RESEARCH CENTER

FIELD
Applied Mathematics, Computation and Simulation

Activity Report 2015

Section Software

Edition: 2016-03-21

ACUMES Team

5. New Software and Platforms

5.1. BuildingSmart

BuildingSmart interactive visualization
KEYWORDS: Physical simulation - 3D rendering - 3D interaction

- Contact: Abderrahmane Habbal

The aim of the BuildingSmart project is to develop a software environment for the simulation and interactive vizualisation for the design of buildings (structural safety, thermal confort). The software is to be integrated in an immersive space (https://www.youtube.com/watch?v=wAm7faixBak) The project is hosted by the ACUMES team(https://team.inria.fr/acumes) in collaboration with the SED service (Service d'Expérimentation et de Développement) and Experts from ArcelorMittal Construction. The project is financed by an Inria ADT which recruited an experienced engineer (starting in december 2015), whose main task is to study and develop solutions dedicated to interactive vizualisation of building performances (heat, structural) in relation to the Building Information Modeling BIM framework.

5.2. Interoperability between Num3sis and Axel Platforms

Num3sis (http://num3sis.inria.fr) is a modular platform devoted to scientific computing and numerical simulation developed at Inria Sophia Antipolis Mediterranee Center. 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 and pedestrian traffic simulation (by Acumes team), Computational Electro-Magnetics (by Nachos project-team). Some components of the platform are also used by Tosca project-team for CO2 market simulation and wind simulation (in collaboration with Ciric Inria-Chile), and by Inria Project-Lab C2S@EXA for high-performance computing applications. Finally, Lemon team will initiate developments for costal environment simulation in a near future.

To facilitate the coupling between simulation and CAD (Computer-Aided Design), a refactoring of the grid management has been achieved (supported by ADT Simon). This allows interoperability between num3sis and Axel platform, which is developed by Galaad team and is devoted to algebraic geometry. From a practical point of view, grids generated by Axel can now be used by Num3sis for simulation, while PDE solvers in Num3sis libraries can by used interactively by Axel to simulate physical problems.

CAGIRE Team

6. New Software and Platforms

6.1. AeroSol

Participants: Simon Delmas [Cagire], Benjamin Lux [Cagire], Nikolaos Pattakos [Cardamom], Vincent Perrier [Cagire, correspondent], Mario Ricchiuto [Cardamom].

Developed since 2011 by V. Perrier in partnership with the Cardamom Inria team, the AeroSol library is a high order finite element library written in C++. The code design has been carried for being able to perform efficient computations, with continuous and discontinuous finite element methods on hybrid and possibly curvilinear meshes.

The work of the Cardamom team is focused on continuous finite element methods, while we focus on discontinuous Galerkin methods. However, everything is done for sharing the largest possible part of code. The distribution of the unknowns is made with the software PaMPA, first developed within the Inria teams Bacchus and Castor, and currently maintained in the Tadaam team.

The generic features of the library are

- **High order**. It can be theoretically any order of accuracy, but the finite element basis, and quadrature formula are implemented for having up to a fifth order of accuracy.
- **Hybrid and curvilinear meshes**. AeroSol can deal with up to fifth order conformal meshes composed of lines, triangles, quadrangles, tetrahedra, hexahedra, prism, and pyramids.
- **Continuous and discontinuous discretization**. AeroSol deals with both continuous and discontinuous finite element methods.

We would like to emphasize three assets of this library:

- **Its development environment** For allowing a good collaborative work and a functional library, a strong emphasis has been put on the use of modern collaborative tools for developing our software. This includes the active use of a repository, the use of CMake for the compilation, the constant development of unitary and functional tests for all the parts of the library (using CTest), and the use of the continuous integration tool Jenkins for testing the different configurations of AeroSol and its dependencies. Efficiency is regularly tested with direct interfacing with the PAPI library or with tools like scalasca.
- **Its genericity** A lot of classes are common to all the discretization, for example classes concerning I/O, finite element functions, quadrature, geometry, time integration, linear solver, models and interface with PaMPA. Adding simple features (e.g. models, numerical flux, finite element basis or quadrature formula) can be easily done by writing the class, and declaring its use in only one class of the code.
- **Its efficiency** This modularity is achieved by means of template abstraction for keeping good performances. Dedicated efficient implementation, based on the data locality of the discontinuous Galerkin method has been developed. As far as parallelism is concerned, we use point-to-point communications, the HDF5 library for parallel I/O. The behavior of the AeroSol library at medium scale (1000 to 2000 cores) was studied in [19].

The AeroSol project fits with the first axis of the Bordeaux Sud Ouest development strategy, which is to build a coherent software suite scalable and efficient on new architectures, as the AeroSol library relies on several tools developed in other Inria teams, especially for the management of the parallel aspects.

At the end of 2014, AeroSol had the following features:

- **Development environment** Use of CMake for compilation (gcc, icc and xlc), CTest for automatic tests and memory checking, lcov and gcov for code coverage reports. Development of a CDash server for collecting the unitary tests and the memory checking. Beginning of the development of an interface for functional tests. Optional linking with HDF5, PAPI, with dense small matrices libraries (BLAS, Eigen)
- **In/Out** Link with the XML library for handling with parameter files. Parallel reader for GMSH, with an embedded geometrical pre-partitioner. Writer on the VTK-ASCII legacy format (cell and point centered). Parallel output in vtu and pvtu (Paraview) for cell-centered visualization, and XDMF/HDF5 format for both cell and point centered visualization. Ability of saving the high order solution and restarting from it. Computation of volumic and probe statistics. Ability of saving averaged layer data in quad and hexa meshes. Ability of defining user defined output visualization variables.
- **Quadrature formula** up to 11th order for Lines, Quadrangles, Hexaedra, Pyramids, Prisms, up to 14th order for tetrahedron, up to 21st order for triangles. Gauss-Lobatto type quadrature formula for lines, triangles, quadrangles and hexaedra.
- **Finite elements** up to fourth degree for Lagrange finite elements and hierarchical orthogonal finite element basis (with Dubiner transform on simplices) on lines, triangles, quadrangles, tetrahedra, prisms, hexaedra and pyramids. Finite element basis that are interpolation basis on Gauss-Legendre points for lines, quadrangles, and hexaedra, and triangle (only 1st and 2nd order).
- **Geometry** Elementary geometrical functions for first order lines, triangles, quadrangles, prisms, tetrahedra, hexaedra and pyramids. Handling of high order meshes.
- **Time iteration** explicit Runge-Kutta up to fourth order, explicit Strong Stability Preserving schemes up to third order. Optimized CFL time schemes: SSP(2,3) and SSP(3,4). CFL time stepping. Implicit integration with BDF schemes from 2nd to 6th order Newton method for stationary problems. Implicit unstationary time iterator non consistent in time for stationary problems. Implementation of in house GMRES and conjugate gradient based on Jacobian free iterations.
- **Linear Solvers** Link with the external linear solver UMFPack, PETSc and MUMPS. Internal solver for diagonal and block-diagonal matrices.
- **Memory handling** discontinuous and continuous, sequential and parallel discretizations based on PaMPA for generic meshes, including hybrid meshes.
- **Models** Perfect gas Euler system, real gas Euler system (template based abstraction for a generic equation of state), scalar advection, Waves equation in first order formulation, generic interface for defining space-time models from space models. Diffusive models: isotropic and anisotropic diffusion, compressible Navier-Stokes. Scalar advection-diffusion model.
- **Numerical schemes** Continuous Galerkin method for the Laplace problem (up to fifth order) with non consistent time iteration or with direct matrix inversion. Explicit and implicit discontinuous Galerkin methods for hyperbolic systems, diffusive and advection-diffusion problems. Beginning of optimization by stocking the geometry for advection problems. SUPG and Residual disribution schemes. Optimization of DG schemes for advection-diffusion problems: stocking of the geometry and use of BLAS for all the linear phases of the scheme.
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- **Parallel computing** Mesh redistribution, computation of Overlap with PaMPA. Collective asynchronous communications (PaMPA based). Asynchronous point to point communications. Tests on the cluster Avakas from MCIA, and on Mésocentre de Marseille, and PlaFRIM. Tier-1 Turing (BlueGene).

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In 2015, N. Pattakos was hired in the team Cardamom, in order to improve the code architecture and for easing the installation of the library. The following features were added or improved:

- **Development environment** The use of CMake was strongly improved, which induced also easier test launching. Documentation, code cleaning and refactorization have also been led. The shared project of Plafrim was updated, and so was the joint Aerosol/Scotch/PaMPA project on the continuous integration platform. Integration of SPack for handling dependencies has begun. Interface with ESSL was fixed.
- **Multigrid** Development of p-multigrid methods. This includes also the possibility of beginning a computation iwth an order and to decrease or increase the order of approximation when restarting. For the p multigrid methods, V and W cycle have been developed, and restriction and prolongation opertors have also been developed. Implementation of h-multigrid has started, with the development of tests of the aggregation methods of PaMPA, and the definition of finite element basis on arbitrary cells.
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- **Postprocessing** Development of high order projections over line postprocessing, possibility of stocking averaged data, such as the average flow and the Reynolds stresses.

CARDAMOM Team

6. New Software and Platforms

6.1. AeroSol

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- **Quadrature formula** up to 11th or
- April-June 2015: A. Javadi (PhD student) from Chalmers University, Gothenburg, Sweden (3 months).der for Lines, Quadrangles, Hexaedra, Pyramids, Prisms, up to 14th order for tetrahedron, up to 21st order for triangles. Gauss-Lobatto type quadrature formula for lines, triangles, quadrangles and hexaedra.
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6.2. Cut-ANOVA

Participants: Pietro Marco Congedo, Kunkun Tang [Corresponding member].

An anchored analysis of variance (ANOVA) method is proposed to decompose the statistical moments. Compared to the standard ANOVA with mutually orthogonal component functions, the anchored ANOVA, with an arbitrary choice of the anchor point, loses the orthogonality if employing the same measure. However, an advantage of the anchored ANOVA consists in the considerably reduced number of deterministic solver's computations, which renders the uncertainty quantification of real engineering problems much easier. Different from existing methods, the covariance decomposition of the output variance is used in this work to take account of the interactions between non-orthogonal components, yielding an exact variance expansion and thus, with a suitable numerical integration method, provides a strategy that converges. This convergence is verified by studying academic tests. In particular, the sensitivity problem of existing methods to the choice of anchor point is analyzed via the Ishigami case, and we point out that covariance decomposition survives from this issue. Also, with a truncated anchored ANOVA expansion, numerical results prove that the proposed approach is less sensitive to the anchor point. The covariance-based sensitivity indices (SI) are also used, compared to the variance-based SI. Furthermore, we emphasize that the covariance decomposition can be generalized in a straightforward way to decompose higher-order moments. For academic problems, results show the method converges to exact solution regarding both the skewness and kurtosis. The proposed method can indeed be applied to a large number of engineering problems.

The Cut-ANOVA code (Fortran 90, MPI + OpenMP) is devoted to the stochastic analysis of numerical simulations. The method implemented is based on the spectral expansion of "anchored ANOVA", allowing the covariance-based sensitivity analysis. Compared to the conventional Sobol method, "Cut-ANOVA" provides three sensitivity indices instead of one, which allows a better analysis of the reliability of the numerical prediction. On the other hand, "Cut-ANOVA" is able to compute the higher order statistical moments such as the Skewness (3-rd order moment) and Kurtosis (4-th order moment). Several dimension reduction techniques have also been implemented to reduce the computational cost. Finally, thanks to the innovative method implemented into the Code Cut-ANOVA, one can obtain a similar accuracy for stochastic quantities by using a considerably less number of deterministic model evaluations, compared with the classical Monte Carlo method.

6.3. Sparse-PDD

Participants: Pietro Marco Congedo, Kunkun Tang [Corresponding member].

The polynomial dimensional decomposition (PDD) is employed in this code for the global sensitivity analysis and uncertainty quantification (UQ) of stochastic systems subject to a moderate to large number of input random variables. Due to the intimate structure between the PDD and the Analysis of Variance (ANOVA) approach, PDD is able to provide a simpler and more direct evaluation of the Sobol' sensitivity indices, when compared to the Polynomial Chaos expansion (PC). Unfortunately, the number of PDD terms grows exponentially with respect to the size of the input random vector, which makes the computational cost of standard methods unaffordable for real engineering applications. In order to address the problem of the curse of dimensionality, this code proposes essentially variance-based adaptive strategies aiming to build a cheap meta-model (i.e. surrogate model) by employing the sparse PDD approach with its coefficients computed by regression. Three levels of adaptivity are carried out in this code: 1) the truncated dimensionality for ANOVA component functions, 2) the active dimension technique especially for second- and higher-order parameter interactions, and 3) the stepwise regression approach designed to retain only the most influential polynomials in the PDD expansion. During this adaptive procedure featuring stepwise regressions, the surrogate model representation keeps containing few terms, so that the cost to resolve repeatedly the linear systems of the least-square regression problem is negligible. The size of the finally obtained sparse PDD representation is much smaller than the one of the full expansion, since only significant terms are eventually retained. Consequently, a much less number of calls to the deterministic model is required to compute the final PDD coefficients.

6.4. RobUQ

Participants: Pietro Marco Congedo [Corresponding member], Maria Giovanna Rodio, Kunkun Tang.

The `RobUQ` platform has been conceived to solve problems in uncertainty quantification and robust design. It includes the optimization code `ALGEN`, and the uncertainty quantification code `NISP`. It includes also some methods for the computation of high-order statistics, efficient strategies for robust optimization, the Simplex2 method. Some methods are developed in partnership with the Stanford University (in the framework of the associated team AQUARIUS). Other methods are developed in the context of ANR `UFO`.

6.5. ORComp

Participants: Pietro Marco Congedo [Corresponding member], Nassim Razaaly, Maria-Giovanna Rodio.

The ORComp platform is a simulation tool permitting to design an ORC cycle. Starting from the solar radiation, this plateform computes the cycle providing the best performance with optimal choices of the fluid and the operating conditions. It includes `RobUQ` , a simulation block of the ORC cycles, the fluidbox code for the simulation of the turbine and of the heat exchanger, the software `FluidProp` (developed at the University of Delft) for computing the fluid thermodynamic properties.

6.6. sDEM

Participants: Pietro Marco Congedo [Corresponding member], Maria-Giovanna Rodio.

The `sDEM` platform is a simulation tool permitting to simulate multiphase flows with transition modelling. In particular, the code relies on the formulation of a DEM method, the use of a complex thermodynamics, the possibility to model cavitating phenomena. Moreover, the method has been generalized in order to take into account directly uncertainty, thus proposing the so-called Stochastic DEM (sDEM) method. This is one of the first stochastic semi-intrusive scheme, permitting to consider uncertainties in multiphase flows including heat and mass transfer terms. This software is developed together with the University of Zurich.

6.7. SLOWS

Participants: Luca Arpaia, Andrea Filippini, Maria Kazolea, Mario Ricchiuto [Corresponding member].

SLOWS is a C-platform allowing the simulation of free surface shallow water flows with friction. It can be used to simulate near shore hydrodynamics, wave transformations processes, etc. Both hydrostatic (shallow water) and non-hydrostatic (Boussinesq-type) versions exist. The latter are currently based on the dispersive model of Madsen and Sorensen (1992). A fully nonlinear (Green-Naghdi) version is under development based on the one dimensional prototype discussed in [99]. Three different approaches are available, based on conditionally depth-positivity preserving implicit schemes, or on conditionally depth-positivity preserving genuinely explicit discretizations, or on an unconditionally depth-positivity preserving space-time approach. Newton and frozen Newton loops are used to solve the implicit nonlinear equations. The linear algebraic systems arising in the discretization are solved with the MUMPS library. This year implicit and explicit (extrapolated) multistep higher order time integration methods have been implemented, and a mesh adaptation technique based on mesh deformation (r-adaptation) has been also included. A node-centred high order MUSCL finite volume discretisation has also been added to benchmark the mesh adaptation strategies, and compare with the residual based method constituting the kernel of the code. To date, SLOWS is the only existing near shore code allowing to choose between a classical finite volume approximation, and the more recent non-linear residual distribution methods developed in CARDAMOM. It allows an accurate simulation of free surface flows on arbitrary topographies with both static and time dependent unstructured mesh adaptation, accounting for both hydrostatic and non-hydrostatic effects.

6.8. TUCWave

Participant: Maria Kazolea [Corresponding member].

TUCWave, developed within the PhD of M. Kazolea, is a high-order well-balanced unstructured finite volume (FV) solver for weakly nonlinear and weakly dispersive water waves over varying bathymetries, as described by the 2D depth-integrated extended Boussinesq equations of Nwogu (1993). The FV scheme numerically solves the conservative form of the equations following the median dual node-centered approach, for both the advective and dispersive part of the equations. The code uses an efficient edge based structure. For the advective fluxes Roe's approximate Riemann solver is used along with a well-balanced treatment of the topography source. Higher order accuracy i is achieved through a MUSCL-type reconstruction technique, and via a strong stability preserving explicit Runge-Kutta time stepping. The numerical techniques implemented in TUCWave are being imported in SLOWS.

6.9. Realfluids

Participants: Héloise Beaugendre [Corresponding member], Pietro Marco Congedo, Andrea Cortesi, Léo Nouveau, Quentin Viville.

`RealFluids` (developed in the `BACCHUS` team) solves compressible viscous turbulent flow equations, with real-gas effects and arbitrarily complex equations of state, with the most recent residual distribution schemes. It is currently used for simulating turbines in ORC optimization, and for the immersed boundary simulations for de-anti icing applications. It is being coupled to the Mutation library to be able to perform some CFD simulations of low-altitude re-entry flows.

6.10. FMG

Participants: Luca Arpaia, Cécile Dobrzynski [Corresponding member], Andrea Cortesi, Léo Nouveau, Mario Ricchiuto.

FMG is a library deforming an input/reference simplicial mesh w.r.t. a given smoothness error monitor (function gradient or Hessian), metric field, or given mesh size distribution. Displacements are computed by solving an elliptic Laplacian type equation with a continuous finite element method. The library returns an adapted mesh with a corresponding projected solution, obtained by either a second order projection, or by an ALE finite element remap. The addiction of a new mass conservative approach developed ad-hoc for shallow water flows is under way.

6.11. MMG platform

Participants: Cécile Dobrzynski [Corresponding member], Algiane Froehly.

MMG is an open source software for surface and volume remeshing. It provides three applications : 1) mmg2d: generation of a triangular mesh , adaptation and optimization of a triangular mesh 2) mmgs: adaptation and optimization of a surface triangulation representing a piecewise linear approximation of an underlying surface geometry 3) mmg3d: adaptation and optimization of a tetrahedral mesh and implicit domain meshing

URL : http://www.mmgtools.org

6.12. Nomesh

Participants: Cécile Dobrzynski [Corresponding member], Ghina El Jannoun.

`Nomesh` is a software allowing the generation of third order curved simplicial meshes. Starting from a "classical" mesh with straight elements composed by triangles and/or tetrahedra, we are able to curve the boundary mesh. Starting from a mesh with some curved elements, we can verify if the mesh is valid, that means there is no crossing elements and only positive Jacobian. If the curved mesh is non valid, we modify it using linear elasticity equations until having a valid curved mesh.

DEFI Project-Team

5. New Software and Platforms

5.1. FVforBlochTorrey

FUNCTIONAL DESCRIPTION

We developed two numerical codes to solve the multiple-compartments Bloch-Torrey partial differential equation in 2D and 3D to simulate the water proton magnetization of a sample under the influence of diffusion-encoding magnetic field gradient pulses.

We coupled the spatial discretization with an efficient time discretization adapted to diffusive problems called the (explicit) Runge-Kutta-Chebyshev method.

The version of the code using Finite Volume discretization on a Cartesian grid is complete (written by Jing-Rebecca Li). The version of the code using linear Finite Elements discretization is complete (written by Dang Van Nguyen and Jing-Rebecca Li).

- Contact: Jing Rebecca Li
- URL: http://www.cmap.polytechnique.fr/~jingrebeccali/

5.2. InvGIBC

A FreeFem++ routines for solving inverse Maxwell's problem for 3D shape identification using a gradient descent method.

- Contact: Houssem Haddar
- URL: http://www.cmap.polytechnique.fr/~haddar/

5.3. RODIN

FUNCTIONAL DESCRIPTION

In the framework of the RODIN project we continue to develop with our software partner ESI the codes Topolev and Geolev for topology and geometry shape optimization of mechanical structures using the level set method.

- Contact: Grégoire Allaire
- URL: http://www.cmap.polytechnique.fr/~allaire/

5.4. samplings-2d

This software solves forward and inverse problems for the Helmholtz equation in 2-D.
FUNCTIONAL DESCRIPTION

This software is written in Fortran 90 and is related to forward and inverse problems for the Helmholtz equation in 2-D. It includes three independent components. The first one solves to scattering problem using integral equation approach and supports piecewise-constant dielectrics and obstacles with impedance boundary conditions. The second one contains various samplings methods to solve the inverse scattering problem (LSM, RGLSM(s), Factorization, MuSiC) for near-field or far-field setting. The third component is a set of post processing functionalities to visualize the results

- Contact: Houssem Haddar
- URL: http://sourceforge.net/projects/samplings-2d/

5.5. Samplings-3d

FUNCTIONAL DESCRIPTION

This software is written in Fortran 90 and is related to forward and inverse problems for the Helmholtz equation in 3-D. It contains equivalent functionalities to samplings-2d in a 3-D setting.

- Contact: Houssem Haddar
- URL: http://www.cmap.polytechnique.fr/~haddar/

ECUADOR Project-Team

5. New Software and Platforms

5.1. AIRONUM

SCIENTIFIC DESCRIPTION
Aironum is an experimental software that solves the unsteady compressible Navier-Stokes equations with k-, LES-VMS and hybrid turbulence modelling on parallel platforms, using MPI. The mesh model is unstructured tetrahedrization, with possible mesh motion.
FUNCTIONAL DESCRIPTION
Aironum was developed by Inria and University of Montpellier. It is used by Inria, University of Montpellier and University of Pisa (I). Aironum is used as an experimental platform for:

- Numerical approximation of compressible flows, such as upwind mixed element volume approximation with superconvergence on regular meshes.
- Numerical solution algorithms for the implicit time advancing of the compressible Navier-Stokes equations, such as parallel scalable deflated additive Schwarz algorithms.
- Turbulence modelling such as the Variational Multiscale Large eddy Simulation and its hybridization with RANS statistical models.
- Participant: Alain Dervieux
- Contact: Alain Dervieux
- URL: http://www-sop.inria.fr/tropics/aironum

5.2. TAPENADE

KEYWORDS: Static analysis - Optimization - Compilation - Gradients
SCIENTIFIC DESCRIPTION
Tapenade implements the results of our research about models and static analyses for AD. For a full specification and description, see [10]. AD produces analytical derivatives, that are exact up to machine precision. Adjoint AD computes gradients at a cost which is independent from the number of input variables. Tapenade performs sophisticated flow- and context-sensitive data-flow analysis on the complete source program to produce an efficient differentiated code. Analyses include Type-Checking, Read-Write analysis, Pointer analysis. AD-specific analyses include:

- Activity analysis: Detects variables whose derivative is either null or useless, to reduce the number of derivative instructions.
- Adjoint Liveness analysis: Detects the source statements that are dead code for the computation of derivatives.
- TBR analysis: In Adjoint AD, reduces the set of source variables that need to be recovered.

FUNCTIONAL DESCRIPTION
Tapenade transforms an original program into a new program that computes derivatives of the original program. Tapenade accepts source programs written in Fortran77, Fortran90, or C. Tapenade can differentiate in tangent, vector tangent, adjoint, and vector adjoint modes. Tapenade can be downloaded and installed on most architectures. Alternatively, it can be used as a web server. Higher-order derivatives can be obtained through repeated application.

- Participants: Laurent Hascoët, Valérie Pascual, Ala Taftaf
- Contact: Laurent Hascoët
- URL: http://www-sop.inria.fr/tropics/tapenade.html

GAMMA3 Project-Team

4. New Software and Platforms

4.1. ABL4FLO

FUNCTIONAL DESCRIPTION

KEYWORDS: Boundary layer, Hybrid meshes
SCIENTIFIC DESCRIPTION

Automatic boundary layer mesh generation for complex geometries

FUNCTIONAL DESCRIPTION

ABL4FLO is designed to generate 3D adapted boundary layer meshes by using a cavity-based operator.

- Participant: Adrien Loseille
- Contact: Adrien Loseille
- URL: https://www.rocq.inria.fr/gamma/Adrien.Loseille/index.php?page=softwares

4.2. AMA4FLO

FUNCTIONAL DESCRIPTION

KEYWORDS: Anisotropic mesh adaptation, Surface and volume remeshing, Non manifold geometries
SCIENTIFIC DESCRIPTION

Robust and automatic generation of anisotropic meshes in 3D

FUNCTIONAL DESCRIPTION

AMA4FLO is designed to generate adapted meshes with respect to a provided anisotropic sizing field. The surface and the volume mesh is adapted simultaneously to guarantee that a 3D valid mesh is provided on output.

- Participant: Adrien Loseille
- Contact: Adrien Loseille
- URL: https://www.rocq.inria.fr/gamma/Adrien.Loseille/index.php?page=softwares

4.3. BL2D

KEYWORDS: Automatic mesher - Delaunay - Anisotropic - Planar domain

SCIENTIFIC DESCRIPTION

The meshing method is of controled Delaunay type, isotropic or anisotropic. The internal point generation follows an advancing-front logic, and their connection is realised as in a classical Delaunay approach. Quadrilaterals are obtained by a pairing process. The direct construction of degree 2 elements has been made possible via the control of the domain boundary mesh, in order to ensure the desired compatibility.

FUNCTIONAL DESCRIPTION

Planar mesh generator (isotropic or anisotropic, adaptive).

- Participants: Houman Borouchaki and Patrick Laug
- Contact: Patrick Laug
- URL: https://www.rocq.inria.fr/gamma/Patrick.Laug/logiciels/logiciels.html

4.4. BL2D-ABAQ

KEYWORDS: Automatic mesher - Delaunay - Anisotropic - Planar domain - error estimation - interpolation

SCIENTIFIC DESCRIPTION

The meshing method is the same as BL2D (see above) in an adaptive process. An error estimation (*a posteriori*) of a solution at the nodes of the current mesh results in a size map. A new mesh satisfying these size specifications (made continuous) is built, and the solution is interpolated on the new mesh.

FUNCTIONAL DESCRIPTION

Planar mesh generator (isotropic or anisotropic, adaptive) for deformable domains, interacting with the ABAQUS solver.

- Participants: Houman Borouchaki, Patrick Laug and Abel Cherouat
- Contact: Patrick Laug
- URL: https://www.rocq.inria.fr/gamma/Patrick.Laug/logiciels/logiciels.html

4.5. BLGEOL

KEYWORDS: Automatic mesher - Hex-dominant - Geologic structures

SCIENTIFIC DESCRIPTION

The aim is to generate hex-dominant meshes of geologic structures complying with different geometric constraints: surface topography (valleys, reliefs, rivers), geologic layers and underground workings. First, a reference 2D domain is obtained by projecting all the line constraints into a horizontal plane. Different size specifications are given for rivers, outcrop lines and workings. Using an adaptive methodology, the size variation is bounded by a specified threshold in order to obtain a high quality quad-dominant mesh. Secondly, a hex-dominant mesh of the geological medium is generated by a vertical extrusion, taking into account the surfaces found (interfaces between two layers, top or bottom faces of underground workings). The generation of volume elements follows a global order established on the whole set of surfaces to ensure the conformity of the resulting mesh.

FUNCTIONAL DESCRIPTION

Hex-dominant mesher of geologic structures and storage facilities.

- Participants: Patrick Laug and Houman Borouchaki
- Contact: Patrick Laug
- URL: https://www.rocq.inria.fr/gamma/Patrick.Laug/logiciels/logiciels.html

4.6. BLMOL

KEYWORDS: Automatic mesher - Molecular surface

SCIENTIFIC DESCRIPTION

To model a molecular surface, each constituting atom is idealized by a simple sphere. First, a boundary representation (B-rep) of the surface is obtained, i.e. a set of patches and the topological relations between them. Second, an appropriate parameterization and a metric map are computed for each patch. Third, meshes of the parametric domains are generated with respect to an induced metric map, using a combined advancing-front generalized-Delaunay approach. Finally these meshes are mapped onto the entire surface.

FUNCTIONAL DESCRIPTION

Molecular surface mesher.

- Participants: Houman Borouchaki and Patrick Laug
- Contact: Patrick Laug
- URL: https://www.rocq.inria.fr/gamma/Patrick.Laug/logiciels/logiciels.html

4.7. BLSURF

KEYWORDS: Automatic mesher - parametric surface - CAD surface

SCIENTIFIC DESCRIPTION

An indirect method for meshing parametric surfaces conforming to a user-specifiable size map is used. First, from this size specification, a Riemannian metric is defined so that the desired mesh is one with unit length edges with respect to the related Riemannian space (the so-called ‚Äòunit mesh‚Äô). Then, based on the intrinsic properties of the surface, the Riemannian structure is induced into the parametric space. Finally, a unit mesh is generated completely inside the parametric space such that it conforms to the metric of the induced Riemannian structure. This mesh is constructed using a combined advancing-front Delaunay approach applied within a Riemannian context.

FUNCTIONAL DESCRIPTION

CAD surface mesher.

- Participants: Houman Borouchaki and Patrick Laug
- Contact: Patrick Laug
- URL: https://www.rocq.inria.fr/gamma/Patrick.Laug/logiciels/logiciels.html

4.8. FEFLOA-REMESH

KEYWORDS: Anisotropic mesh adaptation, Surface remeshing, Cavity-based operator
SCIENTIFIC DESCRIPTION

Automatic generation of metric-aligned and metric-orthogonal anisotropic meshes in 3D

FUNCTIONAL DESCRIPTION

FEFLOA-REMESH is intended to generate adapted 2D, surface and volume meshes by using a unique cavity-based operator. The metric-aligned or metric-orthogonal approach is used to generate high quality surface and volume meshes independently of the anisotropy involved.

- Participants: Adrien Loseille and Frédéric Alauzet
- Contact: Adrien Loseille
- URL: https://www.rocq.inria.fr/gamma/Adrien.Loseille/index.php?page=softwares

4.9. GAMANIC 3D

KEYWORDS: Tetrahedral mesh - Delaunay - Anisotropic size and direction control - Automatic Mesher
SCIENTIFIC DESCRIPTION

Automatic tetrahedral mesher based on an anisotropic Delaunay type point insertion method. A metric field is provided specifying the desired size (edge length) and directional properties.

FUNCTIONAL DESCRIPTION

GAMANIC3D is a volume mesher governed by a (anisotropic) size and directional specification metric field.

- Participants: Houman Borouchaki, Paul Louis George, Frederic Hecht, √Çaric Saltel, Frédéric Alauzet and Adrien Loseille
- Contact: Paul Louis George
- URL: http://www.meshgems.com/volume-meshing.html

4.10. GAMHIC 3D

KEYWORDS: Tetrahedral mesh - Delaunay - Isotropic size control - Automatic Mesher
SCIENTIFIC DESCRIPTION

Automatic tetrahedral mesher based on the Delaunay point insertion method. A metric field is provided specifying the desired size (edge length).

FUNCTIONAL DESCRIPTION

GAMHIC3D is a volume mesher governed by a (isotropic) size specification metric field.

- Participants: Houman Borouchaki, Paul Louis George, Frederic Hecht, √âric Saltel, Frédéric Alauzet and Adrien Loseille
- Contact: Paul Louis George
- URL: http://www.meshgems.com/volume-meshing.html

4.11. GHS3D

KEYWORDS: Tetrahedral mesh - Delaunay - Automatic Mesher
SCIENTIFIC DESCRIPTION

Automatic tetrahedral mesher based on the Delaunay point insertion method.

FUNCTIONAL DESCRIPTION

GHS3D is an automatic volume mesher

- Participants: Paul Louis George, Houman Borouchaki, √âric Saltel, Frédéric Alauzet, Adrien Loseille and Frederic Hecht
- Contact: Paul Louis George
- URL: http://www.meshgems.com/volume-meshing.html

4.12. HEXOTIC

KEYWORDS: Hexahedral mesh - Octree - Automatic mesher
SCIENTIFIC DESCRIPTION

Automatic full hexahedral mesher primarily based on an octree.

FUNCTIONAL DESCRIPTION

HEXOTIC is an automatic hexahedral mesher

- Contact: Loïc Maréchal
- URL: https://www.rocq.inria.fr/gamma/gamma/Membres/CIPD/Loic.Marechal/Research/Hexotic.html

4.13. Metrix

KEYWORD: Scientific calculation
SCIENTIFIC DESCRIPTION

Compute a metric field from a given solution field using various error estimates.

FUNCTIONAL DESCRIPTION

Metrix computes metric field from a given solution field using various error estimates. Available error estimates are feature-based and goal-oriented based error estimates for steady or unsteady fields. Metrix also performs operations on metrics: gradation, intersection, natural metric of a mesh.

- Participants: Frédéric Alauzet and Adrien Loseille
- Contact: Frédéric Alauzet
- URL: https://www.rocq.inria.fr/gamma/Frederic.Alauzet/code_eng.html

4.14. Nimbus 3D

KEYWORDS: Surface reconstruction - Point cloud
SCIENTIFIC DESCRIPTION

Given a point cloud, a surface is constructed primarily based on a Delaunay approach.

FUNCTIONAL DESCRIPTION

Nimbus3D is a surface reconstruction method piece of software

- Participants: Paul Louis George and Houman Borouchaki
- Contact: Paul Louis George
- URL: http://www.meshgems.com/volume-meshing.html

4.15. VIZIR

KEYWORDS: Mesh and solution visualization
SCIENTIFIC DESCRIPTION

Interactive mesh and solution visualization for linear, and high order curved elements

FUNCTIONAL DESCRIPTION

VIZIR is intended to visualize and modify interactively simplicial, hybrid and high order curved meshes.

- Participants: Julien Castelneau, Adrien Loseille and Alexis Loyer
- Contact: Adrien Loseille
- URL: http://www-roc.inria.fr/gamma/gamma/vizir/

4.16. Wolf

KEYWORD: Scientific calculation
SCIENTIFIC DESCRIPTION

General solver platform containing all the Wolf modules: Wolf-Bloom, Wolf-Elast, Wolf-Interpol, Wolf-MovMsh, Wolf-Nsc, Wolf-Shrimp, Wolf-Spyder and Wolf-Xfem.

FUNCTIONAL DESCRIPTION

Wolf is a general solver platform containing all the Wolf modules: Wolf-Bloom, Wolf-Elast, Wolf-Interpol, Wolf-MovMsh, Wolf-Nsc, Wolf-Shrimp, Wolf-Spyder and Wolf-Xfem.

- Participants: Frédéric Alauzet and Adrien Loseille
- Contact: Frédéric Alauzet
- URL: https://www.rocq.inria.fr/gamma/Frederic.Alauzet/code_eng.html

4.17. Wolf-Bloom

KEYWORD: Scientific calculation
SCIENTIFIC DESCRIPTION

Structured boundary layer mesh generator using a pushing approach.

FUNCTIONAL DESCRIPTION

Wolf-Bloom is a structured boundary layer mesh generator using a pushing approach. It start from an existing volume mesh and insert a structured boundary layer by pushing the volume mesh. The volume mesh deformation is solved with an elasticity analogy. Mesh-connectivity optimizations are performed to control volume mesh element quality.

- Participants: Frédéric Alauzet, Adrien Loseille and Dave Marcum
- Contact: Frédéric Alauzet
- URL: https://www.rocq.inria.fr/gamma/Frederic.Alauzet/code_eng.html

4.18. Wolf-Elast

KEYWORD: Scientific calculation
SCIENTIFIC DESCRIPTION

Linear elasticity solver using a P1 Finite-Element method.

FUNCTIONAL DESCRIPTION

Wolf-Elast is a linear elasticity solver using the P1 Finite-Element method. The Young and Poisson coefficient can be parametrized. The linear system is solved using the Conjugate Gradient method with the LUSGS preconditioner.

- Participants: Frédéric Alauzet and Adrien Loseille
- Contact: Frédéric Alauzet
- URL: https://www.rocq.inria.fr/gamma/Frederic.Alauzet/code_eng.html

4.19. Wolf-Interpol

KEYWORD: Scientific calculation
SCIENTIFIC DESCRIPTION

Software transferring scalar, vector and tensor fields from one mesh to another one.

FUNCTIONAL DESCRIPTION

Wolf-Interpol is a tool to transfer scalar, vector and tensor fields from one mesh to another one. Polynomial interpolation (from order 2 to 4) or conservative interpolation operators can be used. Wolf-Interpol also extract solutions along lines or surfaces.

- Participants: Frédéric Alauzet and Adrien Loseille
- Contact: Frédéric Alauzet
- URL: https://www.rocq.inria.fr/gamma/Frederic.Alauzet/code_eng.html

4.20. Wolf-MovMsh

KEYWORD: Scientific calculation
SCIENTIFIC DESCRIPTION

Moving mesh algorithm coupled with mesh-connectivity optimization.

FUNCTIONAL DESCRIPTION

Wolf-MovMsh is a moving mesh algorithm coupled with mesh-connectivity optimization. Mesh deformation is computed by means of a linear elasticity solver or a RBF interpolation. Smoothing and swapping mesh optimization are performed to maintain good mesh quality. It handles rigid bodies or deformable bodies, and also rigid or deformable regions of the domain.

- Participants: Frédéric Alauzet and Adrien Loseille
- Contact: Frédéric Alauzet
- URL: https://www.rocq.inria.fr/gamma/Frederic.Alauzet/code_eng.html

4.21. Wolf-Nsc

KEYWORD: Scientific calculation
SCIENTIFIC DESCRIPTION

Numerical flow solver solving the compressible Navier-Stokes equations.

FUNCTIONAL DESCRIPTION

Wolf-Nsc is numerical flow solver solving steady or unsteady turbulent compressible Euler and Navier-Stokes equations. The available turbulent models are the Spalart-Almaras and the Menter SST k-omega. A mixed finite volume - finite element numerical method is used for the discretization. Second order spatial accuracy is reached thanks to MUSCL type methods. Explicit or implicit time integration are available. It also resolved dual (adjoint) problem and compute error estimate for mesh adaptation.

- Participants: Frédéric Alauzet and Adrien Loseille
- Contact: Frédéric Alauzet
- URL: https://www.rocq.inria.fr/gamma/Frederic.Alauzet/code_eng.html

4.22. Wolf-Shrimp

KEYWORD: Scientific calculation
SCIENTIFIC DESCRIPTION

Mesh partitioner for parallel mesh generation and parallel computation.

FUNCTIONAL DESCRIPTION

Wolf-Shrimp is a generic mesh partitioner for parallel mesh generation and parallel computation. It can partition planar, surface (manifold and non manifold), and volume domain. Several partitioning methods are available: Hilbert-based, BFS, BFS with restart. It can work with or without weight function and can correct the partitions to have only one connected component.

- Participants: Frédéric Alauzet and Adrien Loseille
- Contact: Frédéric Alauzet
- URL: https://www.rocq.inria.fr/gamma/Frederic.Alauzet/code_eng.html

4.23. Wolf-Spyder

KEYWORD: Scientific calculation
SCIENTIFIC DESCRIPTION

Metric-based mesh quality optimizer using vertex smoothing and edge/face swapping.

FUNCTIONAL DESCRIPTION

Wolf-Spyder is a metric-based mesh quality optimizer using vertex smoothing and edge/face swapping.

- Participants: Frédéric Alauzet and Adrien Loseille
- Contact: Frédéric Alauzet
- URL: https://www.rocq.inria.fr/gamma/Frederic.Alauzet/code_eng.html

4.24. Wolf-Xfem

KEYWORD: Scientific calculation
SCIENTIFIC DESCRIPTION

Tool providing the mesh of the intersection between a surface mesh and a volume mesh.

FUNCTIONAL DESCRIPTION

Wolf-Xfem is a tool providing the mesh of the intersection between a surface mesh and a volume mesh.

- Participants: Frédéric Alauzet
- Contact: Frédéric Alauzet
- URL: https://www.rocq.inria.fr/gamma/Frederic.Alauzet/code_eng.html

IPSO Project-Team (section vide)

MATHERIALS Project-Team

5. New Software and Platforms

5.1. SIMOL

KEYWORDS: C++ - Statistical physics - Quantum chemistry - Molecular simulation - OpenMP
FUNCTIONAL DESCRIPTION

SIMOL (SIMulation of MOLecular systems) is a software written in C++. It is a research code aimed at testing new ideas and algorithms, and provides a unified development platform for the members of the project-team. It is composed of three parts: a common core of input/output functions, linear algebra, random number generators, etc; and two specific applicative branches: one for computational statistical physics and one for quantum chemistry. The methods implemented for computational statistical physics are based on discretizations of ergodic stochastic differential equations such as the Langevin dynamics and its overdamped limit. The systems that can be simulated range from a single isolated particle to Lennard-Jones fluids. For quantum chemistry, the building block is the Hartree-Fock model, solved via fixed-point iterations; and various refinements including greedy methods. A first release should be available in Spring 2016.

- Contact: Cédric Doucet

MEMPHIS Team

6. New Software and Platforms

6.1. New Software

6.1.1. NaSCar

This code is devoted to solve 3D-flows past moving and deformable bodies. The incompressible Navier-Stokes equations are solved on fixed grids, and the bodies are taken into account thanks to penalization and/or immersed boundary methods. The interface between the fluid and the bodies is tracked with a level set function or in a Lagrangian way. The numerical code is fully second order (time and space). The numerical method is based on projection schemes of Chorin-Temam type. The code is written in C language and use Petsc (http://www.mcs.anl.gov/petsc/petsc-as/) library for the resolution of large linear systems in parallel. NaSCar can be used to simulate both hydrodynamic bio-locomotion as fish like swimming and aerodynamic flows such wake generated by a wind turbine.

- Main developper: M. Bergmann.
- Version: 1
- Keywords: numerical analysis, fluid mechanics, language C, PETSc
- Software benefit: flow around deformable obstacles, moving into a fluid.
- APP: in progress
- OS/Middelware: unix, linux, mac os
- Required library or software: PETSc item Programming language: C
- Documentation: in progress

6.1.2. NSMulti

The code is devoted to solve incompressible flows modeled by Navier-Stokes equations in two or three-dimensions. The equation of temperature can be added as well as Oldroyd-B model for viscous-elastic fluids. The two-dimensional version allows many sets of boundary conditions based on Dirichlet boundary condition, open boundary condition and periodic boundary condition. Bodies immersed in the fluid are taken into account by means of the volume penalization method as the code uses only uniform Cartesian meshes. The approximation is performed efficiently by a second order scheme for the linear terms and an upwind third order scheme for the convection terms. An efficient multigrid algorithm is used to accelerate the convergence. The whole code is written in FORTRAN 95 with MPI parallelization. When it is possible an hybrid MPI/OPEN MP parallelization is applied. The code yields the approximate solution at chosen times as well as the mean flow. In addition the time evolution of the main quantities at given points and global physical quantities such as the energy, the enstrophy, the lift, the drag are provided.

- Main developper: C.-H. Bruneau
- Version: 3
- Keywords: Incompressible flows, language FORTRAN95, MPI, OPEN MP.
- Software benefit : flow around solid or porous obstacles.
- APP: in progress
- OS/Middelware: unix, linux, mac os
- Required library or software: none
- Documentation: integrated

6.1.3. CoCoFlo

This is a research code to solve compressible multi-material flows modeled by conservation laws and hyperelatic constitutive models in three-dimensions. The whole code is written in FORTRAN 95 with MPI parallelization.

- Main developper: experimental code with contributions from past PhD students, mainly A. de Brauer and Y. Gorsse under the supervision of A. Iollo.
- Version: 0
- Keywords: Compressible material, language FORTRAN95, MPI, OPEN MP.
- Software benefit : impacts.
- APP: not foreseen
- OS/Middelware: unix, linux, mac os
- Required library or software: none
- Documentation: integrated

6.1.4. KOPPA

This code solves a polyatomic extension of the BGK or the ES-BGK models on octree meshes in parallel (Kinetic Octree Parallel Poly Atomic: KOPPA). It is a finite-volume code second-order accurate scheme in space and time with immersed boundaries. In collaboration with STORM team of Inria, Optimad and CINECA a porting on multi-integrated cores (XEON Phi for the moment) of this code is in progress.

- Main developper: F. Bernard
- Version: 0
- Keywords: Rarefied flows language C++, MPI, OPEN MP.
- Software benefit: simulation of non-equilibrium reentry flows, satellite nozzle plumes.
- APP: not foreseen at the moment
- OS/Middelware: unix, linux, mac os
- Required library or software: PABLO for octree.
- Documentation: integrated

MEPHYSTO Team

6. New Software and Platforms

6.1. MODULEF

FUNCTIONAL DESCRIPTION

The numerical method to approximate the constitutive laws for rubber elasticity derived from polymer physics are implemented in the Inria software Modulef.

It is based on : - algorithms from stochastic geometry to generate suitable polymer networks, - Delaunay tessellation algorithms to deal with steric effects (courtesy of the Inria project-team GAMMA2), - the introduction of 1-dimensional finite elements for the polymer-chains in Modulef.

- Participants: Marina Vidrascu and Antoine Gloria
- Contact: Marina Vidrascu
- URL: https://www.rocq.inria.fr/modulef/

MOKAPLAN Project-Team

6. New Software and Platforms

6.1. ALG2

FUNCTIONAL DESCRIPTION

ALG2 for Monge Mean-Field Games, Monge problem and Variational problems under divergence constraint. A generalisation of the ALG2 algorithm has been implemented in FreeFem++.

- Contact: Jean-David Benamou
- URL: https://team.inria.fr/mokaplan/augmented-lagrangian-simulations/

6.2. Mokabajour

FUNCTIONAL DESCRIPTION

We design a software resolving the following inverse problem: define the shape of a mirror which reflects the light from a source to a defined target, distribution and support of densities being prescribed. Classical applications include the conception of solar oven, public lightning, car headlights...Mathematical modeling of this problem, related to the optimal transport theory, takes the form of a nonlinear Monge-Ampere type PDE. The numerical resolution of these models remained until recently a largely open problem. MOKABAJOUR project aims to develop, using algorithms invented especially at Inria and LJK, a reflector design software more efficient than geometrical methods used so far.

- Participants: Jean-David Benamou, Vincent Duval, Simon Legrand, Quentin Mérigot and Boris Thibert
- Contact: Jean-David Benamou
- URL: https://project.inria.fr/mokabajour/

6.3. Entropic OT

FUNCTIONAL DESCRIPTION

We design a software to compute fast approximation of optimal transport (and related problems such as barycenters) on geometric domains (either regular Euclidean grid or triangulated meshes). This numerical scheme relies on two key ideas: entropic regularization of the initial linear problem [3] and fast approximate convolution on geometric domains [22] This algorithm is both extremely fast and highly parallelizable, being able to take advantage of GPU computational architectures.

- Gabriel Peyré, Jean-David Benamou, Guillaume Carlier, Marco Cuturi (Kyoto), Justin Solomon.
- Contact: Gabriel Peyré
- URL: https://github.com/gpeyre/2015-SIGGRAPH-convolutional-ot

6.4. Jupyter Notebook

FUNCTIONAL DESCRIPTION

Several codes deevlloped by the team are available on an online Jupyter Notebook (Julia and Python) In particular the Semi Discrete Principal Agent Code and also a new Monge-Amère second boundary value problem Finite Difference code.

- Simon Legrand, Xavier Dupuis, Vincent Duval, Jean-David Benamou.
- Contact: Simon Legrand
- URL: https://mathmarx.paris.inria.fr:8080

NACHOS Project-Team

5. New Software and Platforms

5.1. MAXW-DGTD

- Participants: Alexandra Christophe-Argenvillier, Loula Fezoui, Stéphane Lanteri, Raphaël Léger, Jonathan Viquerat
- Contact: Stéphane Lanteri
- Keywords: Computational electromagnetics, Maxwell equations, discontinuous Galerkin, tetrahedral mesh.
- OS/Middelware: Linux
- Required library or software: MPI (Message Passing Interface), CUDA
- Programming language: Fortran 77/95

MAXW-DGTD is a software suite for the simulation of time domain electromagnetic wave propagation. It implements a solution method for the Maxwell equations in the time-domain. MAXW-DGTD is based on a discontinuous Galerkin method formulated on unstructured triangular (2d case) or tetrahedral (3d case) meshes [13]. Within each element of the mesh, the components of the electromagnetic field are approximated by an arbitrary high order nodal polynomial interpolation method. This discontinuous Galerkin method combines a centered scheme for the evaluation of numerical fluxes at a face shared by two neighboring elements, with an explicit Leap-Frog time scheme. The software and the underlying algorithms are adapted to distributed memory parallel computing platforms thanks to a parallelization strategy that combines a partitioning of the computational domain with message passing programming using the MPI standard. Besides, a peripheral version of the software has been recently developed which is able to exploit the processing capabilities of a hybrid parallel computing system comprising muticore CPU and GPU nodes.

5.2. MAXW-DGFD

- Participants: Thomas Frachon, Stéphane Lanteri, Ludovic Moya
- Contact: Stéphane Lanteri
- Keywords: Computational electromagnetics, Maxwell equations, discontinuous Galerkin, tetrahedral mesh.
- OS/Middelware: Linux
- Required library or software: MPI (Message Passing Interface)
- Programming language: Fortran 77/95

MAXW-DGFD is a software suite for the simulation of time-harmonic electromagnetic wave propagation. It implements a solution method for the Maxwell equations in the frequency domain. MAXW-DGFD is based on a discontinuous Galerkin method formulated on unstructured triangular (2d case) or tetrahedral (3d case) meshes. Within each element of the mesh, the components of the electromagnetic field are approximated by an arbitrary high order nodal polynomial interpolation method. The resolution of the sparse, complex coefficients, linear systems resulting from the discontinuous Galerkin formulation is performed by a hybrid iterative/direct solver whose design is based on domain decomposition principles. The software and the underlying algorithms are adapted to distributed memory parallel computing platforms thanks to a parallelization strategy that combines a partitioning of the computational domain with a message passing programming using the MPI standard. Some recent achievements have been the implementation of non-uniform order DG method in the 2d case and of a new hybridizable discontinuous Galerkin (HDG) formulation also in the 2d and 3d cases.

5.3. SISMO-DGTD

- Participants: Nathalie Glinsky, Stéphane Lanteri
- Contact: Stéphane Lanteri

SISMO-DGTD is a software for the simulation of time-domain seismic wave propagation. It implements a solution method for the velocity-stress equations in the time-domain. SISMO-DGTD is based on a discontinuous Galerkin method formulated on unstructured triangular (2d case) or tetrahedral (3d case) meshes [2]. Within each element of the mesh, the components of the electromagnetic field are approximated by an arbitrary high order nodal polynomial interpolation method. This discontinuous Galerkin method combines a centered scheme for the evaluation of numerical fluxes at a face shared by two neighboring elements, with an explicit Leap-Frog time scheme. The software and the underlying algorithms are adapted to distributed memory parallel computing platforms thanks to a parallelization strategy that combines a partitioning of the computational domain with a message passing programming using the MPI standard.

NANO-D Project-Team

6. New Software and Platforms

6.1. SAMSON

SAMSON (Software for Adaptive Modeling and Simulation Of Nanosystems) is a software platform for computational nanoscience. SAMSON has a modular architecture that makes it suitable for different domains of nanoscience, including material science, life science, physics, electronics, chemistry, and education.

SAMSON Elements are modules for SAMSON, developed with the SAMSON Software Development Kit (SDK). SAMSON Elements help users perform tasks in SAMSON, including building new models, performing calculations, running interactive or offline simulations, and visualizing and interpreting results.

SAMSON Elements may contain different class types, including for example:

- Apps - generic classes with a graphical user interface that extend the functions of SAMSON
- Editors - classes that receive user interaction events to provide editing functions (e.g., model generation, structure deformation, etc.)
- Models - classes that describe properties of nanosystems (see below)
- Parsers - classes that may parse files to add content to SAMSON's data graph (see below)

SAMSON Elements expose their functions to SAMSON and other Elements through an introspection mechanism, and may thus be integrated and pipelined.

SAMSON represents nanosystems using five categories of models:

- Structural models - describe geometry and topology
- Visual models - provide graphical representations
- Dynamical models - describe dynamical degrees of freedom
- Interaction models - describe energies and forces
- Property models - describe traits that do not enter in the first four model categories

Simulators (potentially interactive ones) are used to build physically-based models, and predict properties. All models and simulators are integrated into a hierarchical, layered structure that form the SAMSON data graph. SAMSON Elements interact with each other and with the data graph to perform modeling and simulation tasks. A signals and slots mechanism makes it possible for data graph nodes to send events when they are updated, which makes it possible to develop e.g., adaptive simulation algorithms.

SAMSON is developed in C++ and implements many features to ease development of SAMSON Elements, including:

- Managed memory
- Signals and slots
- Serialization
- Multilevel undo-redo
- Introspection
- Referencing
- Unit system
- SAMSON Element source code generators

SAMSON, SAMSON Elements and the SAMSON Software Development Kit are distributed via the SAMSON Connect website (http://www.samson-connect.net). The site acts as a repository for the SAMSON Elements being uploaded by developers, and users of SAMSON choose and add Elements from SAMSON Connect.

POEMS Project-Team

5. New Software and Platforms

5.1. COFFEE

FUNCTIONAL DESCRIPTION

COFFEE is a 3D solver for linear elastodynamics based on fast BEMs (full implementation in Fortran 90). The 3-D elastodynamic equations are solved with the boundary element method accelerated by the multi-level fast multipole method or H-matrix based solvers. The fundamental solutions for the infinite or half-space are used. A boundary element-boundary element coupling strategy is also implemented so multi-region problems (strata inside a valley for example) can be solved.

- Contact: Stéphanie Chaillat
- URL: http://perso.ensta-paristech.fr/ chaillat/index.php?page=softwares

5.2. XLiFE++

FUNCTIONAL DESCRIPTION

XLiFE++ is a Finite Element library written in C++ based on a variational approach and standard finite element methods, boundary element methods, spectral approximations. It allows to mix these different methods in a easy way to deal with complex models. A new version (v1.3) has been released in December 2015 but it is still in progress. This year, the main new features are: finite elements at any order (before, they were available up to order 6), some edge elements at any order (Raviart-Thomas, Nedelec), more stable boundary element methods. The performance was highly improved and first tests with multithreading (using OpenMP) have been done. At last, a lot of work to improve and stabilize user interface was done about mesh integrated tools, solvers, and external libraries installation. To make further progress in BEM methods (FMM, H Matrix, SCSD), a DGA project started in October 2015 in collaboration with MyBEM software team at CMAP (François Allouges, Matthieu Aussal, ...). Nicolas Salles has been recruited to enhance the BEM part of XLiFE++.

- Contact: Eric Lunéville
- URL: http://uma.ensta-paristech.fr/soft/XLiFE++/

RAPSODI Team

6. New Software and Platforms

6.1. New Software and Platforms

We develop and freely distribute a new version of the matlab code NS2DDV-M (equipped with a graphic interface and an accurate documentation) to promote new collaborations in the domain, allow some easy comparisons with concurrent codes on the same benchmark cases, and compare alternative numerical solution methods. Contacts: Caterina Calgaro & Emmanuel Creusé.

APICS Project-Team

5. New Software and Platforms

5.1. Dedale-HF

Recent developments allow to use Dedale-HF in combination with Presto-HF and in replacement of the former software RGC. A circuit optimizer has also been added to handle specific coupling topologies, the admissible set of which is not known in terms of a simple polynomial description.

5.2. FindSources3D

A new (Matlab) version of the software that automatically performs the estimation of the quantity of sources is being built (see Section 3.4.2). It uses an alignment criterion in addition to other clustering tests for the selection. Also, the team benefit from an “Action de Développement Technologique” (ADT Inria) BOLIS, 2014-2016, and of the young engineer N. Schnitzler at half-part of the time. The aim is to get from FindSources3D a modular, ergonomic, accessible and interactive platform, providing a convenient graphical interface and a tool that can be easily distributed and used, for medical imaging (EEG, MEG, EIT) or other applications (like inverse source problems in planetary sciences, see Section 6.1.3). Modularity is now granted, though still in progress (using the tools dtk, Qt, still with compiled Matlab libraries; translation in C++ will be continued). The related version of the software now offers a detailed and nice visualization of the data and tuning parameters, of the processing steps and of the computed results (using VTK).

BIPOP Project-Team

5. New Software and Platforms

5.1. ACEF

- Participants: Vincent Acary and Olivier Bonnefon

5.2. Approche

- Participants: Alexandre Derouet-Jourdan, Florence Bertails-Descoubes and Joëlle Thollot
- Contact: Florence Bertails-Descoubes
- URL: Approche

5.3. CloC

- Participants: Florence Bertails-Descoubes and Romain Casati
- Partner: UJF
- Contact: Florence Bertails-Descoubes
- URL: Cloc

5.4. MECHE-COSM

5.4.1. 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 [11]). 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 (which we have started to build in Gilles Daviet's PhD thesis). 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.

5.5. Platforms: SICONOS

5.5.1. Platform A : SICONOS

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

In the framework of the FP5 European project Siconos (2002-2006), Bipop was the leader of the Work Package 2 (WP2), dedicated to the numerical methods and the software design for nonsmooth dynamical systems. This has given rise to the platform SICONOS which is the main software development task in the team. The aim of this work is to provide a common platform for the simulation, modeling, analysis and control of abstract nonsmooth dynamical systems. Besides usual quality attributes for scientific computing software, we want to provide a common framework for various scientific fields, to be able to rely on the existing developments (numerical algorithms, description and modeling software), to support exchanges and comparisons of methods, to disseminate the know-how to other fields of research and industry, and to take into account the diversity of users (end-users, algorithm developers, framework builders) in building expert interfaces in Python and end-user front-end through Scilab.

After the requirement elicitation phase, the Siconos Software project has been divided into 5 work packages which are identified to software products:

1. SICONOS/NUMERICS This library contains a set of numerical algorithms, already well identified, to solve non smooth dynamical systems. This library is written in low-level languages (C,F77) in order to ensure numerical efficiency and the use of standard libraries (Blas, Lapack, ...)
2. SICONOS/KERNEL This module is an object-oriented structure (C++) for the modeling and the simulation of abstract dynamical systems. It provides the users with a set of classes to describe their nonsmooth dynamical system (dynamical systems, intercations, nonsmooth laws, ...) and to perform a numerical time integration and solving.
3. SICONOS/FRONT-END. This module is mainly an auto-generated wrapper in Python which provides a user-friendly interface to the Siconos libraries. A scilab interface is also provided in the Front-End module.
4. SICONOS/CONTROL This part is devoted to the implementation of control strategies of non smooth dynamical systems.
5. SICONOS/MECHANICS. This part is dedicated to the modeling and the simulation of multi-body systems with 3D contacts, impacts and Coulomb's friction. It uses the Siconos/Kernel as simulation engine but relies on a industrial CAD library (OpenCascade and pythonOCC) to deal with complex body geometries and to compute the contact locations and distances between B-Rep description and on Bullet for contact detection between meshes.

Further informations may be found at http://siconos.gforge.inria.fr/

COMMANDS Project-Team

6. New Software and Platforms

6.1. BOCOP

Boite à Outils pour le Contrôle OPtimal
KEYWORDS: Energy management - Numerical optimization - Biology - Identification - Dynamic Optimization - Transportation
FUNCTIONAL DESCRIPTION

Bocop is an open-source toolbox for solving optimal control problems, with collaborations with industrial and academic partners. Optimal control (optimization of dynamical systems governed by differential equations) has numerous applications in transportation, energy, process optimization, energy and biology. Bocop includes a module for parameter identification and a graphical interface, and runs under Linux / Windows / Mac.

- Participants: Joseph Frédéric Bonnans, Pierre Martinon, Olivier Tissot and Benjamin Heymann
- Contact: Pierre Martinon
- URL: http://bocop.org

6.2. Bocop Avion

KEYWORDS: Optimization - Aeronautics
FUNCTIONAL DESCRIPTION

Optimize the climb speeds and associated fuel consumption for the flight planning of civil airplanes.

- Participants: Joseph Frédéric Bonnans, Pierre Martinon, Stéphan Maindrault, Cindie Andrieu, Pierre Jouniaux and Karim Tekkal
- Contact: Pierre Martinon

6.3. Bocop HJB

- Participants: Joseph Frédéric Bonnans, Pierre Martinon, Benjamin Heymann and Olivier Tissot
- Contact: Joseph Frédéric Bonnans
- URL: http://bocop.org

DISCO Project-Team

6. New Software and Platforms

6.1. OreAlgebraicAnalysis

FUNCTIONAL DESCRIPTION

OreAlgebraicAnalysis is a Mathematica implementation of algorithms available in the OreModules and the OreMorphisms packages (developed in Maple). OreAlgebraicAnalysis is based on the implementation of Grobner bases over Ore algebras available in the Mathematica HolonomicFunctions package developed by Christoph Koutschan (RICAM). OreAlgebraicAnalysis can handle larger classes of Ore algebras than the ones accessible in Maple, and thus we can study larger classes of linear functional systems. Finally, Mathematica internal design allows us to consider classes of systems which could not easily be considered in Maple such as generic linearizations of nonlinear functional systems defined by explicit nonlinear equations and systems containing transcendental functions (e.g., trigonometric functions, special functions). This package has been developed within the PHC Parrot project CASCAC.

- Participants: Alban Quadrat and Thomas Cluzeau
- Contact: Alban Quadrat
- URL: http://pages.saclay.inria.fr/alban.quadrat/OreAlgebraicAnalysis/index.html

6.2. OreModules

FUNCTIONAL DESCRIPTION

The OreModules package, based on the commercial Maple package Ore-algebra, is dedicated to the study of linear multidimensional systems defined over certain Ore algebras of functional operators (e.g., ordinary or partial differential systems, time-delay systems, discrete systems) and their applications in mathematical systems theory, control theory and mathematical physics.

- Participants: Frédéric Chyzak and Alban Quadrat
- Contact: Alban Quadrat
- URL: http://wwwb.math.rwth-aachen.de/OreModules/

6.3. OreMorphisms

FUNCTIONAL DESCRIPTION

The OreMorphisms package of OreModules is dedicated to the implementation of homological algebraic tools such as the computations of homomorphisms between two finitely presented modules over certain noncommutative polynomial algebras (Ore algebras), of kernel, coimage, image and cokernel of homomorphisms, Galois transformations of linear multidimensional systems and idempotents of endomorphism rings. Using the packages Stafford and Quillen-Suslin , the factorization, reduction and decomposition problems can be constructively studied for different classes of linear multidimensional systems. Many linear systems studied in engineering sciences, mathematical physics and control theory have been factorized, reduced and decomposed by means of the OreMorphisms package.

- Participants: Alban Quadrat and Thomas Cluzeau
- Contact: Alban Quadrat
- URL: http://pages.saclay.inria.fr/alban.quadrat/OreMorphisms/index.html

6.4. PurityFiltration

FUNCTIONAL DESCRIPTION

The PurityFiltration package, built upon the OreModules package, is an implementation of a new effective algorithm which computes the purity/grade filtration of linear functional systems (e.g., partial differential systems, differential time-delay systems, difference systems) and equivalent block-triangular matrices. This package is used to compute closed form solutions of over/underdetermined linear partial differential systems which cannot be integrated by the standard computer algebra systems such as Maple and Mathematica.

- Contact: Alban Quadrat
- URL: http://pages.saclay.inria.fr/alban.quadrat/OreAlgebraicAnalysis/index.html

6.5. QuillenSuslin

FUNCTIONAL DESCRIPTION

QuillenSuslin is a Maple implementation of a constructive version of the Quillen-Suslin Theorem. It provides an algorithm which computes a basis of a free module over a polynomial ring. In terms of matrices, this algorithm completes a unimodular rectangular matrix (e.g. a unimodular row) to an invertible matrix over the given polynomial ring with rational or integer coefficients. The package was also extended with Park's Algorithm to deal with unimodular rows over Laurent polynomial rings and with heuristic methods for localizations of polynomial rings.

- Participants: Alban Quadrat and Anna Fabiańska
- Contact: Alban Quadrat
- URL: http://wwwb.math.rwth-aachen.de/QuillenSuslin/

6.6. Stafford

FUNCTIONAL DESCRIPTION

The Stafford package of OreModules contains an implementation of two constructive versions of Stafford's famous but difficult theorem [96] stating that every ideal over the Weyl algebra An(k) (resp., Bn(k)) of partial differential operators with polynomial (resp., rational) coefficients over a field k of characteristic 0 (e.g., k=Q,R) can be generated by two generators. Based on this implementation and algorithmic results developed by the authors of the package, two algorithms which compute bases of free modules over the Weyl algebras An(Q) and Bn(Q) have been implemented. The rest of Stafford's results developed in [96] have recently been made constructive (e.g., computation of unimodular elements, decomposition of modules, Serre's splitting-off theorem, Stafford's reduction, Bass' cancellation theorem, minimal number of generators) and implemented in the Stafford package. The development of the Stafford package was motivated by applications to linear systems of partial differential equations with polynomial or rational coefficients (e.g., computation of injective parametrization, Monge problem, differential flatness, the reduction and decomposition problems and Serre's reduction problem). To our knowledge, the Stafford package is the only implementation of Stafford's theorems nowadays available.

- Participants: Alban Quadrat and Daniel Robertz
- Contact: Alban Quadrat
- URL: http://wwwb.math.rwth-aachen.de/OreModules/index_sub.html

6.7. YALTA

FUNCTIONAL DESCRIPTION

The YALTA toolbox is a Matlab toolbox dedicated to the study of classical and fractional systems with delay in the frequency-domain. Its objective is to provide basic but important information such as, for instance, the position of the neutral chains of poles and unstable poles, as well as the root locus with respect to the delay of the system. The corresponding algorithms are based on recent theoretical results and on classical continuation methods exploiting the particularities of the problem.

- Participants: Hugo Cavalera, Catherine Bonnet, Andre Fioravanti, Le Ha Vy Nguyen, Jim Pioche
- Contact: Catherine Bonnet
- URL: http://yalta-toolbox.gforge.inria.fr/

The YALTA toolbox is a Matlab toolbox dedicated to the study of classical and fractional systems with delay in the frequency-domain. Its objective is to provide basic but important information such as, for instance, the position of the neutral chains of poles and unstable poles, as well as the root locus with respect to the delay of the system. The corresponding algorithms are based on recent theoretical results (see, for instance, [78] and [85]) and on classical continuation methods exploiting the particularities of the problem [86], [87].

For classical delay systems, a Pade2 approximation scheme is available as well as a finite-dimensional approximation of the system.

Binaries are freely available at http://yalta-toolbox.gforge.inria.fr/.

The YALTA GUI (graphical user interface) is a graphical application developed in Python that interacts with the Matlab toolbox YALTA. User actions are performed through intuitive graphic elements (dialog boxes, icons, menus, scroll bars) in order to capitalize on the functionalities of YALTA. This software, still in development, is based on PyQt, a Python binding of the cross-platform GUI toolkit Qt (C++).

Recently, some features have been added. YALTA toolbox and YALTA GUI have been designed to support multi-languages settings (English and French languages currently available). Parallely, the implementation of the Pade2 approximation scheme has been improved. Finally, continuous integration processes and tools such as Jenkins Hudson have been configured and managed to ensure long-term software quality.

GECO Project-Team (section vide)

I4S Project-Team

6. New Software and Platforms

6.1. Platform: PEGASE

Plate-forme Experte Générique pour Applications Sans-fil Embarquées
KEYWORD: SHM (Structural Health Monitoring)
SCIENTIFIC DESCRIPTION

I4S is actually finalizing the setup of a new platform named PEGASE 2.0 as the technological successor of the previous PEGASE platform developed by IFSTTAR.

The new version of PEGASE keeps the best of its previous version in its main vocation, to be a generic high level Wireless Sensor Platofrm.

What does not change between PEGASE 1 and 2.0: Based on various feedback from application fields, results from real structures monitored by PEGASE, and due to the rapid obsolescence of electronic devices, the design of the new PEGASE platform has been launched in 2013. Some of the main functions of PEGASE does not change but are reinforced.

Software genericity: use of a Linux embedded OS to make any application developed independently from the hardware, to make the user able to manage the system without ant physical and heavy operations.

Hardware genericity: with a principle of daughter and mother boards, each redundant need is embedded (processing, memory, timing, GPS, energy, etc) which each pluggable daughter board implements a specific function (sensing, 3G, Ethernet, communication, signal processing and relay control).

Accurate time synchronization: based on an original GPS and PPS algorithm, PEGASE platform is one of the only board able to time-stamp data from sensors or any event with an accuracy of some micro-seconds Universal Time.

What's new on PEGASE 2 platform ?

Previous principles are maintained or extended. Full electronic design from scratch occurred in 2014 to maximise its capacities in terms efficiency, cost, energy consumption, etc. Its main characteristics are

Important software evolutions: the platform embedded a real Linux kernel (not
FUNCTIONAL DESCRIPTION

I4S is actually finalizing the setup of a new platform named PEGASE 2.0 as the technological successor of the previous PEGASE platform developed by IFSTTAR.

The new version of PEGASE keeps the best of its previous version in its main vocation, to be a generic high level Wireless Sensor Platofrm.

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Software genericity: use of a Linux embedded OS to make any application developed independently from the hardware, to make the user able to manage the system without ant physical and heavy operations.

Hardware genericity: with a principle of daughter and mother boards, each redundant need is embedded (processing, memory, timing, GPS, energy, etc) which each pluggable daughter board implements a specific function (sensing, 3G, Ethernet, communication, signal processing and relay control).

Accurate time synchronization: based on an original GPS and PPS algorithm, PEGASE platform is one of the only board able to time-stamp data from sensors or any event with an accuracy of some micro-seconds Universal Time.

- Participants: Vincent Le Cam, Mathieu Le Pen, Laurent Mevel and Michael Doehler
- Contact: Michael Doehler
- URL: http://www.a3ip.com/joomla/index.php?option=com_content&view=article&id=12&Itemid=8

6.2. TDISTL

Time domain inverse scattering for transmission lines
KEYWORDS: Transmission lines - Problem inverse - Fault diagnosis
SCIENTIFIC DESCRIPTION

TDISTL is a time domain variant of the previously developed frequency domain software ISTL for numerical computations of the inverse scattering transform applied to electrical transmission lines. It provides an efficient solution to experimentally determining the distributed characteristic impedance of electrical transmission line from the time domain reflectogram (impulse response) measured at one end of the line. Its current applications are in the fields of electrical cable fault diagnosis. It is registered at Agence pour la Protection des Programmes (APP) under the number IDDN.FR.001.250014.000.S.P.2015.000.30705.

FUNCTIONAL DESCRIPTION

Computation of the distributed characteristic impedance of a transmission line from time domain reflectometry measurement

- Participants: Qinghua Zhang and Michel Sorine
- Contact: Qinghua Zhang

6.3. Cloud2SM

Cloud architecture design for Structural Monitoring with in-line Sensors and Models tasking
KEYWORDS: SHM, online physical models, Data Management, Multi-physics Sensing, GPGPU acceleration
SCIENTIFIC DESCRIPTION

From the past decades the monitoring of civil engineering structure became a major field of research and development process in the domains of modelling and integrated instrumentation. This increasing of interest can be attributed in part to the need of controlling the aging of such structures and on the other hand to the need to optimize maintenance costs. From this standpoint the project Cloud2SM (inria ADT) has been launched to develop a robust information system able to assess the long term monitoring of civil engineering structures as well as interfacing various sensors and data. The specificity of such architecture is to be based on the notion of data processing through physical or statistical models. Thus the data processing, whether material or mathematical, can be seen here as a resource of the main architecture. The project can be divided in various items:

- The sensors and their measurement process: Those items provide data to the main architecture and can embed storage or computational resources. Dependent of onboard capacity and the amount of data generated it can be distinguished heavy and light sensors.
- The storage resources: Based on the cloud concept this resource can store at least two types of data, raw data and processed ones.
- The computational resources: This item includes embedded “pseudo real time” resources as the dedicated computer cluster or computational resources.
- The models: Used for the conversion of raw data to meaningful data. Those types of resources inform the system of their needs they can be seen as independents blocks of the system.
- The user interface: This item can be divided in various HMI to assess maintaining operation on the sensors or pop-up some information to the user.
- The demonstrators: The structures themselves.

Beside those objective, the I4S ADT campaign has allowed the development of the first block of the architecture: the data acquisition system. Called Cloud2IR, this prototype implementation of generic sensor interface has been specialized for the long term thermal monitoring of civil engineering structure and opened the way to the development of a whole ecosystem of sensors

6.3.1. Cloud2IR

Cloud 2IR is a software dedicated to the structural health monitoring of civil engineering structures thanks to long term thermal imaging. Its particularity lies in the fact that it is based on a generic approach of the acquisition system concept and the format of the data. That allow it to apply to other types of sensor. Information can be obtained on the inria bil, https://bil.inria.fr/fr/software/view/2536/tab.

Maxplus Team

6. New Software and Platforms

6.1. Boîte à outil Maxplus de SCILAB/Maxplus toolbox of Scilab

Trois chercheurs du groupe (S. Gaubert, J.-P. Quadrat, et G. Cohen) ont développé (à partir d'une première version réalisée par M. Mc Gettrick) la *boîte à outils Maxplus* de Scilab, qui est téléchargeable librement parmi les contributions du site Scilab, et qui est maintenant intégrée par défaut dans Scicoslab. Cette boîte à outils implémente l'ensemble du calcul numérique linéaire max-plus, elle comprend en particulier le stockage creux des matrices, et des algorithmes efficaces pour le calcul de la valeur propre basées sur les itérations sur les politiques. Elle a été utilisées par plusieurs chercheurs, voir notamment [66], [135]. Il faut aussi noter que le groupe de L. Hardouin, du LISA/Istia, a complété la boîte à outils Maxplus en interfaçant leur propre librairie C++, qui permet le calcul des séries de transfert de graphes d'événements temporisés.

English version

Three researchers of the team (S. Gaubert, J.-P. Quadrat, and G. Cohen, building on a preliminary version of M. McGettrick) have developed and released the *Maxplus toolbox* of Scilab, which is freely available among the contributions on the Scilab web site, and which is now included by default in Scicoslab. It implements all basic linear algebra functionalities, with a special attention to large sparse matrices, including efficient algorithms for eigenvalue computation based on policy iteration. The software has been used by several researchers in their work, including [66], [135]. It should be noted that the team of L. Hardouin, from LISA/Istia, has completed the toolbox by interfacing their own C++ library computing the transfer series of a timed event graph.

6.2. Itérations sur les politiques pour les jeux stochastiques à somme nulle/Policy iterations for zero sum stochastic games

L'algorithme d'itérations sur les politiques pour les jeux stochastiques à somme nulle pour le cas de paiements ergodiques (gain moyen par unité de temps), et dégénérés de type "multi-chaîne" a été introduit dans [84]. Plusieurs stages ont permis l'implémentation partielle en Scilab, C ou C++, et le test de ce type d'algorithmes (voir le travail de Vishesh Dhingra [101]), ou de son couplage avec la résolution de systèmes linéaires par des méthodes multigrilles algébriques (stage de Shantanu Gangal en 2007). Le travail de thèse de Sylvie Detournay a permis le développement d'un programme complet. Le code écrit par Sylvie Detournay (en C) a été déposé sur InriaGForge. Pour le moment il n'est accessible qu'aux membres de l'équipe.

English version

The policy iteration algorithm for zero sum repeated games with ergodic payoff (i.e. mean payoff per time unit), and in degenerate "multichain" cases, has been introduced in [84]. Several internships allowed us to implement in Scilab, C or C++, and to test such algorithms (see the work of Vishesh Dhingra [101]), or its combinaison with the resolution of linear systems by algebraic multigrid methods (internship of Shantanu Gangal in 2007). The PhD thesis work of Sylvie Detournay allowed us to develop a complete program. The program written by Sylvie Detournay (in C language) has been posted on InriaGForge. For the moment it can only be seen by members of the team.

6.3. TPLib: bibliothèque pour la manipulation de polyèdres tropicaux/TPLib: tropical polyhedra library

TPLib est une bibliothèque écrite en OCaml qui permet de manipuler des polyèdres tropicaux. Elle est distribuée sous license LGPL https://gforge.inria.fr/projects/tplib.

Cette bibliothèque implémente notamment des algorithmes permettant de passer d'une représentation externe d'un polyèdre à une représentation interne, ou inversement (voir §7.2.1 pour plus de détails). Elle permet aussi de réaliser d'autres opérations fondamentales, comme le calcul du complexe polyédral associé à un polyèdre donné (au sens de Develin et Sturmfels [97]), ou le calcul de cônes tangents tropicaux. Enfin, elle fournit toutes les primitives permettant d'utiliser les polyèdres tropicaux en tant que domaine abstrait numérique, afin de déterminer des invariants de programmes ou systèmes faisant intervenir les opérations $\min$ et $\max$ (voir [61]).

TPLib est utilisé dans le logiciel Polymake [116], développé à la Technische Universität Berlin (Allemagne). Ce dernier logiciel constitue une boite à outils permettant de manipuler des nombreux objets mathématiques (polytopes convexes, complexes polyédraux, graphes, matroïdes, polytopes tropicaux).

Le développement d'interfaces avec d'autres logiciels est désormais facilité grâce à la présence de *bindings* dans le langage C. Grâce à cela, un prototype d'interface a été réalisé entre TPLib et l'outil VerifyTAPN (https://launchpad.net/verifytapn), qui permet la vérification de réseaux de Pétri avec arcs temporisés. De même, une interface à la bibliothèque de domaines abstraits numériques APRON [127] est également en cours de développement.

English version

TPLib is a library written in OCaml, which allows to manipulate tropical polyhedra. It is distributed under LGPL https://gforge.inria.fr/projects/tplib.

This library implements algorithms allowing to pass from an external representation of a polyhedron to an internal description, or inversely (see §7.2.1 for more details). Besides, the library allows to perform several fundamental operations over tropical polyhedra, such as computing the associated polyhedral complex (see Develin and Sturmfels [97]), or determining the tropical tangent cone at any point. Finally, it provides all the primitives allowing to use tropical polyhedra as an numerical abstract domain, in order to determine program/system invariants involving the operations $\min$ and $\max$ (see [61]).

TPLib is used in the software Polymake [116], developed in Technische Universität Berlin (Germany). Polymake is a toolbox allowing to manipulate mathematic objects such as convex polytopes, polyhedral complexes, graphs, matroids, and tropical polytopes.

The development of further interfaces is now easier thanks to the distribution of bindings in C language. Using these bindings, a prototype of interface has been created between TPLib and the model-checker VerifyTAPN (https://launchpad.net/verifytapn), which allows the verification of timed-arc Petri Nets. An interface to the numerical abstract domain APRON [127] is also under development.

6.4. MPGLib

FUNCTIONAL DESCRIPTION

MPGLib is a library written in OCaml, which allows to manipulate tropical polyhedra.

This library implements algorithms allowing to pass from an external representation of a polyhedron to an internal description, or inversely. Besides, the library allows to perform several fundamental operations over tropical polyhedra, such as computing the associated polyhedral complex (see Develin and Sturmfels), or determining the tropical tangent cone at any point. Finally, it provides all the primitives allowing to use tropical polyhedra as an numerical abstract domain, in order to determine program/system invariants involving the operations min and max.

- Participant: Xavier Allamigeon
- Contact: Xavier Allamigeon
- https://gforge.inria.fr/projects/tplib

MCTAO Project-Team

5. New Software and Platforms

5.1. Hampath

KEYWORDS: Geometric control - Second order conditions - Differential homotopy - Ordinary differential equations
FUNCTIONAL DESCRIPTION

Hampath is a software developped to solve optimal control problems but also to study Hamiltonian flow.

- Participants: Jean-Baptiste Caillau, Olivier Cots and Joseph Gergaud
- Contact: Jean-Baptiste Caillau
- URL: http://cots.perso.enseeiht.fr/hampath/index.html

NECS Project-Team

6. New Software and Platforms

6.1. GTL – Grenoble Traffic Lab

Participants: C. Canudas de Wit [contact person], I. Bellicot, P. Bellemain, L. Leon Ojeda, D. Pisarski, A. Kibangou, H. Fourati, F. Morbidi, F. Garin, A. Ladino Lopez, P. Grandinetti, E. Lovisari, R. Singhal, A. Andreev, R. Piotaix.

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 traffic control policies (ramp metering for the south-ring and optimization of urban signals); the micro-simulator is developed using AIMSUN.

More details at http://necs.inrialpes.fr/pages/grenoble-traffic-lab.php

6.2. Senslogs – Sensors recorder for Android application

Participants: T. Michel [contact person], H. Fourati, P. Geneves, N. Layaida.

This Android application records direct and computed measurements from internal sensors (Accelerometer, gyroscope, magnetometer, calibrated gyroscope, calibrated magnetic field, game rotation vector, geomagnetic, rotation vector, gravity, linear acceleration, significant motion, step counter, step detector, ambient temperature, light, pressure, relative humidity, heart rate, proximity, GPS location, cell and wifi location, passive location, NMEA data, wifi signals, Bluetooth signals (not yet), NFC (not yet), and others available...). Data are stored in files using space-separated values. This application has been designed for post-processing projects. It will be used in pedestrian navigation and augmented reality applications. This application is available online: https://play.google.com/store/apps/details?id=fr.inria.tyrex.senslogs&hl=fr_BE

NON-A Project-Team

5. New Software and Platforms

5.1. Blimp

FUNCTIONAL DESCRIPTION

Scientific research and development on the control of autonomous airships have shown a significant growth in recent years. New applications appear in the areas such as freight carrier, advertising, monitoring, surveillance, transportation, military and scientific research. The control of autonomous airships is a very important problem for the aerial robots research.

The development of Blimp by Non-A is used for experimentation and demonstration of controlling algorithms. The blimp is required to provide some environment information and status of itself, such as surveillance video of surrounding environment, gesture of blimp, altitude of blimp. With these basic information, one could localize blimp with certain algorithm (visual SLAM for example) or implement one controller in order to improve the stability and maneuverability of blimp.

- Contact: Jean-Pierre Richard

5.2. SLIM

FUNCTIONAL DESCRIPTION

Multi-robots cooperation can be found as an application in many domains of science and technology: manufacturing, medical robotics, personal assistance, military/security and spatial robots. The market of robots is quickly developing and its capacity is continuously growing. Concerning cooperation of mobile multi-robots, 3 key issues have to be studied: Localization, path planning and robust control, for which Non-A team has worked and proposed new algorithms. Due to the ADT SLIM, we implement our algorithms (localization, path planning and robust control) and integrate them into ROS (Robotic Operating System) as a package, named SLIM.

- Contact: Jean-Pierre Richard

QUANTIC Project-Team (section vide)

SPHINX Team

6. New Software and Platforms

6.1. GPELab

Gross-Pitaevskii equations Matlab toolbox
KEYWORDS: 3D - Quantum chemistry - 2D
FUNCTIONAL DESCRIPTION

GPELab is a Matlab toolbox developed to help physicists for computing ground states or dynamics of quantum systems modeled by Gross-Pitaevskii equations. This toolbox allows the user to define a large range of physical problems (1d-2d-3d equations, general nonlinearities, rotation term, multi-components problems...) and proposes numerical methods that are robust and efficient.

- Contact: Xavier Antoine
- URL: http://gpelab.math.cnrs.fr/

6.2. GetDDM

KEYWORDS: Large scale - 3D - Domain decomposition - Numerical solver
FUNCTIONAL DESCRIPTION

GetDDM combines GetDP and Gmsh to solve large scale finite element problems using optimized Schwarz domain decomposition methods.

- Contact: Xavier Antoine
- URL: http://onelab.info/wiki/GetDDM

6.3. Platform: Vir'Volt

Vir'Volt is a prototype build in ESSTIN, an engineering school of Université de Lorraine, as part of a student project. The prototype enters low-consumption vehicle race, where the winner covers a given distance (depending upon the race, around 20 km) at a given average speed (around 25 km/h) with the lowest energy consumption. Thomas Chambrion has been in charge of the embedded automatic speed control of Vir'Volt for 6 years. In 2016, Vir'Volt will take part in the European Shell Eco Marathon organized in London. The sloping track (up to 5% uphill and 4% downhill) required a complete rebuild of the transmission parts. The proposed configuration has been obtained after intensive numerical simulations.

- Contact: Thomas Chambrion
- URL: http://www.ecomotionteam.org/blog/?page_id=3072

DOLPHIN Project-Team

6. New Software and Platforms

6.1. COCO

COmparing Continuous Optimizers
KEYWORDS: Benchmarking - Numerical optimization - Black-box optimization - Stochastic optimization

6.1.1. SCIENTIFIC DESCRIPTION

COmparing Continuous Optimisers (COCO) is a tool for benchmarking algorithms for black-box optimisation. COCO facilitates systematic experimentation in the field of continuous optimization. COCO provides: (1) an experimental framework for testing the algorithms, (2) post-processing facilities for generating publication quality figures and tables, (3) LaTeX templates of articles which present the figures and tables in a single document. The COCO software is composed of two parts: (i) an interface available in different programming languages (C/C++, Java, Matlab/Octave, R, Python) which allows to run and log experiments on multiple test functions testbeds of functions (noisy and noiseless) are provided (ii) a Python tool for generating figures and tables that can be used in the LaTeX templates. In 2015, we extended the software towards multiobjective optimization and will provide a first release in early 2016.

6.1.2. FUNCTIONAL DESCRIPTION

The Coco Platform provides the functionality to automatically benchmark optimization algorithms for unbounded, unconstrained optimization problems in continuous domains. Benchmarking is a vital part of algorithm engineering and a necessary path to recommend algorithms for practical applications. The Coco platform releases algorithm developers and practitioners alike from (re-)writing test functions, logging, and plotting facilities by providing an easy-to-handle interface in several programming languages. The Coco platform has been developed since 2007 and has been used extensively within the "Blackbox Optimization Benchmarking (BBOB)" workshop series since 2009. Overall, 151 algorithms and algorithm variants by contributors from all over the world have been benchmarked with the platform so far and all data is publicly available for the research community. For 2016, a new suite of benchmark functions for bi-objective problems is expected to build the basis of the next BBOB workshop at GECCO 2016 for which a new software release is planned for January.

- Participants: Dimo Brockhoff, Arnaud Liefooghe, Thanh-Do Tran, Dejan Tušar, Tea Tušar (all Dolphin), Nikolaus Hansen, Anne Auger, Marc Schoenauer, Ouassim Ait Elhara, Asma Atamna, Phillipe Sampaio, and Duc Manh Nguyen (all TAO team)
- Partners: TU Dortmund University, Germany and Czech Technical University, Czech Republic
- Contact: Dimo Brockhoff
- URL: http://coco.gforge.inria.fr/, https://github.com/numbbo/coco

6.2. MO-Mine

SCIENTIFIC DESCRIPTION

MO-Mineclust is the first package of the platform and is dedicated to clustering (unsupervised classification). Indeed, it is well-known that clustering may be seen as a bi-objective optimization problem as the goal is both to minimize distances between data belonging to a same cluster, while maximizing distances between data belonging to different clusters. Several models (objective functions used,...) and engines (optimization algorithms) have been implemented. The framework searches, for a given dataset, the best association of model/engine/parameter without specifiing the number of clusters. MO-Mineclust shows very interesting behavior and shows that the choice of the model and the engine has a great importance in the performance of the method and depends on the dataset to analyze.

FUNCTIONAL DESCRIPTION

MO-Mine is a process of tests and evaluations of multi-objective optimisation algorithms for data mining. MO-Mine platform will provide data sets (literature + synthetics benchmarks), data mining (Features selection, Clustering, Classification and Association rules) algorithms based on multi-objective metaheuristics (Evolutionary algorithm), validation methods and tools to compare algorithms. MO-Mine is based on evolutionary algorithms implemented in ParadisEO and adapted to solve problem of data mining. MO-Mine proposed to users to compare their own methods with different approaches following protocols clearly identified and shared.

- Participants: B. Fisset, L. Jourdan and C. Dhaenens
- Contact: Laetitia Jourdan
- URL: http://mo-mine.gforge.inria.fr/doku.php

6.3. ParadisEO

KEYWORD: Parallelisation
SCIENTIFIC DESCRIPTION

ParadisEO (PARallel and DIStributed Evolving Objects) is a C++ white-box object-oriented framework dedicated to the flexible design of metaheuristics. Based on EO, a template-based ANSI-C++ compliant evolutionary computation library, it is composed of four modules: * Paradiseo-EO provides tools for the development of population-based metaheuristic (Genetic algorithm, Genetic programming, Particle Swarm Optimization (PSO)...) * Paradiseo-MO provides tools for the development of single solution-based metaheuristics (Hill-Climbing, Tabu Search, Simulated annealing, Iterative Local Search (ILS), Incremental evaluation, partial neighborhood...) * Paradiseo-MOEO provides tools for the design of Multi-objective metaheuristics (MO fitness assignment shemes, MO diversity assignment shemes, Elitism, Performance metrics, Easy-to-use standard evolutionary algorithms...) * Paradiseo-PEO provides tools for the design of parallel and distributed metaheuristics (Parallel evaluation, Parallel evaluation function, Island model) Furthermore, ParadisEO also introduces tools for the design of distributed, hybrid and cooperative models: * High level hybrid metaheuristics: coevolutionary and relay model * Low level hybrid metaheuristics: coevolutionary and relay model
FUNCTIONAL DESCRIPTION

Paradiseo is a software framework for metaheuristics (optimisation algorithms aimed at solving difficult optimisation problems). It facilitates the use, development and comparison of classic, multi-objective, parallel or hybrid metaheuristics.

- Partners: CNRS - Université Lille 1
- Contact: El-Ghazali Talbi
- URL: http://paradiseo.gforge.inria.fr/

6.4. VRPsolve

KEYWORDS: C++ - Mobile Computing, Transportation - Optimization

- Participants: Clive Ferret-Canape, Arnaud Liefooghe and Sébastien Vérel
- Contact: Arnaud Liefooghe
- URL: http://gforge.inria.fr/projects/vrpsolve (limited access)

SCIENTIFIC DESCRIPTION

VRPsolve is a software for solving vehicle routing problems dealing with last-mile delivery issues that arise as we approach the final customer. When modeling and solving combinatorial optimization problems, especially problems related to the transport of goods and people, the resulting models are generally subject to a specific development in order to be validated, as industrial needs are highly dependent of the application domain. However, a set of conventional objectives and constraints, such as vehicles capacities, incompatible parcels, time windows, are now commonly encountered. In addition to being efficient and effective, VRPsolve differentiates from other tools by allowing to quickly and conveniently integrate ad-hoc constraints and objectives into a generic software. Indeed, VRPsolve effectively deal with industrial last-mile delivery vehicle routing problems and is able to cope with multiple objectives and a large number of constraints by using advanced optimization algorithms which are usually not available with existing softwares. In addition, VRPsolve allows industrial collaborations to be addressed by solving real-world problems requiring geographic information systems (GIS).

FUNCTIONAL DESCRIPTION

The current release includes the following functional and technical specifications:

- A modular architecture which allows for an easy integration into a global information system (with respect to data standards, weak coupling with external libraries, etc),
- An independent geographic information system with graphic display,
- A resolution engine based on metaheuristics (running in a high-performance computing mode),
- The possibility of coupling with other optimization solvers and frameworks like Paradiseo (in order to enable a quick prototyping of new optimization algorithms),
- Objective- and constraint-handling that can be easily configured by the user,
- Software engineering (build system testing, continuous integration, etc).

6.5. Platforms

6.5.1. Grid'5000

The Grid'5000 experimental platform is a scientific instrument to support computer science research related to distributed systems, including parallel processing, high performance computing, cloud computing, operating systems, peer-to-peer systems and networks. It is distributed on 10 sites in France and Luxembourg, including Lyon. Grid'5000 is a unique platform as it offers to researchers many and varied hardware resources and a complete software stack to conduct complex experiments, ensure reproducibility and ease understanding of results.

- Participants: F. Desprez, F. Huet, E. Jeannot, Y. Jegou, A. Lebre, L. Lefevre, F. Loui, D. Margery, N. Melab, J-M. Menaud, P. Neyron, L. Nussbaum, C. Perez, J-M. Pierson, O. Richard., S. Varette.
- Contact: Frédéric Desprez
- URL: https://www.grid5000.fr/mediawiki/index.php/Grid5000:Home

GEOSTAT Project-Team

6. New Software and Platforms

6.1. Fluex

KEYWORDS: Signal - Signal processing
SCIENTIFIC DESCRIPTION

Fluex is a nonlinear signal processing software for 1D, 2D 3D and 3D+t general signals.
FUNCTIONAL DESCRIPTION

- Fluex is a library in nonlinear signal processing, written in C++, developed under Gforge, able to analyze turbulent and natural complex signals.
- Fluex is able to determine low level features in natural signals that cannot be determined using standard linear techniques.
- Participants: Hussein Yahia, Denis Arrivault, Rémi Paties.
- Contact: Hussein Yahia.
- URL: https://geostat.bordeaux.inria.fr/index.php/downloads.html.
- Fluex is deposited APP, Inter Deposit Digital Number: IDDN.FR.001.51.0028.000.S.P.2015.000.21000

6.2. FluidExponents

- Participants: Hussein Yahia and Antonio Turiel
- Contact: Hussein Yahia
- URL: https://geostat.bordeaux.inria.fr/index.php/downloads.html.

INOCS Team (section vide)

MISTIS Project-Team

6. New Software and Platforms

6.1. MMST

Mixtures of Multiple Scaled Student T distributions
KEYWORDS: Health - Statistics - Brain MRI - Medical imaging - Robust clustering
FUNCTIONAL DESCRIPTION

The package implements mixtures of so-called multiple scaled Student distributions, which are generalisation of multivariate Student T distribution allowing different tails in each dimension. Typical applications include Robust clustering to analyse data with possible outliers. In this context, the model and package have been used on large data sets of brain MRI to segment and identify brain tumors.

- Participants: Alexis Arnaud, Florence Forbes and Darren Wraith
- Contact: Florence Forbes
- URL: http://mistis.inrialpes.fr/realisations.html

6.2. P-LOCUS

KEYWORDS: Health - Neuroimaging - Cancer - Brain MRI - Medical imaging
FUNCTIONAL DESCRIPTION

The Locus software was extended to address the delineation of lesions in pathological brains. Its extension 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.

- Participants: Senan Doyle, Florence Forbes, Michel Dojat and Pascal Rubini
- Partner: INSERM
- Contact: Florence Forbes
- URL: http://p-locus.com/

6.3. PyHRF

KEYWORDS: FMRI - Statistic analysis - Neurosciences - IRM - Brain - Health - Medical imaging
FUNCTIONAL DESCRIPTION

As part of fMRI data analysis, PyHRF provides a set of tools for addressing the two main issues involved in intra-subject fMRI data analysis : (i) the localization of cerebral regions that elicit evoked activity and (ii) the estimation of the activation dynamics also referenced to as the recovery of the Hemodynamic Response Function (HRF). To tackle these two problems, PyHRF implements the Joint Detection-Estimation framework (JDE) which recovers parcel-level HRFs and embeds an adaptive spatio-temporal regularization scheme of activation maps.

- Participants: Thomas Vincent, Solveig Badillo, Lotfi Chaari, Christine Bakhous, Florence Forbes, Philippe Ciuciu, Laurent Risser, Thomas Perret and Aina Frau Pascual
- Partners: CEA - NeuroSpin
- Contact: Florence Forbes
- URL: http://pyhrf.org

MODAL Project-Team

6. New Software and Platforms

6.1. BlockCluster

SCIENTIFIC DESCRIPTION

Simultaneous clustering of rows and columns, usually designated by biclustering, co-clustering or block clustering, is an important technique in two way data analysis. It consists of estimating a mixture model which takes into account the block clustering problem on both the individual and variables sets. The blockcluster package provides a bridge between the C++ core library and the R statistical computing environment. This package allows to co-cluster binary, contingency, continuous and categorical data-sets. It also provides utility functions to visualize the results. This package may be useful for various applications in fields of Data mining, Information retrieval, Biology, computer vision and many more.

FUNCTIONAL DESCRIPTION

BlockCluster is an R package for co-clustering of binary, contingency and continuous data based on mixture models.

- Participants: Parmeet Bhatia, Serge Iovleff, Vincent Brault, Christophe Biernacki, Gilles Celeux and Vincent Kubicki
- Partner: Université de Technologie de Compiègne
- Contact: Serge Iovleff
- URL: http://cran.r-project.org/web/packages/blockcluster/index.html

6.2. Clustericat

FUNCTIONAL DESCRIPTION

Clustericat is an R package for model-based clustering of categorical data. In this package, the Conditional Correlated Model (CCM), published in 2014, takes into account the main conditional dependencies between variables through extreme dependence situations (independence and deterministic dependence). Clustericat performs the model selection and provides the best model according to the BIC criterion and the maximum likelihood estimates.

- Participants: Matthieu Marbac-Lourdelle, Vincent Vandewalle and Christophe Biernacki
- Contact: Matthieu Marbac-Lourdelle
- URL: https://r-forge.r-project.org/R/?group_id=1803

6.3. CoModes

FUNCTIONAL DESCRIPTION

CoModes is another R package for model-based clustering of categorical data. In this package, the Conditional Modes Model (CMM), submitted for publication in 2014, takes into account the main conditional dependencies between variables through particular modality crossings (so-called modes). CoModes performs the model selection and provides the best model according to the exact integrated likelihood criterion and the maximum likelihood estimates.

- Participants: Matthieu Marbac-Lourdelle, Vincent Vandewalle and Christophe Biernacki
- Contact: Christophe Biernacki
- URL: https://r-forge.r-project.org/R/?group_id=1809

6.4. CorReg

FUNCTIONAL DESCRIPTION

The main idea of the CorReg package is to consider some form of sub-regression models, some variables defining others. We can then remove temporarily some of the variables to overcome ill-conditioned matrices inherent in linear regression and then reinject the deleted information, based on the structure that links the variables. The final model therefore takes into account all the variables but without suffering from the consequences of correlations between variables or high dimension.

- Participants: Clément Thery and Christophe Biernacki
- Contact: Clément Thery
- URL: https://cran.r-project.org/web/packages/CorReg/index.html

6.5. FunFEM

FUNCTIONAL DESCRIPTION

FunFEM package for R proposes a clustering tool for functional data. The model-based algorithm clusters the functional data into discriminative subspaces.

- Participants: Charles Bouveyron and Julien Jacques
- Contact: Charles Bouveyron
- URL: https://cran.r-project.org/web/packages/funFEM/index.html

6.6. FunHDDC

FUNCTIONAL DESCRIPTION

FunHDDC package for R proposes a clustering tool for functional data. The model-based clustering algorithm considers that functional data live in cluster-specific subspaces.

- Participants: Charles Bouveyron and Julien Jacques
- Contact: Charles Bouveyron
- URL: https://cran.r-project.org/web/packages/funHDDC/index.html

6.7. Galaxy - MPAgenomics

FUNCTIONAL DESCRIPTION

Galaxy is an open, web-based platform for data intensive biomedical research. Galaxy features user friendly interface, workflow management, sharing functionalities and is widely used in the biologist community. The MPAgenomics R package developped by Modal has been integrated into Galaxy, and the Galaxy-Modal instance has been publicly deployed thanks to the IFB-cloud infrastructure.

- Participants: Guillemette Marot and Samuel Blanck
- Contact: Guillemette Marot
- URL: https://cloud.france-bioinformatique.fr/accounts/login/

6.8. HDPenReg

FUNCTIONAL DESCRIPTION

HDPenReg (High-Dimensional Penalized Regression) is an R-package based on a C++ code dedicated to the estimation of regression model with l1-penalization.

- Participants: Quentin Grimonprez and Serge Iovleff
- Contact: Quentin Grimonprez
- URL: https://cran.r-project.org/web/packages/HDPenReg/index.html

6.9. MPAGenomics

KEYWORDS: Segmentation - Genomics - Marker selection - Biostatistics
SCIENTIFIC DESCRIPTION

MPAgenomics (Multi-Patient Analysis of Genomic markers) is an R package for multi-patients analysis of genomics markers. It enables to study several copy number and SNP data profiles at the same time. It offers wrappers from commonly used packages to offer a pipeline for beginners in R. It also proposes a special way of choosing some crucial parameters to change some default values which were not adapted in the original packages. For multi-patients analysis, it wraps some penalized regression methods implemented in HDPenReg.
FUNCTIONAL DESCRIPTION

MPAgenomics provides functions to preprocess and analyze genomic data. It is devoted to: (i) efficient segmentation and (ii) genomic marker selection from multi-patient copy number and SNP data profiles.

- Participants: Quentin Grimonprez, Guillemette Marot and Samuel Blanck
- Contact: Guillemette Marot
- URL: https://cran.r-project.org/web/packages/MPAgenomics/index.html

6.10. MetaMA

FUNCTIONAL DESCRIPTION

MetaMA (Meta-analysis for MicroArrays) is a specialised software for microarrays. It is an R package which combines either p-values or modified effect sizes from different studies to find differentially expressed genes. The main competitor of metaMA is geneMeta. Compared to geneMeta, metaMA offers an improvement for small sample size datasets since the corresponding modelling is based on shrinkage approaches.

- Participant: Guillemette Marot
- Contact: Guillemette Marot
- URL: https://cran.r-project.org/web/packages/metaMA/index.html

6.11. MetaRNASeq

FUNCTIONAL DESCRIPTION

This is joint work with Andrea Rau (INRA, Jouy-en-Josas). MetaRNASeq is a specialised software for RNA-seq experiments. It is an R package which is an adaptation of the MetaMA package presented previously. Both implement the same kind of methods but specificities of the two types of technologies require some adaptations to each one.

- Participants: Guillemette Marot and Andrea Rau
- Contact: Guillemette Marot
- URL: https://cran.r-project.org/web/packages/metaRNASeq/index.html

6.12. MixAll

FUNCTIONAL DESCRIPTION

MixAll (Clustering using Mixture Models) is a model-based clustering package for modelling mixed data sets. It has been engineered around the idea of easy and quick integration of any kind of mixture models for any kind of data, under the conditional independence assumption. Currently five models (Gaussian mixtures, categorical mixtures, Poisson mixtures, Gamma mixtures and kernel mixtures) are implemented. MixAll has the ability to natively manage completely missing values when assumed as random. MixAll is used as an R package, but its internals are coded in C++ as part of the STK++ library (www.stkpp.org) for faster computation.

- Participant: Serge Iovleff
- Contact: Serge Iovleff
- URL: https://cran.r-project.org/web/packages/MixAll/

6.13. MixCluster

FUNCTIONAL DESCRIPTION

MixCluster is an R package for model-based clustering of mixed data (continuous, binary, integer). In this package, the model, submitted for publication in 2014, takes into account the main conditional dependencies between variables through Gaussian copula. Mixcluster performs the model selection and provides the best model according to Bayesian approaches.

- Participants: Matthieu Marbac-Lourdelle, Christophe Biernacki and Vincent Vandewalle
- Contact: Christophe Biernacki
- URL: https://r-forge.r-project.org/R/?group_id=1939

6.14. Mixmod

FUNCTIONAL DESCRIPTION

Mixmod is a free toolbox for data mining and statistical learning designed for large and highdimensional data sets. Mixmod provides reliable estimation algorithms and relevant model selection criteria.

It has been successfully applied to marketing, credit scoring, epidemiology, genomics and reliability among other domains. Its particularity is to propose a model-based approach leading to a lot of methods for classification and clustering.

Mixmod allows to assess the stability of the results with simple and thorough scores. It provides an easy-to-use graphical user interface (mixmodGUI) and functions for the R (Rmixmod) and Matlab (mixmodForMatlab) environments.

- Participants: Christophe Biernacki, Gilles Celeux, Gérard Govaert, Florent Langrognet, Serge Iovleff, Remi Lebret and Benjamin Auder
- Partners: CNRS - Université Lille 1 - LIFL - Laboratoire Paul Painlevé - HEUDIASYC - LMB
- Contact: Christophe Biernacki
- URL: http://www.mixmod.org

6.15. MixtComp

FUNCTIONAL DESCRIPTION

MixtComp (Mixture Computation) is a model-based clustering package for mixed data originating from the Modal team (Inria Lille). It has been engineered around the idea of easy and quick integration of all new univariate models, under the conditional independence assumption. New models will eventually be available from researches, carried out by the Modal team or by other teams. Currently, central architecture of MixtComp is built and functionality has been field-tested through industry partnerships. Three basic models (Gaussian, multinomial, Poisson) are implemented, as well as two advanced models (Ordinal and Rank). MixtComp has the ability to natively manage missing data (completely or by interval). MixtComp is used as an R package, but its internals are coded in C++ using state of the art libraries for faster computation.

- Participants: Vincent Kubicki, Christophe Biernacki and Serge Iovleff
- Contact: Christophe Biernacki
- URL: https://modal-research.lille.inria.fr/BigStat

6.16. RankCluster

FUNCTIONAL DESCRIPTION

Rankcluster package for R proposes a clustering tool for ranking data. Multivariate and partial rankings can be also taken into account. Rankcluster now supports tied ranking data.

- Participants: Christophe Biernacki, Julien Jacques and Quentin Grimonprez
- Contact: Quentin Grimonprez
- URL: https://cran.r-project.org/web/packages/Rankcluster/index.html

6.17. STK++

FUNCTIONAL DESCRIPTION

STK++ (C++ Statistical ToolKit) is a versatile, fast, reliable and elegant collection of C++ classes for statistics, clustering, linear algebra, arrays (with an API Eigen-like), regression, dimension reduction, etc. The library is interfaced with lapack for many linear algebra usual methods. Some functionalities provided by the library are available in the R environment using rtkpp and rtkore.

STK++ is suitable for projects ranging from small one-off projects to complete data mining application suites.

- Participant: Serge Iovleff
- Contact: Serge Iovleff
- URL: http://www.stkpp.org

6.18. clere

FUNCTIONAL DESCRIPTION

The clere package for R proposes variable clustering in high dimensional linear regression. Available on CRAN and now submitted to an international journal dedicated to software.

- Participants: Loïc Yengo, Christophe Biernacki and Julien Jacques
- Contact: Loïc Yengo
- URL: https://cran.r-project.org/web/packages/clere/index.html

6.19. rtkore

FUNCTIONAL DESCRIPTION

STK++ (http://www.stkpp.org) is a collection of C++ classes for statistics, clustering, linear algebra, arrays (with an Eigen-like API), regression, dimension reduction, etc. The integration of the library to R is using Rcpp. The rtkore (STK++ core library integration to R using Rcpp) package includes the header files from the STK++ core library. All files contain only templated classes or inlined functions. STK++ is licensed under the GNU LGPL version 2 or later. rtkore (the stkpp integration into R) is licensed under the GNU GPL version 2 or later. See file LICENSE.note for details.

- Participant: Serge Iovleff
- Contact: Serge Iovleff
- URL: https://cran.r-project.org/web/packages/rtkore/index.html

REALOPT Project-Team

6. New Software and Platforms

6.1. BaPCod : a generic Branch-And-Price Code

KEYWORDS: Column Generation - Branch-and-Price - Branch-and-Cut - Mixed Integer Programming - Mathematical Optimization - Benders Decomposition - Dantzig-Wolfe Decomposition - Extended Formulation
FUNCTIONAL DESCRIPTION: BaPCod is a prototype code that solves Mixed Integer Programs (MIP) by application of reformulation and decomposition techniques. The reformulated problem is solved using a branch-and-price-and-cut (column generation) algorithm, Benders approaches, or network flow algorithms.

- Participants: Francois Vanderbeck, Ruslan Sadykov, Issam Tahiri, Artur Alves Pessoa, Boris Detienne, François Clautiaux, Pierre Pesneau, Eduardo Uchoa Barboza and Michael Poss
- Partners: Université de Bordeaux - CNRS - IPB - Universidade Federal Fluminense
- Contact: Francois Vanderbeck
- URL: https://realopt.bordeaux.inria.fr/?page_id=2

SELECT Project-Team

5. New Software and Platforms

5.1. MIXMOD software

Participants: Gilles Celeux [Correspondant], Benjamin Auder, Jonas Renault.

Mixture model, cluster analysis, discriminant analysis MIXMOD is being developed in collaboration with Christophe Biernacki, Florent Langrognet (Université de Franche-Comté) and Gérard Govaert (Université de Technologie de Compiègne). MIXMOD (MIXture MODeling) software fits mixture models to a given data set, with either a clustering or a discriminant analysis purpose. MIXMOD uses a large variety of algorithms to estimate mixture parameters, e.g., EM, Classification EM, and Stochastic EM. They can be combined to create different strategies that lead to a sensible maximum of the likelihood (or completed likelihood) function. Moreover, different information criteria for choosing a parsimonious model, e.g. the number of mixture components, some of them favoring either a cluster analysis or a discriminant analysis point of view, are included. Many Gaussian models for continuous variables and multinomial models for discrete variable are included. Written in C++, MIXMOD is interfaced with MATLAB. The software, statistical documentation, and user guide are available here: http://www.mixmod.org.

Since 2010, MIXMOD has a proper graphical user interface. A version of MIXMOD in R is now available: http://cran.r-project.org/web/packages/Rmixmod/index.html.

Benjamin Auder contributes to the software improvement of MIXMOD. He has implemented an interface to test any mathematical library (Armadillo, Eigen, etc.) to replace NEWMAT. He has contributed to the continuous integration setup using Jenkins tools, and has prepared an automated testing framework for unit and non-regression tests.

This year, MIXMOD has received the support of an ADT (MASSICCC) for three years. This ADT MASSICCC has been obtained conjointly with the MODAL team (Inria Lille). This year, an engineer, Jonas Renault, has been appointed for two years. He is in charge of developing a web version of MIXMOD.

5.2. BLOCKCLUSTER software

Participants: Gilles Celeux, Christine Keribin.

Mixture model, Block cluster analysis, Blockcluster is software devoted to model-based block clustering. It is developed in parternship with the MODAL team (Inria Lille). This year, some major bugs have been fixed, and the Bayesian point of view has been reinforced by including Gibbs sampling for binary and categorial data. This Gibbs sampler, coupled with the variational Bayes algorithm, provides solutions which are more stable and less dependent on the initial values of the algorithm. An exact expression of the ICL criterion has been provided. This non-asymptotic criterion appears to be more relevant than the BIC-like approximation of ICL.

Vincent Brault, Christine Keribin and Mahindra Mariadassou have shown the consistency and asymptotic normality of the maximum likelihood and variational estimators in stochastic or latent block models.

SEQUEL Project-Team

6. New Software and Platforms

6.1. Function optimization

Participants: Jean-Bastien Grill, Michal Valko, Rémi Munos.

6.1.1. POO

This is a black-box function optimization toolkit that finds the global optimum of a function given a finite budget of noisy evaluations. The algorithm does not require the knowledge of the function's smoothness. It works for a larger class of functions than what was previously considered, especially for functions that are difficult to optimize, in a precise sense.

SIERRA Project-Team

6. New Software and Platforms

6.1. DICA: Moment Matching for Latent Dirichlet Allocation (LDA) and Discrete Independent Component Analysis (DICA)

The DICA package contains Matlab and C++ (via Matlab mex files) implementations of estimation in the LDA and closely related DICA models [21].

The implementation consists of two parts. One part contains the efficient implementation for construction of the moment/cumulant tensors, while the other part contains implementations of several so called joint diagonalization type algorithms used for matching the tensors. Any tensor type (see below) can be arbitrarily combined with one of the diagonalization algorithms (see below) leading, in total, to 6 algorithms.

Two types of tensors are considered: (a) the LDA moments and (b) the DICA cumulants. The diagonalization algorithms include: (a) the orthogonal joint diagonalization algorithm based on iterative Jacobi rotations, (b) the spectral algorithm based on two eigen decompositions, and (c) the tensor power method.

- Contact: Anastasia Podosinnikova
- URL: https://github.com/anastasia-podosinnikova/dica

6.2. LinearFW: Implementation of linearly convergent versions of Frank-Wolfe

This is the code to reproduce all the experiments in the NIPS 2015 paper: "On the Global Linear Convergence of Frank-Wolfe Optimization Variants" by Simon Lacoste-Julien and Martin Jaggi [17], which covers the global linear convergence rate of Frank-Wolfe optimization variants for problems described as in Eq. (1) in the paper. It contains the implementation of Frank-Wolfe, away-steps Frank-Wolfe and pairwise Frank-Wolfe on two applications.

- Contact: Simon Lacoste-Julien
- URL: https://github.com/Simon-Lacoste-Julien/linearFW

6.3. CNN-Head-Detection: Context-aware CNNs for person head detection

This is the code for the ICCV 2015 paper "Context-aware CNNs for person head detection" [23]. Person detection is a key problem for many computer vision tasks. While face detection has reached maturity, detecting people under a full variation of camera view-points, human poses, lighting conditions and occlusions is still a difficult challenge. In this work we focus on detecting human heads in natural scenes. Starting from the recent local R-CNN object detector, we extend it with two types of contextual cues. First, we leverage person-scene relations and propose a Global CNN model trained to predict positions and scales of heads directly from the full image. Second, we explicitly model pairwise relations among objects and train a Pairwise CNN model using a structured-output surrogate loss. The Local, Global and Pairwise models are combined into a joint CNN framework. To train and test our full model, we introduce a large dataset composed of 369,846 human heads annotated in 224,740 movie frames. We evaluate our method and demonstrate improvements of person head detection against several recent baselines in three datasets. We also show improvements of the detection speed provided by our model.

- Contact: Anton Osokin
- URL: https://github.com/aosokin/cnn_head_detection

TAO Project-Team

6. New Software and Platforms

6.1. CMA-ES

Covariance Matrix Adaptation Evolution Strategy
KEYWORDS: Numerical optimization - Black-box optimization - Stochastic optimization
SCIENTIFIC DESCRIPTION

The CMA-ES is considered as state-of-the-art in evolutionary computation and has been adopted as one of the standard tools for continuous optimisation in many (probably hundreds of) research labs and industrial environments around the world. The CMA-ES is typically applied to unconstrained or bounded constraint optimization problems, and search space dimensions between three and a hundred. The method should be applied, if derivative based methods, e.g. quasi-Newton BFGS or conjugate gradient, (supposedly) fail due to a rugged search landscape (e.g. discontinuities, sharp bends or ridges, noise, local optima, outliers). If second order derivative based methods are successful, they are usually faster than the CMA-ES: on purely convex-quadratic functions, f(x)=xTHx, BFGS (Matlabs function fminunc) is typically faster by a factor of about ten (in terms of number of objective function evaluations needed to reach a target function value, assuming that gradients are not available). On the most simple quadratic function f(x)=‖x‖2=xTx BFGS is faster by a factor of about 30.
FUNCTIONAL DESCRIPTION

The CMA-ES is an evolutionary algorithm for difficult non-linear non-convex black-box optimisation problems in continuous domain.

- Participants: Nikolaus Hansen and Emmanuel Benazera
- Contact: Nikolaus Hansen
- URL: https://www.lri.fr/~hansen/cmaesintro.html

6.2. COCO

COmparing Continuous Optimizers
KEYWORDS: Benchmarking - Numerical optimization - Black-box optimization - Stochastic optimization
SCIENTIFIC DESCRIPTION

COmparing Continuous Optimisers (COCO) is a tool for benchmarking algorithms for black-box optimisation. COCO facilitates systematic experimentation in the field of continuous optimization. COCO provides: (1) an experimental framework for testing the algorithms, (2) post-processing facilities for generating publication quality figures and tables, (3) LaTeX templates of articles which present the figures and tables in a single document.

The COCO software is composed of two parts: (i) an interface available in different programming languages (C/C++, Java, Matlab/Octave, R, Python) which allows to run and log experiments on multiple test functions testbeds of functions (noisy and noiseless) are provided (ii) a Python tool for generating figures and tables that can be used in the LaTeX templates.
FUNCTIONAL DESCRIPTION

The Coco Platform provides the functionality to automatically benchmark optimization algorithms for unbounded, unconstrained optimization problems in continuous domains. Benchmarking is a vital part of algorithm engineering and a necessary path to recommend algorithms for practical applications. The Coco platform releases algorithm developers and practitioners alike from (re-)writing test functions, logging, and plotting facilities by providing an easy-to-handle interface in several programming languages. The Coco platform has been developed since 2007 and has been used extensively within the "Blackbox Optimization Benchmarking (BBOB)" workshop series since 2009. Overall, 123 algorithms and algorithm variants by contributors from all over the world have been benchmarked with the platform so far and all data is publicly available for the research community for the submissions to BBOB-2013).

- Participants: Dimo Brockhoff, Tea Tulsar, Dejan Tulsar, Thanh-Do Tran, Nikolaus Hansen, Anne Auger, Marc Schoenauer, Ouassim Ait Elhara and Asma Atamna
- Partners: Université technique de Dortmund - Université technique de Prague
- Contact: Dimo Brockhoff
- URL: http://coco.gforge.inria.fr/doku.php

6.3. PTraces

Personal digital Traces
KEYWORDS: Information retrieval - Taxonomy induction - Personal Big Data - Ontology
SCIENTIFIC DESCRIPTION Personal digital Traces (PTraces) is a platform for fetching and annotating personal data. Ptraces provides us a demonstration platform for personal semantics and ontology induction. Ptraces includes: (1) modules for securely fetching personal data from external applictions (2) an annotation component that annotates personal information with user-chosen taxonomies (facets). These facets arean experimental framework for testing the algorithms, (3) an information retrieval component

The PTraces software is composed of two parts: (i) A Java backbone, built on Elastic Search (ii) a web-browser user interface for configuring the system (choosing data sources, choosing ontologies to activate) and for query retrieved data.
FUNCTIONAL DESCRIPTION

The system accepts taxonomies in the SKOS format. These taxonomies are presented to the user, along with a number of connectors to otuside data sources (gmail, twitter, facebook, fitbit, ...). The user chooses which sources to index, and which taxonomies to apply. After this initialisation, the system accesses the sources using the indentification tokens that the user has supplied, fetches the user data, annotates the data using the activated taxonomies, and sets up a local server that that user can access to search in their own data, using a browser interface.

- Participants: Gregory Grefenstette, Lawrence Muchemi, Mohamed Bouatira
- Contact: Mohamed Bouatira
- URL: https://gforge.inria.fr/scm/browser.php?group_id=7217

6.4. Cartolabe

FUNCTIONAL DESCRIPTION

Scientific cartography from articles

- Contact: Philippe Caillou
- URL: (project starting in 2016 - no url yet)

6.5. GO

Grid Observatory
KEYWORDS: Green computing - Autonomic computing
FUNCTIONAL DESCRIPTION

The Grid Observatory (GO) software suite collects and publishes traces of the EGI (European Grid Initiative) grid usage. With the release and extensions of its portal, the Grid Observatory has made a database of grid usage traces available to the wider computer science community since 2008. These data are stored on the grid, and made accessible through a web portal without the need of grid credentials. The GO is fully integrated with the evolution of EGI monitoring.

- Participants: Cécile Germain-Renaud, Julien Nauroy and Martine Sebag
- Contact: Cécile Germain-Renaud
- URL: http://grid-observatory.org/

6.6. METIS

KEYWORDS: Optimization - Energy
FUNCTIONAL DESCRIPTION

Many works in Energy Optimization, in particular in the case of high-scale sequential decision making, are based on one software per application, because optimizing the software eventually implies losing generality. Our goal is to develop with Artelys a platform, METIS, which can be used for several applications. In 2012 we interfaced existing codes in Artelys and codes developed in the TAO team, experiments have been performed and test cases have been designed. Several codes have been developped, tested on real world problems, and are (depending on which code) under the process of (i) open source diffusion (ii) code protection.

A big work is the development of a new, independent, open source, simulator for the French power grid, currently under extension to other European countries.

- Participants: Olivier Teytaud, Jérémie Decock, Jean-Joseph Christophe, Vincent Berthier, Marie-Liesse Cauwet and Sandra Cecilia Astete Morales
- Partner: Artelys
- Contact: Olivier Teytaud
- URL: http://www.lri.fr/~teytaud

6.7. Game Test Bed

KEYWORDS: An open source game test bed.
FUNCTIONAL DESCRIPTION

GTB is an open source library of games, including solvers. It includes an interface to noisy continuous optimization of parametric policies, and noise-free continuous optimization, leading to a preliminary continuous optimization platform with real-world test cases.

- Participants: Olivier Teytaud is the only developer, some feedback from Sandra Astete-Morales, and an interfacing with works by Marcus Gallagher at Univ. Queensland in under discussion.
- URL: https://gforge.inria.fr/projects/gametestbed/

6.8. MOGO

KEYWORDS: Computer Go - Monte-Clarlo - UCT
FUNCTIONAL DESCRIPTION

MoGo and its Franco-Taiwanese counterpart MoGoTW is a Monte-Carlo Tree Search program for the game of Go, which made several milestones of computer-Go in the past (first wins against professional players in 19x19, first win with disadvantageous side in 9x9 Go). Recent results include 7 wins out of 12 against professional players (in Brisbane, 2012) in 7x7, and recently an optimization of the random seed which brings a significant improvement in Go and (unpublished) on the difficult case of phantom-Go. However, the work in the UCT-SIG has now shifted to energy management.

- Participants: Sylvain Gelly, Rémi Munos, Olivier Teytaud, Yizao Wang and Jean-Baptiste Hoock
- Contact: Olivier Teytaud
- URL: https://www.lri.fr/~teytaud/taiwanopen2009.html

6.9. MultiBoost

multi-purpose boosting package
KEYWORDS: Multi-class - Multi-label classification
FUNCTIONAL DESCRIPTION

The MultiBoost package provides a fast C++ implementation of multi-class/multi-label/multi-task boosting algorithms. It is based on AdaBoost.MH but it also implements popular cascade classifiers, Arc-GV , and FilterBoost . The package contains common multi-class base learners (stumps, trees, products, Haar filters). Further base learners and strong learners following the boosting paradigm can be easily implemented in a flexible framework.

- Participants: Balasz Kegl, Robert Busa-Fekete and Djalel Benbouzid
- Contact: Balasz Kegl
- URL: http://www.multiboost.org/

6.10. io.datascience

FUNCTIONAL DESCRIPTION

This Data as a Service (DaaS) platform [54] is developed in the context of the Center for Data Science and the TIMCO project. Its overall goals is to exploit the advances in semantic web techniques for efficient sharing and usage of scientific data. A related specific software is the Tester for Triplestore (TFT) software suite [49], which benchmarks the compliance of sparql databases wrt the RDF standard and publishes the results through the SparqlScore service.

- Contact: Cécile Germain
- URL: https://io.datascience-paris-saclay.fr/

ASPI Project-Team (section vide)

CQFD Project-Team

6. New Software and Platforms

6.1. Package PCAmixdata

FUNCTIONAL DESCRIPTION

Mixed data type arise when observations are described by a mixture of numerical and categorical variables. The R package PCAmixdata extends standard multivariate analysis methods to incorporate this type of data. The key techniques included in the package are PCAmix (PCA of a mixture of numerical and categorical variables), PCArot (rotation in PCAmix) and MFAmix (multiple factor analysis with mixed data within a dataset). The MFAmix procedure handles a mixture of numerical and categorical variables within a group - something which was not possible in the standard MFA procedure. We also included techniques to project new observations onto the principal components of the three methods in the new version of the package.

- Participants: Marie Chavent, Amaury Labenne, Jérome Saracco
- Contact: Marie Chavent
- URL: https://cran.r-project.org/web/packages/PCAmixdata/index.html

6.2. Package divclust

FUNCTIONAL DESCRIPTION DIVCLUS-T is a divisive hierarchical clustering algorithm based on a monothetic bipartitional approach allowing the dendrogram of the hierarchy to be read as a decision tree. It is designed for numerical, categorical (ordered or not) or mixed data. Like the Ward agglomerative hierarchical clustering algorithm and the k-means partitioning algorithm, it is based on the minimization of the inertia criterion. However, it provides a simple and natural monothetic interpretation of the clusters. Indeed, each cluster is decribed by set of binary questions. The inertia criterion is calculated on all the principal components of PCAmix (and then on standardized data in the numerical case).

- Participants: Marie Chavent, Marc Fuentes
- Contact: Marie Chavent
- URL: https://github.com/chavent/divclust

6.3. Package ClustGeo

FUNCTIONAL DESCRIPTION This R package is dedicated to the clustering of objects with geographical positions. The clustering method implemented in this package allows the geographical constraints of proximity to be taken into account within the ascendant hierarchical clustering.

- Marie Chavent, Amaury Labenne, Vanessa Kuentz, Jérome Saracco
- Contact: Amaury Labenne
- URL: https://cran.r-project.org/web/packages/ClustGeo/index.html

6.4. Package QuantifQuantile

FUNCTIONAL DESCRIPTION This R package is dedicated to the estimation of conditional quantiles using optimal quantization. It allows the construction of an optimal grid of N quantizers, the estimation of conditional quantiles and the data driven selection of the size N of the grid. Graphical illustrations are available for the selection of N and of resulting estimated curves or surfaces when the dimension of the covariate is one or two.

- Isabelle Charlier, Jérôme Saracco
- Contact: Isabelle Charlier
- URL: https://cran.r-project.org/web/packages/QuantifQuantile/index.html

6.5. Biips: Software for Bayesian Inference with Interacting Particle Systems

FUNCTIONAL DESCRIPTION

Biips is a software platform for automatic Bayesian inference with interacting particle systems. Biips allows users to define their statistical model in the probabilistic programming BUGS language, as well as to add custom functions or samplers within this language. Then it runs sequential Monte Carlo based algorithms (particle filters, particle independent Metropolis-Hastings, particle marginal Metropolis-Hastings) in a black-box manner so that to approximate the posterior distribution of interest as well as the marginal likelihood. The software is developed in C++ with interfaces with the softwares R, Matlab and Octave.

- Participants: François Caron, Adrien Todeschini and Pierrick Legrand
- Contact: Adrien Todeschini
- URL: http://biips.gforge.inria.fr

6.6. VCN: Software for analysis of VCN

FUNCTIONAL DESCRIPTION

VCN is a software for the analysis of the vigilance of the patient based on the analysis of the EEG signals. The code is written in Matlab and provides an interface easy to use for someone without informatics skills.

- Participants: Pierrick Legrand, Julien Clauzel, Laurent Vezard, Charlotte Rodriguez, Borjan Geshkovski.
- Contact: Pierrick Legrand

6.7. EMGView: Software for visualisation and time-frequency analysis of bio signals

FUNCTIONAL DESCRIPTION

EMGView is a software for the visualisation and the analysis of bio-signals. The code is written in Matlab and provides an interface easy to use for someone without informatics skills.

- Participants: Luis Herrera, Eric Grivel, Pierrick Legrand, Gregory Barriere
- Contact: Pierrick Legrand

MATHRISK Project-Team

6. New Software and Platforms

6.1. PREMIA

KEYWORDS: Computational finance - Option pricing
SCIENTIFIC DESCRIPTION

Premia is a software designed for option pricing, hedging and financial model calibration. It is provided with it's C/C++ source code and an extensive scientific documentation. The Premia project keeps track of the most recent advances in the field of computational finance in a well-documented way. It focuses on the implementation of numerical analysis techniques for both probabilistic and deterministic numerical methods. An important feature of the platform Premia is the detailed documentation which provides extended references in option pricing.

Premia is thus a powerful tool to assist Research & Development professional teams in their day-to-day duty. It is also a useful support for academics who wish to perform tests on new algorithms or pricing methods without starting from scratch.

Besides being a single entry point for accessible overviews and basic implementations of various numerical methods, the aim of the Premia project is: 1 - to be a powerful testing platform for comparing different numerical methods between each other, 2 - to build a link between professional financial teams and academic researchers, 3 - to provide a useful teaching support for Master and PhD students in mathematical finance.
FUNCTIONAL DESCRIPTION

- Participants: Mathrisk project team and contributors
- Partners: Inria - Ecole des Ponts ParisTech - Université Paris-Est - Consortium Premia
- Contact: Agnès Sulem
- URL: http://www.premia.fr
- AMS: 91B28;65Cxx;65Fxx;65Lxx;65Pxx
- License: Licence Propriétaire (genuine license for the Consortium Premia)
- Type of human computer interaction: Console, interface in Nsp, Web interface
- OS/Middelware: Linux, Mac OS X, Windows
- APP: The development of Premia started in 1999 and 16 are released up to now and registered at the APP agency. Premia 16 has been registered on 0303/2015 under the number IDDN.FR.001.190010.013.S.C.2001.000.31000
- Programming language: C/C++ librairie Gtk
- Documentation: the PNL library is interfaced via doxygen
- Size of the software: 280580 lines for the Src part only, that is 11 Mbyte of code, 130400 lines for PNL, 105 Mbyte of PDF files of documentation.
- interfaces : Nsp for Windows/Linux/Mac, Excel, binding Python, and a Web interface.
- Publications: [12], [61], [69], [77], [80], [49], [59].

6.1.1. Content of Premia

Premia contains various numerical algorithms (Finite-differences, trees and Monte-Carlo) for pricing vanilla and exotic options on equities, interest rate, credit and energy derivatives.

1. **Equity derivatives:**

   The following models are considered:

Black-Scholes model (up to dimension 10), stochastic volatility models (Hull-White, Heston, Fouque-Papanicolaou-Sircar), models with jumps (Merton, Kou, Tempered stable processes, Variance gamma, Normal inverse Gaussian), Bates model.

For high dimensional American options, Premia provides the most recent Monte-Carlo algorithms: Longstaff-Schwartz, Barraquand-Martineau, Tsitsklis-Van Roy, Broadie-Glassermann, quantization methods and Malliavin calculus based methods.

Dynamic Hedging for Black-Scholes and jump models is available.

Calibration algorithms for some models with jumps, local volatility and stochastic volatility are implemented.

2. **Interest rate derivatives**

   The following models are considered:

   HJM and Libor Market Models (LMM): affine models, Hull-White, CIR++, Black-Karasinsky, Squared-Gaussian, Li-Ritchken-Sankarasubramanian, Bhar-Chiarella, Jump diffusion LMM, Markov functional LMM, LMM with stochastic volatility.

   Premia provides a calibration toolbox for Libor Market model using a database of swaptions and caps implied volatilities.

3. **Credit derivatives: Credit default swaps (CDS), Collateralized debt obligations (CDO)**

   Reduced form models and copula models are considered.

   Premia provides a toolbox for pricing CDOs using the most recent algorithms (Hull-White, Laurent-Gregory, El Karoui-Jiao, Yang-Zhang, Schönbucher)

4. **Hybrid products**

   A PDE solver for pricing derivatives on hybrid products like options on inflation and interest or change rates is implemented.

5. **Energy derivatives: swing options**

   Mean reverting and jump models are considered.

   Premia provides a toolbox for pricing swing options using finite differences, Monte-Carlo Malliavin-based approach and quantization algorithms.

6.1.2. Premia design

To facilitate contributions, a standardized numerical library (PNL) has been developed by J. Lelong under the LGPL since 2009, which offers a wide variety of high level numerical methods for dealing with linear algebra, numerical integration, optimization, random number generators, Fourier and Laplace transforms, and much more. Everyone who wishes to contribute is encouraged to base its code on PNL and providing such a unified numerical library has considerably eased the development of new algorithms which have become over the releases more and more sophisticated. J. Ph Chancelier, B. Lapeyre and J. Lelong are using Premia and Nsp for Constructing a Risk Management Benchmark for Testing Parallel Architecture [59].

Development of the PNL in 2015 (J. Lelong) . Release 1.70 and 1.71, PNL Library (http://pnl.gforge.inria.fr).

1. Release 1.72. of the *PNL* library (http://pnl.gforge.inria.fr/).
   1. Addition of a CMake module to include the library in other projects.
   2. Improvement of the `pnl_basis` module.
   3. Addition of the non central chi squared distribution to the random number generation toolbox.
   4. Addition of new functions in the linear algebra toolbox to build views.

6.1.3. Algorithms implemented in Premia in 2015

Premia 17 has been delivered to the consortium members in March 2015.

It contains the following new algorithms:

6.1.3.1. Commodities, FX, Insurance, Credit Risk

- Variables Annuities GLWB pricing in the Heston and Black-Scholes/Hull-White models with finite difference techniques.
- Variables Annuities GMAB, GMDB, GMMB pricing with Fourier-cosine techniques.
- A numerical scheme for the impulse control formulation for pricing variable annuities with a Guaranteed Minimum Withdrawal Benefit (GMWB) Z.Chen P.Forsyth
  Numerische Mathematik 109, 2008
- Managing Gap Risks in iCPPI for life insurance companies: A risk/return/cost analysis. A.Kalife S.Mouti L.Goudenege
  Insurance Markets and Companies: Analyses and Actuarial Computations, Issue 2 2014
- Simulating CVA on American Options. L. Abbas Turki, M.Mikou

6.1.3.2. Equity Derivatives

- Being particular about calibration. J.Guyon and P. Henry-Labordère.
  Risk magazine, Jan 2012.
- The Heston Stochastic-Local Volatility Model: Efficient Monte Carlo Simulation. A.W. van der Stoepb, L. A. Grzelakb, C. W. Oosterlee
  International Journal of Theoretical and Applied Finance, to appear
- On the Heston model with stochastic interest rates. L. Grzelak C.W.Oosterlee
  SIAM J. Fin. Math. 2,2011.
- Alternating direction implicit finite difference schemes for the Heston Hull-White partial differential equation.
  The Journal of Computational Finance Volume 16/Number 1, Fall 2012
- Pricing American options in the Heston Hull-White and Hull-White2d Models: an hybrid tree-finite difference approach. M.Briani, L.Caramellino, A.Zanette
- Efficient pricing of Asian options under Lévy processes based on Fourier cosine expansions. Part I: European-style products. B.Zhang C.W.Oosterlee.
  SIAM J. Financial Math., 4(1)
- Low-bias simulation scheme for the Heston model by Inverse Gaussian approximation. S. T. Tse J. W. L. Wan.
  Quantitative Finance, Volume 13, Issue 6, 2013
- Simple Simulation Scheme for CIR and Wishart Processes P. Baldi, C.Pisani
  International Journal of Theoretical and Applied Finance Vol. 16, No. 08, 2013
- Importance sampling for jump processes and applications to finance. L. Badouraly Kassim, J. Lelong and I. Loumrhari.
  Journal of Computational Finance, to appear
- A Wiener-Hopf Monte Carlo simulation technique for Lévy process. A. Kuznetsov, A.E.Kyprianou J. C. Pardo and K. van Schaik.
  The Annals of Applied Probability, Volume 21, Number 6, 2011.
- A Wiener-Hopf Monte Carlo simulation approach for pricing path-dependent options under Lévy process. O. Kudryavtsev
  Preprint.
- An Efficient Binomial Lattice Method for Step Double Barrier Options. E.Appolloni, M.Gaudenzi A.Zanette.
  International Journal of Applied and Theoretical Finance Vol.17, Issue No. 6, 2014.

The algorithms

- "Pricing American-Style Options by Monte Carlo Simulation : Alternatives to Ordinary Least Squares" by Stathis Tompaidis and Chunyu Yang
- "Value Function Approximation or Stopping Time Approximation : A comparison of Two Recent Numerical Methods for American Option Pricing using Simulation and Regression" by Lars Stentoft

implemented in 2015 by CélineLabart will be included in the following release.

Moreover, Jérome Lelong has performed the following tasks:

1. Add an importance sampling based code for jump diffusion models.
2. Improve the internal enumeration mechanism (PremiaEnum).
3. Update gnuplot files generation for reports.
4. Everyday maintenance to fix various bugs.
5. Clean the generation of the documentation process.

TOSCA Project-Team

6. New Software and Platforms

6.1. ExitBM

FUNCTIONAL DESCRIPTION

The ExitBM library provides methods to simulate random variables related to the first exit time and position of the Brownian motion from simple domains, namely intervals, squares and rectangles. This is a new software of 2015.

- Participants: Madalina Deaconu and Antoine Lejay
- Contact: Antoine Lejay
- URL: http://exitbm.gforge.inria.fr/

6.2. SDM

Stochastic Downscaling Method
FUNCTIONAL DESCRIPTION

The computation of the wind at small scale and the estimation of its uncertainties is of particular importance for applications such as wind energy resource estimation. To this aim, we have developed a computer code belonging to the family of codes of atmospheric flow calculation, in the atmospheric boundary layer. SDM especially concerns the simulation of wind at small space scales (meaning that the horizontal resolution is one kilometer or less), based on the combination of an existing Numerical Weather Prediction model providing a coarse prediction, and a Lagrangian Stochastic Model for turbulent flows.

This year we added to SDM a software tool for Configuration Interface and Visualization (CIV) of the SDM simulations. This dedicated GUI restitutes the 3D simulation view of all SDM outputs (including the rendering of interactions with mills). It is also a key environment tool to visualize a coarse resolution input, to extract time boundary condition of any chosen subdomain simulation for a NetCDF (Network Common DataForm) input file, to prepare the compilation procedure of any simulation case of SDM, to execute codes.

- Participants: Mireille Bossy, Sélim Kraria
- Contact: Mireille Bossy
- URL: http://windpos.inria.fr

6.3. Triton

KEYWORDS: Image analysis - Oceanography
FUNCTIONAL DESCRIPTION

The Triton software aims at providing a toolbox to analyze nearshore waves images recorded by a camera on the beach. More precisely, it aims at estimating the height, length and speed of waves, to find speed and direction of currents, and to reconstruct the bathymetry from these images. This is a new software of 2015.

- Participants: Stanislas Larnier, Rafael Almar and Antoine Lejay
- Contact: Antoine Lejay