, developed in javascript/HTML5. We rely on the WebRTC JavaScript protocol proposed by Google to develop a communication layer between peers. Many peer-to-peer protocols share common elements, that we group in a generic library for developing peer-to-peer systems. The joint library developed with the ASAP team handles any gossip based communication overlay. We design peer messages, tracker management and resilient behavior. The library is a standard bridge between complex browser to browser applications and low level networking layers such as WebRTC. With the use of our library, we can reproduce systems such as bitTorrent, but also provide new applications without the need of either native applications or identified servers.

5.2. Fluxion: a software plugin for flows in AngularJS

The joint project with Worldline aims at managing mobile code in complex Web architectures. Load variation in data-centers is currently poorly resolved. Most of the time, systems overestimate resource consumption in order to absorb burst usage. These consumption overestimation has a cost both in terms of the SLA negotiated with the client and the non-availability of reserved resources. With Wordline we focus on code mobility for high performance Web architectures and design a fast and reactive framework, transparently moving functions between running systems. The Fluxion model is our approach to design mobile application modules that are a mix of functional programming and flow based reactive systems.

5.3. BitBallot: a decentralized voting protocol

The BitBallot voting protocol is designed to target large scale communities. The protocol allows users to share only restricted amounts of their data and computation with central platforms as well as other peers. Convinced by the need of new election mechanisms, to support emerging forms of more continuous democracy, we are developing BitBallot, to allow elections to be organized independently of any central authority. The protocol guarantees the following properties, anonymity of the data sources, non interruptible run-time, global access to results, and non predictability of results through partial communication spying.

PRIVATICS Team

4. Software and Platforms

4.1. Mobilitics

Mobilitics is a joint project, started in 2012 between Inria and CNIL, which targets privacy issues on smartphones. The goal is to analyze the behavior of smartphones applications and their operating system regarding users private data, that is, the time they are accessed or sent to third party companies usually neither with user's awareness nor consent.

In the presence of a wide range of different smartphones available in terms of operating systems and hardware architecture, Mobilitics project focuses actually its study on the two more widespread mobile platforms which are IOS(Iphone) and Android.

Indeed, both versions of Mobilitics software should provide these common requirements: Be able to capture any event about private data access such as User location, Device Unique Identifier, Address Book... Store these events in a local database on the phone for offline analysis Send this local database to Mobilitics server for privacy leakage statistics

A Mobilitics prototype for Iphone has been developed since January 2012 at Privatics. It has already embedded the features listed above and much more. However, a separate prototype for Android has been also developed since September 2012 fulfilling the same equirements listed above because IOS and Android are different in either software or hardware level.

Indeed, some live experiments have been conducted by CNIL with Mobilitics prototype for IOS with the help of volunteers equipped with iphones which they have used for a period of four(4) months(September 2012-January 2013). As a result, some visualization tools have been developed for the data collected in order to showcase private data leakage by the apps which the participants of the experiment have used. Therefore, a press conference has been held by CNIL in Paris in April 2013 during which Mobilitics results for Iphone have been published onto several French newspapers (see Section 8.3)

Likewise, some live experiments will be conducted on Android this year in February 2014 for at least three(3) months with volunteers equipped with Galaxy Nexus smartphones on which Mobilitics will be deployed. As a consequence, a press release by CNIL will be scheduled for the publication of the results obtained for Android with a perspective of comparing Google privacy policy to Apple one.

SPADES Team

5. Software and Platforms

5.1. Implementations of Synchronous Programs

Participant: Alain Girault.

We have been cooperating for several years with the INRIA team AOSTE (INRIA Sophia-Antipolis and Rocquencourt) on the topic of fault tolerance and reliability of safety critical embedded systems. In particular, we have implemented several new heuristics for fault tolerance and reliability within SYNDEX[4]. Our first scheduling heuristic produces static multiprocessor schedules tolerant to a specified number of processor and communication link failures [62]. The basic principles upon which we rely to make the schedules fault tolerant are, on the one hand, the active replication of the operations [63], and on the other hand, the active replication of communications for point-to-point communication links, or their passive replication coupled with data fragmentation for multi-point communication media (*i.e.*, buses) [64]. Our second scheduling heuristic is multi-criteria: it produces a static multiprocessor schedule such that the reliability is maximized, the power consumption is minimized, and the execution time is minimized [12][4] [37], [38]. Our results on fault tolerance are summarized in a web page [5].

5.2. Apron and BddApron Libraries

Participant: Bertrand Jeannet.

5.2.1. Principles

The APRON library [6] is dedicated to the static analysis of the numerical variables of a program by abstract interpretation [51]. Many abstract domains have been designed and implemented for analysing the possible values of numerical variables during the execution of a program (see Figure 1). However, their API diverge largely (datatypes, signatures, ...), and this does not ease their diffusion and experimental comparison *w.r.t.* efficiency and precision aspects.

The APRON library provides:

- a uniform API for existing numerical abstract domains;
- a higher-level interface to the client tools, by factorizing functionalities that are largely independent of abstract domains.

From an abstract domain designer point of view, the benefits of the APRON library are:

- the ability to focus on core, low-level functionalities;
- the help of generic services adding higher-level services for free.

For the client static analysis community, the benefits are a unified, higher-level interface, which allows experimenting, comparing, and combining abstract domains.

The BDDAPRON library [7] aims at a similar goal, by adding finite-types variables and expressions to the concrete semantics of APRON domains. It is built upon the APRON library and provides abstract domains for the combination of finite-type variables (booleans, enumerated types, bit vectors) and numerical variables (integers, rationals, floating-point numbers). It first allows the manipulation of expressions that freely mix, using BDDs and MTBDDs, finite-type and numerical APRON expressions and conditions. It then provides abstract domains that combine BDDs and APRON abstract values for representing invariants holding on both finite-type variables and numerical variables.

[4] http://www-rocq.inria.fr/syndex
[5] http://pop-art.inrialpes.fr/~girault/Projets/FT
[6] http://apron.cri.ensmp.fr/library/
[7] http://pop-art.inrialpes.fr/~bjeannet/bjeannet-forge/bddapron/index.html

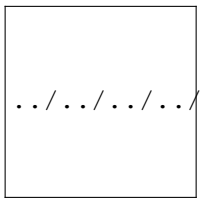

Figure 1. Typical static analyser and examples of abstract domains

5.2.2. Implementation and Distribution

The APRON library (Fig. 2) is written in ANSI C, with an object-oriented and thread-safe design. Both multi-precision and floating-point numbers are supported. A wrapper for the OCAML language is available, and a C++ wrapper is on the way. It has been distributed since June 2006 under the LGPL license and available at http://apron.cri.ensmp.fr. Its development has still progressed much since. There are already many external users (ProVal/Démons, LRI Orsay, France — CEA-LIST, Saclay, France — Analysis of Computer Systems Group, New-York University, USA — Sierum software analysis platform, Kansas State University, USA — NEC Labs, Princeton, USA — EADS CCR, Paris, France — IRIT, Toulouse, France). It is currently packaged as a REDHAT and DEBIAN package.

The BDDAPRON library is written in OCAML, using polymorphism features of OCAML to make it generic. It is also thread-safe. It provides two different implementations of the same domain, each one presenting pros and cons depending on the application. It is currently used by the CONCURINTERPROC interprocedural and concurrent program analyzer.

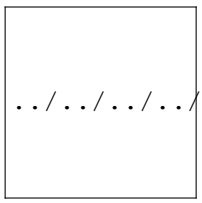

Figure 2. Organisation of the APRON *library*

5.3. ReaVer

Participant: Bertrand Jeannet.

REAVER (REActive VERifier [8]) is a tool framework for the safety verification of discrete and hybrid systems specified by logico-numerical data-flow languages, like LUSTRE, LUCIDSYNCHRONE or ZELUS. It provides time-unbounded analysis based on abstract interpretation techniques.

It features partitioning techniques and several logico-numerical analysis methods based on Kleene iteration with widening and descending iterations, abstract acceleration, max-strategy iteration, and relational abstractions; logico-numerical product and power domains (based on the APRON and BddApron domain libraries)

[8] http://members.ktvam.at/schrammel/research/reaver

with convex polyhedra, octagons, intervals, and template polyhedra; and front-ends for the hybrid NBAC format, LUSTRE via lus2nbac, and ZELUS/LUCIDSYNCHRONE. Compared to NBAC, it is connected to higher-level, more recent synchronous and hybrid languages, and provides many more options regarding analysis techniques.

It has been used for several experimental comparisons published in papers. It integrates all the methods developed by Peter Schrammel in his PhD.

5.4. Prototypes

5.4.1. Logical Causality

Participant: Gregor Goessler.

We are developing LOCA, a prototype tool written in Scala that implements the analysis of logical causality described in 6.1.1 . LOCA currently supports causality analysis in BIP. The core analysis engine is implemented as an abstract class, such that support for other models of computation (MOC) can be added by instantiating the class with the basic operations of the MOC.

5.4.2. Cosyma

Participant: Gregor Goessler.

We have developed COSYMA, a tool for automatic controller synthesis for incrementally stable switched systems based on multi-scale discrete abstractions. The tool accepts a description of a switched system represented by a set of differential equations and the sampling parameters used to define an approximation of the state-space on which discrete abstractions are computed. The tool generates a controller — if it exists — for the system that enforces a given safety or time-bounded reachability specification.

5.4.3. Automatic Controller Generation

Participant: Alain Girault.

We have developed a software tool chain to allow the specification of models, controller synthesis, and the execution or simulation of the results. It is based on existing synchronous tools, and thus consists primarily in the use and integration of SIGALI[9] and Mode Automata [10]. It is the result of a collaboration with Emil Dumitrescu (INSA Lyon) and Eric Rutten from the CTRL-A Inria team.

Useful component templates and relevant properties can be materialized, on one hand, by libraries of task models, and, on the other hand, by properties and synthesis objectives.

5.4.4. The Interproc family of static analyzers

Participant: Bertrand Jeannet [contact person].

These analyzers and libraries are of general use for people working in the static analysis and abstract interpretation community.

- FIXPOINT[11]: a generic fix-point engine written in OCAML. It allows the user to solve systems of fix-point equations on a lattice, using a parameterized strategy for the iteration order and the application of widening. It also implements recent techniques for improving the precision of analysis by alternating post-fixpoint computation with widening and descending iterations in a sound way [66].
- INTERPROC[12]: a simple interprocedural static analyzer that infers properties on the numerical variables of programs in a toy language. It is aimed at demonstrating the use of the previous library and the above-described APRON library, and more generally at disseminating the knowledge in abstract interpretation. It is also deployed through a web-interface [13].
- CONCURINTERPROC extends INTERPROC with concurrency, for the analysis of multithreaded programs interacting via shared global variables. It is also deployed through a web-interface [14].

[9] http://www.irisa.fr/vertecs/Logiciels/sigali.html
[10] http://www-verimag.imag.fr
[11] http://http://pop-art.inrialpes.fr/people/bjeannet/bjeannet-forge/fixpoint
[12] http://pop-art.inrialpes.fr/people/bjeannet/bjeannet-forge/interproc
[13] http://pop-art.inrialpes.fr/interproc/interprocweb.cgi

- PINTERPROC extends INTERPROC with pointers to local variables. It is also deployed through a web-interface [15].

5.4.5. The SIAAM virtual machine

Participants: Quentin Sabah, Jean-Bernard Stefani [contact person].

The SIAAM abstract machine is an object-based realization of the Actor model of concurrent computation. Actors can exchange arbitrary object graphs in messages while still enjoying a strong isolation property. It guarantees that each actor can only directly access objects in its own local heap, and that information between actors can only flow via message exchange [10]. The SIAAM machine has been implemented for Java as a modified Jikes virtual machine. The resulting SIAAM software comprises:

- A modified Jikes RVM that implements actors and actor isolation as specified by the SIAAM machine.
- A set of static analyses build using the Soot Java optimization framework for optimizing the execution of the SIAAM/Jikes virtual machine, and for helping programmers diagnose potential performance issues.
- A formal proof using the Coq proof assistant of the SIAAM isolation property.

[14] http://pop-art.inrialpes.fr/interproc/concurinterprocweb.cgi
[15] http://pop-art.inrialpes.fr/interproc/pinterprocweb.cgi

BIPOP Project-Team

5. Software and Platforms

5.1. Nonsmooth dynamics: Siconos

Participants: Vincent Acary, Maurice Brémond, Olivier Huber, Franck Pérignon.

In the framework of the European project Siconos, Bipop was the leader of the Work Package 2 (WP2), dedicated to the numerical methods and the software design for nonsmooth dynamical systems. 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/

5.2. Optimization

Participant: Claude Lemaréchal.

Essentially two possibilities exist to distribute our optimization software: library programs (say Modulopt codes), communicated either freely or not, depending on what they are used for, and on the other hand specific software, developed for a given application.

The following optimization codes have been developed in the framework of the former Promath project. They are generally available at http://www-rocq.inria.fr/~gilbert/modulopt/; M1QN3 is also distributed under GPL.

5.2.1. Code M1QN3

Optimization without constraints for problems with many variables ($n \geq 10^3$, has been used for $n = 10^6$). Technically, uses a limited-memory BFGS algorithm with Wolfe's line-search (see Chap. 4 of [3] for the terminology).

5.2.2. Code M2QN1

Optimization with simple bound-constraints for (small) problems: D is a parallelotope in R^n. Uses BFGS with Wolfe's line-search and active-set strategy.

5.2.3. Code N1CV2

Minimization without constraints of a convex nonsmooth function by a proximal bundle method (Chap. XV of [10], Chap. 9 of [3]).

5.2.4. Modulopt

In addition to codes such as above, the Modulopt library contains application problems, synthetic or from the real world. It is a field for experimentation, functioning both ways: to assess a new algorithm on a set of test-problems, or to select among several codes one best suited to a given problem.

5.3. Simulation of fibrous materials subject to frictional contact

5.3.1. MECHE: Modeling Entangling within Contacting hair fibErs

Participants: Florence Bertails-Descoubes, Gilles Daviet, Alexandre Derouet-Jourdan, Romain Casati, Laurence Boissieux.

The software MECHE was essentially developed during the MECHE ADT (2009-2011, research engineer: Gilles Daviet), for simulating the dynamics of assemblies of thin rods (such as hair), subject to contact and friction. Currently, this software is extensively used by two PhD students (A. Derouet-Jourdan and R. Casati) and continues to be enriched with new rod models and inversion modules. This software combines a panel of well-accepted models for rods (ranging from reduced coordinates to maximal coordinates models, and including models recently developed by some members of the group) with classical as well as innovative schemes for solving the problem of frictional contact (incorporating the most recent results of the group, as well as the new contact solver we published in [8]). The aim of this software is twofold: first, to compare and analyze the performance of nonsmooth schemes for the frictional contact problem, in terms of realism (capture of dry friction, typically), robustness, and computational efficiency. A first study of this kind was conducted in 2010-2011 onto the different rod models that were available in the software. New studies are planned for evaluating further rod models. Second, we believe such a software will help us understand the behavior of a fibrous material (such as hair) through virtual experiments, thanks to which we hope to identify and understand some important emergent phenomena. A careful validation study against experiments started to be conducted in 2011 in collaboration with physicists from L'Oréal. Once this discrete elements model will be fully validated, our ultimate goal would be to build a continuous macroscopic model for the hair medium relying on nonsmooth laws. The core of this software was transferred to L'Oréal in 2011, and to AGT Digital in early 2013, by Gilles Daviet and Florence Bertails-Descoubes. It was also used for generating a number of simulations supporting at least 4 of our research publications.

5.3.2. Cloc: super-space clothoids

Participants: Romain Casati, Florence Bertails-Descoubes.

This software implements the super-space clothoid model published this year in [25]. This model consists of a new dynamic rod primitive relying upon high-order elements with a linear curvature (clothoidal arcs). The source code of this software is distributed from our webpages from December 2013, based on a dual licensing policy: a free GPLv.3 license, mainly dedicated to academics; and a commercial license, mainly dedicated to industry.

5.3.3. APPROCHE: APPROximate Curves with HElices

Participants: Alexandre Derouet-Jourdan, Florence Bertails-Descoubes.

APPROCHE is a software that implements the 3d floating tangents algorithm published. The algorithm takes as input a set of curves, either represented as splines or sequences of points, and fits each curve to a C^1-smooth piecewise helix. This software has been transferred to L'Oréal in December 2013 and some source code will be made freely available to academics under the GPLv.3 licence.

MISTIS Project-Team

5. Software and Platforms

5.1. The LOCUS software

Participants: Florence Forbes, Senan James Doyle.

Joint work with: Michel Dojat from Grenoble Institute of Neuroscience and Benoit Scherrer from Harvard Medical School, Boston, MA, USA.

From brain MR images, neuroradiologists are able to delineate tissues such as grey matter and structures such as Thalamus and damaged regions. This delineation is a common task for an expert but unsupervised segmentation is difficult due to a number of artefacts. The LOCUS software (http://locus.gforge.inria.fr) automatically perform this segmentation for healthy brains An image is divided into cubes on each of which a statistical model is applied. This provides a number of local treatments that are then integrated to ensure consistency at a global level, resulting in low sensitivity to artifacts. The statistical model is based on a Markovian approach that enables to capture the relations between tissues and structures, to integrate a priori anatomical knowledge and to handle local estimations and spatial correlations.

The LOCUS software has been developed in the context of a collaboration between Mistis, a computer science team (Magma, LIG) and a Neuroscience methodological team (the Neuroimaging team from Grenoble Institut of Neurosciences, INSERM). This collaboration resulted over the period 2006-2008 into the PhD thesis of B. Scherrer (advised by C. Garbay and M. Dojat) and in a number of publications. In particular, B. Scherrer received a "Young Investigator Award" at the 2008 MICCAI conference.

The originality of this work comes from the successful combination of the teams respective strengths i.e. expertise in distributed computing, in neuroimaging data processing and in statistical methods.

5.2. The P-LOCUS software

Participants: Florence Forbes, Senan James Doyle, Flor Vasseur.

Joint work with: Michel Dojat.

The Locus software was extended to address the delineation of lesions in pathological brains. Its extension P-LOCUS (http://p-locus.com) for lesion detection was realized by S. Doyle with financial support from Gravit with the goal to create a Start-up. P-LOCUS software analyses, in few minutes, a 3D MR brain scan and performs fully automatic brain lesion delineation using a combined dataset of various 3D MRI sequences. Its originality comes from:

- it is fully automatic: no external user interaction and no training data required
- the possibility to combine information from several images (MR sequences)
- a statistical Bayesian framework for robustness to image artefacts and a priori knowledge incorporation
- a voxel-based clustering technique that uses Markov random fields (MRF) incorporating information about neighboring voxels for spatial consistency and robustness to imperfect image features (noise).
- the possibility to select and incorporate relevant a priori knowledge via different atlases, e.g. tissue and vascular territory atlases
- a fully integrated preprocessing steps and lesion ROI identification

P-LOCUS software was presented at various conferences and used for the BRATS Challenge on tumor segmentation organized as a satellite challenge of the Miccai conference in Nagoya, Japan. A paper submitted to IEEE trans. on Medical Imaging reports the challenge results [62].

5.3. The PyHRF software

Participants: Christine Bakhous, Florence Forbes, Thomas Vincent.

Joint work with: Philippe Ciuciu and Solveig Badillo from Parietal Team Inria and CEA NeuroSpin, Lotfi Chaari and Laurent Risser from Toulouse University.

As part of fMRI data analysis, the PyHRF package (http://pyhrf.org) 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. With respect to the sole detection issue (i), the classical voxelwise GLM procedure is also available through NIPY, whereas Finite Impulse Response (FIR) and temporally regularized FIR models are implemented to deal with the HRF estimation concern (ii). Several parcellation tools are also integrated such as spatial and functional clusterings. Parcellations may be used for spatial averaging prior to FIR/RFIR analysis or to specify the spatial support of the HRF estimates in the JDE approach. These analysis procedures can be applied either to volumic data sets or to data projected onto the cortical surface. For validation purpose, this package is shipped with artificial and real fMRI data sets. To cope with the high computational needs for inference, PyHRF handles distributing computing by exploiting cluster units as well as multiple cores computers. Finally, a dedicated viewer is available which handles n-dimensional images and provides suitable features for exploring whole brain hemodynamics (display of time series, maps, ROI mask overlay). A paper under revision for Frontiers in Neuroinformatics gives more details on the current PyHRF functionalities.

NANO-D Team

4. Software and Platforms

4.1. SAMSON

Figure 3. SAMSON's architecture.

A major objective of NANO-D is to try and integrate a variety of adaptive algorithms into a unified framework. As a result, NANO-D is developing SAMSON (Software for Adaptive Modeling and Simulation Of Nanosystems), a software platform aimed at including all developments from the group, in particular those described below.

The objective is to make SAMSON a generic application for computer-aided design of nanosystems, similar to existing applications for macrosystem prototyping (CATIA, SolidWorks, etc.).

The current architecture of SAMSON is visible in Figure 3 . The code is organized into four main parts: a) the Base (in which "Core" contains, in particular, the heart of the adaptive algorithms: signaling mechanisms specifically designed for SAMSON), b) the Software Development Kit (SDK: a subset of the base that will be provided to module developers), c) Modules, and d) the SAMSON application itself.

Similar to the concept of Mathematica *toolboxes*, for example, the goal has been to make it possible to personalize the user interface of SAMSON for potentially many distinct applications. For example, we may want to personalize the interface of SAMSON for crystallography, drug design, protein folding, electronics, material science, nano-engineering, etc., by loading different modules at startup, depending on the user application domain.

NECS Project-Team

5. Software and Platforms

5.1. GTL – Grenoble Traffic Lab

Participants: C. Canudas de Wit [contact person], I. Bellicot, P. Bellemain, L. Leon Ojeda, D. Pisarski, A. Kibangou, F. Morbidi.

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

5.2. NeCSCar

Participants: C. Canudas de Wit [contact person], J. Dumon, V. Ciarla.

NeCSCar is an electrical vehicle (scale 1:3) used as an experimental platform to study new control architectures. The vehicle is designed to be remotely tele-operated from our active steering-wheel platform, ant it will be equipped of a 3D vision system to provide the operator with stereo vision capabilities. Bilateral teleoperation can be performed using wheel contact torque measurements, fed back for force deflexion; wireless connection allows us to test coding algorithms, resource sharing, and robustness against transmission delays.

NeCSCar has been recently used for simulation tests in the framework of the VolHand project, a multidisciplinary project with the goal to develop a new generation of electronic power assistance steering (EPAS) systems for disabled people.

5.3. Source-seeking robot

Participants: R. Fabbiano [contact person], J. Dumon, Y. Gaudfrin.

The source-seeking algorithms developed in the thesis of Ruggero Fabbiano have been implemented in hardware, with a wheeled robot performing 2-dimensional search. The considered scenario is a source of pollutant in the ocean, where the pollutant can be detected thanks to the fact that it is warmer than water, so that data from an infra-red camera can be used by one or multiple helicopters to move along the ocean surface towards the source. In our experimental equipment, the 2-dimensional movement has been performed with a wheeled vehicle, and the camera was a regular camera, taking pictures of a color-coded image from an actual infra-red image of a pollutant leak. Videos of the experiments are available online: http://necs.inrialpes.fr/pages/platforms.php

OPALE Project-Team

5. Software and Platforms

5.1. NUM3SIS

Participants: Régis Duvigneau [correspondant], Nora Aïssiouene, Babett Lekouta.

The Opale project-team has initiated a few years ago the development of NUM3SIS (http://num3sis.inria.fr), which is is a modular platform devoted to scientific computing and numerical simulation. It is not restricted to a particular application field, but is designed to host complex multidisciplinary simulations. Main application fields are currently Computational Fluid Dynamics (by Opale project-team), Computational Electro-Magnetics (by Nachos project-team) and pedestrian traffic simulation (by Opale project-team). Some components of the platform are also used by the Tosca project-team for CO2 market simulation and wind simulation in collaboration with Ciric (Inria-Chile).
NUM3SIS provides innovative software tools to overcome some limitations encountered by classical monolithic simulation codes. In particular, the platform is based on abstract concepts commonly used in scientific computing, such as mesh, fields, finite-elements, linear solvers etc, that can be implemented in plugins. A fast prototyping of algorithms can be achieved using a visual programing interface. A component is dedicated to deployment on parallel architectures. Moreover, the platform relies on a "store" system to foster exchange of plugins, scripts or data.
This work is being carried out with the support of two engineers in the framework of an ADT (Action de Développement Technologique) program.

5.2. FAMOSA

Participant: Régis Duvigneau [correspondant].

Opale team is developing the software platform FAMOSA (C++), that is devoted to multidisciplinary design optimization in engineering. It integrates the following components:

- an optimization library composed of various algorithms : several descent methods from steepest-descent method to quasi-Newton BFGS method (deterministic, smooth), the Multi-directional Search Algorithm (deterministic, noisy), the Covariance Matrix Adaption Evolution Strategy (semi-stochastic, multi-modal) and the Efficient Global Optimization method (deterministic, multi-modal). It also contains the Pareto Archived Evolution Strategy to solve multi-objective optimization problems ;
- an evaluation library managing the performance estimation process (communication with external simulation tools) ;
- a metamodel library that contains tools to build a database and kriging models that are used to approximate the objective function for different purposes;
- a scenario library that allows to use the previous components to achieve various tasks:
  - Construct a design of experiments ;
  - Construct a metamodel ;
  - Find the design that minimizes a cost functional ;
  - Find the Pareto front for two cost functionals
  - Play a Nash game to find the equilibrium between two criteria ;
  - Apply a multiple gradient descent strategy to improve simultaneously two criteria.

The FAMOSA platform is employed by Opale project-team to test its methodological developments. The platform is also used by the Fluid Mechanics Laboratory at Ecole Centrale de Nantes for hydrodynamic design applications and ONERA for multidisciplinary design optimization (MDO). Moreover, it is presently tested by Peugeot Automotive industry for external aerodynamic design purpose.

5.3. Plugins for AXEL

Participant: Régis Duvigneau [correspondant].

Opale team is developing plugins in the framework of the algebraic modeler Axel, in collaboration with the Galaad project-team. These developments correspond to two research axes :

- isogeometric analysis and design. In particular, two simulation tools for heat conduction and compressible flows have been implemented, in conjunction with some deterministic and semi-stochastic optimization algorithms for optimum-shape design ;
- geometrical modeling for design optimization.

5.4. Integration platform for multidiscipline optimization applications

Participants: Toan Nguyen, Laurentiu Trifan.

A prototype software integration platform is developed and tested for multidiscipline optimization applications. It is based on a workflow management system called YAWL (http://www.yawlfoundation.org). The goal is to design, develop and assess high-performance distributed scientific workflows featuring resilience, i.e., fault-tolerance and exception-handling capabilities. The platform is used to experiment new resilience algorithms, including monitoring and management of application-level errors. Errors include time-outs and out of bounds data values. They can be added and modified by the users. The platform is tested against use-cases provided by the industry partners in the OMD2 project supported by the French Agence Nationale de la Recherche. For example, an optimization of a car air-conditioning pipe was implemented and deployed on the Grid5000 infrastructure. It also takes into account run-time errors related to resource consumption, e.g., memory overflow, to automatically and dynamically relocate the appplications tasks involved on the various clusters. This work was Laurentiu Trifan's PhD thesis, defended in October 2013 [37]. (See Fig. 1 .)

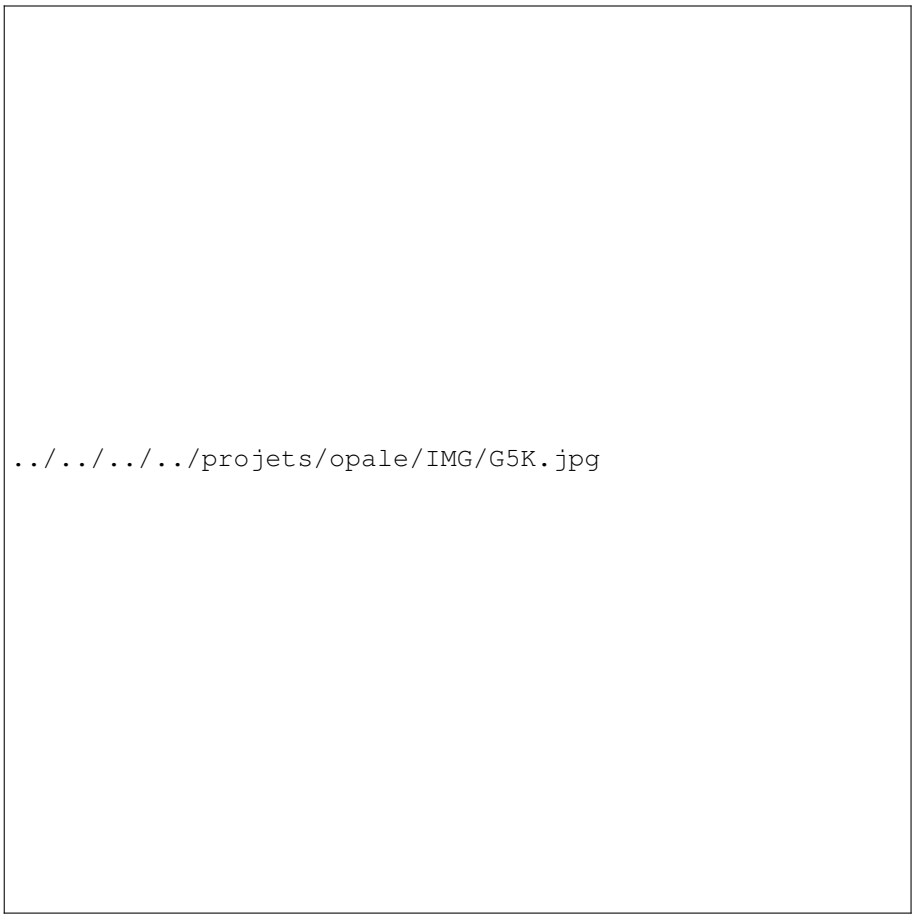

Figure 1. Testcase deployment on the Grid5000 infrastructure.

BAMBOO Project-Team

5. Software and Platforms

5.1. AcypiCyc

Participants: Hubert Charles [EPI], Patrice Baa Puyoule [Contact, Patrice.Baa-Puyoulet@lyon.inra.fr], Stefano Colella [Contact, stefano.colella@lyon.inra.fr], Ludovic Cottret, Marie-France Sagot [EPI], Augusto Vellozo [Contact, augusto@cycadsys.org], Amélie Véron.

Database of the metabolic network of *Acyrthosiphon pisum*.
http://acypicyc.cycadsys.org/

5.2. AlViE

Participants: Pierluigi Crescenzi [Contact, pierluigi.crescenzi@unifi.it, ext. member EPI], Giorgio Gambosi, Roberto Grossi, Carlo Nocentini, Tommaso Papini, Walter Verdese.

ALVIE is a post-mortem algorithm visualization Java environment, which is based on the interesting event paradigm. The current distribution of ALVIE includes more than forty visualizations. Almost all visualizations include the representation of the corresponding algorithm C-like pseudo-code. The ALVIE distribution allows a programmer to develop new algorithms with their corresponding visualization: the included Java class library, indeed, makes the creation of a visualization quite an easy task (once the interesting events have been identified).
http://piluc.dsi.unifi.it/alvie/

5.3. Cassis

Participants: Christian Baudet [EPI, Contact, christian.baudet@univ-lyon1.fr], Christian Gautier [EPI], Claire Lemaitre [Contact, claire.lemaitre@inria.fr], Marie-France Sagot [EPI], Eric Tannier.

Algorithm for precisely detecting genomic rearrangement breakpoints.
http://pbil.univ-lyon1.fr/software/Cassis/

5.4. Coala

Participants: Christian Baudet [EPI, Contact, christian.baudet@univ-lyon1.fr], Pielrluigi Crescenzi, Bea Donati [EPI, Contact, bea.donati@inria.fr], Christian Gautier [EPI], Catherine Matias, Blerina Sinaimeri [EPI, Contact, blerina.sinaimeri@inria.fr], Marie-France Sagot [EPI, Contact, marie-france.sagot@inria.fr].

COALA stands for "CO-evolution Assessment by a Likelihood-free Approach". It is thus a likelihood-free method for the co-phylogeny reconstruction problem which is based on an Approximative Bayesian Computation (ABC).
http://coala.gforge.inria.fr/

5.5. C3Part & Isofun

Participants: Frédéric Boyer, Yves-Pol Deniélou, Anne Morgat [EPI, ext. member], Marie-France Sagot [EPI], Alain Viari [EPI, Contact, alain.viari@inria.fr].

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. It is based on the notion of "common connected components" between graphs.http://www.inrialpes.fr/helix/people/viari/lxgraph/index.html

5.6. CycADS

Participants: Hubert Charles [EPI], Patrice Baa Puyoule [Contact, Patrice.Baa-Puyoulet@lyon.inra.fr], Stefano Colella [Contact, stefano.colella@lyon.inra.fr], Ludovic Cottret, Marie-France Sagot [EPI], Augusto Vellozo [Contact, augusto@cycadsys.org].

Cyc annotation database system.
http://www.cycadsys.org/

5.7. Eucalypt

Participants: Christian Baudet [EPI, Contact, christian.baudet@univ-lyon1.fr], Pielrluigi Crescenzi, Bea Donati [Contact, bea.donati@inria.fr], Blerina Sinaimeri, Marie-France Sagot [EPI].

Algorithm for enumerating all optimal (possibly time-unfeasible) mappings of a parasite tree unto a host tree.
http://eucalypt.gforge.inria.fr/

5.8. Gobbolino & Touché

Participants: Vicente Acuña [EPI], Etienne Birmelé, Ludovic Cottret, Pierluigi Crescenzi, Fabien Jourdan, Vincent Lacroix, Alberto Marchetti-Spaccamela [EPI, ext. member], Andrea Marino, Paulo Vieira Milreu [EPI, Contact, pvmilreu@gmail.com], Marie-France Sagot [EPI, Contact, marie-france.sagot@inria.fr], Leen Stougie [EPI, ext. member].

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. Biologically, stories correspond to alternative metabolic pathways that may explain some stress that affected the metabolites corresponding to the black nodes by changing their concentration (measured by metabolomics experiments).
http://gforge.inria.fr/projects/gobbolino

5.9. KisSNP

Participants: Vincent Lacroix [EPI], Pierre Peterlongo [Contact, pierre.peterlongo@inria.fr], Nadia Pisanti, Marie-France Sagot [EPI], Nicolas Schnel.

Algorithm for identifying SNPs without a reference genome by comparing raw reads.
http://alcovna.genouest.org/kissnp/

5.10. kisSplice & KisSplice2igv

Participants: Lilia Brinza [EPI], Rayan Chikhi, Alice Julien-Lafferière [EPI], Janice Kielbassa, Vincent Lacroix [Contact, EPI], Camille Marchet [EPI], Claire Lemaitre, Pierre Peterlongo, Gustavo Sacomoto [EPI], Marie-France Sagot [EPI], Raluca Uricaru.

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. KisSplice2igv is a pipeline that combines the outputs of KisSplice to a reference transcriptome (obtained with a full-length transcriptome assembler or a reference database). It provides a visualisation of the events found by KisSplice in a longer context using a genome browser (IGV).
http://kissplice.prabi.fr/

5.11. LASAGNE

Participants: Pierluigi Crescenzi [Contact, pierluigi.crescenzi@unifi.it, ext. member EPI], Roberto Grossi, Michel Habib, Claudio Imbrenda, Leonardo Lanzi, Andrea Marino.

LASAGNE is a Java application which allows the user to compute distance measures on graphs by making a clever use either of the breadth-first search or of the Dijkstra algorithm. In particular, the current version of LASAGNE can compute the exact value of the diameter of a graph: the graph can be directed or undirected and it can be weighted or unweighted. Moreover, LASAGNE can compute an approximation of the distance distribution of an undirected unweighted graph. These two features are integrated within a graphical user interface along with other features, such as computing the maximum (strongly) connected component of a graph.
http://amici.dsi.unifi.it/lasagne/?page_id=324

5.12. MetExplore

Participants: Michael Barrett, Hubert Charles [EPI], Ludovic Cottret [Contact, Ludovic.Cottret@toulouse.inra.fr], Fabien Jourdan, Marie-France Sagot [EPI], Florence Vinson, David Wildridge.

Web server to link metabolomic experiments and genome-scale metabolic networks.
http://metexplore.toulouse.inra.fr/metexplore/

5.13. Migal

Participants: Julien Allali [Contact, julien.allali@labri.fr], Marie-France Sagot [EPI, Contact, marie-france.sagot@inria.fr].

RNA, tree comparison
Algorithm for comparing RNA structures.
http://www-igm.univ-mlv.fr/~allali/logiciels/index.en.php

5.14. Mirinho

Participants: Cyril Fournier [EPI], Susan Higashi [EPI, Contact, susan.higashi@inria.fr], Christian Gautier [EPI], Christine Gaspin, Marie-France Sagot [EPI].

Predicts, at a genome-wide scale, microRNA candidates.
http://mirinho.gforge.inria.fr/

5.15. MotusWEB

Participants: Ludovic Cottret, Fabien Jourdan, Vincent Lacroix [EPI, Contact, vincent.lacroix@univ-lyon1.fr], Odile Rogier, Marie-France Sagot [EPI].

Algorithm for searching and inferring coloured motifs in metabolic networks (web-based version - offers different functionalities from the downloadable version).
http://pbil.univ-lyon1.fr/software/motus_web/

5.16. Motus

Participants: Ludovic Cottret, Fabien Jourdan, Vincent Lacroix [EPI, Contact, vincent.lacroix@univ-lyon1.fr], Odile Rogier, Marie-France Sagot [EPI].

Algorithm for searching and inferring coloured motifs in undirected graphs (downloadable version - offers different functionalities from the web-based version).
http://pbil.univ-lyon1.fr/software/motus/

5.17. PhEVER

Participants: Christian Gautier [EPI], Vincent Lotteau, Leonor Palmeira [Contact, mlpalmeira@ulg.ac.be], Chantal Rabourdin-Combe, Simon Penel.

Database of homologous gene families built from the complete genomes of all available viruses, prokaryotes and eukaryotes and aimed at the detection of virus/virus and virus/host lateral gene transfers.
http://pbil.univ-lyon1.fr/databases/phever/

5.18. PepLine

Participants: Jérôme Garin, Alain Viari [EPI, Contact, alain.viari@inria.fr].

Pipeline for the high-throughput analysis of proteomic data.

5.19. Pitufo and family

Participants: Vicente Acuña [EPI], Ludovic Cottret [Contact, Ludovic.Cottret@toulouse.inra.fr], Alberto Marchetti-Spaccamela [EPI, ext. member], Paulo Vieira Milreu [EPI, Contact, pvmilreu@gmail.com], Marie-France Sagot [EPI], Leen Stougie [EPI, ext. member], Fabio Viduani-Martinez.

Algorithms to enumerate all minimal sets of precursors of target compounds in a metabolic network.
http://sites.google.com/site/pitufosoftware/

5.20. Repseek

Participants: Guillaume Achaz [Contact, achaz@abi.snv.jussieu.fr], Eric Coissac, Alain Viari [EPI].

Finding approximate repeats in large DNA sequences.
http://wwwabi.snv.jussieu.fr/public/RepSeek/

5.21. Smile

Participants: Laurent Marsan, Marie-France Sagot [EPI, Contact, marie-france.sagot@inria.fr].

Motif inference algorithm taking as input a set of biological sequences.

5.22. Tuiuiu

Participants: Alair Pereira Do Lago, Pierre Peterlongo [Contact, pierre.peterlongo@inria.fr], Nadia Pisanti, Gustavo Sacomoto [EPI], Marie-France Sagot [EPI].

Multiple repeat search filter with edit distance.
http://mobyle.genouest.org/cgi-bin/Mobyle/portal.py?form=tuiuiu

5.23. UniPathway

Participants: Eric Coissac, Anne Morgat [EPI, Contact, anne.morgat@inria.fr], Alain Viari [EPI].

Database of manually curated pathways developed with the Swiss-Prot group.
http://www.unipathway.org

BEAGLE Project-Team

5. Software and Platforms

5.1. aevol (artificial evolution)

Participants: Guillaume Beslon, Stephan Fischer, Carole Knibbe, David P Parsons, Bérénice Batut.

- Contact: Carole Knibbe (carole.knibbe@inria.fr).
- Aevol is a simulation software dedicated to the study of genome evolution. It allows to carry out *in silico* experimental evolution. Populations of digital organisms reproduce and mutate randomly, with both small mutations and large chromosomic rearrangements, in a steady or varying environment. A curve-fitting task is used to determine the fitness of the organisms and thus their rate of reproduction. The number of genes, their order, their sequences, their intergenic distances are all free to evolve.
- URL: http://www.aevol.fr

5.2. FluoBacTracker

Participants: Hugues Berry, David P Parsons, Magali Vangkeosay.

- Contact: Hugues Berry (hugues.berry@inria.fr)
- FluoBacTracker is a software for automated quantification of bacterial cells in microscopy movies, developed in collaboration with INSERM U1001 and Paris 5 MAP (Applied Mathematics) Labs. The development (started october 2012) is supported by is a 2-year grant (ADT) funded by Inria's Technological Development Department (Sept 2012- July 2014, project name: "MultiPop"). We hope this software will be useful to all the experimental biology labs that tries to derive single-cell data from bacteria growth microscopy movies. Co-developers include Magali Vangkeosay (Beagle), David P Parsons (SED, Inria Grenoble) and Xiaohu Song (INSERM U1001).

5.3. Ancestral Genome Reconstructions

Participant: Eric Tannier.

- Contact: Eric Tannier (eric.tannier@inria.fr).
- We participated in the development of a series of softwares for genome organization analysis:
  - ANGES, for ANcestral GEnomeS maps, is a toolkit for ordering ancestral genomic markers in chromosomes. An application note has been published in *Bioinformatics* in 2012 to advertise its first release. It is hosted at SFU in Vancouver, URL: http://paleogenomics.irmacs.sfu.ca/ANGES/, under a GNU license, 2012.
  - DeCo and DeCoLT, for Detection of Co-evolution (with Lateral gene Transfer), reconstruct neighborhood relationships between genes of ancient genomes, in the presence of gene duplications, transfer and losses. Both are hosted at the PRABI, the bioinformatics platform in Lyon, under a Cecill license, 2012 and 2013. URL: http://pbil.univ-lyon1.fr/software/DeCo/ and http://pbil.univ-lyon1.fr/software/DeCoLT/.
  - DCJ2HP provides bayesian samples of rearrangements scenarios between two genomes. It is hosted at the Renyi Institute in Budapest. URL: http://www.renyi.hu/~miklosi/DCJ2HP/

5.4. DMT4SP mining tool

Participant: Christophe Rigotti.

- Contact: Christophe Rigotti (christophe.rigotti@insa-lyon.fr).
- DMT4SP (Data-Mining Tool For Sequential Patterns) – DMT4SP is command-line tool to extract episodes and episode rules over a single sequence or several sequences of events. It allows to specify constraints on the episodes or on the rules. Three kinds of patterns can be extracted: (1) serial episodes, (2) serial episode rules having a single event type in the consequent, and (3) quantitative episodes (aka grouping of "homogeneous" occurrences of serial episodes with respect to the time gap between events). DMT4SP is a prototype that is freely distributed (http://liris.cnrs.fr/~crigotti/dmt4sp.html).

DRACULA Project-Team

5. Software and Platforms

5.1. CelDyn

Participants: Laurent Pujo-Menjouet, Alen Tosenberger, Vitaly Volpert [correspondant].

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.

IBIS Project-Team

4. Software and Platforms

4.1. Genetic Network Analyzer (GNA)

Participants: Hidde de Jong [Correspondent], Michel Page, François Rechenmann, Delphine Ropers.

Keywords. Gene regulatory networks, qualitative simulation, model checking

GENETIC NETWORK ANALYZER (GNA) is the implementation of methods for the qualitative modeling and simulation of gene regulatory networks developed in the IBIS project. 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. GNA is currently distributed by the company Genostar, but remains freely available for academic research purposes. The current version is GNA 8.5. In comparison with the previously distributed versions, GNA 8.5 has the following additional functionalities: (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 [6]. For more information, see http://www-helix.inrialpes.fr/gna.

4.2. WellReader

Participants: Johannes Geiselmann, Hidde de Jong [Correspondent], Michel Page, Delphine Ropers.

Keywords. Gene expression, reporter gene data

WELLREADER is a program for the analysis of gene expression data obtained by means of fluorescent and luminescent reporter genes. WELLREADER reads data files in an XML format or in a format produced by microplate readers, and allows the user to detect outliers, perform background corrections and spline fits, compute promoter activities and protein concentrations, and compare expression profiles across different conditions. WELLREADER has been written in MATLAB and is available under an LGPL licence, both as source code (M files) and compiled code (platform-specific binary files). For more information, see: http://ibis.inrialpes.fr/article957.html.

MOISE Project-Team

5. Software and Platforms

5.1. Adaptive Grid Refinement

Participants: Laurent Debreu, Marc Honnorat.

AGRIF (Adaptive Grid Refinement In Fortran, [85], [84]) 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. As an example, AGRIF is currently used in the following ocean models: MARS (a coastal model developed at IFREMER-France), ROMS (a regional model developed jointly at Rutgers and UCLA universities), NEMO ocean modelling system (a general circulation model used by the French and European scientific community) and HYCOM (a regional model developed jointly by University of Miami and the French Navy).
In 2013, a new contract has been signed with IFREMER to add online degradation capabilities. The software will be used operationally to attain a resolution of 500meters along the French coasts. (http://www.previmer.org) AGRIF is licensed under a GNU (GPL) license and can be downloaded at its web site (http://ljk.imag.fr/MOISE/AGRIF/index.html).

5.2. NEMOVAR

Participants: Arthur Vidard, Pierre-Antoine Bouttier, Bénédicte Lemieux-Dudon.

NEMOVAR is a state-of-the-art multi-incremental variational data assimilation system dedicated to the European ocean modelling platform NEMO for research and operational applications. It is co-developed by MOISE, CERFACS (FR), ECMWF (EU) and MetOffice (UK) under the CeCILL license, written in fortran and python. It is now in use in both ECMWF and MetOffice for their operational oceanic forecasting systems. It has also been used for specific studies in collaboration with Mercator-Ocean, LPO, LOCEAN and LEGI in France and University of Namur in Belgium. It is also a likely candidate for becoming the future Black-Sea forecasting system of the Marine Hydrographical Institute of Ukraine with whom we collaborate actively. Previously part of NEMOVAR, NEMO-TAM (Tangent and adjoint models for NEMO) that have been developed by the MOISE team will be now distributed directly by the NEMO consortium. The first official tagged release including NEMO-TAM has been published early 2013.

5.3. DatIce

Participant: Bénédicte Lemieux-Dudon.

Antarctic and Greenland ice cores provide a mean to study the phase relationships of climate changes in both hemispheres. They also enable to study the timing between climate and greenhouse gases or orbital forcings. One key step for such studies is to improve the absolute and relative precisions of ice core age scales (for ice and trapped gas), and beyond that, to try to reach the best consistency between chronologies of paleo-records of any kind.

The DatIce tool is designed to increase the consistency between pre-existing core chronologies (also called background). It formulates a variational inverse problem which aims at correcting three key quantities that uniquely define the core age scales: the accumulation rate, the total thinning function, and the close-off depth. For that purpose, it integrates paleo-data constraints of many types among which age markers (with for instance documented volcanoes eruptions), and stratigraphic links (with for instance abrupt changes in methane concentration). A cost function is built that enables to calculate new chronologies by making a trade-off between all the constraints (background chronologies and paleo-data).

DatIce enables to circumvent the limits encountered with other dating approaches, in particular because it controls the model errors, which are still large despite efforts to better describe the firn densification, the ice flow and the forcing fields (ice sheet elevation, temperature and accumulation rate histories). Controlling the model error makes it possible to assimilate large set of observations, to constrain both the gas and ice age scales, and to apply the process on several cores at the same time by including stratigraphic links between cores. This approach greatly improves the consistency of ice cores age scales.

The method presented in [93], [94] has already been applied simultaneously to EPICA EDML and EDC, Vostok and NGRIP drillings. The code has also been applied in two publications [78] and [106] which aimed at the construction of a unified chronology for Antarctic ice cores. LGGE, LSCE and MOISE are partners to extend the code to marine and terrestrial cores. On going development efforts are made to ensure the robustness of the dating solution (diagnostics on the assimilation system, calibration of the background error covariance matrices).

5.4. SDM toolbox

Participant: Antoine Rousseau.

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, we develop a new method based on the combination of an existing numerical weather prediction model providing a coarse prediction, and a Lagrangian Stochastic Model adapted from a pdf method introduced by S.B. Pope for turbulent flows. This Stochastic Downscaling Method (SDMhttp://sdm.gforge.inria.fr/) is thus aimed to be used as a refinement toolbox of large-scale numerical models. SDM requires a specific modelling of the turbulence closure, and involves various simulation techniques whose combination is totally new (such as Poisson solvers, optimal transportation mass algorithm, original Euler scheme for confined Langevin stochastic processes, and stochastic particle methods). Since 2011, we work on the comparison of the SDM model (endowed with a physical geostrophic forcing and a wall log law) with simulations obtained with a LES method (Méso-NH code) for the atmospheric boundary layer (from 0 to 750 meters in the vertical direction), in the neutral case.

5.5. CompModSA package

Participants: Clémentine Prieur, Alexandre Janon, Céline Helbert.

Alexandre Janon is a contributor of the packages CompModSA - Sensitivity Analysis for Complex Computer Models (see http://cran.open-source-solution.org/web/packages/CompModSA/index.html), and sensitivity (see http://cran.r-project.org/web/packages/sensitivity/index.html). These packages are useful for conducting sensitivity analysis of complex computer codes.

Celine Helbert is now the maintainer of the packages DiceDesign (see http://cran.r-project.org/web/packages/DiceDesign/index.html) and DiceEval (see http://cran.r-project.org/web/packages/DiceEval/index.html). These packages are useful for conducting design and analysis of computer experiments.

NUMED Project-Team

4. Software and Platforms

4.1. SimPHyT

SimPHyt has been developed by Morgan Martinet (junior engineer). SimPHyt is an implementation in Python of the low grad glioma model developped by Benjamin Ribba. The aim is to predict the evolution of the glioma size of patients. It is used by Dr François Ducray in Pierre Wertheimer Hospital in Lyon.

4.2. SETIS

We are currently developing the SETIS software which 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 our colleagues in Lyon Hospital). It will be freely distributed and is based on open source technology, so that it can easily be adapted to specific needs by other users.

4.3. Zebre

Participant: Thierry Dumont [correspondant].

Thierry Dumont is currently developping a toolbox to solve stiff reaction diffusion equations using splitting methods, together with refined numerical schemes for ODEs (RADO 5).

This code was first designed to serve as demonstrator of the theoretical results of Descombes and Massot on the solution of stiff reaction-diffusion systems by alternate directions methods, and as a first step towards complex chemistry simulations. Later it was used and improved to solve the ionic model of strokes, and incorporated stabilized explicit Runge Kutta methods for diffusion steps. Coded in C++, it solves stiff systems with various schemes in dimension 1, 2 and 3, in complex geometries. The code is multithreaded.

4.4. OptimChemo

Participants: Violaine Louvet [correspondant], Emmanuel Grenier.

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.

4.5. Simstab

Stability prediction of vaccine, intellectual property of Sanofi, covered by a US patent demand (Sanofi, Benjamin Ribba, Emmanuel Grenier).

4.6. Bingham flows

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.

STEEP Team

5. Software and Platforms

5.1. TEOS: Tranus Exploration and Optimization Software

Participants: Anthony Tschirhard, Mathieu Vadon, Elise Arnaud, Emmanuel Prados.

The TEOS software offers a set of tools to help the calibration of the land use and transport integrated model TRANUS. It uses some exploration and optimization procedures of the relevant parameters.

5.2. REDEM: REDuction Of GHG EMission software

Participant: Emmanuel Prados.

REDEM software (REDuction of EMissions) is a tool designed for the benchmarking of national GHG emission reduction trajectories. We have developed REDEM in collaboration with EDDEN Laboratory (Patrick Criqui and Constantin Ilasca). 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. We envisage to distribute this software as an open source software.

5.3. Wassily

Participants: Julien Alapetite, Jean-Yves Courtonne, Lara Antonela Colombo, Pablo Virgolini.

In collaboration with the association "Groupe de Réflexion sur les Empreintes Ecologiques Locales" (eco-data.fr), STEEP contributes to the development of Wassily (in tribute to Wassily Leontief who first designed the relevant concepts), to perform input-output analyses applied to environmental issues (see section 4.2). The purpose of this software is to automatize most of the work of standard input-output analysis and to visualize the results in a user-friendly way in order to efficiently address the related key environmental questions.

The software is structured in three different modules:

- the database module stores all the input-output data coming from Eurostat, OCDE, Insee or other sources.
- the computation module performs the input-output calculations
- the visualization module displays the results in a synthetic manner.

The database module is based on the SQlite format and makes use of SQL to manipulate the various tables involved in the process. The goal of this module is to provide a normalized data interface for the computation module, from various types of input-output data which are often stored as Excel sheet on web sites.
The computation module is based on QT and C++ and deals mostly with matrix manipulation.
The visualization module is based on a JavaScript library called D3 and allows the user to visualize the results in a number of different ways, such as bar charts, pie charts, sankey diagrams to name a few. The integration between the C++ and JavaScript pieces of code is performed with QTScript.

AVALON Team

5. Software and Platforms

5.1. BitDew

Participants: Gilles Fedak [correspondant], Haiwu He.

BITDEW is an open source middleware implementing a set of distributed services for large scale data management on Desktop Grids and Clouds. BITDEW relies on five abstractions to manage the data : i) replication indicates how many occurrences of a data should be available at the same time on the network, ii) fault-tolerance controls the policy in presence of hardware failures, iii) lifetime is an attribute absolute or relative to the existence of other data, which decides of the life cycle of a data in the system, iv) affinity drives movement of data according to dependency rules, v) protocol gives the runtime environment hints about the protocol to distribute the data (http, ftp, or bittorrent). Programmers define for every data these simple criteria, and let the BITDEW runtime environment manage operations of data creation, deletion, movement, replication, and fault-tolerance operation.

BITDEW is distributed open source under the GPLv3 or Cecill licence at the user's choice. 10 releases were produced over the last two years, and it has been downloaded approximately 6,000 times on the Inria forge. Known users are Université Paris-XI, Université Paris-XIII, University of Florida (USA), Cardiff University (UK) and University of Sfax (Tunisia). In terms of support, the development of BitDew is partly funded by the Inria ADT BitDew and by the ANR MapReduce projects. Thanks to this support, we have developed and released the first prototype of the MapReduce programming model for Desktop Grids on top of BitDew. In 2012, 8 versions of the software have been released, including the version 1.2.0 considered as a stable release of BitDew with many advanced features. Our most current work focuses on providing reliable storage on top of hybrid distributed computing infrastructures.

5.2. DIET

Participants: Daniel Balouek, Eddy Caron [correspondant], Frédéric Desprez, Maurice-Djibril Faye, Arnaud Lefray, Guillaume Verger, Jonathan Rouzaud-Cornabas, Lamiel Toch, Huaxi Zhang.

Huge problems can now be processed over the Internet thanks to Grid and Cloud middleware systems. The use of on-the-shelf applications is needed by scientists of other disciplines. Moreover, the computational power and memory needs of such applications may of course not be met by every workstation. Thus, the RPC paradigm seems to be a good candidate to build Problem Solving Environments on the Grid or Cloud. The aim of the DIET project (http://graal.ens-lyon.fr/DIET) is to develop a set of tools to build computational servers accessible through a GridRPC API.

Moreover, the aim of a middleware system such as DIET is to provide a transparent access to a pool of computational servers. DIET focuses on offering such a service at a very large scale. A client which has a problem to solve should be able to obtain a reference to the server that is best suited for it. DIET is designed to take into account the data location when scheduling jobs. Data are kept as long as possible on (or near to) the computational servers in order to minimize transfer times. This kind of optimization is mandatory when performing job scheduling on a wide-area network. DIET is built upon *Server Daemons*. The scheduler is scattered across a hierarchy of *Local Agents* and *Master Agents*. Applications targeted for the DIET platform are now able to exert a degree of control over the scheduling subsystem via *plug-in schedulers*. As the applications that are to be deployed on the Grid vary greatly in terms of performance demands, the DIET plug-in scheduler facility permits the application designer to express application needs and features in order that they be taken into account when application tasks are scheduled. These features are invoked at runtime after a user has submitted a service request to the MA, which broadcasts the request to its agent hierarchy.

DIET provide a support for Cloud architecture. and it takes benefits from virtualized resources. As cloud resources are dynamic, we have on-going research in the field of automatic and elastic deployment for middleware systems. DIET will be able to extend and reduce the amount on aggregated resources and adjust itself when resources fail.

In the context of the Seed4C project, we have studied how secured our platform, authenticated and secured interactions between the different parts of our middleware and between our middleware and its users. By the way, we have added the SSL support into the DIET communication layer. We have worked to show how to securely use public cloud storage without taking the risk of losing confidentiality of data stored on them.

We have started a work to design a plug-in schedulers into DIET to deal with energy management. Using this scheduler we have obtain a significatif gain close to 25% with a minor weakening of performance (6%). Moreover we have experimented some dynamic resources management through DIET based on the energy criteria.

5.3. Pilgrim

Participants: Eddy Caron, Matthieu Imbert [correspondant].

Pilgrim (http://pilgrim.gforge.inria.fr) is an open metrology and prediction performance framework whose goal is to provide easy and powerful tools for instrumenting computer platforms and predicting their behavior. Those tools are aimed at being used not only by humans but also by programs, in particular by resource managers and schedulers. Pilgrim is designed to be a loosely coupled integration of various custom-developed or off-the-shelf tools.

5.4. Sam4c

Participants: Eddy Caron, Arnaud Lefray [correspondant], Jonathan Rouzaud-Cornabas.

Sam4C (https://gforge.inria.fr/projects/sam4c/) -Security-Aware Models for Clouds- is a graphical and textual editor to model Cloud applications (as virtual machines, processes, files and communications) and describe its security policy. Sam4C is suitable to represent any static application without deadline or execution time such as n-tiers or parallel applications. This editor is generated in Java from an EMF -Eclipse Modeling Framework- metamodel to simplify any modifications or extensions. The application model and the associated security policy are compiled in a single XML file which serves as input for an external Cloud security-aware scheduler. Alongside with this editor, Cloud architecture models and provisioning algorithms are provided for simulation (in the current version) or real deployments (in future versions). During this step of development this software is private and available only for Seed4C project members. The design of Sam4c is a joint effort with ENSIB (Bourges).

5.5. SimGrid

Participants: Georgios Markomanolis, Jonathan Rouzaud-Cornabas, Frédéric Suter [correspondant].

SIMGRID is a toolkit for the simulation of distributed applications in heterogeneous distributed environments. The specific goal of the project is to facilitate research in the area of parallel and distributed large scale systems, such as Grids, P2P systems and clouds. Its use cases encompass heuristic evaluation, application prototyping or even real application development and tuning. SIMGRID has an active user community of more than one hundred members, and is available under GPLv3 from http://simgrid.gforge.inria.fr/.

5.6. HLCMi, L^{2}C, & Gluon++

Participants: Zhengxiong Hou, Vincent Lanore, Christian Perez [correspondant].

HLCMI (http://hlcm.gforge.inria.fr) is an implementation of the HLCM component model. HLCM is a generic extensible component model with respect to component implementations and interaction concerns. Moreover, HLCM is abstract; it is its specialization—such as HLCM/L^{2}C—that defines the primitive elements of the model, such as the primitive components and the primitive interactions.

HLCMI is making use of Model-driven Engineering (MDE) methodology to generate a concrete assembly from an high level description. It is based on the Eclipse Modeling Framework (EMF). HLCMI contains 700 Emfatic lines to describe its models and 7000 JAVA lines for utility and model transformation purposes. HLCMI is a general framework that supports several HLCM specializations: HLCM/CCM, HLCM/JAVA, HLCM/L^{2}C and HLCM/Charm++ (known as Gluon++).

L^{2}C (http://hlcm.gforge.inria.fr) is a *Low Level Component* model implementation targeting at use-cases where overhead matters such as High-Performance Computing. L^{2}C does not offer network transparency neither language transparency. Instead, L^{2}C lets the user choose between various kinds of interactions between components, some with ultra low overhead and others that support network transport. L^{2}C is extensible as additional interaction kinds can be added quite easily. L^{2}C currently supports C++, FORTRAN 2013, MPI and CORBA interactions.

Gluon++(http://hlcm.gforge.inria.fr) is a thin component model layer added on top of Charm++ (http://charm.cs.uiuc.edu/). It defines chare components as a Charm++ chare with minimal metadata, C++ components as a C++ class with minimal metadata, (asynchronous) entry method calls between components, and plain C++ method calls between components.

L^{2}C and Gluon++ are implemented in the LLCMc++ framework (http://hlcm.gforge.inria.fr). It is distributed under a LGPL licence and represents 6400 lines of C++.

5.7. Execo

Participants: Matthieu Imbert [correspondant], Laurent Pouilloux.

Execo (http://execo.gforge.inria.fr) offers a Python API for local or remote, standalone or parallel, processes execution. It is especially well suited for scripting workflows of parallel/distributed operations on local or remote hosts: automating a scientific workflow, conducting computer science experiments, performing automated tests, etc. The core python package is `Execo`. The `execo_g5k` package provides a set of tools and extensions for GRID'5000. The `execo_engine` package and `execo-run` script provide an extendable experiment engine.

Execo currently has more than 10 users in and outside the AVALON team, who rely on it to automate experimental workflows, mainly on GRID'5000 ([26]).

It is distributed under GPLv3 and it is made of 5200 lines of Python.

5.8. Grid'5000

Participants: Frédéric Desprez, Simon Delamare, Laurent Lefèvre, Christian Perez.

The GRID'5000 experimental platform (http://www.grid5000.fr) 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.

Not only GRID'5000 is heavily used for Avalon research, but several team members are also involved in GRID'5000 direction:

- Frédéric Desprez is leading the "Groupement d'Intérêt Scientifique Groupement Grille 5K" which drives GRID'5000.
- Laurent Lefèvre is responsible of the GRID'5000 Lyon platform and member of the GRID'5000 direction committee.
- Christian Perez is leading the Hemera initiative (https://www.grid5000.fr/Hemera) and he is a member of the GRID'5000 direction committee.
- Simon Delamare is the operational manager of the technical team.

DANTE Team

5. Software and Platforms

5.1. Sensor Network Tools: drivers, OS and more

Participants: Éric Fleury [correspondant], Sandrine Avakian.

As a outcomes of the ANR SensLAB project and the Inria ADT SensTOOLS and SensAS, several softwares (from low level drivers to OSes) were delivered and made available to the research community. The main goal is to lower the cost of developing/deploying a large scale wireless sensor network application. All software are gathered under the SensLAB web site: http://www.senslab.info/ web page where one can find:

- low C-level drivers to all hardware components;
- ports of the main OS, mainly TinyOS, FreeRTOS and Contiki;
- ports and development of higher level library like routing, localization.

5.2. Queueing Systems

Participant: Thomas Begin [correspondant].

Queueing models, steady-state solution, online tool, web interface Online tool: http://queueing-systems.ens-lyon.fr

This tool aims at providing an ergonomic web-based interface to promote the use of our proposed solutions to numerically solve classical queueing systems. This tool was launched in 2011 and presented at the conference [30]. It attracts each month hundreds of visitors scattered accross the world. Its initial implementation only includes the solution for a queue with multiple servers, general arrivals, exponential services and a possibly finite buffer (*i.e.*, $Ph/M/c/N$-like queue). The steady-state solution to this queue is based on a simple and stable recurrence [31] and was performed in collaboration with Pr. Brandwajn (UCSC). Since then, we added new models such that a mono server queue with Poisson arrivals, general services and a possibly finite buffer (*i.e.*, $M/Ph/1/N$-like queue). In 2013, we extended our tool so as to include the solution for a queue with multiple servers, general service times and Poisson arrivals (*i.e.*, $M/Ph/c/N$-like queue). The solution is based on a new approximation that we developed this year in collaboration with Pr. Brandwajn (UCSC) [32]. Associated URL is: http://queueing-systems.ens-lyon.fr

MESCAL Project-Team

5. Software and Platforms

5.1. Tools for cluster management and software development

Participant: Olivier Richard [correspondent].

The KA-Tools is a software suite developed by MESCAL for exploitation of clusters and grids. It uses a parallelization technique based on spanning trees with a recursive starting of programs on nodes. Industrial collaborations were carried out with Mandrake, BULL, HP and Microsoft.

KA-DEPLOY is an environment deployment toolkit that provides automated software installation and reconfiguration mechanisms for large clusters and light grids. The main contribution of KA-DEPLOY 2 toolkit is the introduction of a simple idea, aiming to be a new trend in cluster and grid exploitation: letting users concurrently deploy computing environments tailored exactly to their experimental needs on different sets of nodes. To reach this goal KA-DEPLOY must cooperate with batch schedulers, like OAR, and use a parallel launcher like TAKTUK (see below).

TAKTUK is a tool to launch or deploy efficiently parallel applications on large clusters, and simple grids. Efficiency is obtained thanks to the overlap of all independent steps of the deployment. We have shown that this problem is equivalent to the well known problem of the single message broadcast. The performance gap between the cost of a network communication and of a remote execution call enables us to use a work stealing algorithm to realize a near-optimal schedule of remote execution calls. Currently, a complete rewriting based on a high level language (precisely Perl script language) is under progress. The aim is to provide a light and robust implementation. This development is lead by the MOAIS project-team.

5.2. OAR: Batch scheduler for clusters and grids

Participant: Olivier Richard [correspondent].

The OAR project (see http://oar.imag.fr) focuses on robust and highly scalable batch scheduling for clusters and grids. Its main objectives are the validation of grid administration tools such as TAKTUK, the development of new paradigms for grid scheduling and the experimentation of various scheduling algorithms and policies.

The grid development of OAR has already started with the integration of best effort jobs whose purpose is to take advantage of idle times of the resources. Managing such jobs requires a support of the whole system from the highest level (the scheduler has to know which tasks can be canceled) down to the lowest level (the execution layer has to be able to cancel awkward jobs). OAR is perfectly suited to such developments thanks to its highly modular architecture. Moreover, this development is used for the CiGri grid middleware project.

The OAR system can also be viewed as a platform for the experimentation of new scheduling algorithms. Current developments focus on the integration of theoretical batch scheduling results into the system so that they can be validated experimentally.

5.3. CiGri: Computing resource Reaper

Participant: Olivier Richard [correspondent].

CiGri (see http://cigri.imag.fr/) is a middleware which gathers the unused computing resource from intranet infrastructure and makes it available for the processing of large set of tasks. It manages the execution of large sets of parametric tasks on lightweight grid by submitting individual jobs to each batch scheduler. It is s associated to the OAR resource management system (batch scheduler). Users can easily monitor and control their set of jobs through a web portal. CiGri provides mechanisms to identify job error causes, to isolate faulty components and to resubmit jobs in a safer context.

5.4. FTA: Failure Trace Archive

The Failure Trace Archive [11] is available at http://fta.inria.fr. Since Derrick Kondo left on sabbatical, the Failure Trace Archive has been migrated to University of Western Sidney, Australia (http://fta.scem.uws.edu.au/), which allows an easier management by his colleagues Bahman Javadi who was working as a post-doc in the MESCAL team while initializing the FTA.

With the increasing functionality, scale, and complexity of distributed systems, resource failures are inevitable. While numerous models and algorithms for dealing with failures exist, the lack of public trace data sets and tools has prevented meaningful comparisons. To facilitate the design, validation, and comparison of fault-tolerant models and algorithms, we led the creation of the Failure Trace Archive (FTA), an on-line public repository of availability traces taken from diverse parallel and distributed systems.

While several archives exist, the FTA differs in several respects. First, it defines a standard format that facilitates the use and comparison of traces. Second, the archive contains traces in that format for over 20 diverse systems over a time span of 10 years. Third, it provides a public toolbox for failure trace interpretation, analysis, and modeling. The FTA was released in November 2009. It has received over 11,000 hits since then. The FTA has had national and international impact. Several published works have already cited and benefited from the traces and tools of the FTA. Simulation toolkits for distributed systems, such as SimGrid (CNRS/Inria, France) and GridSim (University of Melbourne, Australia), have incorporated the traces to allow for simulations with failures.

5.5. SimGrid: simulation of distributed applications

Participants: Arnaud Legrand [correspondent], Lucas Mello Schnorr, Luka Stanisic, Augustin Degomme.

SimGrid (see http://simgrid.gforge.inria.fr/) is a toolkit that provides core functionalities for the simulation of distributed applications in heterogeneous distributed environments. The specific goal of the project is to facilitate research in the area of distributed and parallel application scheduling on distributed computing platforms ranging from simple network of workstations to Computational Grids.

5.6. TRIVA: interactive trace visualization

Participants: Lucas Mello Schnorr [correspondent], Arnaud Legrand.

TRIVA (see http://triva.gforge.inria.fr/) is an open-source tool used to analyze traces (in the Pajé format) registered during the execution of parallel applications. The tool serves also as a sandbox for the development of new visualization techniques. Some features include: Temporal integration using dynamic time-intervals; Spatial aggregation through hierarchical traces; Scalable visual analysis with squarified treemaps; A Custom Graph Visualization.

5.7. ψ and ψ^2: perfect simulation of Markov Chain stationary distributions

Participant: Jean-Marc Vincent [correspondent].

ψ and ψ^2 (see http://psi.gforge.inria.fr) are two software tools implementing perfect simulation of Markov Chain stationary distributions using *coupling from the past*. ψ starts from the transition kernel to derive the simulation program while ψ^2 uses a monotone constructive definition of a Markov chain.

5.8. GameSeer: simulation of game dynamics

Participant: Panayotis Mertikopoulos [correspondent].

Mathematica toolbox (graphical user interface and functions library) for efficient, robust and modular simulations of game dynamics.

5.9. Kameleon: environment for experiment reproduction

Participants: Olivier Richard [correspondent], Joseph Emeras.

Kameleon is a tool developed to facilitate the building and rebuilding of software environment. It helps the experimenter to manage his experiment's software environment which can include the operating system, libraries, runtimes, his applications and data. This tool is an element in the experimental process to obtain repeatable experiments and therefore reproducible results.

5.10. Platforms

5.10.1. Grid'5000

The MESCAL project-team is involved in development and management of Grid'5000 platform. The Digitalis and IDPot clusters are integrated in Grid'5000 as well as of CIMENT.

5.10.2. The ICluster-2, the IDPot and the new Digitalis Platforms

The MESCAL project-team manages a cluster computing center on the Grenoble campus. The center manages different architectures: a 48 bi-processors PC (ID-POT), and the center is involved with a cluster based on 110 bi-processors Itanium2 (ICluster-2) and another based on 34 bi-processor quad-core XEON (Digitalis) located at Inria. The three of them are integrated in the Grid'5000 grid platform.

More than 60 research projects in France have used the architectures, especially the 204 processors Icluster-2. Half of them have run typical numerical applications on this machine, the remainder has worked on middleware and new technology for cluster and grid computing. The Digitalis cluster is also meant to replace the Grimage platform in which the MOAIS project-team is very involved.

5.10.3. The Bull Machine

In the context of our collaboration with Bull the MESCAL project-team exploits a Novascale NUMA machine. The configuration is based on 8 Itanium II processors at 1.5 Ghz and 16 GB of RAM. This platform is mainly used by the Bull PhD students. This machine is also connected to the CIMENT Grid.

MOAIS Project-Team

5. Software and Platforms

5.1. KAAPI

Participants: Thierry Gautier [correspondant], Vincent Danjean, François Broquedis, Joao Ferreira Lima.

- ACM: D.1.3
- License: CeCILL
- OS/Middelware: Unix (Linux, MacOSX, ...)
- Programming language: C/C++, Fortran
- Characterization of Software : A-3 / SO-4 / SM-3 / EM-3 / SDL-4
- Own Contribution: DA-4 / CD-4 / MS-4 / TPM-4
- Additional information:

  Kaapi (http://kaapi.gforge.inria.fr, coordinator T. Gautier) is a middleware for high performance applications running on multi-cores/multi- processors as well as cluster or computational grid. Kaapi provides 1/ a very high level API based on macro data flow language; 2/ several scheduling algorithms for multi-threaded computations as well as for iterative applications for numerical simulation on multi-CPUs / multi-GPUs; 3/ fault-tolerant protocols. Publicly available at http://kaapi.gforge.inria.fr under CeCILL licence. Kaapi has won the 2008 Plugtest organized by Grid@Works. Kaapi provides ABI compliant implementations of Quark (PLASMA, Linear Algebra, Univ. of Tennesse) and libGOMP (GCC runtime for OpenMP). Direct competitors with 1/: Quark (UTK), OMPSs (UPC, BSC), OpenMP. Direct competitors with 2/: StarSs, StarPU (Inria RUNTIME). Direct competitors providing 3/: Charm++, MPI.

5.2. FlowVR

Participants: Bruno Raffin [correspondant MOAIS], Matthieu Dreher, Jérémy Jaussaud.

- ACM: D.1.3
- License: GPL and LGPL
- OS/Middelware: Unix (Linux, MacOSX, ...)
- Programming language: C/C++
- Characterization of Software : A-3 / SO-4 / SM-3 / EM-3 / SDL-4
- Own Contribution: DA-4 / CD-3 / MS-3 / TPM-4
- Additional information: FlowVR (http://flowvr.sf.net, coordinator B. Raffin) provides users with the necessary tools to develop and run high performance interactive applications on PC clusters and Grids. The main target applications include virtual reality, scientific visualization and in situ analytics. FlowVR enforces a modular programming that leverages software engineering issues while enabling high performance executions on distribued and parallel architectures. FlowVR is the reference backbone for Grimage. See also the web page http://flowvr.sf.net.

5.3. TakTuk - Adaptive large scale remote execution deployment

Participants: Guillaume Huard [correspondant], Pierre Neyron.

- Characterization of Software : A-2 / SO-3 / SM-5 / EM-3 / SDL-4
- Own Contribution: DA-4 / CD-4 / MS-4 / TPM-4
- Additional information:
  - web site: http://taktuk.gforge.inria.fr, Coordinator G. Huard
  - Objective of the software: TakTuk is a tool for deploying parallel remote executions of commands to a potentially large set of remote nodes. It spreads itself using an adaptive algorithm and sets up an interconnection network to transport commands and perform I/Os multiplexing/demultiplexing. The TakTuk mechanics dynamically adapt to environment (machine performance and current load, network contention) by using a reactive work-stealing algorithm that mixes local parallelization and work distribution.
  - Users community: TakTuk is a research open source project available in the Debian GNU/Linux distribution (package taktuk) used in lower levels of Grid5000 software architectures (nodes monitoring in OAR, environment diffusion in Kadeploy). The community is small : developers and administrators for large scale distributed platforms, but active.
  - Positioning: main competing tools are pdsh (but uses linear deployment) and gexec (not fault tolerant, requires installation), for more details : B. Claudel, G. Huard and O. Richard. TakTuk, Adaptive Deployment of Remote Executions. In Proceedings of the International Symposium on High Performance Distributed Computing (HPDC), 2009. TakTuk is the only tool to provide to deployed processes a communication layer (just like an MPIrun, but not tied to a specific environment) and synchronization capabilities.

5.4. Triva

Participant: Guillaume Huard [correspondant].

- Characterization of Software : A-2 / SO-4 / SM-5 / EM-3 / SDL-3
- Own Contribution: DA-4 / CD-3 / MS-3 / TPM-3
- Additional information:
  - web site: http://triva.gforge.inria.fr/, Coordinator, Lucas Schnorr
  - Objective of the software: Triva is an open-source tool used to analyze traces (in the pajé format) registered during the execution of parallel applications. The tool serves also as a sandbox to the development of new visualization techniques.
  - Users community: Research open source project, applications developers, especially parallel applications.
  - Positioning: Main competing tools are Vampir (classical 2D Gantt charts) and Tau (less advanced agregation techniques), more details in : A Hierarchical Aggregation Model to achieve Visualization Scalability in the analysis of Parallel Applications. Lucas Mello Schnorr, Guillaume Huard, Philippe Olivier Alexandre Navaux. Parallel Computing. Volume 38, Issue 3, March 2012.

5.5. OAR

Participants: Pierre Neyron [correspondant MOAIS], Grégory Mounié.

- Characterization of Software : A-5 / SO-3 / SM-4 / EM-4 / SDL-5
- Own Contribution: DA-3 / CD-2 / MS-1 / TPM-1
- Additional information: OAR (http://oar.imag.fr, Coordinator O. Richard, Inria MESCAL) is a batch scheduler. The MOAIS team develops the central automata and the scheduling module that includes successive evolutions and improvements of the policy.OAR is used to schedule jobs both on the CiGri (Grenoble region) and Grid50000 (France) grids. CiGri is a production grid that federates about 500 heterogeneous resources of various Grenoble laboratories to perform computations in physics. MOAIS has also developed the distributed authentication for access to Grid5000.

5.6. SOFA

Participant: Bruno Raffin [correspondant].

- ACM: D.1.3
- Programming language: C/C++
- Characterization of Software : A-5 / SO-4 / SM-4 / EM-4 / SDL-5
- Own Contribution: DA-2 / CD-2 / MS-1 / TPM-1
- Additional information: SOFA (http://www.sofa-framework.org/, Coordinator F. Faure, Inria IMAGINE) 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 newer algorithms, but can also be used as an efficient prototyping tool. Moais contributes to parallelization of kernel algorithms used in the simulation.

5.7. LinBox

Participants: Clément Pernet [correspondant], Thierry Gautier.

- Characterization of Software : A-3 / SO-4 / SM-2 / EM-3 / SDL-5
- Own Contribution: DA-4 / CD-3 / MS-3 / TPM-4
- Additional information:
  - web site: http://linalg.org
  - Objective of the software: 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.
  - The LinBox group is an international collaboration (USA: NCSU, UDel; Canada: U Waterloo, U Calgary; France: LIP, LIRMM, LJK and LIG). Articles related to the library have been published in the main Conferences of the area: ISSAC, ICMS. MOAIS contributes to its development and more specifically to its parallelization in the context of ANR HPAC project. It is currently experiencing a major change of design, to better integrate parallelism.
  - Users community: mostly researchers doing computational mathematics (number theory, cryptology, group theory, persistent homology. They use the library by either linking against it directly (the library is packaged in Debian, Fedora, etc) or withing the general purpose math software Sage (sagemath.org very broad diffusion) which includes LinBox as a kernel for exact linear algebra.

ROMA Team

5. Software and Platforms

5.1. MUMPS

Participants: Patrick Amestoy, Alfredo Buttari, Jean-Yves L'Excellent [correspondent], Wissam M. Sid-Lakhdar, Bora Uçar.

MUMPS (for *MUltifrontal Massively Parallel Solver*) see http://mumps-solver.org is a software package for the solution of large sparse systems of linear equations. It implements a direct method, the so called multifrontal method; it is a parallel code capable of exploiting distributed-memory computers as well as multithreaded libraries; its main originalities are its numerical robustness and the wide range of functionalities available.

The latest public release is MUMPS 4.10.0 (May 2011).

The development of MUMPS was initiated by the European project PARASOL (Esprit 4, LTR project 20160, 1996-1999), whose results and developments were public domain. Since then, MUMPS has been supported by CERFACS, CNRS, ENS Lyon, INPT(ENSEEIHT)-IRIT, Inria, and University of Bordeaux. Following a contractual agreement signed by those institutes, the next release of MUMPS will be distributed under the Cecill-C license; a technical committee was also defined, currently composed of Patrick Amestoy, Abdou Guermouche, and Jean-Yves L'Excellent.

In the context of an ADT project (Action of Technological Development), Maurice Brémond (from Inria "SED" service in Grenoble) also worked part-time on the project, in particular on visualization tools helping researchers to analyze the behaviour of a parallel MUMPS execution.

More information on MUMPS is available on http://mumps-solver.org. See also Section 6.20 of this report.

SOCRATE Project-Team

5. Software and Platforms

5.1. WSnet

Socrate is an active contributor to WSnet (http://wsnet.gforge.inria.fr/) a multi-hop wireless network discrete event simulator. WSnet was created in the ARES team and it is now supported by the D-NET team of Inria Rhône-Alpes.

5.2. Wiplan

Wiplan is a software including an Indoor propagation engine and a wireless LAN optimization suite, which has been registered by INSA-Lyon. The heart of this software is the propagation simulation core relying on an original method, MR-FDPF (multi-resolution frequency domain ParFlow). The discrete ParFlow equations are translated in the Fourier domain providing a large linear system, solved in two steps taking advantage of a multi- resolution approach. The first step computes a cell-based tree structure referred to as the pyramid. In the second phase, a radiating source is simulated, taking advantage of the pre-processed pyramidal structure. Using of a full-space discrete simulator instead of classical ray-tracing techniques is a challenge due to the inherent high computation requests. However, we have shown that the use of a multi-resolution approach allows the main computation load to be restricted to a pre-processing phase. Extensive works have been done to make predictions more realistic. The network planning and optimization suite is based on a multi-criteria model relying on a Tabu solver. The development of the wiplan software is a part of the european project iPlan (IAPP-FP7 project).

5.3. FloPoCo

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. FloPoCo is a generator of operators written in C++ and outputting synthesizable VHDL automatically pipelined to an arbitrary frequency. In 2013, a CORDIC-based arctangent was written in Socrate.

Among the known users of FloPoCo are U. Bristol,U. Cape Town, U.T. Cluj-Napoca, Imperial College, U. Essex, U. Madrid, U. P. Milano, T.U. Muenchen, T. U. Kaiserslautern, U. Paderborn, CalTech, U. Pernambuco, U. Perpignan, U. Tohoku, U. Tokyo, Virginia Tech U. and several companies.

Web page: http://flopoco.gforge.inria.fr/

URBANET Team

5. Software and Platforms

5.1. WSNet

UrbaNet is an active contributor to WSnet (http://wsnet.gforge.inria.fr/), a discrete event simulator dedicated to large scale wireless networks developed and maintained by members of Inria and CITI lab. A major part of this contribution is represented by the implementation of state of the art protocols for medium access control and routing.

The WSNet simulation results obtained following this process are sometimes used as an input for another part of our development effort, which consists in prototype software based on the combination of CPLEX and AMPL for solving mixed integer linear programming problems with column generation.

5.2. TAPASCologne vehicular mobility dataset

Based on the data made available by the Institute of Transportation Systems at the German Aerospace Center (ITS-DLR), the dataset aims at reproducing, with a high level of realism, car traffic in the greater urban area of the city of Cologne, 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.

The resulting synthetic trace of the car traffic in a the city of Cologne covers a region of 400 square kilometers for a period of 24 hours, comprising more than 700.000 individual car trips. More information is available on the project website at http://kolntrace.project.citi-lab.fr/ .

E-MOTION Project-Team

4. Software and Platforms

4.1. PROTEUS Software

Participants: Amaury Nègre, Juan Lahera-Perez.

This toolkit offers a automatic mobile robot driver, some sensors drivers sensors as Sick laser, GPS, motion tracker, mono or stereo camera), and a 3D Simulator.

The latest developments have been focuses on the robotics simulator. This simulator is based on the simulation and 3D rendering engine “mgEngine“ (http://mgengine.sourceforge.net/) embedded with the physics engine “bullets physics” (http://bulletphysics.org) for realistic robot dynamic simulation.

We also worked on the interface with the robotics middleware “ROS“ (http://www.ros.org) in order to offer interoperability with many robotics applications.

The simulator is now fully integrated with the robotics middleware "ROS" (http://www.ros.org) which allow interoperability with a large set of robotics applications and visualization tools. This software is developed in C++ and the simulator operates with the Lua scripting language. The simulation software is used in the ANR Proteus (http://www.anr-proteus.fr), as a simulation engine for the PROTEUS Toolkit.

- Version: 2.0
- APP:IDDN.FR.001.510040.000.S.P.2005.000.10000
- Programming language: C/C++, Lua

4.2. AROSDYN

Participants: Igor Paromtchik, Mathias Perrollaz, Alexandros Makris, Amaury Nègre, Christian Laugier.

ArosDyn (http://arosdyn.gforge.inria.fr/) is a system which integrates our recently developped techniques to provide a real-time collision risk estimation in a dynamic environment. The main features of this software are:

1. The design provides high maintainability, scalability and reuseness of the models and algorithms.
2. The software has a user interface (UI) which is user-friendly.
3. The software facilitates the parameter tuning of the models.
4. It uses the GPU to accelerate the computation.
5. Working together with the Hugr middleware (http://gforge.inria.fr/projects/cycabtk), it can run on our experimental vehicle in real-time.

Another important property of this software is a large part of the computation task executed on GPU. As the processing of stereo image and the computaion in the BOF can be highly parallelized, we run these tasks on the GPU to improve the time performance. The GPU calculation is based on CUDA library and is carried out in an independent thread.

Furthermore, thanks to the design of the software, we can easily add new models to it and let them work together. The fast detection and tracking algorithm (FCTA) and the Gaussian process based collision assessment algorithm are added into this framework. The sofware is implemented on the Lexus car. In 2012, a demand for deposing the GPU BOF software to the APP is in progress.

4.3. Embedded Perception

Participants: Mathias Perrollaz, Amaury Nègre, Christian Laugier.

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.

The program has been deposed to the APP in 2012, under the reference: IDDN.FR.001.270004.000.S.P.2012.000.10800

4.4. Bayesian Occupancy Filter

People involved: Kamel Mekhnacha, Tay Meng Keat Christopher, C. Laugier, M. Yguel, Pierre Bessière.
The BOF toolbox is a C++ library that implements the Bayesian Occupancy Filter. It is often used for modelling dynamic environments. It contains the relevant functions for performing bayesian filtering in grid spaces. The output from the BOF toolbox are the estimated probability distributions of each cell's occupancy and velocity. Some basic sensor models such as the laser scanner sensor model or Gaussian sensor model for gridded spaces are also included in the BOF toolbox. The sensor models and BOF mechanism in the BOF toolbox provides the necessary tools for modelling dynamic environments in most robotic applications. This toolbox is patented under two patents : "Procédé d'assistance à la conduite d'un véhicule et dispositif associé" n. 0552735 (9 september 2005) and "Procédé d'assistance à la conduite d'un véhicule et dispositif associé amélioré" n. 0552736 (9 september 2005) and commercialized by ProBayes.

- Version: 1
- Patent: 0552736 (2005), 0552735 (2005)
- Programming language: C/C++

4.5. PROBT

People involved: Juan-Manuel Ahuactzin, Kamel Mekhnacha, Pierre Bessière, Emmanuel Mazer, Manuel Yguel, Christian Laugier.
ProBT is both available as a commercial product (ProBAYES.com) and as a free library for public research and academic purposes (http://emotion.inrialpes.fr/BP/spip.php?rubrique6). Formerly known as *OPL*, *ProBT* is a C++ library for developing efficient Bayesian software. It is available for Linux, Unix, PC Windows (Visual C++), MacOS9, MacOSX and Irix systems. The ProBT library (http://www.probayes.com/) has two main components: (i) a friendly Application Program Interface (API) for building Bayesian models, and (ii) a high-performance Bayesian Inference Engine (BIE) allowing to execute all the probability calculus in exact or approximate way. *ProBT* is now commercialized by our start-up *Probayes*; it represents the main Bayesian programming tool of the *e-Motion* project-team, and it is currently used in a variety of external projects both in the academic and industrial field (e.g., for the European project BACS and for some industrial applications such as Toyota or Denso future driving assistance systems).

EXMO Project-Team

5. Software and Platforms

5.1. Alignment API

Participants: Jérôme Euzenat [Correspondent], Jérôme David, Nicolas Guillouet, Armen Inants, Luz Maria Priego-Roche.

We have designed a format for expressing alignments in a uniform way [1]. The goal of this format is to share available alignments on the web. It should help systems using alignments, e.g., mediators, translators, to take advantage of any alignment algorithm and it will help alignment algorithms to be used in many different tasks. This format is expressed in RDF, so it is freely extensible.

The API itself [1] is a JAVA description of tools for accessing the common format. It defines five main interfaces (OntologyNetwork, Alignment, Cell, Relation and Evaluator) and proposes the following services:

- Storing, finding, and sharing alignments;
- Piping matching algorithms (improving an existing alignment);
- Manipulating alignments (thresholding and hardening);
- Generating processing output (transformations, axioms, rules);
- Comparing alignments.

We provide an implementation for this API which can be used for producing transformations, rules or bridge axioms independently from the algorithm which 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 which allows for generating evaluation datasets;
- a library of wrappers for several ontology API;
- 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.

We have developed on top of the Alignment API an Alignment server that can be used by remote clients for matching ontologies and for storing and sharing alignments. It is developed as an extensible platform which allows to plug-in new interfaces. The Alignment server can be accessed through HTML, web service (SOAP and REST) and agent communication interfaces.

The Alignment API is used in the Ontology Alignment Evaluation Initiative data and result processing (§6.1.1). It is also used by more than 30 other teams worldwide.

The Alignment API is freely available since december 2003, under the LGPL licence, at http://alignapi.gforge.inria.fr.

5.2. The OntoSim library

Participants: Jérôme David [Correspondent], Jérôme Euzenat.

OntoSim is a library offering similarity and distance measures between ontology entities as well as between ontologies themselves. It materialises our work towards better ontology proximity measures.

There are many reasons for measuring a distance between ontologies. For example, in semantic social networks, when a peer looks for a particular information, it could be more appropriate to send queries to peers having closer ontologies because it will be easier to translate them and it is more likely that such a peer has the information of interest. OntoSim provides a framework for designing various kinds of similarities. In particular, we distinguish similarities in the ontology space from those in the alignment space. The latter ones use available alignments in an ontology network while the former only rely on ontology data. OntoSim is provided with 4 entity measures which can be combined using various aggregation schemes (average linkage, Hausdorff, maximum weight coupling, etc.), 2 kinds of vector space measures (boolean and TF.IDF), and 4 alignment space measures. It also features original comparison methods such as agreement/disagreement measures. In addition, the framework embeds external similarity libraries which can be combined to our own.

OntoSim is based on an ontology interface allowing for using ontology parsed with different APIs. It is written in Java and is available, under the LGPL licence, at http://ontosim.gforge.inria.fr.

IMAGINE Project-Team

4. Software and Platforms

4.1. MyCorporisFabrica

Participants: Ali-Hamadi Dicko, François Faure, Olivier Palombi.

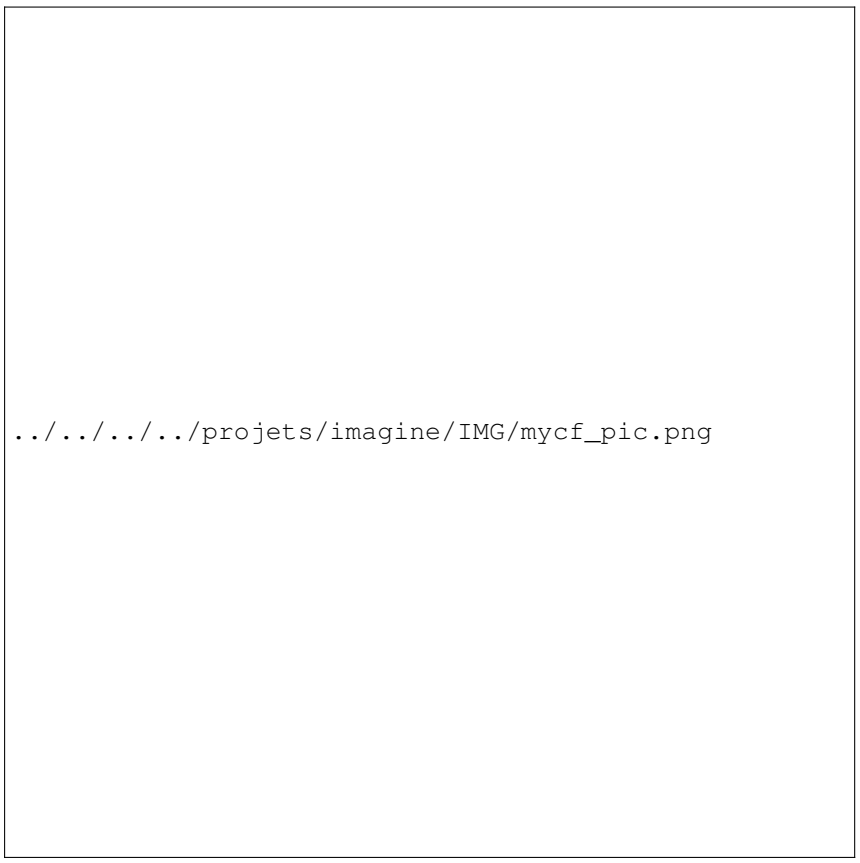

Figure 1. My Corporis Fabrica is an anatomical knowledge database developed in our team.

My Corporis Fabrica (MyCF) is an anatomical knowledge database (see fig. 1). During 2011, we have added new anatomical entities and improved some parts of FMA (Foundational Model of Anatomy). The FMA's license is now under Creative Commons licenses (CC-by : Licensees may copy, distribute, display and perform the work and make derivative works based on it only if they give the author or licensor the credits in the manner specified by these). The license of MyCF is not yet defined. Our new contribution this year, is the creation of a brand new ontology about human functions. Based on the International Classification of Functioning, Disability and Health, also known as ICF, we have organized human functions through a tree of 4330 items. A original journal paper must be submitted soon. MyCF browser is now available on line: http://www.mycorporisfabrica.org/. The MyCf's generic programming framework can be used for other domains. The link with semantic and 3D models matches research activities of IMAGINE towards interactive digital creation media. Anatomy can be seen as a study case.

4.2. SOFA

Participants: François Faure, Ali Hamadi Dicko, Armelle Bauer, Olivier Carré, Matthieu Nesme, Romain Testylier, Moreno Trlin.

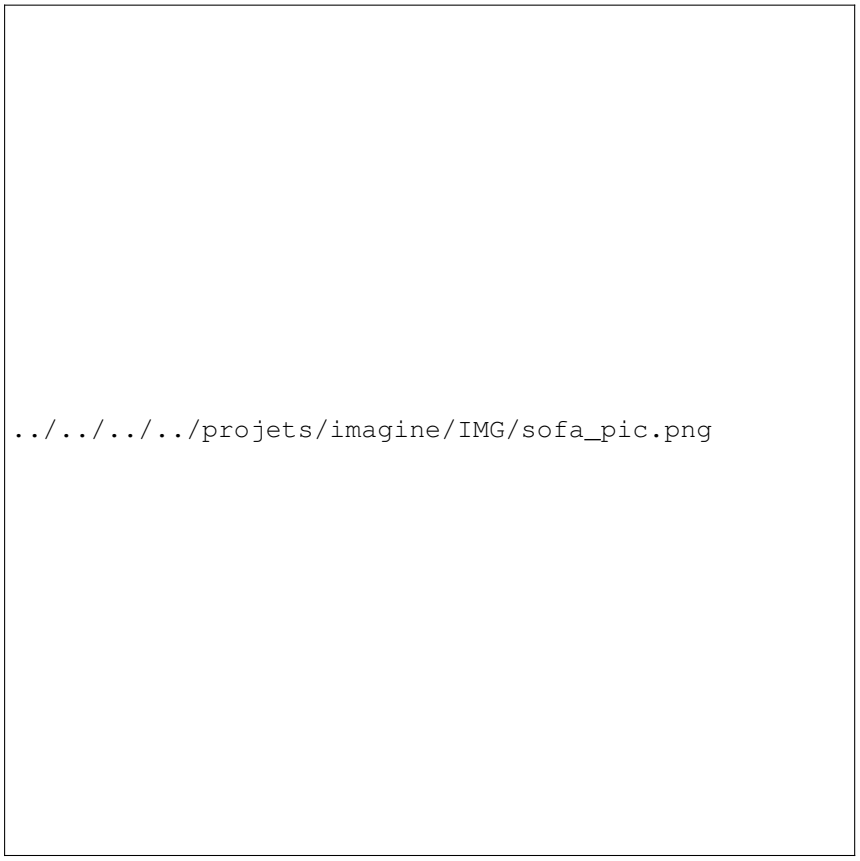

Figure 2. SOFA is an open source simulator for physically based modeling.

SOFA is a C++ library primarily targeted at medical simulation research. Based on an advanced software architecture, it allows to (1) create complex and evolving simulations by combining new algorithms with algorithms already included in SOFA; (2) modify most parameters of the simulation – deformable behavior, surface representation, solver, constraints, collision algorithm, etc. – by simply editing an XML file; (3) build complex models from simpler ones using a scene-graph description; (4) efficiently simulate the dynamics of interacting objects using abstract equation solvers; and (5) reuse and easily compare a variety of available methods.
SOFA is gaining momentum. A start-up based on SOFA, InSimo, has been created in Strasbourg by Inria people, and one of our former engineers, François Jourdes, has been hired. A SOFA-specific workshop was co-located with conference Vriphys'13 in Lille, with 50 attendants and the participation of several companies including CAE (a Canadian world leader in simulation), Haption, BASF, InSimo and others.

4.3. Expressive

Participants: Marie-Paule Cani, Amaury Jung, Mohamed-Galal Koraa, Maxime Quiblier, Cédric Zanni, Antoine Begault.

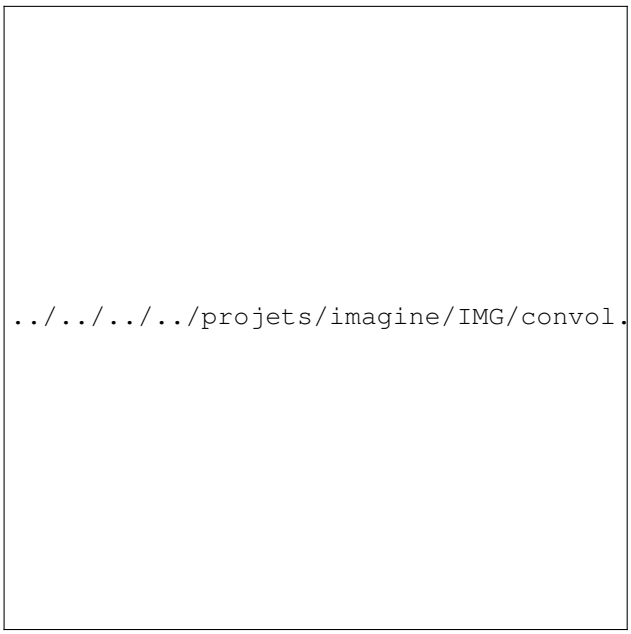

Figure 3. GUI and Example of implicit surface and modeled with the Expressive platform.

Expressive is a new C++ library developed to gather and share the models and algorithms developed within the ERC Expressive project. It enables us to make our latest research results on new creative tools; typically high level models together with intuitive, sketching or sculpting interfaces - soon available to the rest of the group and easily usable in our industrial partnerships. Its most developed part is Convol, a library dedicated implicit surfaces; and more particularly to the sub-classes of convolution surfaces and other integral surfaces along skeletons. Convol incorporates all the necessary material for constructive implicit modeling: skeleton-based convolution and SCALIS primitives, with closed form solution for the field values and gradient whenever possible; a variety of blending operators; and several methods for tessellating an implicit surface into a mesh, and for refining the later in highly curved regions. The creation of new geometry can be performed by direct manipulation of skeletal primitives or through sketch-based modeling.

LEAR Project-Team

5. Software and Platforms

5.1. Large-scale image classification

Participants: Matthijs Douze [correspondant], Zaid Harchaoui, Florent Perronnin [XRCE], Cordelia Schmid.

JSGD is the implementation of a Stochastic Gradient Descent algorithm used to train linear multiclass classifiers. It is biased towards large classification problems (many classes, many examples, high-dimensional data). It can be used on the ImageNet large scale classification challenge. It uses several optimization techniques, both algorithmic (scale factors to spare vector multiplications, vector compression with product quantizers) and technical (vector operations, multithreading, improved cache locality). It has Python and Matlab interfaces. It is distributed under a Cecill licence. Project page: http://lear.inrialpes.fr/src/jsgd.

5.2. Fisher vector image representation

Participants: Matthijs Douze [correspondant], Hervé Jégou [TEXMEX Team Inria Rennes], Cordelia Schmid.

We developed a package that computes Fisher vectors on sparse or dense local SIFT features. The dense feature extraction was optimized, so that they can be computed in real time on video data. The implementation was used for several publications and in our submisssion to the Trecvid 2013 MED task. We provide a binary version of the local descriptor implementation, and the Fisher implementation is integrated in the Yael library, with Python and Matlab interface, see http://lear.inrialpes.fr/src/inria_fisher.

5.3. Video descriptors

Participants: Clement Leray, Dan Oneata, Cordelia Schmid [correspondant], Heng Wang, Jakob Verbeek.

We have developed and made on-line available software for video description based on dense trajectories and motion boundary histograms. The trajectories capture the local motion information of the video. A state-of-the-art optical flow algorithm enables a robust and efficient extraction of the dense trajectories. Descriptors are aligned with the trajectories and based on motion boundary histograms (MBH) which are robust to camera motion. This year we have further developed this software to increase its robustness and scalability to large datasets. Most importantly, we have added a robust background stabilization technique, which allows to remove camera motion. This has shown to significantly improve the performance. Furthermore, we have improved the efficiency of the approach. For example, we avoid writing the raw MBH descriptors to disk, but rather aggregate them directly into a signature for the complete video using Fisher vectors. This allowed us to use these descriptors on the 4,000 hour video dataset of the TrecVid 2013 MED task as well as on the 3500 hours of AXES broadcast videos.

5.4. SPArse Modeling Software (SPAMS)

Participants: Julien Mairal [correspondant], Jean-Paul Chieze [WILLOW Project-Team], Jean Ponce [WILLOW Project-Team], Francis Bach [SIERRA Project-Team].

SPAMS v2.4 was released as open-source software in December 2013 (v1.0 was released in September 2009). It is an optimization toolbox implementing algorithms to address various machine learning and signal processing problems involving

- Dictionary learning and matrix factorization (NMF, sparse PCA, ...);
- Solving medium-scale sparse decomposition problems with LARS, coordinate descent, OMP, SOMP, proximal methods;
- Solving large-scale sparse estimation problems with stochastic optimization;
- Solving structured sparse decomposition problems (sparse group lasso, tree-structured regularization, structured sparsity with overlapping groups,...).

The software and its documentation are available at http://spams-devel.gforge.inria.fr/.

This year, we added new functionalities to the toolbox. A graphical tool for visualizing dictionaries was developed by Jean-Paul Chieze, and stochastic optimization tools corresponding to the papers [24], [23] were added for dealing with large-scale sparse estimation problems.

5.5. FlipFlop: Fast Lasso-based Isoform Prediction as a Flow Problem

Participants: Elsa Bernard [Institut Curie, Ecoles des Mines-ParisTech], Laurent Jacob [CNRS, LBBE Laboratory], Julien Mairal [correspondant], Jean-Philippe Vert [Institut Curie, Ecoles des Mines-ParisTech].

FlipFlop is an open-source software, implementing a fast method for de novo transcript discovery and abundance estimation from RNA-Seq data [36]. It differs from classical approaches such as Cufflinks by simultaneously performing the identification and quantitation tasks using a penalized maximum likelihood approach, which leads to improved precision/recall. Other softwares taking this approach have an exponential complexity in the number of exons of a gene. We use a novel algorithm based on network flow formalism, which gives us a polynomial runtime. In practice, FlipFlop was shown to outperform penalized maximum likelihood based softwares in terms of speed and to perform transcript discovery in less than 1/2 second for large genes.

FlipFlop 1.0.0 is a user friendly bioconductor R package. It is freely available on the Bioconductor website under a GPL licence: http://bioconductor.org/packages/release/bioc/html/flipflop.html.

5.6. DeepFlow

Participants: Philippe Weinzaepfel, Jerome Revaud, Zaid Harchaoui, Cordelia Schmid.

We developed a package for the "deep flow" algorithm [31]. "Deep flow" combines a standard variational framework with a our new matching algorithm "deep matching". The code for "deep matching" is in python and the code for "deep flow" in C. Both of them are available on-line at http://lear.inrialpes.fr/src/deepmatching. Note that the run time is a few seconds per images pair, which is less than for most other methods.

5.7. Object category localization

Participants: Ramazan Cinbis, Matthijs Douze, Cordelia Schmid, Jakob Verbeek.

We developed an object category localization system based on a Fisher vector representation over densly extracted local SIFT descriptors [18]. To improve the robustness with respect to background clutter in the detection windows we developed an approximate object segmentation method that is used to weigh the contribution of local SIFT descriptors. Our system achieves state-of-the-art localization performance as measured on the PASCAL VOC 2007 and 2010 datasets. The system is developed in both C, python, and Matlab. The system will be released in early 2014.

MAVERICK Project-Team

5. Software and Platforms

5.1. Introduction

Maverick insists on sharing the software that is developed for internal use. These are all listed in a dedicated section on the web site http://artis.imag.fr/Software.

5.2. Gratin

Participant: Romain Vergne [contact].

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. In a research context, Gratin aims at facilitating the creation of prototypes, testing ideas and exchanging data. For students, Gratin can be used to show real-time demos/videos, or help learning how to program with the GPU. Gratin has already been used for creating new computer graphics tools but also for designing perceptual experiments. Most of the work published by R. Vergne was done with Gratin.

5.3. PlantRad

Participant: Cyril Soler [contact].

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. Its main domains of applications are urban simulation, remote sensing simulation (See the collaboration with Noveltis, Toulouse) and plant growth simulation, as previously demonstrated during our collaboration with the LIAMA, Beijing.

5.4. High Quality Renderer

Participant: Cyril Soler [contact].

In the context of the European project RealReflect, the Maverick team has developed the HQR software 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. HQR is freely available for download at http://artis.imag.fr/~Cyril.Soler/HQR.

5.5. MobiNet

Participants: Fabrice Neyret [contact], Joëlle Thollot.

Figure 2. Gratin interface.

The MobiNet software allows for the creation of simple applications such as video games, virtual physics experiments or pedagogical math illustrations. It relies on an intuitive graphical interface and language which allows the user to program a set of mobile objects (possibly through a network). It is available in public domain at http://mobinet.inrialpes.fr for Linux,Windows and MacOS, and originated in a collaboration with the EVASION project-team.

The main aim of MobiNet is to allow young students at high school level with no programming skills to experiment, with the notions they learn in math and physics, by modeling and simulating simple practical problems, and even simple video games. This platform has been massively used during the Grenoble INP "engineer weeks" since 2002: 150 senior high school pupils per year, doing a 3 hour practice. This work is partly funded by Grenoble INP. Various contacts are currently developed in the educational world. Besides "engineer weeks", several groups of "monitors" PhD students conducts experimentations based on MobiNet with a high scool class in the frame of the courses. Moreover, presentation in workshops and institutes are done, and a web site repository is maintained. A web version is currently under preliminary developpement.

5.6. Freestyle

Freestyle is a software for Non-Photorealistic Line Drawing rendering from 3D scenes (Figure 3). It is designed as a programmable interface to allow maximum control over the style of the final drawing: the user "programs" how the silhouettes and other feature lines from the 3D model should be turned into stylized strokes using a set of programmable operators dedicated to style description. This programmable approach, inspired by the shading languages available in photorealistic renderers such as Pixar's RenderMan, overcomes the limitations of integrated software with access to a limited number of parameters and permits the design of an infinite variety of rich and complex styles. The system currently focuses on pure line drawing as a first step. The style description language is Python augmented with our set of operators. Freestyle was developed in the framework of a research project dedicated to the study of stylized line drawing rendering from 3D scenes. This research has lead to two publications [25], [26].

In 2008, Freestyle get a new life, completely outside Maverick or Inria: it was the basis of one of the 6 *Google Summer of Code* projects awarded to the *Blender Foundation* [1]! The goal of the project was to integrate Freestyle to the well known free 3D modeler *Blender*, as its standard NPR line-drawing renderer. Maxime Curioni (under the mentoring of Jean-Luc Peurière from the *Blender Foundation*), is currently making the integration. First beta versions are publicly available, and tested by enthusiasts around the web.

5.7. Diffusion Curves

Participant: Joëlle Thollot [contact].

We provide an implementation of the vector drawing tool described in our Diffusion Curves Siggraph paper [2] (Figure 4). This prototype is composed of the Windows binary, along with the required shader programs (ie. in source code). The software is available for download at http://artis.imag.fr/Publications/2008/OBWBTS08 for free, for non-commercial research purposes.

5.8. VRender: vector figures

Participant: Cyril Soler [contact].

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.

[1] http://www.blender.org/

Figure 3. Stylized plane using Freestyle.

Figure 4. Diffusion curves freely downloadable demo.

VRender is also responsible for the vectorial snapshot feature of the QGLViewer library. VRender is released under the LGPL licence and is freely available for download at http://artis.imag.fr/Software/VRender.

5.9. ProLand

Participants: Fabrice Neyret [contact], Eric Bruneton.

Now available at http://proland.inrialpes.fr/ in double licencing GPL/commercial.

Proland (for procedural landscape) is a software platform originally developed at the Evasion team-project by Eric Bruneton, and currently funded by the ANR-JCJC SimOne. The goal of this platform is the real-time quality rendering and editing of large landscapes. All features can work with planet-sized terrains, for all viewpoints from ground to space. Most of the work published by Eric Bruneton and Fabrice Neyret has been done within Proland, and a large part has been integrated in the main branch. Several licences have been transfered to companies. Eric Bruneton was hired by Google-Zürich in september 2011, but will be able to keep some participation in the project.

5.10. GigaVoxels

Participants: Fabrice Neyret [contact], Goswami Prashant, Sinoir Jérémy, Cyril Crassin, Pascal Guehl, Eric Heitz.

Soon available at http://gigavoxels.inrialpes.fr/index.htm in double licencing GPL/commercial.

Gigavoxel is a software platform initiated from the PhD work of Cyril Crassin, and currently funded by the ANR CONTINT RTIGE (Figure 5). The goal of this platform is the real-time quality rendering of very large and very detailed scenes which couldn't fit memory. Performances permit showing details over deep zooms and walk through very crowdy scenes (which are rigid, for the moment). The principle is to represent data on the GPU as a Sparse Voxel Octree which multiscale voxels bricks are produced on demand only when necessary and only at the required resolution, and kept in a LRU cache. User defined producer lays accross CPU and GPU and can load, transform, or procedurally create the data. Another user defined function is called to shade each voxel according to the user-defined voxel content, so that it is user choice to distribute the appearance-making at creation (for faster rendering) or on the fly (for storageless thin procedural details). The efficient rendering is done using a GPU differential cone-tracing using the scale corresponding to the 3D-MIPmapping LOD, allowing quality rendering with one single ray per pixel. Data is produced in case of cache miss, and thus only whenever visible (accounting for view frustum and occlusion). Soft-shadows and depth-of-field is easily obtained using larger cones, and are indeed cheaper than unblurred rendering. Beside the representation, data management and base rendering algorithm themself, we also worked on realtime light transport, and on quality prefiltering of complex data. Ongoing researches are addressing animation. GigaVoxels is currently used for the quality real-time exploration of the detailed galaxy in ANR RTIGE. This work led to several publications and several licences have been sold to companies.

Figure 5. GigaVoxels freely downloadable demo.

MORPHEO Team

5. Software and Platforms

5.1. Platforms

5.1.1. The Grimage platform

The Grimage platform is an experimental multi-camera platform dedicated to spatio-temporal modeling including immersive and interactive applications. It hosts a multiple-camera system connected to a PC cluster, as well as visualization facilities including head mounted displays. This platform is shared by several research groups, most proeminently Moais, Morpheo and Perception. In particular, Grimage allows challenging real-time immersive applications based on computer vision and interactions between real and virtual objects, Figure 1 . Note that the Grimage platform will be replaced by the Kinovis platform that will exhibit a larger acquisition space and better acquisition facilities.

Figure 1. Platform: the Grimage acquisition.

5.1.2. Kinovis

Kinovis (http://kinovis.inrialpes.fr/) is a new multi-camera acquisition project that was was selected within the call for proposals ”Equipements d’Excellence” of the program “Investissement d’Avenir´´ funded by the French government. The project involves 2 institutes: the Inria Grenoble Rhône-Alpes, the université Joseph Fourier and 4 laboratories: the LJK(laboratoire Jean Kuntzmann - applied mathematics), the LIG (laboratoire d’informatique de Grenoble - Computer Science), the Gipsa lab (Signal, Speech and Image processing) and the LADAF (Grenoble Hospitals - Anatomy). The Kinovis environment will be composed of 2 complementary platforms. A first platform located at the Inria Grenoble will have a 10mx10m acquisition surface and will be equipped with 60 cameras. It is the evolution of the Grimage platform previously described towards the production of better models of more complex dynamic scenes. A second platforms located at Grenoble Hospitals, within the LADAF anatomy laboratory, will be equipped with both color and X-ray cameras to enable combined analysis of internal and external shape structures, typically skeleton and bodies of animals. Installation works of both platforms started in 2013 and should be finished in 2014. Members of Morpheo are highly involved in this project. Edmond Boyer is coordinating this project and Lionel Reveret is in charge of the LADAF platform.

Figure 2. Kinovis platforms: on the left the Inria platform; on the right Grenoble Hospital platform.

5.1.3. Multicamera platform for video analysis of mice behavior

This project is a follow-up of the experimental set-up developed for a CNES project with Mathieu Beraneck from the CESeM laboratory (centre for the study of sensorimotor control, CNRS UMR 8194) at the Paris-Descartes University. The goal of this project was to analyze the 3D body postures of mice with various vestibular deficiencies in low gravity condition (3D posturography) during a parabolic flight campaign. The set-up has been now adapted for new experiments on motor-control disorders for other mice models. This experimental platform is currently under development for a broader deployment for high throughput phenotyping with the technology transfer project ETHOMICE. This project involves a close relationship with the CESeM laboratory and the European Mouse Clinical Institute in Strasbourg (Institut Clinique de la Souris, ICS).

5.2. Software packages

5.2.1. LucyViewer

Lucy Viewer http://4drepository.inrialpes.fr/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 various websites over the world including the 4D repository website hosted by Inria Grenoble http://4drepository.inrialpes.fr/. The software was developed in the context of the European project iGlance, it is available as an open source software under the GNU LGP Licence.

5.2.2. Ethomice

Ethomice http://morpheo.inrialpes.fr/people/reveret/ethomice/ is a motion analysis software to characterize motor behavior of small vertebrates such as mice or rats. From a multiple views video input, a biomechanical model of the skeleton is registered. Study on animal model is the first important step in Biology and Clinical research. In this context, the analysis of the neuro-motor behaviour is a frequent cue to test the effect of a gene or a drug. Ethomice is a platform for simulation and analysis of the small laboratory animal, such as rat or mouse. This platform links the internal skeletal structure with 3D measurements of the external appearance of the animal under study. From a stream of multiple views video, the platform aims at delivering a three dimensional analysis of the body posture and the behaviour of the animal. The software was developed by Lionel Reveret and Estelle Duveau. An official APP repository has been issued this year.

Figure 3. Ethomice: Experimental platform for video analysis of mice behavior.

5.3. Databases

5.3.1. 4D repository (http://4drepository.inrialpes.fr/)

This website hosts dynamic mesh sequences reconstructed from images captured using a multi-camera set up. Such mesh-sequences offer a new promising vision of virtual reality, by capturing real actors and their interactions. The texture information is trivially mapped to the reconstructed geometry, by back-projecting from the images. These sequences can be seen from arbitrary viewing angles as the user navigates in 4D (3D geometry + time) . Different sequences of human / non-human interaction can be browsed and downloaded from the data section. A software to visualize and navigate these sequences is also available for download.

PERCEPTION Team

5. Software and Platforms

5.1. Mixed camera platform

We started to develop a multiple camera platform composed of both high-definition color cameras and low-resolution depth cameras. This platform combines the advantages of the two camera types. On one side, depth (time-of-flight) cameras provide relatively accurate 3D scene information. On the other side, color cameras provide information allowing for high-quality rendering. The software package developed during the year 2011 contains the calibration of TOF cameras, alignment between TOF and color cameras, and image-based rendering. These software developments were performed in collaboration with the Samsung Advanced Institute of Technology. The multi-camera platform and the basic software modules are products of 4D Views Solutions SAS, a start-up company issued from the PERCEPTION group.

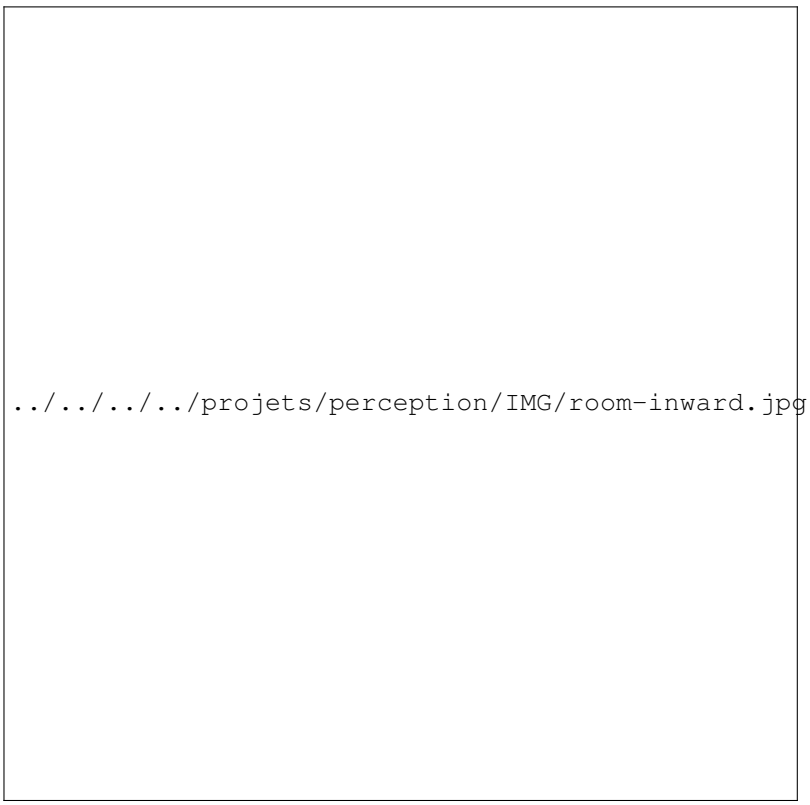

Figure 1. The mixed multi-camera system composed of four TOF-stereo sensor units.

5.2. Audiovisual robot heads

We have 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 (https://team.inria.fr/perception/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 (http://humavips.inrialpes.fr) 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.

For more information on POPEYE and on NAO please visit https://team.inria.fr/perception/popeye/ and https://team.inria.fr/perception/nao/.

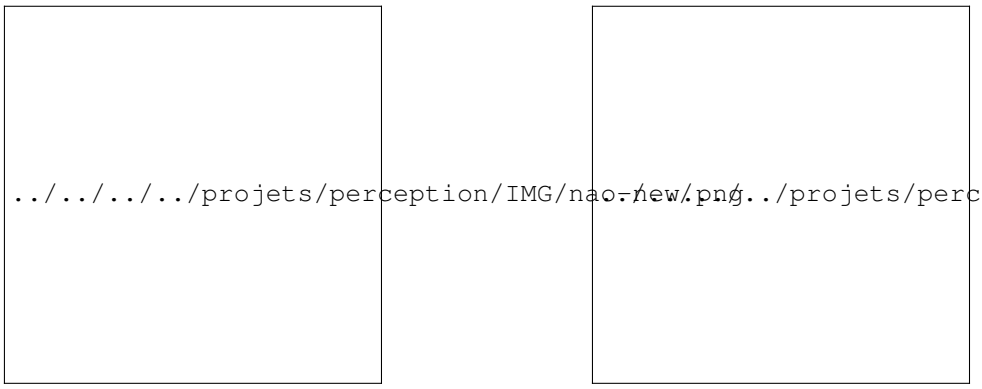

Figure 2. Left: The consumer humanoid robot NAO is equipped with a binocular-binaural head specially designed for human-humanoid interaction; Right: The binocular-binaural robot head POPEYE equipped with a four degrees of freedom stereo camera pair and with a dummy head.

Prima Project-Team

4. Software and Platforms

4.1. OMiSCID Middleware for Distributed Multimodal Perception

Participants: Rémi Barraquand, Amaury Nègre, Patrick Reignier, Dominique Vaufreydaz [correspondant].

Middleware, Distributed perceptual systems

OMiSCID is lightweight middleware for dynamic integration of perceptual services in interactive environments. This middleware abstracts network communications and provides service introspection and discovery using DNS-SD (*DNS-based Service Discovery* [31]). Services can declare simplex or duplex communication channels and variables. The middleware supports the low-latency, high-bandwidth communications required in interactive perceptual applications. It is designed to allow independently developed perceptual components to be integrated to construct user services. Thus our system has been designed to be cross-language, cross-platform, and easy to learn. It provides low latency communications suitable for audio and visual perception for interactive services.

OMiSCID has been designed to be easy to learn in order to stimulate software reuse in research teams and is revealing to have a high adoption rate. To maximize this adoption and have it usable in projects involving external partners, the OMiSCID middleware has been released under an open source licence. To maximize its target audience, OMiSCID is available from a wide variety of programming languages: C++, Java, Python and Matlab. A website containing informations and documentations about OMiSCID has been set up to improve the visibility and promote the use of this middleware.

The OMiSCID graphical user interface (GUI) is an extensible graphical application that facilitates analysis and debugging of service oriented applications. The core functionality of this GUI is to list running services, their communication channels and their variables. This GUI is highly extensible and many modules (i.e. plugins) have been created by different members of the team: figure 2 shows an example of some of these modules. OMiSCID GUI is based on the Netbeans platform and thus inherits from its dynamic installation and update of modules.

4.2. Pal-Gate

Participants: Rémi Barraquand, Amaury Nègre, Dominique Vaufreydaz [correspondant].

Middleware, Distributed perceptual systems, Robotic Operating System (ROS), IPL PAL

A part of our efforts in the PAL project has been put toward developing a solution that would ease the integration of our multi-partners' software components. We refer to this solution as PALGate.

The design of PALGate results from the obvious observation that, within the PAL project, each partner must be considered as an ecosystem characterized, among other things, by 1) its software culture e.g. its curiosity and knowledge about software concepts, software architectures and design patterns, programatic languages, etc.; 2) its resources, e.g. its manpower, its possession or not of an experimental platform; 3) its competences and fields of research and expertise; 4) its habits e.g. its uses of a particular programming language, (c/c++, Java, Python) and computing platforms (OSx, Linux, Windows, Android, etc.), its adoption or not of a dedicated technology to interconnect software components (OSGi, OMiSCID, MPI, PVM, etc.); and 5) its particular needs and constraints e.g. requirement of a hard real-time system, mobility, etc.

For it to be widely accepted, PALGate is therefore designed to be ecologic and pragmatic. Ecologic in the sense that the solution does not perturb the ecology of each ecosystem [1], pragmatic in the sense that setting up this solution did not require an heavy development effort, also because it was targetted to PAL and is taking as much as possible advantage of existing solutions.

[1] namely, if a partner is used to Java and OSGi, deploying PALGate will not affect this in any way nor engender an heavy effort to interface it.

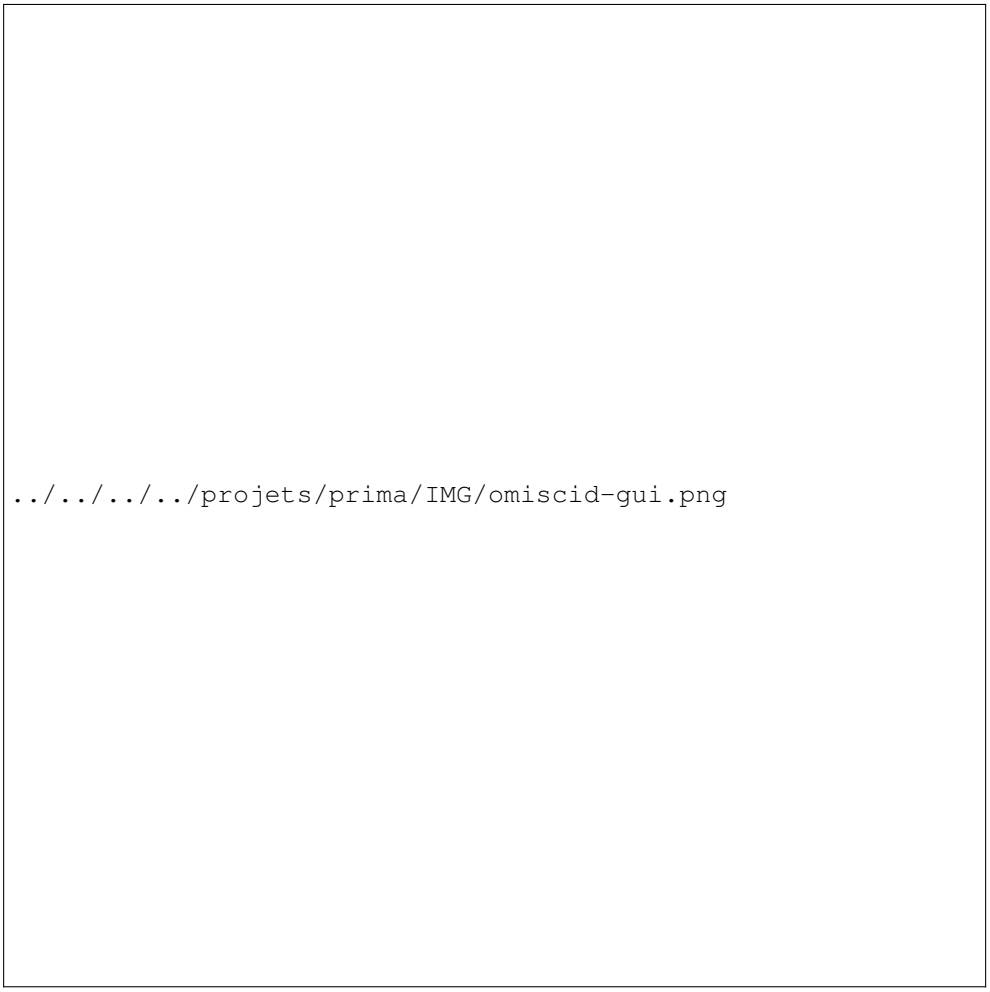

Figure 2. OMiSCID GUI showing a list of running services and some modules for service interconnections, variable plotting, live video stream display and variable control

For developing PALGate we introduced a novel concept: software gate. Unlike software components/services which can be instantiated, a software gate is only a concept, it is defined as an ecologic and hermetic interface between different ecosystems. A software gate is characterized by the subset of functionalities it exposes to other gates, where the functionalities it exposes are provided by the software components/services of its belonging ecosystem. A software gate is hermetic in the sense that only a selected subset of functionalities of an ecosystem are exposed but also because it propagates only filtered information exposed by other gates into its ecosystem. The last characteristic of a software gate is that it makes explicit to other gates the communication mechanisms it uses.

While a software gate is only conceptual, PALGate is an implementation of a gate oriented middleware. PALGate uses ROS to support the basic communication between gates. Within PALGate, each ecosystem is associated to only one software gate. Practically, PALGate 1) is a ROS stack containing gates definition 2) is a set of conventions (e.g. stack organization, package/node/topic/service names, namespaces, etc.) 3) it provides dedicated tools to ease the integration and its usage by partners. A software gate in PALGate is a ROS package containing definition of ROS types (i.e. msgs and srvs types), but also exposed ROS communication channels (i.e. topics and RPCs).

With this architecture each partner has to provide PALGate with a package containing the definition of its gate. Then in order a) to expose functionalities out of their ecosystem and b) to propagate information into their ecosystem, each partner must create ROS nodes. These ROS nodes let each partner interface their ecosystem through ROS topics and ROS services without having to change anything about their architecture. For instance if a partner is using Java and OSGi, it can create nodes in ROS Java that will expose/register functionalities through ROS services, publish/subscribe information using ROS topics.

4.3. EmoPRAMAD

Participants: Claudine Combe, Dominique Vaufreydaz [correspondant].

Affective computing,

Within the Pramad project, we want to offer a full affective loop between the companion robot and the elderly people at home. This affective loop is necessary within the context of everyday interaction of elderly and the companion robot. A part of this loop is to make the robot express emotions in response to the emotional state of the user. To do that, we need to test our working hypothesis about the visual representation of emotions with the 3D face of robot. EmoPRAMAD is an evaluation tool designed to conduct comparative studies between human faces and the 3D faces expressing a defined set of emotions.

The evaluation conducted though EmoPRAMAD concerns both unimodal (facial only) and bimodal conditions (facial/sound). The emotions set is composed of 4 basic emotions (joy, fear, anger, sadness) and a neutral state. While experimenting, the software collects several parameters in order to evaluate more than correctness of the answers: time to respond, length of mouse moves, etc. Experimentation is still in progress at Inria in Grenoble, University Pierre and Marie Currie and Broca Hospital in Paris. A set of 235 participants from 14 to 88 years old was already recorded.

4.4. Detection and Tracking of Pedestrians in INRETS Intelligent Urban Spaces Platform

Participants: Claudine Combe, James Crowley [correspondant], Lukas Rummelhard.

Visual detection and tracking of pedestrians, Intelligent Urban Space

The project ANR-07-TSFA-009-01 CIPEBUS ("Carrefour Intelligent - Pole d'Echange - Bus) has been proposed by INRETS-IFSTTAR, in collaboration with Inria, Citilog, Fareco, and the city of Versaille. The Objective of the CIPEBUS project is to develop an experimental platform for observing activity in a network of urban streets in order to experiment with techniques for optimizing circulation by context aware control of traffic lights.

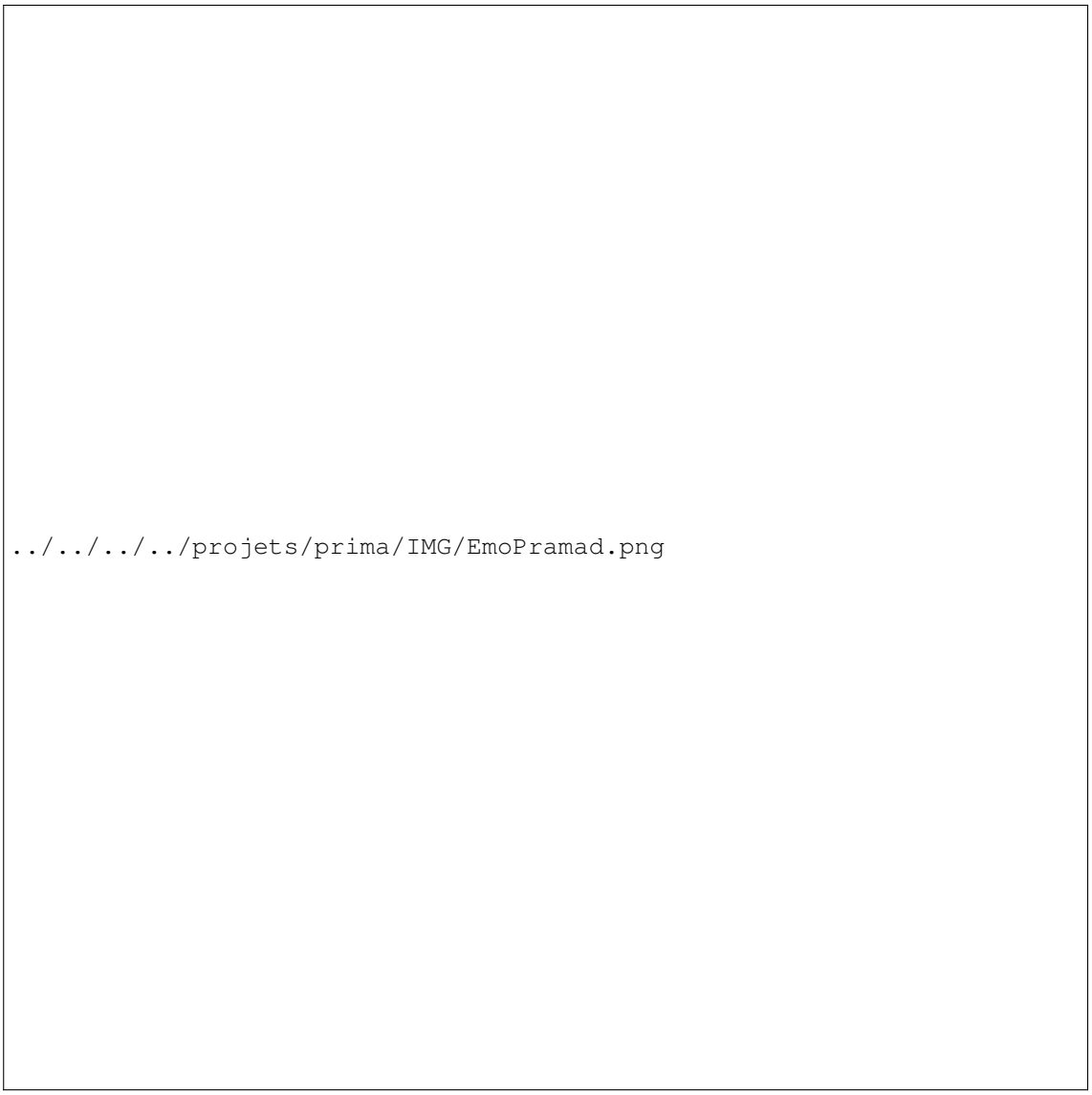

Figure 3. EmoPRAMAD interfaces with a human face and a 3D face from our virtual agent.

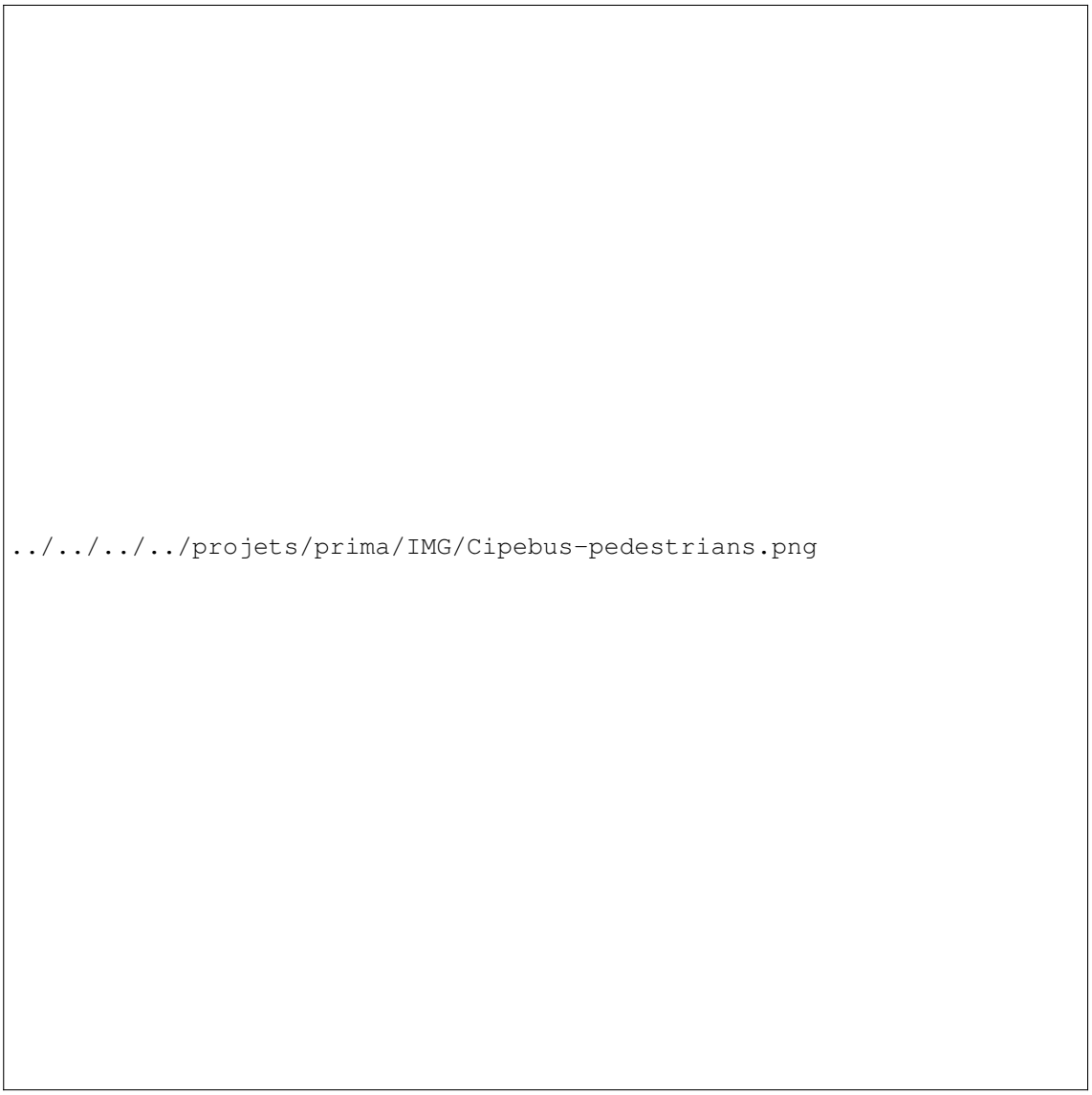

Figure 4. Cipebus: pedestrian tracking system.

Within CipeBus, Inria has developed a real time multi-camera computer vision system to detect and track people using a network of surveillance cameras. The CipeBus combines real time pedestrian detection with 2D and 3D Bayesian tracking to record the current position and trajectory of pedestrians in an urban environment under natural view conditions. The system extends the sliding window approach to use a half-octave Gaussian Pyramid to explore hypotheses of pedestrians at different positions and scales. A cascade classifier is used to determine the probability that a pedestrian can be found at a particular position and scale. Detected pedestrians are then tracked using a particle filter.

The resulting software system has been installed and tested at the INRETS CipeBus platform and is currently used for experiments in controlling the traffic lights to optimize the flow of pedertrians and public transportation while minimizing the delay imposed on private automobiles.

4.5. Multisensor observation of human activity for integrated energy and comfort management

Participants: Claudine Combe, James Crowley [correspondant], Lucas Nacsa, Amaury Nègre, Lukas Rummelhard.

multimodal tracking of human activity

As part of Inria's contribution of ICTLabs Action TSES - Smart Energy Systems, we have constructed a system that integrates information from multiple environmental sensor to detect and track people in indoor environments. This system, constructed as part of activity 11831 Open SES Experience Labs for Prosumers and New Services, has been released to ICTLabs partners in June 2012. It has also been used for construction of a smart spaces testbed at Schneider Electric.

This software, named MultiSensor activity tracker, integrates information from multiple environmental sensors to keep track of the location and activity of people in a smart environment. This model is designed to be used by a home energy broker that would work in conjunction with a smart grid to manage the energy consumption of home appliances, balancing the needs of inhabitants with opportunities for savings offered by electricity rates. This database will also be used for by advisor services that will offer advice to inhabitants on the consequences to energy consumption and energy cost that could potentially result from changes to lifestyle or home energy use.

Work in this task draws from earlier result from a number of development projects at Inria. In the ANR Casper project Inria created Bayesian tracking system for human activity using a voxel based occupancy grid. Within the INRA ADT PAL project, Inria is creating methods for plug and play installation of visual and acoustic sensors for tracking human activity within indoor environments.

While a voxel based Bayesian tracker has served well for a number of applications, a number of limitations have been observed. For example, under certain circumstances, the sensor data can provide contradictory or ambiguous data about the location and activities of people. Resolving such cases required the Bayesian tracker to choose between a numbers of competing hypotheses, potentially resulting in errors. Several members of our group have argued that an alternative integration approach based on the use of a Particle filter would solve these problems and provide a more reliable tracking system. This task has been undertaken to evaluate this hypothesis. The system configured and optimized for detecting and tracking people within rooms using multiple calibrated cameras. The system currently uses corner mounted cartesian cameras, ceiling mounted cameras with wide angle lenses and panoramic cameras placed on tables. Cameras may be connected and disconnected while the component is running, but they must be pre-calibrated to a common room reference frame. We are currently experimenting with techniques for Bayesian estimation of camera parameters for auto-calibration. Cameras may be connected dynamically.

The original system 3DBT has been declared with the APP "Agence pour la Protection des Programmes" under the Interdeposit Digital number IDDN.FR.001.490023.000.S.P.2006.000.10000. A revised declaration for the latest version of the system is currently being prepared.

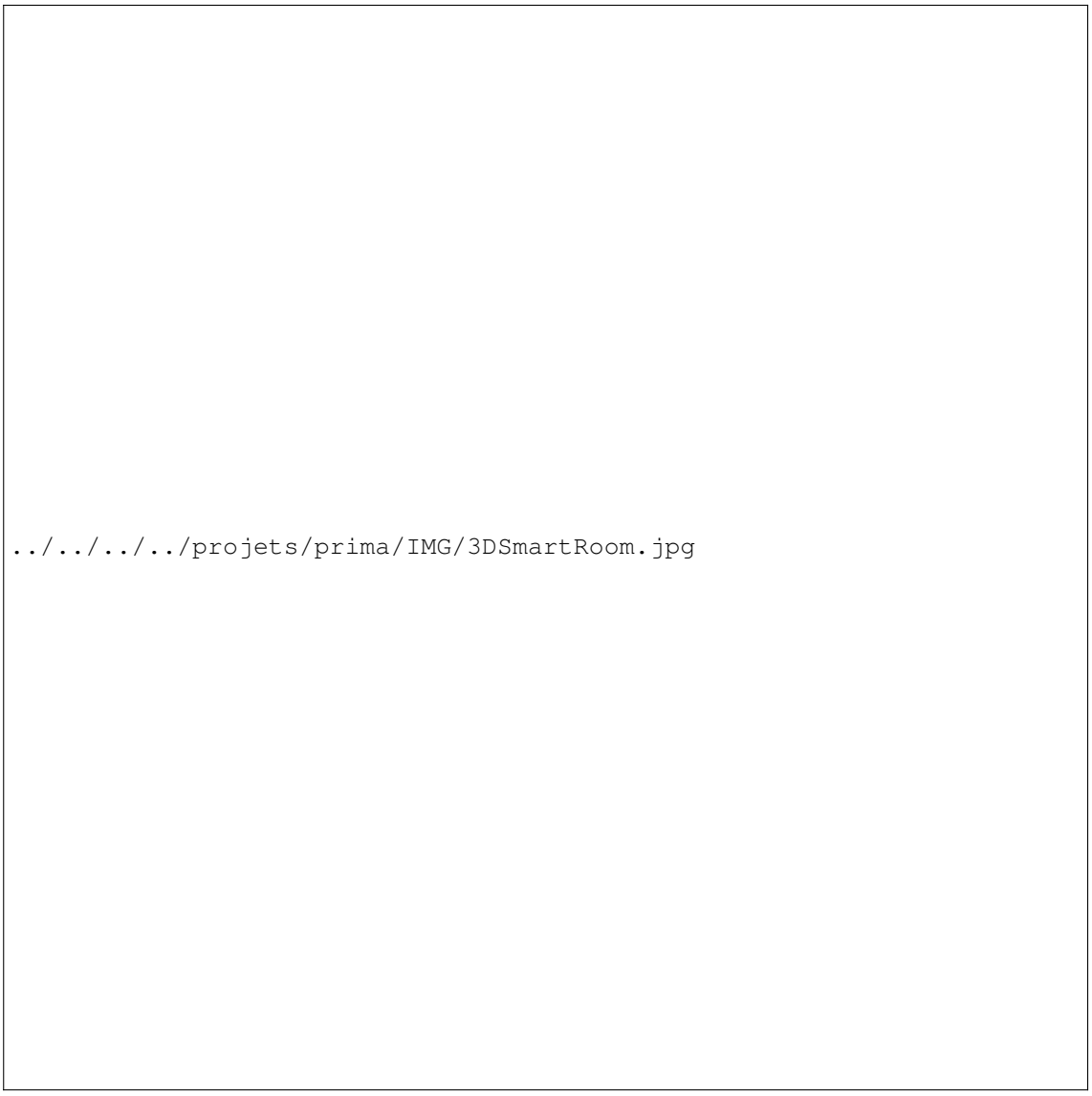

Figure 5. The 3D tracker integrates observations from multiple sensors

4.6. Stereo Viewfinder

Participants: Frédéric Devernay [correspondant], Loic Lefort, Elise Mansilla, Sergi Pujades-Rocamora.

Stereoscopy, Auto-calibration, Real-time video processing, Feature matching

This software has been filed with the APP "Agence pour la Protection des Programmes" under the Interdeposit Digital number IDDN.FR.001.370083.000.S.P.2007.000.10000

4.7. Tracking Focus of Attention for Large Screen Interaction

Participants: Rémi Barraquand, Claudine Combe, James Crowley [correspondant], Varun Jain, Sergi Pujades-Rocamora, Lukas Rummelhard.

Embedded Detection and Tracking of Faces for Attention Estimation.

Large multi-touch screens may potentially provide a revolution in the way people can interact with information in public spaces. Technologies now exist to allow inexpensive interactive displays to be installed in shopping areas, subways and urban areas. Such displays can provide location aware access to information including maps and navigation guidance, information about local businesses and and commercial activities. While location information is an important component of a users context, information about the age and gender of a user, as well as information about the number of users present can greatly enhance the value of such interaction for both the user and for local commerce and other activities.

The objective of this task is to leverage recent technological advances in real time face detection developed for cell phones and mobile computing to provide a low-cost real time visual sensor for observing users of large multi-touch interactive displays installed in public spaces.

People generally look at things that attract their attention. Thus it is possible to estimate the subject of attention by estimating where people look. The location of visual attention is manifested by a region of space known as the horopter where the optical axis of the two eyes intersect. However estimating the location of attention from human eyes is notoriously difficult, both because the eyes are small relative to the size of the face, and because eyes can rotate in their socket with very high accelerations. Fortunately, when a human attends to something, visual fixation tends to remain at or near that subject of attention, and the eyes are relaxed to a symmetric configuration by turning the face towards the subject of attention. Thus it is possible to estimate human attention by estimating the orientation of the human face.

We have constructed an embedded software system for detecting, tracking and estimating the orientation of human faces. This software has been designed to be embedded on mobile computing devices such as laptop computers, tablets and interactive display panels equipped with a camera that observes the user. Noting the face orientation with respect to the camera makes it possible to estimate the region of the display screen to which the user is attending.

The system uses a Bayesian Particle filter tracker operating on a Scale invariant Gaussian pyramid to provide integrated tracking and estimation of face orientation. The use of Bayesian tracking greatly improves both the reliability and the efficiency for face detection and orientation estimation. The scale invariant Gaussian pyramid provides automatic adaptation to image scale (as occurs with a change in camera optics) and makes it possible to detect and track faces over a large range of distances. Equally important the Gaussian Pyramid provides a very fast computation of a large number of image features that can be used by a variety of image analysis algorithms.

An similar software was released in 2007 using face color rather than appearance. The system SuiviDeCiblesCouleur located individuals in a scene for video communications. FaceStabilsationSystem renormalised the position and scale of images to provide a stabilised video stream. SuiviDeCiblesCouleur has been declared with the APP "Agence pour la Protection des Programmes" under the Interdeposit Digital number IDDN.FR.001.370003.000.S.P.2007.000.21000.

4.8. Visual Emotion Recognition for Health and Well Being.

Participants: Rémi Barraquand, Claudine Combe, James Crowley [correspondant], Varun Jain, Sergi Pujades-Rocamora, Lukas Rummelhard.

Visual Emotion Recognition

People express and feel emotions with their face. Because the face is the both externally visible and the seat of emotional expression, facial expression of emotion plays a central role in social interaction between humans. Thus visual recognition of emotions from facial expressions is a core enabling technology for any effort to adapt ICT to improve Health and Wellbeing.

Constructing a technology for automatic visual recognition of emotions requires solutions to a number of hard challenges. Emotions are expressed by coordinated temporal activations of 21 different facial muscles assisted by a number of additional muscles. Activations of these muscles are visible through subtle deformations in the surface structure of the face. Unfortunately, this facial structure can be masked by facial markings, makeup, facial hair, glasses and other obstructions. The exact facial geometry, as well as the coordinated expression of muscles is unique to each individual. In additions, these deformations must be observed and measured under a large variety of illumination conditions as well as a variety of observation angles. Thus the visual recognition of emotions from facial expression remains a challenging open problem in computer vision.

Despite the difficulty of this challenge, important progress has been made in the area of automatic recognition of emotions from face expressions. The systematic cataloging of facial muscle groups as facial action units by Ekman [41] has let a number of research groups to develop libraries of techniques for recognizing the elements of the FACS coding system [33]. Unfortunately, experiments with that system have revealed that the system is very sensitive to both illumination and viewing conditions, as well as the difficulty in interpreting the resulting activation levels as emotions. In particular, this approach requires a high-resolution image with a high signal-to-noise ratio obtained under strong ambient illumination. Such restrictions are not compatible with the mobile imaging system used on tablet computers and mobile phones that are the target of this effort.

As an alternative to detecting activation of facial action units by tracking individual face muscles, we propose to measure physiological parameters that underlie emotions with a global approach. Most human emotions can be expressed as trajectories in a three dimensional space whose features are the physiological parameters of Pleasure-Displeasure, Arousal-Passivity and Dominance-Submission. These three physiological parameters can be measured in a variety of manners including on-body accelerometers, prosody, heart-rate, head movement and global face expression.

The PRIMA Group at Inria has developed robust fast algorithms for detection and recognition of human faces suitable for use in embedded visual systems for mobile devices and telephones. The objective of the work described in this report is to employ these techniques to construct a software system for measuring the physiological parameters commonly associated with emotions that can be embedded in mobile computing devices such as cell phones and tablets.

A revised software package has recently been released to our ICTlab partners for face detection, face tracking, gender and age estimation, and orientation estimation, as part of ICTlabs Smart Spaces action line. This software has been declared with the APP "Agence pour la Protection des Programmes" under the Interdeposit Digital number IDDN.FR.001.370003.000.S.P.2007.000.21000.

A software library, named PrimaCV has been designed, debugged and tested, and released to ICTLabs partners for real time image acquisition, robust invariant multi-scale image description, highly optimized face detection, and face tracking. This software has been substantially modified so as to run on an mobile computing device using the Tegra 3 GPU.

TYREX Team

5. Software and Platforms

5.1. XML Reasoning Solver

Participants: Pierre Genevès, Nabil Layaïda, Nils Gesbert, Manh-Toan Nguyen.

The XML Reasoning Solver is a tool for the static analysis of XPath queries and XML schemas based on the latest theoretical advances [9]. It allows automated verification of properties that are expressed as logical formulas over trees. A logical formula may for instance express structural constraints or navigation properties (like e.g. path existence and node selection) in finite trees.

The tool can solve many fundamental XML problems such as satisfiability of XPath expressions in the presence of XML schemas, containment and equivalence of XPath expressions, and many other problems that can be formulated with XPath expressions and schemas (DTDs, XML Schemas, Relax-NG).

The system is implemented in Java and uses symbolic techniques (binary decision diagrams) in order to enhance its performance. It is capable of comparing path expressions in the presence of real-world DTDs (such as the W3C SMIL and XHTML language recommendations, for instance). The cost ranges from a few milliseconds, for comparison of XPath queries without tree types, to several seconds for queries under very large and heavily recursive type constraints such as the XHTML DTD. These measurements shed light for the first time on the cost of solving static analysis problems in practice. Furthermore, the analyzer generates XML counter-examples that allow program defects to be reproduced independently from the analyzer.

5.1.1. Extensions for CSS

We have introduced the first system capable of statically verifying properties of a given cascading style sheet (CSS) over the whole set of documents to which this stylesheet applies [8]. The system is composed of a set of parsers for reading the CSS and schema files (XML Schema, Relax NG, or DTD) together with a text file corresponding to the problem description as a logical formula. We have developed a compiler that translates CSS files into their logical representations. Then, the solver takes the overall problem formulation and checks it for satisfiability.

5.1.2. XQuery IDE

We have started the development of an XQuery IDE with a web interface. This prototype integrates static analyses performed by the solver inside a development environment suited for XQuery programmers.

5.2. ClaireCourseMaker Library

Participants: Nicolas Hairon, Cécile Roisin.

The goal of the ClaireCourseMakeris to provide straightforward editing tools for structuring, annotating and timeline-based authoring of continuous content such as audio or video. Even if it can be used for any content, it is mainly devoted to synchronize pedagogical material (video, slides, chaptering, etc.) in order to provide rich media online courses à la MOOC. The underlying technology is standard-based and uses the open source JavaScript Popcorn library and Popcorn Maker web application by Mozilla.

The result is a wysiwyg web-based authoring tool which benefits from all the generic features of Popcorn and the specific services that cope with chaptering and synchronization needs.

ClaireCourseMaker is the direct follow-up tool of the Timesheet library which is a cross-browser JavaScript implementation for scheduling the dynamic behavior of HTML5 content that can be described with declarative SMIL markup (SMIL Timing and Synchronization, SMIL Timesheets).

ClaireCourseMaker is developed in collaboration with the OpenClassrooms company in the context of the Claire project (see section 7.1.1).

5.3. Mobile Audio Language

Participants: Yohan Lasorsa, Jacques Lemordant.

5.3.1. MAUDL library

The MAUDL library (Mobile AUDio Language) is an evolution of the ARIA library whose primary target was games on mobile devices.

Augmented Reality Audio applications use sound objects to create a soundscape. A sound object is a time structure of audio chunks whose duration is on the time scale of 100 ms to several seconds. These sound objects have heterogeneous and time-varying properties. In order to describe Interactive Audio (IA) contents, we created MAUDL, an XML language inspired by iXMF that is well adapted to the design of dynamic soundtracks for navigation systems.

MAUDL prevents audio information overwhelming through categorization at the declarative level and the use of priority queues at the execution level. This takes account of speed when walking, and of rapid hand gestures when interrogating the environment, for example. MAUDL can be used as an authoring time interchange file format for interactive mobile applications or as a runtime file format that is actually loaded through the web and played directly in the device. MAUDL is a cue-oriented interactive audio system, where audio services are requested using named events and the system's response to each event is determined by the audio artist.

The library has been implemented in C++ and now supports different mobile operating systems such as Android and iOS. MAUDL has been widely used in the first demonstrator of the VENTURI project consisting of a mobile augmented reality game.

5.3.2. 3D Audio Pointer

A virtual 3D audio pointer provides an intuitive guide to the user of a mobile navigation application, reducing the need for cognitive work when compared to vocal instructions. We have built such a pointer using the MAUDL language. It gives the user the azimuth using HRTF spatialized audio cues, with additional hints taking the form of variations in the sound used. It allows superposing other kinds of audio contents, such as voice while the pointer is active, to indicate distance for example. This audio object is suitable for different sorts of navigation systems, such as POI browsers, self-guided audio tours, or applications for following predefined routes.

As the 3D audio pointer is based on MAUDL this technology is also available for both platforms, iOS and Android. It has been used by Metaio for the micro-navigation which is part of the second VENTURI demonstrator. The use case was to help a visually impaired person to find a box on a shelf with computer vision and 3D audio rendering.

5.4. PDRTrack

Participants: Jacques Lemordant, Mathieu Razafimahazo.

PDRTrack is a localization utility running on iOS or Android smartphones used for recording and playing data sets (accelerometer, gyroscope, barometer and magnetometer values) to find out the effect of different pedometer and map matching parameters and their result on localization accuracy. This application uses the PDR library, written in C++ and developed by the team, which provides the user's location in real time based on the interpretation of sensor readings. Three main modules have been designed to build this localization system:

- a pedometer that estimates the distance the user has walked and his speed
- 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)
- a map-matching algorithm that provides a new location based on a given OpenStreetMap file description and the current user's trajectory

The PDR library has been shared to the VENTURI consortium for the first part of the second year demonstrator: guiding a visually impaired person from Fondazione Bruno Kessler's bus stop to the building entrance. Others partners have used this localization system for retrieving a scale factor needed for the computer vision part (i.e SLAM).

5.5. Interactive eXtensible Engine (IXE)

Participants: Yohan Lasorsa, Jacques Lemordant, David Liodenot, Thibaud Michel, Mathieu Razafimahazo.

GPS navigation systems, when used in an urban environment, are limited in precision and can only give instructions at the level of the street and not of the pavement. GPS is also limited to outdoor navigation and requires some delicate transitioning system when switching to another positioning system to perform indoor navigation.

IXE is an open source urban pedestrian navigation system based on Inertial Measurement Units (IMU) and running on mobile phones with onboard geographic data and a routing engine. With IXE, the distinction between indoor and outdoor is blurred as an IMU-based location engine can run indoor and outdoor. IXE allows augmented reality queries on customized embedded geographical data. Queries on route nodes or POIs, on ways and relations are predefined for efficiency and quality of information.

Following the web paradigm, IXE is a browser for XML documents describing navigation networks: by using the micro-format concept, one can define inside OpenStreetMap a complex format for pedestrian navigation networks allowing navigation at the level of pavements or corridors. The big advantage of doing this instead of defining new XML languages is that we can use the standard OpenStreetMap editor JOSM to create navigation networks in a short amount of time.

The purpose of the IXE browser is to read these OSM documents and to generate from them visible or audible navigation information. IXE works on any mobile phone running under iOS or Android. Its heart is composed of three engines, one for dead-reckoning navigation, one for interactive audio and the last one for Augmented Reality visual information, allowing quick reconfiguration for extremely varied applications.

IXE can be used for accessible navigation allowing independent living for people with disabilities.

IXE Android is an enhanced version of our iOS navigation demonstrator. It uses our latest work on the localization positioning system such as PDR, GPS, user and NFC. This application is based on predetermined walks described in a XML format extending OpenStreetMap for navigation purpose, everybody can create and share their walks. In order to create a new walk, the author has to follow specifications described in part 6.3.1. We added some functionalities to the open source application Java OpenStreetMap Editor to enhance walk authoring for the IXE app.

- IXE-iOS
- IXE-Android