



RESEARCH CENTER

FIELD

**Applied Mathematics, Computation
and Simulation**

Activity Report 2016

Section Software

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ACUMES Project-Team

6. New Software and Platforms

6.1. 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 visualisation 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 project-team 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 visualisation of building performances (heat, structural) in relation to the Building Information Modeling BIM framework.

CAGIRE Project-Team

6. New Software and Platforms

6.1. AeroSol

Participants: Simon Delmas [Université de Bordeaux], Sébastien de Brye [Université de Bordeaux], 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 Adaptive wall treatment for a second moment closure in the industrial context

- **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 [27].

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 2015, AeroSol had the following features:

- **Boundary conditions** Periodic boundary conditions, time-dependent inlet and outlet boundary conditions. Adiabatic wall and isothermal wall. Steger-Warming based boundary condition. Synthetic Eddy Method for generating turbulence.
- **C++/Fortran interface** Tests for binding fortran with C++.
- **Development environment** An upgraded use of CMake for compilation (gcc, icc and xlc), CTest for automatic tests and memory checking, lcov and gcov for code coverage reports. A CDash server for collecting the unitary tests and the memory checking. An under development interface for functional tests. Optional linking with HDF5, PAPI, with dense small matrices libraries (BLAS, Eigen). An updated shared project Plafrim and joint project Aerosol/Scotch/PaMPA project on the continuous integration platform. An on-going integration of SPack for handling dependencies. A fixed ESSL interface.
- **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.
- **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.
- **Instrumentation** Aerosol can give some traces on memory consumption/problems with an interfacing with the PAPI library. Tests have also been performed with VTUNE and TAU. Tests with Maqao and Scalasca (VIHPS workshop).
- **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. Linearized Euler equations, and Sutherland model for non isothermal diffusive flows. Shallow-water model.
- **Multigrid** Development of p -multigrid methods. This includes also the possibility of beginning a computation with 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 operators have also been developed. In progress implementation of h -multigrid, with the development of tests of the aggregation methods of PaMPA, and the definition of finite element basis on arbitrary cells.
- **Numerical fluxes** Centered fluxes, exact Godunov' flux for linear hyperbolic systems, and Lax-Friedrich flux. Riemann solvers for Low Mach flows. Numerical flux accurate for steady and unsteady computations.

- **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. In progress optimization by stocking the geometry for advection problems. SUPG and Residual distribution 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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In 2016, the following features have been added:

- Geometric multigrid methods: aggregation of the mesh based on PaMPA, definition of finite element basis on arbitrary shape cells. Definition of geometry, quadratures and numerical schemes on aggregated finite elements.
- Sutherland law in the Navier-Stokes equations.
- Mass matrix free implementation of discontinuous Galerkin methods.
- Improvement of installation documentation. Spack based installation.
- Implementation of Boussinesq type models and Shallow water discretizations with well balancing, positivity preserving, wet-dry handling, limiters based on entropy viscosity,
- Implementation of Barotropic Euler equations
- Implementation of Taylor-based basis on simplices.

CARDAMOM Project-Team

5. New Software and Platforms

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- Implementation of Barotropic Euler equations
- Implementation of Taylor-based basis on simplices.

5.2. CAKE

KEYWORDS: Moving bodies, Rarefied flows

- Contact: Luc Mieussens
- URL: <http://www.cake-solver.com/>

FUNCTIONAL DESCRIPTION

Cake (Cut cell Algorithm for Kinetic Equations) can simulate 2D plane rarefied flows around moving obstacles, by using an immersed boundary technique with Cartesian grids. This code can simulate flows induced by temperature gradients, like the thermal creep flow. It has for instance been applied to the simulation of the Crookes radiometer.

5.3. Crysa

KEYWORDS: Image processing, structural analysis, 2D crystallography

- Participants: Jean Mercat and Cécile Dobrzynski
- Partners: ISM - LCPO - LCTS (UMR 5801)
- Contact: Cécile Dobrzynski

Crysa is a library allowing to study the organization of objects once placed in an hexagonal grid thus allowing to analyze the crystal structure/organization of an image. The library allows to detect regions of coherence in an image of crystals, and it allows to determine e.g. the good separation of objects in an experiment (new polymeric materials, plasma, ...).

5.4. Cut-ANOVA

KEYWORDS: Stochastic models - Uncertainty quantification

- Participants: Pietro-Marco Congedo
- Contact: Pietro-Marco Congedo

SCIENTIFIC DESCRIPTION

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.

FUNCTIONAL DESCRIPTION

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.

5.5. Fmg

KEYWORDS: Mesh adaptation, mesh deformation, elasticity, laplacian mesh equation

- Participants: Cécile Dobrzynski, Mario Ricchiuto, Leo Nouveau and Luca Arpaia
- Contact: Cécile Dobrzynski

FUNCTIONAL DESCRIPTION

FMG is a library deforming an input/reference simplicial mesh w.r.t. a given smoothness error monitor (function gradient or Hessian), metric field, or given mesh size distribution. Displacements are computed by solving an elliptic Laplacian type equation with a continuous finite element method. The library returns an adapted mesh with a corresponding projected solution, obtained by either a second order projection, or by an ALE finite element remap. This year a new semi-linear elasticity formulation has been implemented involving a constant coefficient PDE with a nonlinear *force* accounting for the smoothness of the target function. The advantage of this approach is that the non-linearity does not influence the elastic differential operator thus leading to a description of the deformation governed by a time-invariant matrix even in unsteady simulations. Other developments currently implemented in SLOWS are being imported in FMG.

5.6. MMG3D

KEYWORDS: Mesh - Anisotropic - Mesh adaptation

- Participants: Cécile Dobrzynski, Pascal Frey, Charles Dapogny and Algiane Froehly
- Partners: CNRS - IPB - Université de Bordeaux - UPMC
- Contact: Cécile Dobrzynski
- URL: <http://www.mmgtools.org>

SCIENTIFIC DESCRIPTION

Mmg3d is an open source software for tetrahedral remeshing. It performs local mesh modifications. The mesh is iteratively modified until the user prescriptions satisfaction.

Mmg3d can be used by command line or using the library version (C, C++ and Fortran API) : - It is a new version of the MMG3D4 software. It remesh both the volume and surface mesh of a tetrahedral mesh. It performs isotropic and anisotropic mesh adaptation and isovalue discretization of a level-set function.

Mmg3d allows to control the boundaries approximation: The "ideal" geometry is reconstructed from the piecewise linear mesh using cubic Bezier triangular patches. The surface mesh is modified to respect a maximal Hausdorff distance between the ideal geometry and the mesh.

Inside the volume, the software performs local mesh modifications (such as edge swap, pattern split, isotropic and anisotropic Delaunay insertion...).

FUNCTIONAL DESCRIPTION

Mmg3d is one of the software of the Mmg platform. It is dedicated to the modification of 3D volume meshes. It performs the adaptation and the optimization of a tetrahedral mesh and allows to discretize an isovalue.

Mmg3d performs local mesh modifications. The mesh is iteratively modified until the user prescription satisfaction.

5.7. Mmg platform

KEYWORDS: Mesh - Mesh generation - Anisotropic - Mesh adaptation - Isovalue discretization

- Participants: Cécile Dobrzynski, Charles Dapogny, Pascal Frey and Algiane Froehly
- Partners: CNRS - IPB - Université de Bordeaux - UPMC
- Contact: Cécile Dobrzynski
- URL: <http://www.mmgtools.org>

SCIENTIFIC DESCRIPTION

The Mmg platform gathers open source software for two-dimensional, surface and volume remeshing. The platform software performs local mesh modifications. The mesh is iteratively modified until the user prescriptions satisfaction.

The 3 softwares can be used by command line or using the library version (C, C++ and Fortran API) : - Mmg2d performs mesh generation and isotropic and anisotropic mesh adaptation. - Mmgs allows isotropic and anisotropic mesh adaptation for 3D surface meshes. - Mmg3d is a new version of the MMG3D4 software. It remesh both the volume and surface mesh of a tetrahedral mesh. It performs isotropic and anisotropic mesh adaptation and isovalue discretization of a level-set function.

The platform software allow to control the boundaries approximation: The "ideal" geometry is reconstructed from the piecewise linear mesh using cubic Bezier triangular patches. The surface mesh is modified to respect a maximal Hausdorff distance between the ideal geometry and the mesh.

Inside the volume, the software perform local mesh modifications (such as edge swap, pattern split, isotropic and anisotropic Delaunay insertion...).

FUNCTIONAL DESCRIPTION

The Mmg platform gathers open source software for two-dimensional, surface and volume remeshing. It provides three applications : 1) mmg2d: generation of a triangular mesh , adaptation and optimization of a triangular mesh 2) mmgs: adaptation and optimization of a surface triangulation representing a piecewise linear approximation of an underlying surface geometry 3) mmg3d: adaptation and optimization of a tetrahedral mesh and isovalue discretization

The platform software perform local mesh modifications. The mesh is iteratively modified until the user prescription satisfaction.

5.8. NOMESH

- Participants: Cécile Dobrzynski and Algiane Froehly
- Partners: CNRS - IPB - Université de Bordeaux
- Contact: Cécile Dobrzynski

KEYWORDS: Mesh - Curved mesh - Tetrahedral mesh

FUNCTIONAL DESCRIPTION

NOMESH is a software allowing the generation of three 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.

5.9. SLOWS

KEYWORDS: Free surface flows, Unstructured meshes, shallow water equations, Boussinesq equations

- Participants: Luca Arpaia, Andrea Filippini, Maria Kazolea, Mario Ricchiuto and Nikolaos Pattakos
- Contact: Mario Ricchiuto

FUNCTIONAL DESCRIPTION

SLOWS (Shallow-water fLOWS) 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. The kernel of the CODE is a shallow water solver based on second order residual distribution or second and third order finite volume schemes. Three different approaches are available to march in time, 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. Linear algebraic sparse systems arising in the discretization are solved with This year several enhancements have been implemented

- a correction of both the residual distribution and finite volume methods to solve the shallow water equations in spherical (or Mercator) curvilinear coordinates;

- mass-conserving mesh movement to adapt an initial grid to wet-dry interfaces as well as to other physical features of the flow;
- a new library has been developed to enhance the shallow water equations. This library computes an algebraic source term by inverting an elliptic (grad-div type) PDE. The addition of this term to the shallow water version of SLOWS allows to recover the a fully nonlinear weakly dispersive Green-Naghdi solver. The solution of the elliptic PDE is performed with a classical Galerkin FEM approach, and MUMPS is the MUMPS library is used to invert the resulting matrix;
- Initial optimization and OpenMP parallelization of the shallow water kernel.

SLOWS is our main simulation tool in both the TANDEM and Tides projects.

5.10. Sparse-PDD

Adaptive sparse polynomial dimensional decomposition for global sensitivity analysis

KEYWORDS: Stochastic models - Uncertainty quantification

- Participants: Pietro-Marco Congedo
- Contact: Pietro-Marco Congedo

SCIENTIFIC DESCRIPTION

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.

FUNCTIONAL DESCRIPTION

This code allows an efficient meta-modeling for a complex numerical system featuring a moderate-to-large number of uncertain parameters. This innovative approach involves polynomial representations combined with the Analysis of Variance decomposition, with the objective to quantify the numerical output uncertainty and its sensitivity upon the variability of input parameters.

5.11. TUCWave

KEYWORDS: free surface flows, Boussinesq equations, weakly nonlinear models, unstructured grids

- Participants: Maria Kazolea, Argiris Delis and Ioannis Nikolos
- Contact: Maria Kazolea

FUNCTIONAL DESCRIPTION

Fortran Planform which accounts for the study of near shore processes. TUCWave uses a high-order well-balanced unstructured finite volume (FV) scheme on triangular meshes for modeling weakly nonlinear and weakly dispersive water waves over varying bathymetries, as described by the 2D depth-integrated extended Boussinesq equations of Nwogu (1993), rewritten in conservation law form. The FV scheme numerically solves the conservative form of the equations following the median dual node-centered approach, for both the advective and dispersive part of the equations. The code developed follows an efficient edge based structured technique. For the advective fluxes, the scheme utilizes an approximate Riemann solver along with a well-balanced topography source term up-winding. Higher order accuracy in space and time is achieved through a MUSCL-type reconstruction technique and through a strong stability preserving explicit Runge-Kutta time stepping. Special attention is given to the accurate numerical treatment of moving wet/dry fronts and boundary conditions. Furthermore, the model is applied to several examples of wave propagation over variable topographies and the computed solutions are compared to experimental data. TUCWave is used in the TANDEM project to provide reference solutions with a weakly nonlinear and dispersive model.

DEFI Project-Team

6. New Software and Platforms

6.1. 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/>

6.2. InvGIBC

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

- Contact: Housseem Haddar
- URL: <http://www.cmap.polytechnique.fr/~haddar/>

6.3. 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/>

6.4. 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: Housseem Haddar
- URL: <http://www.cmap.polytechnique.fr/~haddar/>

6.5. 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: Housseem Haddar
- URL: <http://sourceforge.net/projects/samplings-2d/>

6.6. SAXS-EM

This software solves the inverse problem of determining nono-paticles size distrubutions from SAXS measurements.

FUNCTIONAL DESCRIPTION

This software is written in matlab and determine size distributions is isotropic samples from measurements of X-ray diffraction at small angles. It treats the case of diluted and dense particle distributions.

- Contact: Housseem Haddar, Zixian Jiang
- URL: <http://www.cmap.polytechnique.fr/~haddar/>

ECUADOR Project-Team

5. New Software and Platforms

5.1. AIRONUM

Aironum is an experimental software that solves the unsteady compressible Navier-Stokes equations with k-, LES-VMS (Large Eddy Simulation - Variational Multi-Scale) and hybrid turbulence modelling on parallel platforms, using MPI. The mesh model is unstructured tetrahedrization, with possible mesh motion.

Aironum was developed by Inria and University of Montpellier. It is used by Inria, University of Montpellier and University of Pisa. 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 (Reynolds Averaged Navier-Stokes) 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

Tapenade [10] is an Algorithmic Differentiation tool that transforms an original program into a new program that computes derivatives of the original program. Being an AD tool, Tapenade produces analytical derivatives exact up to machine precision, and in adjoint mode computes gradients at a cost independent of the number of input variables.

Tapenade implements the results of our research about models and static analyses for AD. Tapenade can be downloaded and installed on most architectures. Alternatively, it can be used as a web server. Higher-order derivatives can be obtained through repeated application. Tapenade accepts source programs written in Fortran77, Fortran90, or C. It provides differentiation in the following modes: tangent, vector tangent, adjoint, and vector adjoint.

Tapenade performs sophisticated data-flow analysis, flow-sensitive and context-sensitive, on the complete source program to produce an efficient differentiated code. Analyses performed are Type-Checking, Read-Write analysis, Pointer analysis, and AD-specific analyses including Activity analysis, Adjoint Liveness analysis, and TBR analysis.

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

GAMMA3 Project-Team

3. New Software and Platforms

3.1. 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>

3.2. 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>

3.3. BL2D

KEYWORDS: Automatic mesher - Delaunay - Anisotropic - Planar domain

SCIENTIFIC DESCRIPTION

The meshing method is of controlled Delaunay type, isotropic or anisotropic. The internal point generation follows an advancing-front logic, and their connection is realized 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>

3.4. 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 *a posteriori* error estimation 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>

3.5. 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>

3.6. 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 parametrization 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>

3.7. 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 should have unit length edges with respect to the related Riemannian space (the so-called “unit mesh”). 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>

3.8. 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>

3.9. 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, Eric Saltel, Frédéric Alauzet and Adrien Loseille
- Contact: Paul Louis George
- URL: <http://www.meshgems.com/volume-meshing.html>

3.10. 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, Eric Saltel, Frédéric Alauzet and Adrien Loseille
- Contact: Paul Louis George
- URL: <http://www.meshgems.com/volume-meshing.html>

3.11. 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, Eric Saltel, Frédéric Alauzet, Adrien Loseille and Frederic Hecht
- Contact: Paul Louis George
- URL: <http://www.meshgems.com/volume-meshing.html>

3.12. 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>

3.13. 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

3.14. 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>

3.15. 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/>

3.16. 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, for details see thereafter.

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

3.17. 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

3.18. 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 a 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

3.19. 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 a 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

3.20. 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 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

3.21. 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

3.22. 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

3.23. 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

3.24. Wolf-Xfem

KEYWORD: Scientific calculation

SCIENTIFIC DESCRIPTION

Tool providing the mesh of the intersection between a surface mesh and a volume mesh in the goal of simulating mechanical fractures.

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

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.

- Contact: Gabriel Stoltz
- URL: <https://gitlab.inria.fr/materials/simol>

MEMPHIS Project-Team

6. New Software and Platforms

6.1. COCOFLOW

FUNCTIONAL DESCRIPTION

The code is written in fortran 95 with a MPI parallelization. It solves equations of conservation modeling 3D compressible flows with elastic models as equation of state.

- Contact: Florian Bernard
- URL: <https://gforge.inria.fr/projects/cocoflow>

6.2. KOPPA

Kinetic Octree Parallel PolyAtomic

FUNCTIONAL DESCRIPTION

KOPPA is a C++/MPI numerical code solving a large range of rarefied flows from external to internal flows in 1D, 2D or 3D. Different kind of geometries can be treated such as moving geometries coming from CAO files or analytical geometries. The models can be solved on Octree grids with dynamic refinement.

- Participant: Florian Bernard
- Contact: Florian Bernard
- URL: <https://git.math.cnrs.fr/gitweb/?p=plm/fbernard/KOPPA.git;a=summary>

6.3. NS-penal

Navier-Stokes-penalization

KEYWORDS: 3D - Incompressible flows - 2D

FUNCTIONAL DESCRIPTION

The software can be used as a black box with the help of a data file if the obstacle is already proposed. For new geometries the user has to define them. It can be used with several boundary conditions (Dirichlet, Neumann, periodic) and for a wide range of Reynolds numbers.

- Partner: Université de Bordeaux
- Contact: Charles-Henri Bruneau

6.4. NaSCar

Navier-Stokes Cartesian

KEYWORDS: HPC - Numerical analyse - Fluid mechanics - Langage C - PETSc

SCIENTIFIC DESCRIPTION

NaSCar can be used to simulate both hydrodynamic bio-locomotion as fish like swimming and aerodynamic flows such wake generated by a wind turbine.

FUNCTIONAL DESCRIPTION

This code is devoted to solve 3D-flows in around moving and deformable bodies. The incompressible Navier-Stokes equations are solved on fixed grids, and the bodies are taken into account thanks to penalization and/or immersed boundary methods. The interface between the fluid and the bodies is tracked with a level set function or in a Lagrangian way. The numerical code is fully second order (time and space). The numerical method is based on projection schemes of Chorin-Temam's type. The code is written in C language and use Petsc library for the resolution of large linear systems in parallel.

NaSCar can be used to simulate both hydrodynamic bio-locomotion as fish like swimming and aerodynamic flows such wake generated by a wind turbine.

- Participant: Michel Bergmann
- Contact: Michel Bergmann
- URL: <https://gforge.inria.fr/projects/nascar/>

MEPHYSTO Project-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. 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. Different solvers

- Participants: Simon Legrand, Jean-David Benamou, Quentin Merigot and Boris Thibert
- Contact: Jean-David Benamou
- URL: <https://project.inria.fr/mokabajour/>

6.2. Wasserstein Fisher Rao

Lenaic Chizat

<https://github.com/lchizat/optimal-transport>

This Julia toolbox provides several tools for solving optimal transport, the unbalanced extensions and related problems.

6.3. OT and Sparse Scaling

Bernhard Schmitzer

<http://wwwmath.uni-muenster.de/num/wirth/people/Schmitzer/index.html?content=code>

NACHOS Project-Team

5. New Software and Platforms

5.1. DIOGENeS

Discontinuous Galerkin Nanoscale Solvers

KEYWORDS: High-Performance Computing - Computational electromagnetics - Discontinuous Galerkin - Computational nanophotonics

FUNCTIONAL DESCRIPTION

DIOGENeS is a software suite dedicated to the numerical modeling of light interaction with nanometer scale structures with applications to nanophotonics and nanoplasmonics. DIOGENeS relies on a two layer architecture. The core of the suite is a library of generic software components (data structures and algorithms) for the implementation of high order DG (Discontinuous Galerkin) and HDG (Hybridizable Discontinuous Galerkin) schemes formulated on unstructured tetrahedral and hybrid structured/unstructured (cubic/tetrahedral) meshes. This library is used to develop dedicated simulation software for time-domain and frequency-domain problems relevant to nanophotonics and nanoplasmonics, considering various material models.

- Contact: Stéphane Lanteri
- URL: <http://www-sop.inria.fr/nachos/index.php/Software/DIOGENeS>

5.2. GERShWIN

discontinuous Galerkin Solver for microWave Interaction with biological tissues

KEYWORDS: High-Performance Computing - Computational electromagnetics - Discontinuous Galerkin - Computational bioelectromagnetics

FUNCTIONAL DESCRIPTION

GERShWIN is based on a high order DG method formulated on unstructured tetrahedral meshes for solving the 3D system of time-domain Maxwell equations coupled to a Debye dispersion model.

- Contact: Stéphane Lanteri
- URL: <http://www-sop.inria.fr/nachos/index.php/Software/GERShWIN>

5.3. HORSE

High Order solver for Radar cross Section Evaluation

KEYWORDS: High-Performance Computing - Computational electromagnetics - Discontinuous Galerkin

FUNCTIONAL DESCRIPTION

HORSE is based on a high order HDG (Hybridizable Discontinuous Galerkin) method formulated on unstructured tetrahedral and hybrid structured/unstructured (cubic/tetrahedral) meshes for the discretization of the 3D system of frequency-domain Maxwell equations, coupled to domain decomposition solvers.

- Contact: Stéphane Lanteri
- URL: <http://www-sop.inria.fr/nachos/index.php/Software/HORSE>

NANO-D Project-Team

5. New Software and Platforms

5.1. SAMSON

Software for Adaptive Modeling and Simulation Of Nanosystems

KEYWORDS: Bioinformatics - Simulation - Nanosystems - Structural Biology - Chemistry

SCIENTIFIC DESCRIPTION

Please refer to <https://www.samson-connect.net>

FUNCTIONAL DESCRIPTION

SAMSON is a software platform for real-time modelling and simulation of natural or artificial nanosystems. The objective is to make SAMSON a generic application for computer-aided design of nanosystems, similar to existing applications for macrosystem prototyping (CATIA, SolidWorks, etc.).

- Contact: Stéphane Redon
- URL: <http://www.samson-connect.net/>

POEMS Project-Team

6. New Software and Platforms

6.1. 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>

6.2. 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 (v1.5) has been released in November 2016. This year, many bugs have been fixed and many improvements have been done. The main new features are: introduction of hierarchical matrix, new development for BEM computation (2D Helmholtz is now available), re-engineering of the automatic installation and compilation and connection to a Jenkins test platform. Two training days gathering thirty people have been organized in June 2016.

- Contact: Eric Lunéville and Nicolas Kielbasiewicz
- URL: <http://uma.ensta-paristech.fr/soft/XLiFE++/>

RAPSODI Team

6. New Software and Platforms

6.1. New Software

6.1.1. NS2DDV-M: a code for the simulation of inhomogeneous fluid flow

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.

6.1.2. A scientific computing software for fast simulation of large systems of interacting particles

Benoît Merlet and Thomas Rey have developed a set of numerical codes for the numerical simulation of large systems of interacting particles. For a system of N particles, the number of interactions is a quadratic functions of N , leading to a quadratic cost of a brut force implementation. This fact limits simulations by “naïve” methods to systems with “only” tenth of thousands of particles. In order to treat larger systems (involving millions of particles), the team has implemented a method based on the Non Uniform Fast Fourier Transform which reduces the computation cost of the interactions to $O(N \log N)$. The NUFFT is used to handle the long range smooth interactions. To treat the possibly singular short range interactions (involving only neighboring particles) a quadtree-like method is used. The method is applied to two kind of problems : computations of the dynamics of interacting particles where a standard ordinary differential equation is used; numerical optimization of the energy of a system of interacting particles thanks to a Nonlinear Conjugate Gradient method.

As an illustration of the efficiency of the code, the team has performed numerical experiments which support the following crystallization conjecture : in 2D, a large number of identical charged particles tend to arrange themselves into a regular triangular lattice.

A user friendly version will be released to the public in 2017.

6.1.3. The Fast Spectral Kinetic Scheme

The Fast Spectral Kinetic Scheme (FSKS), has been jointly developed by researchers from the universities of Ferrara, Toulouse, and Lille, and is the first high-order 7-dimensional deterministic numerical method capable of dealing with the complete physics of rarefied gas dynamics. The FSKM indeed solves the Boltzmann equation in 1 dimension of time, 3 of physical space and 3 of velocity space, and has been used to model accurately aerospace engineering problems such as space shuttle re-entry in the atmosphere or very rarefied gas flow in microscopic devices (Knudsen pump).

APICS Project-Team (section vide)

BIPOP Project-Team

5. New Software and Platforms

5.1. ACEF

- Participants: Vincent Acary and Olivier Bonnefon (previous Expert Engineer now at INRA).
- Contact: Vincent Acary.

5.2. Approche

KEYWORD: Geometric computing

- Participants: Alexandre Derouet-Jourdan, Florence Descoubes and Joelle Thollot
- Contact: Florence Descoubes
- URL: <http://bipop.inrialpes.fr/~bertails/Papiers/floatingTangents3d.html>

5.3. CloC

Super Space Clothoids in C

KEYWORD: Physical simulation

FUNCTIONAL DESCRIPTION

Reference software implementing the paper "Super Space Clothoids", R. Casati and F. Bertails-Descoubes, ACM Transactions on Graphics, 2013

- Participants: Florence Descoubes and Romain Casati
- Partner: UJF
- Contact: Florence Descoubes
- URL: <http://bipop.inrialpes.fr/people/casati/publications/codes/ssc.html>

5.4. MECHE-COSM

Modeling Entangled fiber with frictional Contact in Hair

KEYWORDS: Physical simulation - Frictional contact - Thin elastic rod

FUNCTIONAL DESCRIPTION

Implements super-helices [Bertails et al. 2006] coupled together by a hybrid algorithm for frictional contact [Daviet et al. 2011].

- Participants: Gilles Daviet, Florence Bertails Descoubes and Florent Cadoux
- Contact: Florence Descoubes

5.5. SALADYN MULTIBODY

- Participants: Vincent Acary and Olivier Bonnefon
- Contact: Vincent Acary

5.6. SICONOS

KEYWORDS: NSDS - MEMS - DCDC - SD - Collision - Friction - Mechanical multi-body systems

FUNCTIONAL DESCRIPTION

Siconos is an open-source scientific software primarily targeted at modeling and simulating nonsmooth dynamical systems in C++ and in Python: - Mechanical systems (rigid or solid) with unilateral contact and Coulomb friction and impact (nonsmooth mechanics, contact dynamics, multibody systems dynamics or granular materials). - Switched Electrical Circuit such as electrical circuits with ideal and piecewise linear components: power converter, rectifier, Phase-Locked Loop (PLL) or Analog-to-Digital converter. - Sliding mode control systems. - Biology (Gene regulatory network). Other applications are found in Systems and Control (hybrid systems, differential inclusions, optimal control with state constraints), Optimization (Complementarity systems and Variational inequalities), Fluid Mechanics, and Computer Graphics.

- Participants: Vincent Acary, Olivier Bonnefon, Maurice Bremond and Franck Perignon
- Contact: Bernard Brogliato
- URL: <http://siconos.gforge.inria.fr>

5.7. Platforms: SICONOS

5.7.1. 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, intercatations, 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, Benjamin Heymann and Jinyan Liu
- 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, Stéphane Maindrault, Cindie Andrieu, Pierre Jouniaux and Karim Tekkal
- Contact: Pierre Martinon
- URL: <http://www.safety-line.fr>

6.3. Bocop HJB

- Participants: Joseph Frédéric Bonnans, Pierre Martinon, Benjamin Heymann and Jinyan Liu
- Contact: Joseph Frédéric Bonnans
- URL: <http://bocop.org>

DISCO Project-Team (section vide)

GECO Project-Team

6. New Software and Platforms

6.1. ARTIV1 INPAINTING

ARTIV1 INPAINTING

FUNCTIONAL DESCRIPTION

ARTIV1 INPAINTING is a software for reconstruction of corrupted and damaged images. One of the main features of the algorithm on which the software is based is that it does not require any information about the location and character of the corrupted places. Another important advantage is that this method is massively parallelizable, this allows to work with sufficiently large images. Theoretical background of the presented method is based on the model of geometry of vision due to Petitot, Citti and Sarti. The main step is numerical solution of the equation of 3D hypoelliptic diffusion. A new version of the software has just be submitted for protection at APP (Agence pour la protection des programmes).

- Contact: Ugo Boscain

I4S Project-Team

6. New Software and Platforms

6.1. Cloud2IR

KEYWORDS: Sensors - SHM (Structural Health Monitoring) - Sensors network - Open Geospatial Consortium - OGC

SCIENTIFIC DESCRIPTION

Cloud2IR is an helpful tool to build physicals models for the SHM of civil engineering structures.

In this context the software is deployed in the SenseCity-EQUIPEX driven by IFSTTAR (<http://sense-city.iftstar.fr/>)

FUNCTIONAL DESCRIPTION

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.

- Partner: IFSTTAR
- Contact: Jean Dumoulin

This work has been developed during the ADT of Antoine Crinière, Cloud2SM.

6.2. PEGASE

KEYWORD: Sensors - SHM (Structural Health Monitoring)

SCIENTIFIC DESCRIPTION

PEGASE (Plate-forme Experte Générique pour Applications Sans-fil Embarquées) is a generic and high level wireless sensor platform. Currently, the setup of the new PEGASE 2 platform is finalized as the technological successor of the previous PEGASE platform developed by IFSTTAR. This PEGASE 1 platform is licensed and disseminated by the third party company A3IP since 2008 and has been sold in thousands of units.

Based on various feedback from monitoring applications of PEGASE, and due to the fast obsolescence of electronic devices, the design of the new PEGASE 2 platform has been launched in 2013. Some of the main functions of PEGASE are reinforced:

- Software genericity: use of a Linux embedded OS to make application development independent from the hardware, and to enable the user to manage the system without any 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) where each pluggable daughter board implements a specific function (sensing, 3G, Ethernet, communication, signal processing and relay control).
- Accurate time synchronization principle: based on an original GPS and PPS algorithm, PEGASE platform is one of the only boards able to time-stamp data from sensors or any event with high accuracy and in a deterministic way.

On PEGASE 2 platform, previous principles are maintained or extended. A full electronic design from scratch has been decided by the team in 2014 to maximize its capacities in terms efficiency, cost, energy consumption, etc. The main new characteristics of PEGASE 2 are:

- A “real” Linux kernel is now flashed inside the board based on a professional Debian 4.0 (or higher version) of Linux. This Linux branch is the only one validated by IEEE to suit embedded applications
- Previous SDK in C language has been ported and improved in C++ with a generalization of the signal/slot principle to offer end-users a full programming context based on “event driven developments”.
- Extended hardware capacities: GigaBytes of memory, multiple USB port, etc...
- PEGASE 2 board implements new hardware such as a on-board Battery Management System (BMS) to be able to manage an energy efficiency based on a battery and a solar cell; PEGASE 2 mother board integrates a MEMS Mpu9150 from InvenSense company which is a MEMS that provides Acceleration, Temperature and Gyroscope in 3D,...

In 2015 and 2016 various functional daughter boards have been designed to complete the PEGASE 2 panoply:

- 8 analog and 8 digital daughter boards
- LORA protocol Daughter Board
- 3G Daughter Board



Figure 6. PEGASE and PEGASE daughter board

In 2016, based on an industrial contract with the company SDEL-CC (subsidiary company of Vinci group) an important algorithm has been implemented in PEGASE 2 board to make it able to time stamp any physical event up to 10 nanoseconds (independently from the wireless protocol or the distances between the platform that could be some tens of kilometers). This time stamping ability is unique and makes PEGASE 2 the only wireless device in the world with such a time accuracy in a deterministic way and in universal time (based on its GSP/PPS principle).

The most significant development in the PEGASE 2 context is the development of a Generic Cloud Server Application:

- manage multiple instrumentation projects
- various sensors (based on PEGASE 1 or 2 or others) can be set up
- collect big data based on Mongo DB database
- visualize the graphs of data from sensors in $f(t)$ on dynamic charts
- export data to files, through specific API, or to third-party software (Matlab, QT C++...)

In the last two years the Generic Supervisor became a professional software product that is transferred under industrial Licensing, e.g. to the companies Power Lan and Stimio. By the end of 2016, at least these 2 companies will be officially licensed by IFSTTAR to disseminate the Supervisor.

- 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



Figure 7. Supervisor

6.3. TrackingMecaSys

KEYWORDS: Bayesian estimation - Monte-Carlo - GPGPU - Kalman filter - Particular filter - Vibrating system
FUNCTIONAL DESCRIPTION

Implementation of a method based on the use of Bayesian modal parameter recursive estimation based on a particular Kalman filter algorithm with decoupled distributions for mass and stiffness. Algorithm optimized for a GPGPU implementation. This work has been done during ADT of Antoine Crinière and will be updated during the postdoc of S. Sen.

- Contact: Laurent Mevel

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 an open-source software developed to solve optimal control problems by coupling shooting and homotopy methods. More generally, it can be used to solve general Hamiltonian boundary value problems. It also implements an efficient computation of Jacobi fields (allowing in particular second order optimality condition checks) based on the repeated use of automatic differentiation.

- Participants: Jean-Baptiste Caillau, Olivier Cots and Joseph Gergaud
- Contact: Oliver Cots
- URL: <http://www.hampath.org>

NECS Project-Team

6. New Software and Platforms

6.1. GTL

Grenoble Traffic Lab

FUNCTIONAL DESCRIPTION

The Grenoble Traffic Lab (GTL) initiative, led by the NeCS team, is a real-time traffic data Center (platform) that collects traffic road infrastructure information in real-time with minimum latency and fast sampling periods. The main elements of the GTL are: a real-time data-base, a show room, and a calibrated micro-simulator of the Grenoble South Ring. Sensed information comes from a dense wireless sensor network deployed on Grenoble South Ring, providing macroscopic traffic signals such as flows, velocities, densities, and magnetic signatures. This sensor network was set in place in collaboration with Inria spin-off Karrus-ITS, local traffic authorities (DIR-CE, CG38, La Metro), and specialized traffic research centers. In addition to real data, the project also uses simulated data, in order to validate models and to test the ramp-metering, the micro-simulator is a commercial software (developed by TSS AIMSUN ©). More details at <http://necs.inrialpes.fr/pages/grenoble-traffic-lab.php>.

- Participants: Carlos Canudas De Wit, Iker Bellicot, Pascal Bellemain, Dominik Pisarski, Alain Kibangou, Hassen Fourati, Fabio Morbidi, Federica Garin, Andres Alberto Ladino Lopez, Pietro Grandinetti, Enrico Lovisari, Rohit Singhal, Anton Andreev, Remi Piotaix, Vadim Bertrand, Maria Laura Delle Monache and Paolo Frasca
- Contact: Carlos Canudas De Wit
- URL: <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

6.3. Wifi Scan Interval for Android application

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

This app records the wifi scan sampling rate on your phone. This application is available online: <https://play.google.com/store/apps/details?id=fr.inria.tyrex.wifiscaninterval> To contribute to a database: <http://thibaud-michel.com/mobile/wifi-scan-interval.txt> More information: <https://github.com/ThibaudM/WifiScanInterval><http://stackoverflow.com/questions/37193175>

NON-A Project-Team

6. New Software and Platforms

6.1. Blimp

FUNCTIONAL DESCRIPTION

Scientific research and development on the control of autonomous airship 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 airship 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
- URL: <https://bil.inria.fr/fr/software/view/2279/tab>

6.2. ControlHub

The driving idea is to interconnect a group of actors (researchers, engineers, etc.) around a control problem and grant them remote access to existing experimental facilities, thus allowing them to verify their theoretical results online, and finally share them with the project members.

The platform architecture relies on three key principles:

- Problem centric: The control problem to be solved is the core project, whereas the software resources, tools and online experiments are web services available to support experimental verification of the solutions.
- Separation of concerns: setup and maintenance of experiment facilities, installation of software tools, problem formulation and theoretical analysis, etc.
- Resource sharing: software packages, experimental facilities, open problems.
- Contact: R. Dagher, A. Polyakov, J.-P. Richard
- URL: <https://bil.inria.fr/fr/software/view/2830/tab>

6.3. 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: G. Zheng
- URL: <https://bil.inria.fr/fr/software/view/2278/tab>

QUANTIC Project-Team (section vide)

SPHINX Project-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 compute 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. μ -diff

μ -diff is a Matlab toolbox developed with B. Thierry (UPMC, France) for solving 2D multiple scattering problems by a random collection of circular cylinders.

- Contact: Xavier Antoine
- URL: <http://mu-diff.math.cnrs.fr/mu-diff/>

6.4. Platforms

6.4.1. A software for the efficient assignment of L-INP students

Each year, the 1500 students of the L-INP Collégium (gathering most of the engineering students in Lorraine) have to choose one or several among the 70+ courses. J-F. Scheid, a member of our team, is a faculty member of TELECOM Nancy and developed a solver giving a fair, fast and reliable assignment of the students to the courses. The solver works with integer linear optimization and is written in Python and CBC/COIN-OR.

TROPICAL Team

6. New Software and Platforms

6.1. New Software

6.1.1. Coq-Polyhedra

Coq-Polyhedra is a library which aims at formalizing convex polyhedra in Coq. A description of the associated contributions can be found in Section 7.3.1 . Coq-Polyhedra is distributed under the CeCILL-B licence, and can be found at <https://github.com/nhojem/Coq-Polyhedra>.

ANJA Team

5. New Software and Platforms

5.1. New Software

5.1.1. Law

In order for our research to become used in a non-technological domain as is law, we make special efforts to develop user-friendly software tools. We have already made available an iOS application for computing the amount of child support. Another application is currently being developed for spousal support.

Future user-friendly software we intend to propose will be concerned with the areas of personal injury and intellectual property.

5.1.2. Economy and finance

The software toolbox FracLab (<http://fraclab.saclay.inria.fr>) contains a number of tools related to multistable processes, including their simulation and calibration. We intend to pursue these developments in particular by proposing methods dealing with self-stabilizing processes.

We also hope to be able to collaborate with financial institutions, in view of advancing the idea that current regulations, because they are model-based, perform the economy in a way that needs to be carefully scrutinized.

5.1.3. Archaeology

Our software ChronoModel provides a set of Bayesian statistical tools for constructing chronologies using measurement coming from different dating methods (e.g. 14C, TL/OSL, AM, typo-chronology). Chronomodel is a free and open-source cross-platform software that can be downloaded at <http://www.chronomodel.fr>

It offers a user-friendly interface for entering both data and archaeological facts : stratigraphy, temporal order constraints, contemporaneous events.

ChronoModel is currently used by researchers in laboratories of archaeology and earth science, and also by archaeologists working in the organizations of rescue archaeology.

DOLPHIN Project-Team

6. New Software and Platforms

6.1. COCO

COMparing Continuous Optimizers

KEYWORDS: Benchmarking - Numerical optimization - Black-box optimization - Stochastic optimization

SCIENTIFIC DESCRIPTION

COMparing Continuous Optimisers (COCO) is a tool for benchmarking algorithms for black-box optimisation. COCO facilitates systematic experimentation in the field of continuous optimization. COCO provides: (1) an experimental framework for testing the algorithms, (2) post-processing facilities for generating publication quality figures and tables, (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, 140+ 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). A new extension towards bi-objective problems will be used for the BBOB-2016 workshop at GECCO.

- Participants: Dimo Brockhoff, Arnaud Liefooghe, Thanh-Do Tran, Nikolaus Hansen, Anne Auger, Marc Schoenauer, Ouassim Ait Elhara, Asma Atamna, Tea Tusar and Dejan Tusar
- Partners: Université technique de Dortmund - Université technique de Prague
- Contact: Dimo Brockhoff
- URL: <https://github.com/numbbo/coco>

6.2. ParadisEO

KEYWORD: Metaheuristics, multi-objective optimization, Parallel metaheuristics

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 schemes, MO diversity assignment schemes, 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: Université Lille 1
- Contact: El-Ghazali Talbi
- URL: <http://paradiseo.gforge.inria.fr/>

6.3. VRPsolve

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

- Participants: Clive Ferret-Canape, Arnaud Liefoghe and Sebastien Verel
- URL: <http://gforge.inria.fr/projects/vrpsolve>

6.4. Platform 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

5. New Software and Platforms

5.1. Fluex

KEYWORDS: Signal - Signal processing

SCIENTIFIC DESCRIPTION

Fluex is a package consisting of the Microcanonical Multiscale Formalism for 1D, 2D 3D and 3D+t general signals.

FUNCTIONAL DESCRIPTION Fluex is a C++ library developed under Gforge. Fluex is a library in nonlinear signal processing. Fluex is able to analyze turbulent and natural complex signals, Fluex is able to determine low level features in these signals that cannot be determined using standard linear techniques.

- Participants: Rémi Paties and Hussein Yahia
- Contact: Hussein Yahia
- URL: <https://geostat.bordeaux.inria.fr/index.php/downloads.html>
- URL: <https://bil.inria.fr/fr/software/view/2113/tab>

5.2. FluidExponents

- Participants: Hussein Yahia and Antonio Turiel
- Contact: Hussein Yahia
- URL: <https://bil.inria.fr/fr/software/view/336/tab>

INOCS Team (section vide)

MISTIS Project-Team

6. New Software and Platforms

6.1. BOLD model FIT

KEYWORDS: Functional imaging - fMRI - Health

FUNCTIONAL DESCRIPTION

This Matlab toolbox performs the automatic estimation of biophysical parameters using the extended Balloon model and BOLD fMRI data. It takes as input a MAT file and provides as output the parameter estimates achieved by using stochastic optimization

- Authors: Pablo Mesejo Santiago, Jan M Warnking and Florence Forbes
- Contact: Pablo Mesejo Santiago
- URL: <https://hal.archives-ouvertes.fr/hal-01221115v2/>

6.2. 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 generalization 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>

6.3. 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, Aina Frau Pascual and Jaime Eduardo Arias Almeida
- Partners: CEA - NeuroSpin
- Contact: Florence Forbes
- URL: <http://pyhrf.org>

6.4. xLLiM

High dimensional locally linear mapping

KEYWORDS: Clustering - Regression

FUNCTIONAL DESCRIPTION

This is an R package available on the [CRAN](#).

XLLiM provides a tool for non linear mapping (non linear regression) using a mixture of regression model and an inverse regression strategy. The methods include the GLLiM model (Deleforge et al (2015)) based on Gaussian mixtures and a robust version of GLLiM, named SLLiM (see [71]) based on a mixture of Generalized Student distributions.

- Participants: Emeline Perthame, Florence Forbes and Antoine Deleforge
- Contact: Florence Forbes
- URL: <https://cran.r-project.org/web/packages/xLLiM/index.html>

MODAL Project-Team

6. New Software and Platforms

6.1. BlockCluster

Block Clustering

KEYWORDS: Statistic analysis - Clustering package

SCIENTIFIC DESCRIPTION

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

FUNCTIONAL DESCRIPTION

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

- 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) (published in 2016) 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: Matthieu Marbac-Lourdelle
- 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

KEYWORDS: Bioinformatics - Data mining - Statistics - Genomics

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 developed 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

High-Dimensional Penalized Regression

FUNCTIONAL DESCRIPTION

HDPenReg 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

Multi-Patient Analysis of Genomic markers

KEYWORDS: Segmentation - Genomics - Marker selection - Biostatistics

SCIENTIFIC DESCRIPTION

MPAgenomics 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

Meta-analysis for MicroArrays

KEYWORDS: Transcriptomics - Meta-analysis - Differential analysis - Microarrays - Biostatistics

FUNCTIONAL DESCRIPTION

MetaMA 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

KEYWORDS: Transcriptomics - Meta-analysis - Differential analysis - High throughput sequencing - Biostatistics

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

Clustering using Mixture Models

KEYWORDS: Clustering - Clustering package - Generative Models

FUNCTIONAL DESCRIPTION

MixAll is a model-based clustering package for modelling mixed data sets. It has been engineered around the idea of easy and quick integration of any kind of mixture models for any kind of data, under the conditional independence assumption. Currently five models (Gaussian mixtures, categorical mixtures, Poisson mixtures, Gamma mixtures and kernel mixtures) are implemented. MixAll has the ability to natively manage completely missing values when assumed as random. MixAll is used as an R package, but its internals are coded in C++ as part of the STK++ library (<http://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: Matthieu Marbac-Lourdelle
- URL: https://r-forge.r-project.org/R/?group_id=1939

6.14. Mixmod

Many-purpose software for data mining and statistical learning

KEYWORDS: Data mining - Classification - Mixed data - Data modeling - Big data

FUNCTIONAL DESCRIPTION

Mixmod is a free toolbox for data mining and statistical learning designed for large and high dimensional 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 Lebreton and Benjamin Auder
- Partners: CNRS - HEUDIASYC - Laboratoire Paul Painlevé - LIFL - LMB - Université Lille 1
- Contact: Gilles Celeux
- URL: <http://www.mixmod.org>

6.15. MixtComp

Mixture Computation

KEYWORDS: Clustering - Statistics - Missing data

FUNCTIONAL DESCRIPTION

MixtComp (Mixture Computation) is a model-based clustering package for mixed data originating from the Modal team (Inria Lille). It has been engineered around the idea of easy and quick integration of all new univariate models, under the conditional independence assumption. New models will eventually be available from researches, carried out by the Modal team or by other teams. Currently, central architecture of MixtComp is built and functionality has been field-tested through industry partnerships. Three basic models (Gaussian, multinomial, Poisson) are implemented, as well as two advanced models (Ordinal and Rank). A new advanced model concerning functional data is also available in 2016. 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://massiccc.lille.inria.fr/#/>

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++

Statistical ToolKit

KEYWORDS: Statistics - Linear algebra - Framework

FUNCTIONAL DESCRIPTION

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

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

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

6.18. clere

FUNCTIONAL DESCRIPTION

The clere package for R proposes variable clustering in high dimensional linear regression. Available on CRAN and now published to an international journal dedicated to software: [24].

- 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

STK++ core library integration to R using Rcpp

KEYWORDS: C++ - Data mining - Clustering - Statistics - Regression

FUNCTIONAL DESCRIPTION

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

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

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, Romain Leguay, Artur Alves Pessoa, Boris Detienne, Franck Labat, François Clautiaux, Pierre Pesneau, Eduardo Uchoa Barboza, Michael Poss and Halil Sen
- Partners: CNRS - IPB - Universidade Federal Fluminense - Université de Bordeaux
- Contact: François Vanderbeck
- URL: <https://wiki.bordeaux.inria.fr/realopt/pmwiki.php/Project/BaPCod>

SELECT Project-Team

5. New Software and Platforms

5.1. BlockCluster

Block Clustering

KEYWORDS: Mixture model - Block cluster analysis

SCIENTIFIC DESCRIPTION

Blockcluster is software devoted to model-based block clustering. It is developed in partnership 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 categorical 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 also been provided. This non-asymptotic criterion appears to be more relevant than the BIC-like approximation of ICL.

FUNCTIONAL DESCRIPTION

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

- Participants: Gilles Celeux, Christine Keribin, Christophe Biernacki and Serge Iovleff
- Contact: Gilles Celeux
- URL: <http://cran.r-project.org/web/packages/blockcluster/index.html>

5.2. Mixmod

Multi-purpose software for model-based clustering and classification with continuous and categorical variables.

KEYWORDS: Mixture model - cluster analysis - discriminant analysis

FUNCTIONAL DESCRIPTION

MIXMOD is being developed in collaboration with Christophe Biernacki, Florent Langrogné (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>.

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

Jonas Renault, an engineer, is in charge of developing a web version of MIXMOD.

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

5.3. MASSICCC

Massive Clustering with Cloud Computing

KEYWORDS: Statistic analysis - Big data - Machine learning - Web Application

SCIENTIFIC DESCRIPTION

The web application let users use several software packages developed by Inria directly in a web browser. Mixmod is a classification library for continuous and categorical data. MixtComp allows for missing data and a larger choice of data types developed by MODAL team (Inria Lille). BlockCluster is a library for co-clustering data. When using the web application, the user can first upload a data set, then configure a job using one of the libraries mentioned and start the execution of the job on a cluster. The results are then displayed directly in the browser allowing for rapid understanding and interactive visualisation.

FUNCTIONAL DESCRIPTION

The MASSICCC web application offers a simple and dynamic interface for analysing heterogeneous data with a web browser. Various software packages for statistical analysis are available (Mixmod, MixtComp, BlockCluster) which allow for supervised and supervised classification of large data sets.

- Participants: Christophe Biernacki, Gilles Celeux, Benjamin Auder, Josselein Demont, Jonas Renault
- Contact: Jonas Renault
- URL: <https://massiccc.lille.inria.fr>

SEQUEL Project-Team

6. New Software and Platforms

6.1. BAC

Bayesian Policy Gradient and Actor-Critic Algorithms

KEYWORDS: Machine learning - Incremental learning - Policy Learning

FUNCTIONAL DESCRIPTION

To address this issue, we proceed to supplement our Bayesian policy gradient framework with a new actor-critic learning model in which a Bayesian class of non-parametric critics, based on Gaussian process temporal difference learning, is used. Such critics model the action-value function as a Gaussian process, allowing Bayes' rule to be used in computing the posterior distribution over action-value functions, conditioned on the observed data. Appropriate choices of the policy parameterization and of the prior covariance (kernel) between action-values allow us to obtain closed-form expressions for the posterior distribution of the gradient of the expected return with respect to the policy parameters. We perform detailed experimental comparisons of the proposed Bayesian policy gradient and actor-critic algorithms with classic Monte-Carlo based policy gradient methods, as well as with each other, on a number of reinforcement learning problems.

- Contact: Michal Valko
- URL: <https://team.inria.fr/sequel/Software/BAC/>

6.2. Collaborative Filtering Network

KEYWORDS: Recommender system - Neural networks - Deep learning

FUNCTIONAL DESCRIPTION

Recommendation systems advise users on which items (movies, musics, books etc.) they are more likely to be interested in. A good recommendation system may dramatically increase the amount of sales of a firm or retain customers. For instance, 80% of movies watched on Netflix come from the recommender system of the company. Collaborative Filtering (CF) aims at recommending an item to a user by predicting how a user would rate this item. To do so, the feedback of one user on some items is combined with the feedback of all other users on all items to predict a new rating. For instance, if someone rated a few books, CF objective is to estimate the ratings he would have given to thousands of other books by using the ratings of all the other readers.

The following module tackles Collaborative Filtering tasks by using a novel approach based on neural networks (sparse denoising autoencoders). In a few words, the module lets the user train neural networks to predict unknown entries in a history files.

The input files are classic csv files. The output files can either be the full matrix of ratings and/or the network weights. The root mean square error is computed to assess the quality of the training.

This module is based on Lua/Torch Framework. It works on both CPU/GPU and it is multithreaded.

- Contact: Florian Strub
- URL: https://github.com/fstrub95/Autoencoders_cf

SIERRA Project-Team

5. New Software and Platforms

5.1. DICA : Discrete Independent Component Analysis

FUNCTIONAL DESCRIPTION

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.

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>

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

FUNCTIONAL DESCRIPTION

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, 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>

5.3. cnn_head_detection: Context-aware CNNs for person head detection

FUNCTIONAL DESCRIPTION

Code for ICCV 2015 paper "Context-aware CNNs for person head detection": 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

5.4. Lightning: large-scale linear classification, regression and ranking in Python

FUNCTIONAL DESCRIPTION

Lightning is a Python library for large-scale machine learning. More specifically, the library focuses on linear models for classification, regression and ranking. Lightning is the first project to integrate scikit-learn-contrib, a repository of high-quality projects that follow the same API conventions as scikit-learn. Compared to scikit-learn, the main advantages of lightning are its scalability and its flexibility. Indeed, lightning implements cutting-edge optimization algorithms that allow to train models with millions of samples within seconds on commodity hardware. Furthermore, lightning can leverage prior knowledge thanks to so-called structured penalties, an area of research that has recently found applications in domains as diverse as biology, neuroimaging, finance or text processing. Lightning is available under the 3-clause BSD license at <http://contrib.scikit-learn.org/lightning/>.

- Contact: Fabian Pedregosa
- URL: <http://contrib.scikit-learn.org/lightning/>

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, $f(x)=x^T H x$, BFGS (Matlabs function `fminunc`) is typically faster by a factor of about ten (in terms of number of objective function evaluations needed to reach a target function value, assuming that gradients are not available). On the most simple quadratic function $f(x)=\|x\|^2=x^T x$ 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) [65] 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, Python) which allows to run and log experiments on a suite of test functions. Several testbeds are provided. (ii) a Python tool for generating figures and tables that can be browsed in `html` or used in LaTeX templates.

FUNCTIONAL DESCRIPTION

The COCO platform provides the functionality to automatically benchmark optimization algorithms for bounded or unbounded, (yet) 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, 140+ 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. A new test suite of bi-objective problems [74] has been used for the BBOB-2016 workshop at GECCO.

- Participants: Dimo Brockhoff, Arnaud Liefooghe, Thanh-Do Tran, Nikolaus Hansen, Anne Auger, Marc Schoenauer, Ouassim Ait Elhara, Asma Atamna, Tea Tusar and Dejan Tusar
- Partners: Université technique de Dortmund - Université technique de Prague
- Contact: Dimo Brockhoff
- URL: <https://github.com/numbbo/coco>

6.3. Cartolabe

FUNCTIONAL DESCRIPTION

The goal of Cartolabe is to build a visual map representing the scientific activity of an institution/university/domain from published articles and reports. Using the HAL Database and building upon the AnHALytics processing chain, Cartolabe provides the user with a map of the thematics, authors and articles and their dynamics along time. ML techniques are used for dimensionality reduction, cluster and topics identification; visualisation techniques are used for a scalable 2D representation of the results.

- Participants: Felix Loustisserand, Philippe Caillou, Michèle Sebag, Jean-Daniel Fekete (AVIZ)
- Partners: AVIZ (Inria)
- Contact: Philippe Caillou
- URL: <https://cartolabe.lri.fr>

6.4. 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. A main further work is the introduction of generic tools for stochastic dynamic programming into the platform, for comparison and hybridization with other tools from the UCT-SIG.

- Participants: Olivier Teytaud, Jeremie Decock, Jean-Joseph Christophe, Vincent Berthier, Marie Liesse Cauwet and Sandra Cecilia Astete Morales
- Partner: Artelys
- Contact: Olivier Teytaud
- URL: <https://www.lri.fr/~teytaud/metis.html>

6.5. io.datascience

FUNCTIONAL DESCRIPTION

This Data as a Service (DaaS) platform is developed in the context of the Center for Data Science and the TIMCO project. Its overall goal is to exploit the advances in semantic web techniques for efficient sharing and usage of scientific data [41], [73]. A related specific software is the Tester for Triplestore (TFT) software suite, which benchmarks the compliance of sparql databases wrt the RDF standard and publishes the results through the SparqlScore service. The io.datascience platform has been selected for presentation at numerous venues, see section 10.3 for details.

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

6.6. CodaLab

KEYWORDS Benchmarking, competitions.

FUNCTIONAL DESCRIPTION

Challenges in machine learning and data science are competitions running over several weeks or months to resolve problems using provided datasets or simulated environments. Challenges can be thought of as crowdsourcing, benchmarking, and communication tools. They have been used for decades to test and compare competing solutions in machine learning in a fair and controlled way, to eliminate “inventor-evaluator” bias, and to stimulate the scientific community while promoting reproducible science.

Codalab Competitions (<http://competitions.codalab.org>) is a project that was started by Microsoft Research in 2013 in which Isabelle Guyon has taken an active part, to promote the use of challenges in Machine Learning and Data Science. The TAO team has been selected to take over the project under Isabelle Guyon’s leadership. The transfer has been successfully completed in the fall 2016. New features are being implemented, including developing a Wizard <http://staging.chalab.eu/>.

With already over 50 public competitions (including this year the Data Science Game, a student Olympiad co-organized by our PhD. student Benjamin Donnot <http://www.datasciencegame.com/>, the AutoML challenge <http://automl.chalearn.org/> [42] and a new contest in the LAP challenge series <http://chalearnlap.cvc.uab.es/> [47], co-organized by Isabelle Guyon), Codalab is taking momentum in medical imaging, computer vision, time series prediction, text mining, and other applications. TAO is going to continue expanding Codalab to accommodate new needs. For example, two competitions in preparation – TrackML competition (in High Energy Physics) [72] and the See.4C competition (spatio-temporal time series in collaboration with RTE) [48] – will require code submission, permitting to benchmark methods in a controlled environment. We are re-designing the backend of CodaLab to allow organizers to add more servers to satisfy on-the-fly demands of new competitions. Other features coming soon will be the possibility of interacting with a data generating model (rather than analyzing “canned” data), which enables the organization of reinforcement learning competitions and the possibility of organizing “coopetitions” (a mix of competition and collaboration). Other existing challenge platforms are too restrictive to simulate collaboration between participants and implement “coopetitions”. Our starting PhD. student Lisheng Sun designed and implemented a first prototype of coopetition “Beat AutoSKLearn”, which was run at the NIPS Challenges in Machine Learning workshop (CiML 2016 <http://ciml.chalearn.org/>).

- Contact: Isabelle Guyon
- URL: <http://competitions.codalab.org>

ASPI Project-Team (section vide)

CQFD Project-Team

6. New Software and Platforms

6.1. 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 described 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>

6.2. 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, Jérôme Saracco
- Contact: Amaury Labenne
- URL: <https://cran.r-project.org/web/packages/ClustGeo/index.html>

6.3. 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, Jérôme Saracco
- Contact: Marie Chavent
- URL: <https://cran.r-project.org/web/packages/PCAmixdata/index.html>

6.4. QuantifQuantile

FUNCTIONAL DESCRIPTION

QuantifQuantile is an R package that allows to perform quantization-based quantile regression. The different functions of the package allow the user to construct an optimal grid of N quantizers and to estimate conditional quantiles. This estimation requires a data driven selection of the size N of the grid that is implemented in the functions. Illustration of the selection of N is available, and graphical output of the resulting estimated curves or surfaces (depending on the dimension of the covariate) is directly provided via the plot function.

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

6.5. biips

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: Francois Caron and Adrien Todeschini
- 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: Financial products - Computational finance - Option pricing

6.2. Scientific Description

Premia is a software designed for option pricing, hedging and financial model calibration.

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.

6.3. Functional Description

- Participants: Mathrisk project team and contributors
- Partners: Ecole des Ponts ParisTech - Inria - 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)
- OS/Middleware: Linux, Mac OS X, Windows
- APP: The development of Premia started in 1999 and 17 are released up to now and registered at the APP agency. Premia 16 has been registered on 03/03/2015 under the number IDDN.FR.001.190010.013.S.C.2001.000.31000
- Programming language: C/C++
- Documentation: scientific documentation of all the algorithm implemented. PNL has a 100 pages user documentation
- Size of the software: For the Src part of Premia : 337046 lines , that is 14 Mbyte of code, and 117 Mbyte of PDF files of documentation; For PNL: 747952 lines , that is 25 MO.
- interfaces : Nsp for Windows/Linux/Mac, Excel, binding Python, and a Web interface.
- Publications: [15], [68], [75], [83], [86], [56], [66].

6.4. Content

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.

- **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.

- **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.

- **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)

- **Hybrid products**

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

- **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.

6.5. PNL numerical library

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.

This year, Jérôme Lelong has performed the following tasks on the development of PNL:

Releases 1.7.3 and 1.7.4. of the *PNL* library (<http://pnl.gforge.inria.fr/>).

1. Simplify the use of PNL under Visual Studio. It can either be compiled using CMake or added as an external library to an existing project.
2. Improve the construction of large `PnlBasis` objects and make it possible to deal with non tensor functions.
3. Add complex error functions.

6.6. Consortium Premia

The software Premia is supported by a Consortium of financial institutions created in 1999. The members of the Consortium give an annual financial contribution and receive every year a new version enriched with new algorithms. They participate to the annual meeting where future new developments are discussed.

6.7. Diffusion

All releases of the software Premia (18 in 2016) are registered at the French agency APP. The most recent is provided to the Consortium with an appropriate licence. An opensource version is also available for academic purposes. The software is thus used in many universities, with in France and abroad.

6.8. Algorithms implemented in Premia in 2016

Premia 18 has been delivered to the consortium members in March 2016.

It contains the following new algorithms:

6.8.1. Insurance, Risk Management, Optimal Trade Execution

- A Forward Solution for Computing Derivatives Exposure. M. Ben Taarit, B. Lapeyre.
- Monte Carlo Calculation of Exposure Profiles and Greeks for Bermudan and Barrier Options under the Heston Hull-White Model. Q. Feng, C.W. Oosterlee.
- Dynamic optimal execution in a mixed-market-impact Hawkes price model. A. Alfonsi, P. Blanc. *Finance & Stochastics*
- A Hamilton Jacobi Bellman approach to optimal trade execution. P. Forsyth, *Applied Numerical Mathematics* 61, 2011.

6.8.2. Equity Derivatives

- Value function approximation or stopping time approximation: a comparison of two recent numerical methods for American option pricing using simulation and regression. L. Stentoft, *Journal of Computational Finance*, 18(1), 2014.
- Pricing American-Style Options by Monte Carlo Simulation: Alternatives to Ordinary Least Squares. S. Tompaidis, C. Yang, *Journal of Computational Finance*, 18(1), 2014,
- Solving Optimal Stopping Problems using Martingale Bases. J.Lelong
- The Stochastic Grid Bundling Method: Efficient Pricing of Bermudan Options and their Greeks. S. Jain, C.W. Oosterlee.
- Two-dimensional Fourier cosine series expansion method for pricing financial options. C.W.Oosterlee M.J. Ruijter, *SIAM J. Sci. Comput.*, 34(5), 2012.
- Estimation of the parameters of the Wishart process. A.Alfonsi, A.Kebaier, C.Rey, *Preprint*
- The 4/2 Stochastic Volatility Model. M. Grasselli, *Preprint*.
- Ninomiya Victoir Scheme and Multi Level Scheme. A. Al Gerbi, E. Clement, B. Jourdain.
- Importance Sampling for Multilevel Monte Carlo. A.Kebaier J.Lelong
- The evaluation of barrier option prices under stochastic volatility. C.Chiarella, B.Kang, G.H.Meyer, *Computers and Mathematics with Applications* 64, 2012.
- Volatility swaps and volatility options on discretely sampled realized variance. G.Lian, C.Chiarella, P.S.Kalev, *Journal of Economic Dynamics Control* 47 2014
- Efficient variations of the Fourier transform in applications to option pricing. S. Boyarchenko and S.Levendorski, *Journal of Computational Finance*, 18(2), 2014.
- Model-free implied volatility: from surface to index. M. Fukasawa et al., *Int. J. Theor. Appl. Finan.* 14, 433, 2011

- Stratified approximations for the pricing of options on average. N.Privault J.Yu *Journal of Computational Finance*.

Moreover, J. Lelong has ensured everyday maintenance to fix various bugs, especially related to Visual C++; and has get rid of the old bunch of scripts to generate the HTML documentation by implementing the required mechanism directly in TeX. This makes the system much more robust; He has also worked on the continuous integration process with Sébastien Hinderer. Moreover, part of Premia documentation is now generated directly from the source code. The 3000 lines of undocumented C code used so far had become unmaintainable. Now, it is replaced by a much more flexible and efficient Python script.

TOSCA Project-Team

5. New Software and Platforms

5.1. AGH

FUNCTIONAL DESCRIPTION

AGH (for Analysis of Galton-Watson Harris paths) is a Matlab toolbox providing methods for statistical analysis of ordered trees from their Harris paths in a user-friendly environment. More precisely it allows to easily compute estimators of the relative scale of trees which share the same shape. These estimators have been introduced for Galton-Watson trees conditioned on their number of nodes but may be computed for any ordered tree.

- Participants: Romain Azaïs, Alexandre Genadot, Benoît Henry
- Contact: Benoît Henry
- URL: <http://agh.gforge.inria.fr/>

5.2. ExitBM

FUNCTIONAL DESCRIPTION

The exitbm library provides methods to simulate random variables related to the first exit time and position of the Brownian motion from simple domains, namely intervals, squares and rectangles.

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

5.3. SDM-WindPoS

Stochastic Downscaling Method and Wind Power Simulation

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-windpos 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.

The ability of SDM-WindPoS to regamma the wind computation in the horizontal scale but also in the vertical scale is of particular interest for wind farm power production assessment. WindPoS couples direct actuator disk approach and SDM Atmospheric Boundary Layer (ABL) model for wind farm simulation.

This year we start to introduce more accurate ABL convection models in SDM. Moreover, we start to add the possibility to introduce more accurate topography when SDM is running with some coarse scale atmospheric input data. Our dedicated GUI was also improved (better rendering for the 2D and 3D views).

- Participants: Mireille Bossy
- Contact: Mireille Bossy
- URL: <http://windpos.inria.fr>