INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE

Team BIPOP

Modeling, Simulating, Controlling Non-Regular Dynamical Systems

Rhône-Alpes

THEME NUM

Activity Report

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1. Team

Head of project-team
Bernard Brogliato [senior research scientist]

Administrative assistant
Marie Wiernsperger [till November 2005]

Staff members Inria
Vincent Acary [junior research scientist]
Bernard Espiau [Head of the Inria Rhône-Alpes Laboratory]
Claude Lemaréchal [senior research scientist]
Pierre-Brice Wieber [junior research scientist]

Ph. D. students
Sophie Chareyron [Siconos fellowship]
Jean-Baptiste Charlety [Siconos grant, till April 2005]
Mathieu Guilbert [Cifre fellowship]
Rodolphe Heliot [CEA fellowship]
Jérôme Malick [ENS fellowship]
Georges Petrou [Cifre, FT&D]
Doh-Elvis Taha [Inria-Schneider Electric fellowship, till October 2005]

Post-Doc students
Matthieu Renouf [Bipop-Siames; Ministry fellowship, till October 2005]

Specialist Engineer
Pascal Denoyelle [Inria grant, since September 2005]

Training students
Pascal Denoyelle [Master 2 IMSN, from March to August 2005]
Fabien Jammes
Charles Poussot-Vassal

Expert engineers
Jean-Michel Barbier [till April 2005; Siconos fellowship]
Florence Billet [RNTS Mimes]
Franck Perignon [Siconos fellowship, since April 2005]

2. Overall Objectives

2.1. Overall Objectives

Generally speaking, this project deals with nonregular systems, control, modelling and simulation, with emphasis on

- dynamic systems, mostly mechanical systems with unilateral constraints and Coulomb friction, but also electrical circuits with ideal diodes and transistors Mos, etc;
- biped robots and their connection with human walking, a rich and instructive instance of such systems;
- numerical methods for nonsmooth optimization, and more generally the connection between continuous and combinatorial optimization.

3. Scientific Foundations

3.1. Dynamic non-regular systems

Keywords: *analysis*, *complementarity*, *control*, *convex analysis*, *impacts*, *mechanical systems*, *modeling*, *simulation*, *unilateral constraints*.

Dynamical systems (we limit ourselves to finite-dimensional ones) are said to be *non-regular* whenever some nonsmoothness of the state arises. This nonsmoothness may have various roots: for example some outer impulse, entailing so-called *differential equations with measure*. An important class of such systems can be described by the complementarity system

$$\left\{\begin{array}{l} \dot{x} = f(x, u, \lambda)\,, \\ 0 \le y \perp \lambda \ge 0\,, \\ g(y, \lambda, x, u, t) = 0\,, \\ \text{re-initialization law of the state } x(\cdot)\ , \end{array}\right. \tag{1}$$

where $\perp$ denotes orthogonality; u is a control input. Now (1) can be viewed from different angles.

- Hybrid systems: it is in fact natural to consider that (1) corresponds to different models, depending whether $y_i = 0$ or $y_i > 0$ (y_i being a component of the vector y). In some cases, passing from one mode to the other implies a jump in the state x; then the continuous dynamics in (1) may contain distributions.
- Differential inclusions: $0 \le y \perp \lambda \ge 0$ is equivalent to $-\lambda \in \mathrm{N}_K(y)$, where K is the nonnegative orthant and $\mathrm{N}_K(y)$ denotes the normal cone to K at y. Then it is not difficult to reformulate (1) as a differential inclusion.
- Dynamic variational inequalities: such a formalism reads as $\langle \dot{x}(t) + F(x(t), t), v - x(t)\rangle \ge 0$ for all $v \in K$ and $x(t) \in K$, where K is a nonempty closed convex set. When K is a polyhedron, then this can also be written as a complementarity system as in (1).

Thus, the 2nd and 3rd lines in (1) define the modes of the hybrid systems, as well as the conditions under which transitions occur from one mode to another. The 4th line defines how transitions are performed by the state x. There are several other formalisms which are quite related to complementarity. Two tutorial-survey papers have been published [2], [7], whose aim is to introduce the dynamics of complementarity systems and the main available results in the fields of mathematical analysis, analysis for control (controllability, observability, stability), and feedback control.

3.2. Biped robots

Keywords: *control*, *mechanics*, *mobile robotics*, *modeling*, *robotics*, *sensor-based control*, *simulation of mechanical systems*, *solid mechanics*.

3.2.1. Modeling

A biped robot can be modeled [57], [58] as a tree-like articulated chain of rigid bodies in R^3. Walking is characterized by different phases, mainly (for a given leg): swing (35% of the cycle), support (65%); there is a double-support phase (12%), which does not exist when running. A finer decomposition takes into account the movement of the mass center, and above all of the foot. These different phases are characterized by different contacts between the system and the ground.

As a result, the mechanical model of such a system has three aspects:

- the dynamics of a rigid articulated system, free in the space, representable by Lagrangian equation;
- a set of equality and inequality constraints, depending on the phase, which expresses the existence of contacts without penetration nor sliding; each one of these sets defines an operating mode;

- the selection of impact laws modeling the transitions (assumed instantaneous) between these modes.

This makes up a sophisticated hybrid system, whose study is still little explored, see [10] for a survey on modeling, stability and control of biped robots.

3.2.2. Controlling

The pace naturally adopted by a human walker is regular and symmetric, consuming little energy for a reasonable speed. Some hybrid systems, such as leaping robots or transmissions with slack, present likewise limit cycles corresponding to dynamic equilibria, possibly stable in a certain domain. For the simplest walking robot – a compass on a slope – these cycles correspond to passive periodic trajectories (without external action), in which the transition between kinematic and potential energies is entirely balanced by the energy absorbtion during the impact [53].

As a result of these considerations, our approach of control aims at constructing cyclic trajectories, minimizing energy – whatever this means. Also, it is important to guarantee a global progression while preserving a particular mechanical stability, which is dynamic. Classical approaches – for example following accurately nominal articulated trajectories – are therefore inadequate, except if one is just interested in controlling the attitude. The field is far from being settled, so we have to explore diverse control techniques: nonsmooth optimization, predictive control, adaptive learning, task function control [56]... including sensor-based control, allowing to use local measures of distance, proximity, reaction to the ground etc.

3.3. Nonsmooth optimization

Keywords: *Lagrangian relaxation*, *combinatorial optimization*, *convexity*, *numerical algorithm*, *optimization*.

Here we are dealing with the minimization of a function f (say over the whole space R^n), whose derivatives are discontinuous. A typical situation is when f comes from dualization, if the primal problem is not strictly convex – for example a large-scale linear program – or even nonconvex – for example a combinatorial optimization problem. Also important is the case of spectral functions, where $f(x) = F(\lambda(A(x)))$, A being a symmetric matrix and λ its spectrum.

For these types of problems, we are mainly interested in developing efficient resolution algorithms. Our basic tool is bundling [9] and we act along two directions:

- To explore application areas where nonsmooth optimization algorithms can be applied, possibly after some tayloring. A rich field of such application is combinatorial optimization, with all forms of relaxation [12], [11].
- To explore the possibility of designing more sophisticated algorithms. This implies an appropriate generalization of second derivatives when the first derivative does not exist, and we use advanced tools of nonsmooth analysis, for example [13].

4. Application Domains

4.1. Application Domains

Many systems (either actual or abstract) can be represented by (1). Some typical examples are:

- Mechanical systems with unilateral constraints and dry friction (the biped robot is a typical example), including kinematic chains with slack, phenomena of liquid slosh, etc.
- Electrical circuits with ideal diodes and/or transistors MOS.
- Optimal control with constraints on the state, closed loop of a system controlled by an MPC algorithm, etc.

This class of models is not too large (to allow thorough studies), yet rich enough to include many applications. This goes in contrast to a study of general hybrid systems. Note for example that (1) is a "continuous" hybrid system, in that the continuous variables x and u prevail in the evolution (there is no discrete control to commute from a mode to the other: only the input u can be used).

We have created this year an activity in micro-electronics. Electronic circuits – either integrated on a single substrate or as a set of components on a board – are very often a complex assembly of many basic components with non linear characteristics. Designers of electronic products are relying on various checking softwares, among which electrical time domain simulators were the first to be developed in the early '70s. The SPICE 2 simulator (Simulation Program with Integrated Circuit Emphasis) was released in 1975 by the Berkeley university as a free software. It provides insight into the evolution of voltages and currents in a circuit modelled as an assembly of dipoles. Some of the algorithms embedded in SPICE evolved in commercial versions, but its main original features were kept: use of smooth models and solution of nonlinear equations with the Newton-Raphson algorithm. The models of devices and especially of MOS transistors followed the increasing role of parasitic effects due to geometries shrinkage and speed increase.

Besides this 20 year story, the IC technologies evolved and now allow the integration of hundreds of millions of transistor switching at GHz frequencies on a die of 1cm^2. It is out of question to simulate a whole such IC with a SPICE simulator, even with today's computers! Thus developers mainly rely on a thorough SPICE simulation of small subsets of circuits (logic gates, RAM blocks, ...) providing a coarse model of each subset that will be used in a less accurate simulator (logic simulator).

Nevertheless, some parasitic effects can strongly affect the operation (crosstalk between lines, signal integrity, power distribution, ...). Some of these require a physical model to be properly characterized. With an electrical simulator like SPICE, it is still possible to study their effects. But a logic simulator used for a whole chip simulation cannot handle properly these effects. Thus there is today a need for a fast time domain electrical simulator that will allow the simulation of a huge number of MOS transistors, transmission lines, discrete components with an accuracy as close as possible to SPICE's one, and much faster.

The nonsmooth approach in modelling and simulating dynamical systems carried by the BIPOP team has already provided interesting results for simulating standard power electronic circuits like rectifiers. These first attempts done during a training course led us to launch a deeper involvement in this application: a dedicated plug-in able to simulate a whole circuit comprising various components, some modelled in a nonsmooth way. This development is led by INRIA/BIPOP. A cooperation with IMAG/LMC/MOSAIC team (J. DellaDora, J.-G. Dumas) has already started on specific topics (linear algebra, DAE index analysis). We also plan to have next year two training students working on the automatic equations setting and the MOS parameter computation.

Walking robots – for example hexapods – possess definite advantages over the rolling ones whenever the ground is not plane or free: clearing obstacles is easier, holding on the ground is lighter, adaptivity is improved. However, if the working environment of the system is adapted to man, the biped technology must be preferred, to preserve good displacement abilities without modifying the environment. This explains the interest displayed by the international community in robotics toward humanoid systems, whose aim is to back man in some of his activities, professional or others. For example, a certain form of help at home to disabled persons could be done by biped robots, as they are able to move without any special adaptation of the environment.

In virtual reality, a major issue is the representation of real phenomena and the fine control of the model behind this. In particular, the interaction between objects, and therefore the treatment of contact, friction and impacts, is crucial. This treatment is usually decomposed into two tasks. The first one, which corresponds to the geometric detection of the interaction, is now carried out in a very efficient way for simple geometric primitives. The second task, numerical, constitutes the core of the collaboration between the Siames (Irisa/Rennes) and Bipop projects. Our main aim is to bridge the gap between the know-how of Bipop in nonsmooth mechanics and the know-how of Siames in virtual reality applications.

Optimization exists in virtually all economic sectors. Simulation tools can be used to optimize the system they simulate. Another domain is parameter *identification* (Idopt or Estime teams), where the deviation between measurements and theoretical predictions must be minimized. Accordingly, giving an exhaustive list of applications is impossible. Some domains where Inria has been implied in the past, possibly through the former Promath and Numopt teams are: production management, geophysics, finance, molecular modeling, robotics, networks, astrophysics, crystallography, ...

5. Software

5.1. Software

Two sorts of software are developed within Bipop.

5.1.1. Nonsmooth dynamics

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

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

1. *Siconos/Numerics* This library contains a set of numerical algorithms, already well identified, to solve non smooth dynamical systems. This library is written in low-level languages (C,F77) in order to ensure numerical efficiency and the use of standard libraries (Blas, Lapack, ...)
2. *Siconos/Kernel(Engine + Front-End)* The Engine is an object-oriented structure (C++) for modeling and simulation of abstract dynamical systems. The Front-End is the driver interface of the Engine thanks to two types of API's. The first one is an API in C++, interfaced in Python for scripting uses. The second API, in C, will be interfaced with Scilab for a more user-friendly platform.
3. *Siconos/Analysis* This part is devoted to the stability and bifurcation analysis of nonsmooth dynamical systems.
4. *Siconos/Control* This part is devoted to the implementation of control strategies of non smooth dynamical systems.
5. *Siconos/*IMSE The final product is an Integrated modeling and Simulation Environment dedicated to applied nonsmooth problems.

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

5.1.2. Optimization

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

The following optimization codes have been developed in the framework of the former Promath project.

5.1.2.1. Code M1QN3

Optimization without constraints for problems with many variables ($n \geq 10^3$, has been used for $n = 10^6$). Technically, uses a limited-memory BFGS algorithm with Wolfe's line-search (see [1] for the terminology).

5.1.2.2. Code M2QN1

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

5.1.2.3. Code N1CV2

Minimization without constraints of a convex nonsmooth function by a proximal bundle method ([9], [1]).

5.1.2.4. Modulopt

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

6. New Results

6.1. Stability and Feedback Control

6.1.1. Stability of evolution variational inequalities

Participant: Bernard Brogliato.

We continued our work with D. Goeleven, from the University of la Réunion on systems of the type $\langle \dot{x}(t) + Ax(t), v - x(t) \rangle \geq 0$ for all $v \in K$, $x(t) \in K$ (K being a nonempty closed convex set). Necessary conditions for the asymptotic stability have been obtained in [24], where the notion of Brouwer degree of a function is used. The difficulty here is that the function is nonsmooth. The results are applied to the asymptotic stabilization of a controlled variational inequality. They show that in general the controllability of the unconstrained system, is neither sufficient nor necessary to guarantee the existence of a constant feedback which guarantee asymptotic stability.

The LaSalle invariance principle has also been studied for the case of evolution variational inequalities, see Sect. 6.1.4.

6.1.2. Absolute stability with maximal monotone mappings

Participant: Bernard Brogliato.

We recall that the absolute stability problem consists of studying the stability of a system made of the negative feedback interconnection of a dissipative system with a nonlinear characteristic. Last year [52] we extended absolute stability to a feedback branch containing a maximal monotone operator. There is an additional difficulty in the sense that we now consider inclusions which are non-autonomous. All of these works use well-posedness results for monotone differential inclusions *à la* Brézis.

6.1.3. Tracking control of complementarity Lagrangian systems

Participant: Bernard Brogliato.

As a sequel to our previous works [4], [5], we clarified in [18] the design and the role of the transition phases (stabilisation on the constraint surface or detachment from this surface) in the closed-loop stability, extending the so-called passivity-based control design to unilaterally constrained systems. In [30], the robustness of this family of controllers has been tested with numerical simulations.

6.1.4. Stability theory for nonsmooth dynamical systems

Participant: Sophie Chareyron.

The framework of nonsmooth dynamical systems appears as particularly powerful and adequate for analyzing the dynamics of rigid bodies with non-permanent contact. But it introduces mathematical tools which are unusual in control theory, such as velocities with locally bounded variations, measure accelerations, measure differential inclusions, and the control theory for such systems is just beginning to emerge, even the basic stability theory still needing to be established thoroughly. Fortunately Lyapunov stability theory is not strictly bounded to smooth dynamical systems.

For example, in the general setting of dynamical systems described by flows possibly non-differentiable and even discontinuous, we could derive in [33] a Lyapunov stability theorem and in [31] a LaSalle invariance theorem. Building on these theorems, we can propose a Lagrange-Dirichlet theorem for nonsmooth Lagrangian dynamical systems by showing that their energy can be naturally taken as Lyapunov function. Based on this result we prove in [32], for the first time, the stability of a passivity-based control law for the position and force regulation of a walking robot, without any assumption on the state of the contacts. This work is synthetized in the PhD thesis [15].

6.1.5. Friction compensation on the BIP robot

Participants: Pierre-Brice Wieber, Charles Poussot-Vassal.

The BIP robot is getting old: its ability to precisely track reference trajectories is severely hampered now by strong friction in the nonlinear actuators. Different friction compensation schemes have been tested with varying success. In this process, a precise measurement of this friction confirmed that it is very strongly position dependent, explaining the poor results obtained with simple model-based compensation schemes. We implemented therefore a simple observer-based adaptive compensation scheme with good, promising results; see [48].

6.1.6. Reconstruction of 3D movements with inertial and/or optical sensors

Participants: Pierre-Brice Wieber, Fabien Jammes.

The problem of reconstructing the 3D movements of a person, based on inertial and/or optical measurements can be considered as an inverse problem, with the help of a “direct” model of both the biomechanics of the person and the measurement process. This reconstruction can be seen then as a nonlinear least-squares problem with box constraints, which is solved successfully with a classical Gauss-Newton iterations scheme.

6.1.7. Optimal trajectory generation for industrial robot

Participants: Matthieu Guilbert, Pierre-Brice Wieber.

Recall that this work is done with Staübli SCA, Faverges (Luc Joly).

We continued the work begun in 2004 on the optimal trajectory generator for manipulator robots based on the optimal control theory. To solve our optimal control problem, we have used a direct transcription method based on cubic and quintic spline discretizations (quintic splines are used to get continuity of the acceleration on the boundaries, in order to avoid vibrations). We have developed an offline software, described in [43]. We are now turning to developing an online optimal trajectory generator.

We have been working for 7 months on an alternative approach to optimize trajectories (which we call global approach); this global approach is based on nonlinear optimization without derivatives. A software has been developed, which works satisfactorily; more details on this approach is described in [42]; a patent has been applied for, [46].

6.1.8. Detection of postural modifications and motion monitoring - Application to Rehabilitation

Participants: Bernard Espiau, Rodolphe Héliot.

This work is conducted with Christine Azevedo (Lirmm) and Dominique David (Cea-Leti).

When controlling postural movements through artificial prosthetic limbs or muscle Functional Electrical Stimulation (FES), an important issue is the enhancement of the interaction of the patient with the artificial system through his valid limb motions. We believe that a clever observation of valid limbs could improve the global postural task by giving the patient an active role in the control of his deficient limbs. We developed an approach to identify a postural task by observing one limb. Our objectives are : 1) to detect and to identify the voluntary actions of a subject as early as possible after a movement decision is taken, and 2) to monitor the current motion in order to estimate the task state variables. We employed a set of micro sensors (Cea-Leti Trident system) providing us with accelerations and absolute 3D orientations; then we implemented specific signal processing methods. Two directions have already been investigated:

1. Early detection of Sit-to-Stand. Trunk sensor acceleration information allows the detection of task initiation 500ms before legs started moving in 10 healthy subjects. This delay is sufficient to envision using this detection in order to control a leg FES system in paraplegic patients. To achieve this, we tested two methods: a correlation computation method, and an abrupt change detection method which relies on SLR (Sequential Likelihood Ratio) estimates, and reveals to be a powerful tool for such applications.
2. Gait phase identification in a steady-state walk by observing one leg with two sensors placed unilaterally at the thigh and shank levels during a walking task. Eight healthy subjects and 7 stroke patients have been involved in experiments carried out in Bronderslev rehabilitation center (Denmark). We were able to define a list of events associated with gait cycle phases which could be robustly detected. These results will find application in stroke patient rehabilitation, as part of early therapy, by triggering pre-computed stimulation sequences of deficient leg. This study has been realized in collaboration with D. Popovic during R. Héliot's 3-month visit at SMI (Aalborg, Denmark).

6.2. Modeling

6.2.1. Multiple impacts

Participants: Vincent Acary, Bernard Brogliato, Doh-Elvis Taha.

An impact is said to be multiple when several impacts occur at the same time on the system. The multiple impact mappings which have already been proposed in the literature, are not satisfactory because they often result in post-impact velocities that obviously disagree with experiments, and/or are not tractable from the numerical point of view. Based on previous works in Bipop [50], the goal of the PhD thesis of D.E. Taha in collaboration with Schneider Electric is to extend the multiple impact law to finite-dimensional systems such as circuit breakers, and to exhibit the limit of validity of the approach (assumption of quasi-rigid solids). First results have been obtained in extending the unidimensional multiple impact laws to bidimensional cases.

6.3. Nonsmooth optimization

6.3.1. Geometrical study of structured nonsmooth fonctions

Participant: Jerôme Malick.

Work done with A. Daniilidis (Barcelona univ.) and W. Hare (Mc Master univ.)

In [25], we have established connections between Newton methods of the $\mathcal{U}$-Lagragian, SQP methods and the Riemannian Newton method. In [41] (submitted), the connections between geometry and nonsmooth analysis are further explored. In particular, we give:

– nonsmooth properties of the (geometrical) Riemmannian gradient;
– geometrical properties of the (nonsmooth) proximal points.

6.3.2. Toward second-order semidefinite least-squares solvers

Participant: Jerôme Malick.

Work done with P. N'Diaye (RaisePartner SAS) and H. Sendov (Guelph univ., Canada)

Our dual approach [54] to solve semidefinite least-squares problems uses the standard quasi-Newton algorithm, whose superlinear convergence is unlikely in this particular setting (see some heuristic arguments in [51]). It is therefore appropriate to study the viability of the so-called generalized Newton algorithm [55] instead. A first step was to give a handy description of the generalized Hessians in this context, which is done in [47].

6.3.3. *New developments in semidefinite optimization*

Participant: Jerôme Malick.

Work done with F. Rendl (Klagenfurt univ., Austria)

Standard methods for semidefinite programming (SDP), based on the interior-point paradigm, become heavy or even impractical for really large problems. By contrast, semidefinite least-square problems (SDLS, which have a quadratic objective function) are amenable to dual algorithms less sensitive to dimensionality: see [54]. We propose in [37] to solve SDP problems via SDLS by a (primal) proximal approach. This can equivalently be viewed as the (dual) augmented Lagrangian approach, which turns out to be currently investigated by F. Rendl and his team. We therefore started a collaboration with F. Rendl, a paper is in preparation.

6.4. Software development

6.4.1. *The HuMAnS toolbox, software for humanoid motion analysis and simulation*

Participants: Pierre-Brice Wieber, Florence Billet, Laurence Boissieux, Roger Pissard-Gibollet.

The HuMAnS toolbox offers tools for the modelling, control and analysis of humanoid motion, be it of a robot or a human. It is a C/C++/Scilab/Maple-based set of integrated tools for the generation of dynamical models of articulated bodies with unilateral contact and friction, their simulation with an event-driven integration scheme, their 3D visualization, the computation of stability measures, optimal positions and trajectories, the generation of control laws and observers, the reconstruction of movements from different sensing systems.

In particular, the event-driven scheme allows the integration of the hybrid dynamics that appears in the muscle contraction model developed by the DEMAR team at Inria Sophia-Antipolis. A complete simulation of the functional electric stimulation (FES) of paraplegic people for their rehabilitation to walking is thus allowed.

6.4.2. *Siconos Project: Deliverable D2.2, second updated and revised version*

Participants: Vincent Acary, Jean-Baptiste Charlety, Pascal Denoyelle, Franck Perignon, Mathieu Renouf.

An updated and revised version of the deliverable D2.2 has been prepared for the Siconos review meeting in October 2005. We recall that this deliverable contains all of the software documentation (Quality, Design, implementation and user documentation) and reports the work carried out at Iniia (CO1) and LMGC (AC2) on the architectural design of the Siconos/Platform (Numerics, Kernel, Front-end) and the work of the University of Bristol (CR6) for designing and managing the Siconos/Analysis module. This new document is produced on the basis of a set of standard HTML documents for the design and development of software (http://readyset.tigris.org). The restructuring improves the readability and maintenance of the development document.

Most of these documents will continue to be improved.

6.4.3. *Platform development*

Participants: Vincent Acary, Jean-Baptiste Charlety, Pascal Denoyelle, Franck Perignon, Mathieu Renouf.

Between May and September 2005, a huge effort has been devoted to validating the platform from the numerical point of view. Now that the software engineering work is done, the development is focused on the implementation of numerical methods, together with the validation of the architecture of new templates:

- Franck Perignon and Vincent Acary have focused their works on validating new benchmarks for non linear Lagrangian systems with unilateral contact.
- Pascal Denoyelle has implemented the first benchmarks on linear complementarity systems in simulating several electrical circuits with ideal diodes. Several comparisons have been made with SPICE.
- Mathieu Renouf and Vincent Acary have validated the algorithms for solving LCP in Siconos/Numerics and have added new types of algorithms.

7. Contracts and Grants with Industry

7.1. Contracts and Grants with Industry

– Schneider Elecric, contract 682: multiple impacts;
– Staübli SCA, contract 16: control of an articulated robot;
– FT R&D, contract 444: robust design of telecommunication networks;
– RaisePartner SAS, contract 1233: optimization in finance.

8. Other Grants and Activities

8.1. European Actions

The Bipop project coordinates the European project Siconos (modeling, SImulation and COntrol of NOnsmooth dynamical Systems, IST 2001-37172), which is an FP5 project starting September 2002 and ending September 2006. See http://siconos.inrialpes.fr.

8.2. Invitation of specialists

– D. Henrion (Laas, Toulouse) 2 days;
– K.C. Kiwiel (Systems Research Institute, Warsaw) 2 weeks;
– F. Rendl, A. Wiegele (Univ. Klagenfurt) 2 days.

8.3. Visits abroad

– R. Héliot: 3-month visit at SMI (Sensory Motor Interaction Center, Aalborg univ., Denmark), supported by a Marie Curie grant, under the supervision of Pr. D.B. Popovic;
– P.-B. Wieber: 2 month JSPS Fellowship at the CNRS-AIST Joint Research Laboratory, Tsukuba (Japan);
– J. Malick: 1 week at Klagenfurt Univ. (Austria).

8.4. Teaching

– Univ. Joseph Fourier, Grenoble (V. Acary: tutoring “Mathematical models for physics” 48h; S. Chareyron: tutoring discrete time control, 12h; J. Malick: calculus, matrix algebra, 60h);
– Polytech’Grenoble (J.-M. Bourgeot: tutoring automatic control, 21h; S. Chareyron: tutoring identification and control, 21h);
– Ensimag, Grenoble (C. Lemaréchal, V. Acary: Numerical Optimization, 27h);
– Ensieg, Grenoble (S. Chareyron: linear control, 2x28h);
– École de Physique, Chimie, Électronique de Lyon (C. Lemaréchal: Numerical Optimization, 16h).

8.5. Participation to conferences, seminars

– 2nd Workshop “Optimization and Applications”, Oberwolfach, Jan. 2005 (co-organization and 1 communication);

– 8th Workshop on Combinatorial Optimization; Aussois, March 2005 (1 presentation);
– HSCC05, Zürich, March 2005 (1 presentation);
– Mid-term technical Siconos meeting, Montbonnot, March-April 2005;
– Congrès SMAI, Évian, May 2005 (1 presentation);
– 8th Siam Conf. on Optimization, Stockholm, May 2005 (1 presentation);
– Journées Thématiques sur les Robots Humanoïdes (1 presentation);
– Motor Control Sandbjerg symposium (Denmark), May 2005;
– Kotor Summer School “How to evaluate the efficacy of neural prostheses”, Aalborg Univ., June 2005;
– ECCOMAS Thematic Conference on Multibody Dynamics, Madrid, June 2005 (1 presentation);
– Siconos/Da Vinci joint conference, Montbonnot, June 2005;
– ICAR’2005 (Int. Conf. on Advanced Robotics), Seattle, July 2005 (1 presentation);
– Siconos 4th General Meeting, Technical University Eindhoven, Aug. 2005;
– ENOC 2005, 5th Euromech Nonlinear Dynamics conference, Eindhoven University of Technology, Aug. 2005 (2 presentations);
– CLAWAR, London, Sept. 2005 (1 presentation);
– AMAM’2005 (Adaptive Motion in Animals and Machines), Ilmenau, Sept. 2005 (1 presentation);
– Int. Workshop on Fast Motion in Biomechanics and Robotics, Heidelberg (1 presentation);
– Journées Nationales de la Recherche en Robotique, Rennes (1 presentation);
– Seminars at: JRL, AIST Digital Human Research Center (Tokyo), Toulouse Univ., LIRMM, LMS

9. Dissemination

9.1. Dissemination of software

9.1.1. HuMAnS toolbox

This toolbox is used in the BIPOP team and at LMS in Poitiers for applications on the Bip robot and in biomechanics, at JRL in Japan for applications on the HRP-2 robot, in the DEMAR team in Montpellier and at SMI in Aalborg to analyze FES of paralyzed muscles. It is distributed under the GNU general public license.

9.1.2. First release of the platform

The first release (version 0.1) of the platform has been delivered in September 2005 under the GPL licence. The distribution will be performed through the web interface of the development project: Gforge (http://gforge.inria.fr/projects/siconos). The bug tracker tools and the discussion lists will be open to a public access.

9.1.3. Optimization codes

– M1QN3 at Univ. Toulouse (autocorrelated state vectors);
– M2QN1 at Design Processing Technologies (optimum design in electrical engineering).

9.2. Animation of the scientific community

B. Brogliato is:
– Associate Editor for Automatica (June 1999 to June 2005: Intelligent and Adaptive Systems; since June 2005: Nonlinear Systems and Control)
– Reviewer for Mathematical Reviews since 2001
– Reviewer for ASME Applied Mechanics Reviews since 2001

B. Espiau is a member of
– the Steering Committees of Laas and Lirm,
– the Scientific Committee of JRL-France (Joint Robotics Laboratory),
– Programm Committe of ISR2006, ICAR2006 and others.

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