



RESEARCH CENTER
Lille - Nord Europe

FIELD

Activity Report 2017

Section Application Domains

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BONSAI Project-Team

4. Application Domains

4.1. Life Sciences and health

Our research plays a pivotal role in all fields of life sciences and health where genomic data are involved. This includes more specifically the following topics: plant genomics (genome structure, evolution, microRNAs), cancer (leukemia, mosaic tumors), drug design (NRPSs), environment (metagenomics and metatranscriptomics), virology (evolution, RNA structures) ...

DEFROST Project-Team

4. Application Domains

4.1. Industry

Robotics in the manufacturing industry is already highly diffused and is one of the ways put forward to maintain the level of competitiveness of companies based in France and to avoid relocation in cheap labor countries. Yet, in France, it is considered that the level of robotization is insufficient compared to Germany, for instance. One of the challenge is the high investment cost for buying robotic arms. In the recent years, it has led the development of « generic » and « flexible » (but rigid) robotic solution that can be produced in series. But their applicability to specific tasks is still challenging or too costly. With the development of 3D printing, we can imagine the development of a complete opposite strategy: a « task-specific » design of robots. Given a task that needs to be performed by a deformable robot: we would optimize the shape of its structure to create the set of desired motion. An second important aspect is the reduction of the manufacturing cost: It is often anticipated that the cost of deformable robots will be low compared to classical rigid robotics. The robot could be built on one piece using rapid prototyping or 3D printers and be more adapted for collaborative work with operators. In this area, using soft materials are particularly convenient as they provide a mass/carried load ratio several orders higher than traditional robots, highly decreasing the kinetic energy and so increasing the motion speed allowed in presence of humans. Moreover, the technology allows more efficient and ergonomic wearable robotic devices, opening the options for exo-skeletons. This remains to be put in place, but it can open new perspectives in robotic applications. A last remarkable property of soft robots is their adaptability to fragile or tortuous environment. For some particular industry (chemistry, food industry...) this could also be an advantage compared to existing rigid solutions. For instance, the German company <https://www.festo.com/group/en/cms/12747.htm>, key player in the industrial robots field, is experiencing with deformable trunk robot and we are working on their accurate control.

This year (2017), we have started to work more concretely on this domain, with a research contrat with TDR company on design of deformable graspers.

4.2. Personal and service robotics

The personal and service robotics are considered as an important source of economic expansion in the coming years. The potential applications are numerous and particularly include the challenge of finding robotic solutions for active and healthy aging at home. We plan to develop functional orthosis for which it is better not to have a rigid exoskeleton that is particularly not comfortable. These orthosis will be ideally personalised for each patient and built using rapid prototyping. On this topic, the place of our team will be to provide algorithms for controlling the robots. We will find some partners to build these robots that would fall in the category of « wearable robots ». With this thematic we also connect with a strong pole of excellence of the region on intelligent textile (see <http://www.up-tex.fr/Up-Text>) and with the strategic plan of Inria (Improving Rehabilitation and Autonomy).

4.3. Entertainment industry and arts

Robots have a long history with entertainment and arts where <https://en.wikipedia.org/wiki/Animatronics> animatronics have been used since years for cinematographic shootings, theater, amusement parc (https://en.wikipedia.org/wiki/List_of_Disney_attractions_using_Audio-Animatronics Disney's audio-animatronic) and performing arts. We believe that soft robots could be a good support for art. We have currently a collaboration with the artist Jonathan Pepe (see <http://jonathanpepe.tumblr.com/Haruspices>).



Figure 1. Exobiote project

DOLPHIN Team

4. Application Domains

4.1. Smart grids

With the smart grid revolution, house energy consumption will play a significant role in the energy system. Home users are indeed responsible for a significant portion of the world's energy needs portion, but are totally inelastic with respect to the market (i.e. the energy demand does not follow the price of the energy itself). Thus, the whole energy generation and distribution system performance can be improved by optimizing the house energy management. Those problems are concerned by multiple objectives such as cost and users' comfort, and multiple decision makers such as end-users and energy operators. We propose a home automation system that can monitor appliance scheduling in order to simultaneously optimize the total energy cost and the customer satisfaction [17].

The key challenge is to propose new optimization models and new hybrid optimization algorithms to the demand side management of smart grids in a context of uncertainty and in the presence of several conflicting objectives. Those complex optimization problems are also characterized by the presence of both continuous and discrete variables [18].

4.2. Transportation and logistics

- **Scheduling problems under uncertainty:** The flow-shop scheduling problem is one of the most well-known problems from scheduling. However, most of the works in the literature use a deterministic single-objective formulation. In general, the minimized objective is the total completion time (makespan). Many other criteria may be used to schedule tasks on different machines: maximum tardiness, total tardiness, mean job flowtime, number of delayed jobs, maximum job flowtime, etc. In the DOLPHIN project, a bi-criteria model, which consists in minimizing the makespan and the total tardiness, is studied. A bi-objective flow-shop problem with uncertainty on the duration, minimizing in addition the maximum tardiness, is also studied. It allows us to develop and test multi-objective (and not only bi-objective) optimization methods under uncertainty.
- **Routing problems under uncertainty:** The vehicle routing problem (VRP) is a well-known problem and it has been studied since the end of the fifties. It has a lot of practical applications in many industrial areas (ex. transportation, logistics, etc). Existing studies of the VRP are almost all concerned with the minimization of the total distance only. The model studied in the DOLPHIN project introduces a second objective, whose purpose is to balance the length of the tours. This new criterion is expressed as the minimization of the difference between the length of the longest tour and the length of the shortest tour. Uncertainty on the demands has also been introduced in the model.

4.3. Bioinformatics and Health care

Bioinformatic research is a great challenge for our society and numerous research entities of different specialities (biology, medical or information technology) are collaborating on specific themes.

4.3.1. Genomic and post-genomic studies

Previous studies of the DOLPHIN project mainly deal with genomic and postgenomic applications. These have been realized in collaboration with academic and industrial partners (IBL: Biology Institute of Lille; IPL: Pasteur Institute of Lille; IT-Omics firm).

First, genomic studies aim at analyzing genetic factors which may explain multi-factorial diseases such as diabetes, obesity or cardiovascular diseases. The scientific goal was to formulate hypotheses describing associations that may have any influence on diseases under study.

Secondly, in the context of post-genomic, a very large amount of data are obtained thanks to advanced technologies and have to be analyzed. Hence, one of the goals of the project was to develop analysis methods in order to discover knowledge in data coming from biological experiments.

These problems can be modeled as classical data mining tasks (Association rules, feature selection). As the combinatoric of such problems is very high and the quality criteria not unique, we proposed to model these problems as multi-objective combinatorial optimization problems. Evolutionary approaches have been adopted in order to cope with large scale problems.

Nowadays the technology is still going fast and the amount of data increases rapidly. Within the collaboration with Genes Diffusion, specialized in genetics and animal reproduction for bovine, swine, equine and rabbit species, we study combinations of Single Nucleotide Polymorphisms (SNP) that can explain some phenotypic characteristics. Therefore feature selection for regression is addressed using metaheuristics.

4.3.2. Optimization for health care

The collaboration with the Alicante company, a major actor in the hospital decision making, deals with knowledge extraction by optimization methods for improving the process of inclusion in clinical trials. Indeed, conducting a clinical trial, allowing for example to measure the effectiveness of a treatment, involves selecting a set of patients likely to participate to this test. Currently existing selection processes are far from optimal, and many potential patients are not considered. The objective of this collaboration consists in helping the practitioner to quickly determine if a patient is interesting for a clinical trial or not. Exploring different data sources (from a hospital information system, patient data...), a set of decision rules have to be generated. For this, approaches from multi-objective combinatorial optimization are implemented, requiring extensive work to model the problem, to define criteria optimization and to design specific optimization methods.

In another project we address the problems, proper models and suitable solving approaches to optimize the design and planning of a medical laboratory. It comes from the observation that human biology laboratories tend to get bigger and more complicated. The goal of this project is to design and apply solutions to optimize human biology laboratory decisions and operations. As a result of mutualisation phenomenon, huge medical laboratories are emerging all over the world. Medical laboratories are responsible for analyzing medical tests ordered by physicians on patient's samples. Large number of prescriptions and tubes are received by a laboratory make a complicated workflow into the system. The aim of this thesis is to design and plan a medical laboratory to minimize the costs and time required to perform the tests. Medical laboratory optimization is an immense problem which encompasses many subproblems. In the literature, there are only few studies that refer directly to medical laboratory planning and optimization from different points of view. In this thesis, the problem of designing and planning of medical laboratory is studied in a comprehensive form for both existing and new labs to provide practical models and solutions that can be implemented to real cases. The problem is studied from two different aspects: strategic and operational problems. In strategic level, machine selection and analyzer configuration problem and facilities layout problem are modeled and solved to achieve an optimal medical laboratory design. Mathematical programming is used for this phase. For operational level, the problems of assignment and scheduling are emerged. Mathematical programming, heuristic and meta-heuristic algorithms are proposed to deal with such problems. Simulation as a powerful tool is applied to verify and validate the solutions proposed from the previous analytical steps and also to aid decision making in some problems. FlexSim is a simulation software which is used in this study and provide us the ability to model and analyze complex systems. It is worth mentioning that this project is raised by Normand-Info, a Beckman Coulter subsidiary which is an international company mainly producing human biology instruments. Thus, it is a collaborative research work with industry.

FUN Project-Team

4. Application Domains

4.1. Application Domains

The set of applications enabled through FUN and IoT is very large and can apply in every application area. We can thus not be exhaustive but among the most spread applications, we can name every area, event or animal monitoring, understanding and protection. To illustrate this, we may refer to the use cases addressed by our PREDNET project which goals is to equip rhinoceros with smart communicating devices to fight against poaching.

Other field of application is exploration of hostile and/or unknown environment by a fleet of self-organizing robots that cooperate with RFID and sensors to ensure a continue monitoring afterwards.

Also, IoT and FUN ca play a key role in logistics and traceability by relying on the use of sensors or RFID technologies as implemented in our TRACAVERRRE project or our collaboration with the start up TRAXENS.

Finally, IoT and FUN leverage a lot of applications in Smart City concept , ranging from parking aid to a better energy consumption going through air quality monitoring, traffic fluidizing etc. (See our CityLab Inria and VITAL projects).

INOCS Team

4. Application Domains

4.1. Energy

In energy, the team mainly focuses on pricing models for demand side management. Demand side management methods are traditionally used to control electricity demand which became quite irregular recently and resulted in inefficiency in supply. We have explored the relationship between energy suppliers and customers who are connected to a smart grid. The smart grid technology allows customers to keep track of hourly prices and shift their demand accordingly, and allows the provider to observe the actual demand response to its pricing strategy. We tackle pricing problems in energy according to the bilevel optimization approaches. Some research works in this domain are supported by bilateral grants with EDF.

4.2. Transportation and Logistics

In transportation and logistics, the team addresses mainly integrated problems, which require taking into account simultaneously different types of decision. Examples are location and routing, inventory management and routing or staff scheduling and warehouse operations management. Such problems occur from the supply chain design level to the logistic facility level. Some research works in this application domain are supported by bilateral grants/contrats with Colisweb, DHL, HappyChic, INFRABEL, or Kéolis.

4.3. Telecommunications

In telecommunications, the team mainly focuses on network design problems and on routing problems. Such problems are optimization problems with complex structure, since the optimization of capacity installation and traffic flow routing have to be addressed simultaneously. Some research works are conducted within a long-term cooperation with Nokia (formerly Alcatel-Lucent Bell Labs).

LINKS Project-Team

4. Application Domains

4.1. Linked Data Integration

There are many contexts in which integrating linked data is interesting. We advocate here one possible scenario, namely that of integrating business linked data to feed what is called Business Intelligence. The latter consists of a set of theories and methodologies that transform raw data into meaningful and useful information for business purposes (from Wikipedia). In the past decade, most of the enterprise data was proprietary, thus residing within the enterprise repository, along with the knowledge derived from that data. Today's enterprises and businessmen need to face the problem of information explosion, due to the Internet's ability to rapidly convey large amounts of information throughout the world via end-user applications and tools. Although linked data collections exist by bridging the gap between enterprise data and external resources, they are not sufficient to support the various tasks of Business Intelligence. To make a concrete example, concepts in an enterprise repository need to be matched with concepts in Wikipedia and this can be done via pointers or equalities. However, more complex logical statements (i.e. mappings) need to be conceived to map a portion of a local database to a portion of an RDF graph, such as a subgraph in Wikipedia or in a social network, e.g. LinkedIn. Such mappings would then enrich the amount of knowledge shared within the enterprise and let more complex queries be evaluated. As an example, businessmen with the aid of business intelligence tools need to make complex sentimental analysis on the potential clients and for such a reason, such tools must be able to pose complex queries, that exploit the previous logical mappings to guide their analysis. Moreover, the external resources may be rapidly evolving thus leading to revisit the current state of business intelligence within the enterprise.

4.2. Data Cleaning

The second example of application of our proposal concerns scientists who want to quickly inspect relevant literature and datasets. In such a case, local knowledge that comes from a local repository of publications belonging to a research institute (e.g. HAL) need to be integrated with other Web-based repositories, such as DBLP, Google Scholar, ResearchGate and even Wikipedia. Indeed, the local repository may be incomplete or contain semantic ambiguities, such as mistaken or missing conference venues, mistaken long names for the publication venues and journals, missing explanation of research keywords, and opaque keywords. We envision a publication management system that exploits both links between database elements, namely pointers to external resources and logical links. The latter can be complex relationships between local portions of data and remote resources, encoded as schema mappings. There are different tasks that such a scenario could entail such as (i) cleaning the errors with links to correct data e.g. via mappings from HAL to DBLP for the publications errors, and via mappings from HAL to Wikipedia for opaque keywords, (ii) thoroughly enrich the list of publications of a given research institute, and (iii) support complex queries on the corrected data combined with logical mappings.

4.3. Real Time Complex Event Processing

Complex event processing serves for monitoring nested word streams in real time. Complex event streams are gaining popularity with social networks such as with Facebook and Twitter, and thus should be supported by distributed databases on the Web. Since this is not yet the case, there remains much space for future industrial transfer related to Links' second axis on dynamic linked data.

MAGNET Project-Team

4. Application Domains

4.1. Domain

Our main targeted applications are browsing, monitoring, recommending and mining in information networks. The learning tasks considered in the project such as node clustering, node and link classification and link prediction are likely to yield important improvements in these applications. Application domains cover social networks for cultural data and e-commerce, and biomedical informatics.

We also target applications related to decentralized learning and privacy preserving systems when users or devices are interconnected in large networks. We develop solutions based on urban and mobility data where privacy is a specific requirement.

MEPHYSTO Project-Team (section vide)

MINT2 Team

4. Application Domains

4.1. Domain

MINT team currently devotes application to domains such as cultural heritage, retail, and health.

Mjolnir Team

4. Application Domains

4.1. Application Domains

Mjolnir works on fundamental aspects of Human-Computer Interaction that can be applied to diverse application domains. Our 2017 research concerned desktop, touch-based, haptics, and BCI interfaces with notable applications to education, genetics research, as well as creativity support tools (3D audio production and design of Digital Musical Instruments).

MODAL Project-Team

4. Application Domains

4.1. Economic world

The Modal team applies its research to the economic world through CIFRE PhD supervision such as CA CF (credit scoring), A-Volute (expert in 3D sound), Meilleur Taux (insurance comparator), ... It also has many contracts with companies such as Running care (sport and medical coaching), Arcelor-Mittal (steel industry), Alstom (integrated transport systems) and Vallourec (tubular solutions for the energy markets and for other demanding industrial applications).

4.2. Biology

The second main application domain of the team is the biology. Members of the team are involved in the supervision and scientific animation of the bilille platform, the bioinformatics and bioanalysis platform of Lille. A 2 months research contact has been performed for the Florimond Desprez company (seed industry), and several academic projects have been led in collaboration with research teams in health and biology.

NON-A Project-Team

4. Application Domains

4.1. Robots and networked systems

Inria Lille and team FUN are hosting an “equipment of excellence”, named FIT-IoT lab. It gives a remote access to thousands of wireless sensors to be connected with hundreds of mobile robots. Today, many sensor scenarios are available, with few robot testbeds.

The package SLIM, developed by Non-A under ROS (Robot Operating System) with the support of an Inria ADT, aims at contributing to this environment. The self deployment of autonomous groups of mobile robots in an unknown and variable environment is a next step for IoT-lab, involving localization, path planning and robust control problems. Our ROS package SLIM aims at combining various algorithms developed by Non-A (localization, path planning, robust control). It should also offer a software library for multi-robot including: optimal local planner based on flatness; plugin for communication between different ROS cores; module Multi-Mapping for robot cooperation; plugin for YEI IMU.

4.2. Living systems: ecological monitoring, modelling, estimation and identification of biological systems, human-computer interaction

Modelling, estimation or detection for living is difficult because such systems cannot be isolated from external influences. Using our numerical differentiation tools, together with modelling techniques, we want to study the following four applications:

- *Biosensing*: Unlike classical approaches deploying physical sensors, biological systems can be used as living sensors. The marine biology lab EPOC (CNRS, Bordeaux) has developed underwater sensors for bivalve molluscs (such as oysters) measuring and sending through RGPS the opening gap between the two valves. We want to use it for water quality monitoring by either identifying oyster’s rhythm I/O models or by using our differentiation tools. Spawning detection is also considered (ANR WaQMoS).
- *Human-Computer Interaction*: Reduction of the latency between the human input and the system visual response in HCI (ANR TurboTouch). To do that, a simple forecasting algorithm for latency compensation in indirect interaction using a mouse has to be developed based on differentiators.
- *Smart bracelet*: Design a dynamical model for the GSR and for the development of an online algorithm making the GSR signal independent of the user movements. Most resulting computations should be embedded into the bracelet. Collaboration with NEOTROPE (start-up developing a bracelet intended for strong human emotion detection).
- *Microbial populations*: Real-time control of synthetic microbial communities (Inria Project Lab, COSY, under evaluation).

4.3. Turbulent flow control for aircrafts and vehicles

Non-A is active in a Regional consortium gathering micro-technologies (ONERA, IEMN, LAMIH, LML and PPrime lab, Univ. of Poitiers) which aims at developing methods for active control of separated flows (ContrATech subprogram of CPER ELSAT).

Aerodynamic losses are believed to be a major source of energy wastage for a vehicle at speeds higher than 50 km/h. Optimization of the vehicles shapes has reached its limit and such a passive control approach cannot deal with unsteady incoming flow. Similarly, in aeronautics, controlling boundary layer airflow could reduce stall drastically. In such contexts, active control strategies (air blowers, hot film sensors, etc.) are very attractive. But the natural phenomena ruling turbulent flows lead to highly nonlinear and infinite-dimension dynamics. Till now, researchers use either nonlinear PDEs (Navier-Stokes equations) allowing for analysis but improper for control design or unrealistic linear finite-dimension models for classical – but non robust – control. Non-A first wants to propose a model with intermediate complexity (bilinear with time delays, “grey-box” identification on experimental data) and then develop model-based sliding mode and optimal control algorithms.

4.4. Industry and society: i-PID for industry and society, mechatronics (Safran)

- Industry is keen on simple and powerful controllers. The tuning simplicity of the classical PID controller explains its omnipresence in industrial control systems, although its performances drop when the working conditions change. AL.I.E.N SAS was created in 2011 as a spin-off of the Inria project ALIEN, which gave rise to Non-A, working on algebraic estimation and i-PID controller (i.e., using algebraic estimation of the perturbations and apply a simple PID control on some “ultra-local” model). These control technique uses the information contained in the output signal and its estimated derivatives, which can be regarded as “signal-based” controllers. Model-free control technique has been applied in many different domains (electronics, hydroelectric power, etc.).

Recent research is focused on traffic control and biology. The quality of traffic control laws depends on a good knowledge of the highway characteristics, especially the critical density and the free-flow speed, which are unfortunately most difficult to estimate in real time. Therefore, we aim at developing an algorithm which shows the possibility to control the traffic without the knowledge of density and free-flow speed.

- A collaboration with the Safran Electronics & Defense company has been developed (CIFRE PhD thesis) on the parametric stabilization of gyrostabilized platforms. To do that, we first aim at developing new symbolic-numeric methods for the standard H_∞ -loop shaping design problem for models of gyrostabilized platforms in terms of the physical parameters (masses, inertia, etc.) considered as unknown/slowly varying parameters. Using Non-A techniques for the estimation of the physical parameters, we then want to develop new embeddable and adaptive controllers for the robust stabilization of gyrostabilized platforms.

RAPSODI Project-Team

4. Application Domains

4.1. Porous media flows

Porous media flows are of great interest in many contexts, like, e.g., oil engineering, water resource management, nuclear waste repository management, or carbon dioxide sequestration. We refer to [61], [60] for an extensive discussion on porous media flow models.

From a mathematical point of view, the transport of complex fluids in porous media often leads to possibly degenerate parabolic conservation laws. The porous rocks can be highly heterogeneous and anisotropic. Moreover, the grids on which one intends to solve numerically the problems are prescribed by the geological data, and might be non-conformal with cells of various shapes. Therefore, the schemes used for simulating such complex flows must be particularly robust.

4.2. Corrosion and concrete carbonation

The team is interested in the theoretical and numerical analysis of mathematical models describing degradation of materials as concrete carbonation and corrosion. The study of such models is an important environmental and industrial issue. Atmospheric carbonation degrades reinforced concretes and limits the lifetime of civil engineering structures. Corrosion phenomena issues occur for instance in the reliability of nuclear power plants and the nuclear waste repository. The study of the long time evolution of these phenomena is of course fundamental in order to predict the lifetime of the structures.

From a mathematical point of view, the modeling of concrete carbonation (see [56]) as the modeling of corrosion in an underground repository (DPCM model developed by Bataillon *et al.* [1]) lead to systems of PDEs posed on moving domains. The coupling between convection-diffusion-reaction equations and moving boundary equations leads to challenging mathematical questions.

4.3. Complex fluid flows

The team is interested in some numerical methods for the simulation of systems of PDEs describing complex flows, like for instance, mixture flows, granular gases, rarefied gases, or quantum fluids.

Let us first focus on fluid mixture flows. The fluid is described by its density, its velocity and its pressure. These quantities obey mass and momentum conservation. On the one hand, when we deal with the 2D variable density incompressible Navier-Stokes equations, we aim to study the ability of the numerical scheme to reproduce some instabilities phenomena such as the Rayleigh-Taylor instability. On the other hand, diffuse interface models have gained renewed interest for the last few years in fluid mechanics applications. From a physical viewpoint, they allow to describe some phase transition phenomena. If the Fick's law relates the divergence of the velocity field to derivatives of the density, one obtains the so called Kazhikhov-Smagulov model [87]. Here, the density of the mixture is naturally highly non homogeneous, and the constitutive law accounts for diffusion effects between the constituents of the mixture. Models of this type can be used for instance to simulate powder-snow avalanches [6], low-Mach flows, or hydrodynamic models arising in combustion theory or transport of pollutants.

Kinetic theory of molecular gases models a gas as a system of elastically colliding spheres, conserving mechanical energy during impact. Once initialized, it takes a molecular gas not more than few collisions per particle to relax to its equilibrium state, characterized by a Maxwellian velocity distribution and a certain homogeneous density (in the absence of external forces). A granular gas is a system of dissipatively colliding, macroscopic particles (grains). This slight change in the microscopic dynamics (converting energy into heat) cause drastic changes in the behavior of the gas: granular gases are open systems, which exhibits self-organized spatio-temporal cluster formations, and has no equilibrium distribution. They can be used to model silos, avalanches, pollen or planetary rings.

The quantum models can be used to describe superfluids, quantum semiconductors, weakly interacting Bose gases or quantum trajectories of Bohmian mechanics. They have attracted considerable attention in the last decades, due in particular to the development of the nanotechnology applications. To describe quantum phenomena, there exists a large variety of models. In particular there exist three different levels of description: microscopic, mesoscopic and macroscopic. The quantum Navier-Stokes equations deal with a macroscopic description in which the quantum effects are taken into account through a third order term called the quantum Bohm potential. This Bohm potential arises from the fluid dynamical formulation of the single-state Schrödinger equation. The non-locality of quantum mechanics is approximated by the fact that the equations of state do not only depend on the particle density but also on its gradient. These equations were employed to model field emissions from metals and steady-state tunneling in metal- insulator- metal structures and to simulate ultra-small semiconductor devices.

4.4. Stratigraphy

The knowledge of the geology is a prerequisite before simulating flows within the subsoil. Numerical simulations of the geological history thanks to stratigraphy numerical codes allow to complete the knowledge of the geology where experimental data are lacking. Stratigraphic models consist in a description of the erosion and sedimentation phenomena at geological scales.

The characteristic time scales for the sediments are much larger than the characteristic time scales for the water in the river. However, the (time-averaged) water flux plays a crucial role in the evolution of the stratigraphy. Therefore, defining appropriate models that take the coupling between the rivers and the sediments into account is fundamental and challenging. Once the models are at hand, efficient numerical methods must be developed.

4.5. Low frequency electromagnetism

Numerical simulation is nowadays an essential tool in order to design electromagnetic systems, by estimating the electromagnetic fields generated in a wide variety of devices. An important challenge for many applications is to quantify the intensity of the electric field induced in a conductor by a current generated in its neighborhood. In the low-frequency regime, we can for example quote the study of the impact on the human body of a high-tension line or, for higher frequencies, the one of a smartphone. But the ability to simulate accurately some electromagnetic fields is also very useful for non destructive control, in the context of the maintenance of nuclear power stations for example. The development of efficient numerical tools, among which the so-called “*a posteriori* error estimators”, is consequently necessary to reach a high precision of calculations in order to provide estimations as reliable as possible.

RMOD Project-Team

4. Application Domains

4.1. Programming Languages and Tools

Many of the results of RMoD are improving programming languages or development tools for such languages. As such the application domain of these results is as varied as the use of programming languages in general. Pharo, the language that RMoD develops, is used for a very broad range of applications. From pure research experiments to real world industrial use (the Pharo Consortium, <http://consortium.pharo.org>, has more than 25 company members).

Examples are web applications, server backends for mobile applications or even graphical tools and embedded applications

4.2. Software Reengineering

Moose is a language-independent environment for reverse and re-engineering complex software systems. Moose provides a set of services including a common meta-model, metrics evaluation and visualization. As such Moose is used for analyzing software systems to support understanding and continuous development as well as software quality analysis.

SEQUEL Project-Team

4. Application Domains

4.1. Sequential decision making under uncertainty and prediction

The spectrum of applications of our research is very wide: it ranges from the core of our research, that is sequential decision making under uncertainty, to the application of components used to solve this decision making problem.

To be more specific, we work on computational advertizing and recommendation systems; these problems are considered as a sequential matching problem in which resources available in a limited amount have to be matched to meet some users' expectations. The sequential approach we advocate paves the way to better tackle the cold-start problem, and non stationary environments. More generally, these approaches are applied to the optimization of budgeted resources under uncertainty, in a time-varying environment, including constraints on computational times (typically, a decision has to be made in less than 1 ms in a recommendation system). An other field of applications of our research is related to education which we consider as a sequential matching problem between a student, and educational contents.

The algorithms to solve these tasks heavily rely on tools from machine learning, statistics, and optimization. Henceforth, we also apply our work to more classical supervised learning, and prediction tasks, as well as unsupervised learning tasks. The whole range of methods is used, from decision forests, to kernel methods, to deep learning. For instance, we have recently used deep learning on images. We also have a line of works related to software development studying how machine learning can improve the quality of software being developed. More generally, we apply our research to data science.

SPIRALS Project-Team

4. Application Domains

4.1. Introduction

Although our research is general enough to be applied to many application domains, we currently focus on applications and distributed services for the retail industry and for the digital home. These two application domains are supported by a strong expertise in mobile computing and in cloud computing that are the two main target environments on which our research prototypes are built, for which we are recognized, and for which we have already established strong collaborations with the industrial ecosystem.

4.2. Distributed software services for the retail industry

This application domain is developed in relation with the **PICOM** (*Pôle de compétitivité Industries du Commerce*) cluster. We have established strong collaborations with local companies in the context of former funded projects, such as Cappucino and **Macchiato**, which focused on the development of a new generation of mobile computing platforms for e-commerce. We are also involved in the Datalyse and OCCIware funded projects that define cloud computing environments with applications for the retail industry. Finally, our activities in terms of crowd-sensing and data gathering on mobile devices with the APISENSE[®] platform share also applications for the retail industry.

4.3. Distributed software services for the digital home

We are developing new middleware solutions for the digital home, in particular through our long standing collaboration with Orange Labs. We are especially interested in developing energy management and saving solutions with the POWERAPI software library for distributed environments such the ones that equip digital homes. We are also working to bridge the gap between distributed services hosted on home gateways and distributed services hosted on the cloud to be able to smoothly transition between both environments. This work is especially conducted with the SALOON platform.