RESEARCH CENTER

FIELD
Perception, Cognition and Interaction

Activity Report 2014

Section Application Domains

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DAHU Project-Team

4. Application Domains

4.1. Application Domains

Databases are pervasive across many application fields. Indeed, most human activities today require some form of data management. In particular, all applications involving the processing of large amounts of data require the use of a database. Increasingly complex Web applications and services also rely on DBMS, and their correctness and robustness is crucial.

We believe that the automated solutions that Dahu aims to develop for verifying such systems will be useful in this context.

DREAM Project-Team

4. Application Domains

4.1. Introduction

The Dream project-team research applications have been oriented towards surveillance, monitoring and decision support. Our domains of application are:

- Agriculture and environment
- Health
- Exploitation of execution traces in an industrial setting

4.2. Environmental decision making

environment, decision methods

The need for decision support systems in the environmental domain is now well-recognized. It is especially true in the domain of water quality. The challenge is to preserve the water quality from pollutants as nitrates and herbicides, when these pollutants are massively used by farmers to weed their agricultural plots and improve the quality and increase the quantity of their crops. The difficulty is then to find solutions which satisfy contradictory interests and to get a better knowledge on pollutant transfer.

In this context, we are cooperating with INRA (Institut National de Recherche Agronomique) and developing decision support systems to help regional managers in preserving the river water quality. This work began in ANR projects like APPEAU and ACASSYA or the PSDR GO CLIMASTER project (Changement climatique, systèmes agricoles, ressources naturelles et développement territorial).

The approach we advocate is to rely on a qualitative modeling, in order to model biophysical processes in an explicative and understandable way. The SACADEAU model associates a qualitative biophysical model, able to simulate the biophysical process, and a management model, able to simulate farmers' decisions. One of our main contributions is the use of qualitative spatial modeling, based on runoff trees, to simulate the pollutant transfer through agricultural catchments.

The second issue is the use of learning/data mining techniques to discover, from model simulation results, the discriminant variables and automatically acquire rules relating these variables. One of the main challenges is that we are faced with spatiotemporal data. The learned rules are then analyzed in order to recommend actions to improve a current "unsatisfactory" situation.

Our main partners are the SAS INRA research group, located in Rennes and the BIA INRA and AGIR INRA research groups in Toulouse.

Ecosystem Management.
The objective of ecosystem management is to ensure sustainable ecosystems even when submitted to various stressors such as natural disturbances or human pressures. Several studies have already shown the interest of qualitative modelling for ecosystems [38]. In our case, we propose to couple a qualitative modelling with model-checking tools to explore marine ecosystems (as explained section 3.2). We applied our approach on a small-scale subsistence fishery in a coral reef lagoon (Uvea, New Caledonia). A well described foodweb model provides us with useful input data for steady-state biomass data and estimates of production and consumption. A timed automata model was developed using EcoMata to investigate the direct and indirect effects of various fishing strategies on a subset of the trophic network.

This work has been realized in collaboration with ecologists: Yves-Marie Bozec (today in position in Marine Spatial Ecology, University of Queensland, Australia) and Guy Fontenelle (Professeur at Agrocampus Ouest).

A second application has been studied in the dairy management area. Over an hydrid modelling on the grazing activities, four methods to generate the best grazing management activity has been proposed. The expert partners are researchers from the SAS INRA research group, located in Rennes.

4.3. Health

health-care, patient monitoring, medicament usage, pharmaco-immunology, health-care pathways, wireless sensors

Clinical monitoring, electronic patient records and computer supported disease management produce more and larger volumes of clinical data. This data is a strategic resource for healthcare institutions. Data mining brings the facility to discover patterns and correlation hidden within the data repository and assists professionals to uncover these patterns and to exploit them to improve medical care.

We are working on two aspects of health-care:

- exploitation of data from the french care insurance (Assurance Maladie) that contains records of medicament reimbursements for pharmaco-immunology purposes. Our goal is to reconstruct and mine patients' healthcare pathways in order to detect regularities and anomalies in the way patients take medicaments and alert medical authorities in case some problem is detected, such as non expected negative consequences of medicament intake. We are working in the framework of a project funded by the National Medicament Security Agency (ANSM - Agence Nationale de la Sécurité du Médicament) for building a platfom enabling focused studies on specific medicaments as well as discovering potential problems with medicament usage. This means selecting from billions of patients records, patients sharing similar medical contexts and showing different consequences of medicament intake,
- veterinary monitoring of feedlot cattle in big farms from sensors recording behavioral and physiological data. As farms are becoming bigger and bigger, detecting ill animals by visual appraisal is becoming more and more difficult. With the advent of cheap wireless sensors, animals (i.e. cows or steers) may be monitored in quasi real time for detecting relevant changes in their behavior that could be related to specific diseases. We are exploring diverse methods for detecting changes on multivariate data, such as cusum charts, specific sequential patterns or distribution of frequent patterns. We are specifically working with veterinaries from the university of Calgary (Canada) for monitoring feedlot cattle in farms growing up to 50.000 animals.

4.4. Exploitation of execution traces

log analysis, data mining, embedded systems.

We have an ongoing collaborations with STMicroelectronics, which is one of the world top-5 electronic chip makers. Nowadays, set-top boxes, smartphones or onboard car computers are powered by highly integrated chips called *System-on-Chip (SoC)*. Such chips contain on a single die processing units, memories, IO units and specialized accelerators (such as audio and video encoding/decoding). Programming SoC is a hard task due to their inherent parallelism, leading to subtle bugs when several components do not deliver their results within a given time frame. Existing debuggers and profilers are ill-adapted in this case because of their high intrusivity that modifies the timings. Hence the most used technique is to capture a *trace* of the execution and analyze it post-mortem. While Alexandre Termier was in Grenoble he initiated several works for analyzing such traces with data mining techniques [55], [50], which he is now pursuing with his colleagues of the Dream project-team [14].

4.5. Software components monitoring

software components, web services, distributed diagnosis

Web-services cover nowadays more and more application areas, from travel booking to goods supplying in supermarkets or the management of an e-learning platform. Such applications need to process requests from users and other services on line, and respond accurately in real time. Errors may occur, which need to be addressed in order to still be able to provide the correct response with a satisfactory quality of service (QoS): on-line monitoring, especially diagnosis and repair capabilities, becomes then a crucial concern.

We have been working on this problem within the WS-DIAMOND project [61], a large European funded project involving eight partners in Italy, France, Austria and Netherlands http://wsdiamond.di.unito.it/.

We do not work anymore on the diagnosis of web services, now we aim at coupling diagnosing and repair, in order to implement *adaptive web services*. We started this study by proposing an architecture inspired from the one developed during the WS-DIAMOND project and dedicated to the adaptive processing when faults occur and propagate through the orchestration.

EXMO Project-Team

4. Application Domains

4.1. Semantic web technologies

The main application context motivating our work is the “semantic web” infrastructure [18].

Internet technologies support organisations and people in accessing and sharing knowledge, often difficult to access in a documentary form. However, these technologies quickly reach their limits: web site organisation is expensive and full-text search inefficient. Content-based information search is becoming a necessity. Content representation enables computers to manipulate knowledge on a more formal ground and to carry out similarity or generality search. Knowledge representation formalisms are good candidates for expressing content.

The vision of a “semantic web” [14] complements the web, with formal knowledge representation spanning across sites. Taking advantage of this semantic web requires the manipulation of various knowledge representation formats. EXMO concerns are thus central to the semantic web implementation. Our work aims at enhancing content understanding, including the intelligibility of communicated knowledge and formal knowledge transformations.

In addition, EXMO also considers more specific uses of semantic web technologies in wider context (typically in the smart city context, §7.2.1.1).

GRAPHIK Project-Team

4. Application Domains

4.1. Semantic Metadata

Semantic metadata are at the core of the applications we have been working on for several years. These three last years, we have switched from semantic annotations of documents to interlinking problems between individual references in annotations of documents. The main linkage problem in our current ANR project Qualinca (see Section 8.1) consists of identifying an authority (*i.e.*, an element of a referential described by metadata) in a bibliographic notice (*i.e.*, metadata describing a document). This problem is an instance of the intensively studied reference resolution problem. In the Semantic Web, it can be recast as the computation of `OWL:sameAs` links between two metadata bases, clearly a fundamental problem for the Linked Open Data. We use a knowledge-based approach to solve this problem, and this year we have especially studied key notions for building rules that conclude on coreference or difference links between entities.

4.2. Agronomy

Within this field, we investigate two different agronomy scenarios: (1) in the context of a public health controversy about bread making, choosing between different kinds of flour in function of nutritional, economic, health and other criteria and (2) designing ecoefficient and biodegradable packaging. The second scenario is part of a larger decision support system implemented within the EU FP7 project EcoBioCap (see Section 8.2).

Both scenarios rely upon different criteria which bring conflicting information for decision making. The aim is then twofold. First to properly model the knowledge using facts, rules and negative constraints. Then, in a second step, in the possibly inconsistent knowledge base thus obtained, to select maximally consistent subsets that will be used for decision making. We have chosen to use argumentation in this context (of reasoning in the presence of inconsistency) due to the fact that we aim to investigate, in the future, the explanation power of argumentation approaches (very useful in this context where the domain experts are not computer scientists).

LINKS Team

3. Application Domains

3.1. Collective Intelligence

[0] Links represented in the data are important for web users, who try to locate relevant information. They typically want to pose their queries locally and obtain the answers from both local and remote repositories. With the concept of linked data collections,the users are provided with a virtual collection of data and links.The answers to a query need to follow both explicit and implicit links to external repositories. Nevertheless, we argue that the benefits of links are not limited to casual users. In this paragraph, we briefly discuss two applications in which linked data collections need to be created. 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.Todays enterprises need to face the problem of in formation explosion, due to the Internet's instability to rapidly convey large amounts of information throughout the world via end-user applications and tools. A linked data collection thus represents a virtual knowledge repository, in which relevant data is collected and meaningful mappings between this data and external world are inferred. A linked data collections would ease the task of experts users to (i) process data, metadata and knowledge that derives from machine to machine processing and eventually make sense of it; (ii) assemble and disassemble pieces of data, metadata and knowledge to create aggregate opinions or to disaggregate opinions in a way that turns to be useful in decision making; (iii) continuously learn from user feedback to produce better knowledge and to enhance the semantics of data processing.

3.2. Linked Bibliographic Collections

The second example 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 in complete 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.A linked data collection would lead to build both implicit and explicit links by(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 opaquekeywords, (ii) thoroughly complete the list of publications of the research institute, and (iii) support complex queries on the corrected data combined with external links. Links are thus useful in all scenarios, in which massive data need to be understood, analyzed and processed. Finally, they can be processed in highly distributed scenarios, such as in the cloud, where their evaluation can be run on many different sites.

[0]Collective intelligence is a shared or group intelligence that emerges from the collaboration and competition of many individuals and appears in consensus decision making" (from Wikipedia - Collective Intelligence)

MAGNET Team

4. Application Domains

4.1. Overview

Our main targeted applications are browsing, monitoring and mining in information networks. Such discovered structures would also be beneficial to predicting links between users and texts which is at the core of recommender systems. All 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.

MAIA Project-Team

4. Application Domains

4.1. Decision Making

Our group is involved in several applications of its more fundamental work on autonomous decision making and complex systems. Applications addressed include:

- Robotics, where the decision maker or agent is supported by a physical entity moving in the real world;
- Medicine or Personally Assisted Living, where the agent can be an analytic device recommending tests and/or treatments, or able to gather different sources of information (sensors for example) in order to help a final user, detecting for example anormal situation needing the rescue of a person (fall detection of elderly people, risk of hospitalization of a person suffering from chronic disease;
- Active Sensing, where decisions have to be taken in order to gather information on a system. This can be applied to many fields, like for example monitoring the integrity of airplanes wings or the behavior of people in public areas.

4.2. Ambient intelligence

As the Nancy – Grand Est Research Center scientific strategy pushes the development of plateforms on Robotics and Smart Living Apartments, some members of the team have recentered their research toward “ambient intelligence and AI” . This choice is backed up by the Inria Large-scale initiative project termed PAL (Personal assistant Living) in which we are strongly involved. The regional council of Lorraine also supports this new research line through the CPER, (project "situated computing" or "INFOSITU" http://infositu.loria.fr) whose coordinator is a member of MAIA Team. Within this new domain of research in MAIA, we explore how intelligent decentralized complex systems can help designing intelligent environments dedicated to elderly people with loss of autonomy. This domain of research is currently very active, taking up a societal challenge that developed countries have to address.

OAK Project-Team

4. Application Domains

4.1. Social Networks

We develop models and algorithms for efficiently exploiting, enhancing, and querying social network data, in particular based on structured content, semantic annotations, and user interaction networks. We pursue this research with many industrial partners within the ALICIA project (Section 7.2.1) as well as in the Structured, Social, and Semantic Search project (Section 7.2.2).

4.2. Computational Journalism

Modern journalism increasingly relies on content management technologies in order to represent, store, and query source data and media objects themselves. Writing news articles increasingly requires consulting several sources, interpreting their findings in context, and crossing links between related sources of information. OAKresearch results directly applicable to this area provide techniques and tools for rich Web content warehouse management. We have launched a collaboration with Le Monde's "Les Décodeurs" team to investigate these topics.

4.3. Open Data Intelligence

The Web is a vast source of information, to which more is added every day either in unstructured form (Web pages) or, increasingly, as partially structured sources of information, in particular as Open Data sets, which can be seen as connected graphs of data, most frequently described in the RDF data format recommended by the W3C. Further, RDF data is also the most appropriate format for representing structured information extracted automatically from Web pages, such as the DBPedia database extracted from Wikipedia or Google's InfoBoxes. To intelligently exploit such Open Data collections, OAKhas developed a complete framework for RDF data analytics within the recently completed DW4RDF project and continues work on this topic within the ODIN project started this year.

4.4. Hybrid Data Warehousing

Increasingly many modern applications need to exploit data from a variety of formats, including relations, text, trees, graphs etc. The recent development of data management systems aimed at "Big Data", including NoSQL platforms, large-scale distributed systems etc. provides enteprise architects with many systems to chose from. This makes it hard to decide which part of the application data to handle in which system, especially given that each system is best at handling a specific kind of data and a certain class of operations. OAKinvestigates principled techniques for distributing an application's data sources across a variety of systems and data models, based on materialized views. We test our ideas in this area within the Datalyse project.

ORPAILLEUR Project-Team

4. Application Domains

4.1. Biology and Chemistry

Participants: Mehwish Alam, Aleksey Buzmakov, Adrien Coulet, Marie-Dominique Devignes, Elias Egho, Nicolas Jay, Bernard Maigret, Amedeo Napoli, Nicolas Pépin-Hermann, Gabin Personeni, David Ritchie, Mohsen Sayed, Malika Smaïl-Tabbone, Yannick Toussaint.

Keywords: knowledge discovery in life sciences, bioinformatics, biology, chemistry, genomics

One major application domain which is currently investigated by the Orpailleur team is related to life sciences, with particular emphasis on biology, medicine, and chemistry. The understanding of biological systems provides complex problems for computer scientists, and the developed solutions bring new research ideas or possibilities for biologists and for computer scientists as well. Accordingly, the Orpailleur team includes biologists, chemists, and a physician, making Orpailleur a very original EPI at Inria. Indeed, the interactions between researchers in biology and researchers in computer science improve not only knowledge about systems in biology, chemistry, and medicine, but knowledge about computer science as well.

Knowledge discovery is gaining more and more interest and importance in life sciences for mining either homogeneous databases such as protein sequences and structures, or heterogeneous databases for discovering interactions between genes and environment, or between genetic and phenotypic data, especially for public health and pharmacogenomics domains. The latter case appears to be one main challenge in knowledge discovery in biology and involves knowledge discovery from complex data depending on domain knowledge.

On the same line as biological data, chemical data are presenting important challenges w.r.t. knowledge discovery, for example for mining collections of molecular structures and collections of chemical reactions in organic chemistry. The mining of such collections is an important task for various reasons among which the challenge of graph mining and the industrial needs (especially in drug design, pharmacology and toxicology). Molecules and chemical reactions are complex data that can be modeled as undirected labeled graphs. One objective for guiding computer-based synthesis in organic chemistry is to discover general synthesis methods (i.e. kinds of "meta-reactions") from currently available chemical reaction databases for designing generic and reusable synthesis plans.

Graph mining methods may play an important role in this framework as illustrated in [125], but Formal Concept Analysis (FCA) can also be used in an efficient and well-founded way [101]. Combining supervised methods –with a training sets where objects are tagged– and unsupervised methods, "jumping emerging patterns" can be detected that characterize classes of interest, e.g. toxic molecules or inhibitors. Then, a hybrid classification method based on FCA can be used for building a concept lattice where some of the concepts can be used as reference classes for classifying unknown objects, for recognition and prediction tasks. Graph mining in the framework of FCA is a very important task on which we are actively working, whose results can be transferred to text mining as well.

4.2. Medicine

Participants: Aleksey Buzmakov, Adrien Coulet, Elias Egho, Nicolas Jay, Jean Lieber, Amedeo Napoli, Matthieu Osmuk, Chedy Raïssi, Yannick Toussaint, Mickaël Zehren.

Keywords: knowledge representation, description logics, classification-based reasoning, case-based reasoning, semantic web, formal concept analysis, sequence mining, text mining

We are working on several applications in medicine, mainly in knowledge management and analysis of patient trajectories as sequences. In the first case, the Kasimir research project is about decision support and knowledge management for the treatment of cancer. This is a multidisciplinary research project in which participate researchers in computer science (Orpailleur), experts in oncology ("Institut de Cancérologie de Lorraine Alexis Vautrin" in Vandœuvre-lès-Nancy), Oncolor (a healthcare network in Lorraine involved in oncology), and A2Zi (a company working in Web technologies and involved in several projects in the medical informatics domain, http://www.a2zi.fr/). For a given cancer localization, a treatment is based on a protocol, which is applied in 70% of the cases and provides a treatment. The 30% remaining cases are "out of the protocol", e.g. contraindication, treatment impossibility, etc. and the protocol should be adapted, based on discussions among specialists. This adaptation process is modeled in Kasimir thanks to CBR, where the semantic Web technologies are used and adapted in the Kasimir project for several years.

Another work is in concern with the analysis of patient trajectories, i.e. the "path" of a patient during illness (chronic illnesses and cancer), considered as sequences. It is important to understand these sequence data and temporal data mining methods are good candidate tools for that. However, these methods should be adapted for addressing the complex nature of medical events. Thus, there is an ongoing work on the analysis of trajectories with different levels of granularity and w.r.t. external domain ontologies. In addition, it is also important to be able to compare and classify trajectories according to their content. This is why there is also a work on the definition of a similarity measure able to take into account the complex nature of trajectories and that can be efficiently implemented for allowing quick and reliable classifications.

4.3. Cooking

Participants: Valmi Dufour-Lussier, Emmanuelle Gaillard, Florence Le Ber, Jean Lieber, Amedeo Napoli, Emmanuel Nauer.

Keywords: cooking, knowledge representation, knowledge discovery, case-based reasoning, semantic wiki

The origin of the Taaable project is the Computer Cooking Contest (CCC). A contestant to CCC is a system that answers queries about recipes, using a recipe base; if no recipe exactly matches the query, then the system adapts another recipe. Taaable is a case-based reasoning system based on various technologies from semantic web, knowledge discovery, knowledge representation and reasoning. From a research viewpoint the system enables to test scientific results and to study the complementarity of various research trends in an application domain which is simple to understand and which raises complex issues at the same time. Taaable has been at the origin of the ANR CONTINT project Kolflow, whose application domain is WikiTaaable, the semantic wiki of Taaable.

4.4. Agronomy

Participants: Sébastien Da Silva, Florence Le Ber [contact person], Jean-François Mari.

Keywords: simulation, Markov model, Formal Concept Analysis, graph

In September, Sébastien da Silva has defended his PhD thesis [13]. His research was conducted in the framework of an Inria-INRA collaboration, which takes place in the INRA research network PAYOTE about landscape modeling. The thesis, supervised both by Claire Lavigne (DR in ecology, INRA Avignon) and Florence Le Ber, was concerned with the characterization and the simulation of hedgerows structures in agricultural landscapes, based on Hilbert-Peano curves and Markov models [6] [13], [66], [98].

An on-going research work about the representation of peasant knowledge is involved within a collaboration with IRD in Madagascar [40]. Sketches drawn by peasants were transformed into graphs and compared thanks to Formal Concept Analysis.

SMIS Project-Team

4. Application Domains

4.1. Application Domains

Our work addresses varied application domains. Typically, data management techniques on chip are required each time data-driven applications have to be embedded in ultra-light computing devices. This situation occurs for example in healthcare applications where medical folders are embedded into smart tokens (e.g., smart cards, secured USB keys), in telephony applications where personal data (address book, agenda, etc.) is embedded into cellular phones, in sensor networks where sensors log row measurements and perform local computation on them, in smart-home applications where a collection of smart appliances gather information about the occupants to provide them a personalized service, and more generally in most applications related to ambient intelligence.

Safeguarding data confidentiality has become a primary concern for citizens, administrations and companies, broadening the application domains of our work on access control policies definition and enforcement. The threat on data confidentiality is manifold: external and internal attacks on the data at rest, on the data on transit, on the data hosted in untrusted environments (e.g., Database Service Providers, Web-hosting companies) and subject to illegal usage, insidious gathering of personal data in an ambient intelligence surrounding. Hence, new access control models and security mechanisms are required to accurately declare and safely control who is granted access to which data and for which purpose.

While the application domain mentioned above is rather large, two applications are today more specifically targeted by the SMIS team. The first one deals with privacy preservation in EHR (Electronic Health Record) systems and PCEHR (Personally Controlled EHR). We are developing technologies tackling this issue and experiment them in the field. The second application area deals with privacy preservation in the context of personal Cloud, that is personal data hosted in dedicated servers staying under the holder's control (e.g., in a personal internet box or in a home automation box).

WIMMICS Project-Team

4. Application Domains

4.1. Introduction

A number of evolutions have changed the face of information systems in the past decade but the advent of the Web is unquestionably a major one and it is here to stay. From an initial wide-spread perception of a public documentary system, the Web as an object turned into a social virtual space and, as a technology, grew as an application design paradigm (services, data formats, query languages, scripting, interfaces, reasoning, etc.). The universal deployment and support of its standards led the Web to take over nearly all of our information systems. As the Web continues to evolve, our information systems are evolving with it.

Today in organizations, not only almost every internal information system is a Web application, but these applications also more and more often interact with external Web applications. The complexity and coupling of these Web-based information systems call for specification methods and engineering tools. From capturing the needs of users to deploying a usable solution, there are many steps involving computer science specialists and non-specialists.

We defend the idea of relying on Semantic Web formalisms to capture and reason on the models of these information systems supporting the design, evolution, interoperability and reuse of the models and their data as well as the workflows and the processing.

4.2. Linked Data on the Web and on Intranets

With billions of triples online (see Linked Open Data initiative), the Semantic Web is providing and linking open data at a growing pace and publishing and interlinking the semantics of their schemas. Information systems can now tap into and contribute to this Web of data, pulling and integrating data on demand. Many organisations also started to use this approach on their intranets leading to what is called linked enterprise data.

A first application domain for us is the publication and linking of data and their schemas through Web architectures. Our results provide software platforms to publish and query data and their schemas, to enrich these data in particular by reasoning on their schemas, to control their access and licenses, to assist the workflows that exploit them, to support the use of distributed datasets, to assist the browsing and visualization of data, etc.

Examples of collaboration and applied projects include: Viseo Joint Laboratory, Corese/KGRAM, Datalift, DBpedia, ALU/BLF Convention, ADT SeGViz.

4.3. Assisting Web-based Epistemic Communities

In parallel to linked open data on the Web, social Web applications also spread virally (e.g. Facebook growing toward 800 million users) first giving the Web back its status of a social read-write media and then leading it to its full potential of a virtual place where to act, react and interact. In addition, many organizations are now considering deploying social Web applications internally to foster community building, expert cartography, business intelligence, technological watch and knowledge sharing in general.

Reasoning on the Linked Data and the semantics of the schemas used to represent social structures and Web resources, we intend to provide applications supporting communities of practice and interest and fostering their interactions.

We use typed graphs to capture and mix: social networks with the kinds of relationships and the descriptions of the persons; compositions of Web services with types of inputs and outputs; links between documents with their genre and topics; hierarchies of classes, thesauri, ontologies and folksonomies; recorded traces and suggested navigation courses; submitted queries and detected frequent patterns; timelines and workflows; etc.

Our results assist epistemic communities in their daily activities such as biologists exchanging results, business intelligence and technological watch networks informing companies, engineers interacting on a project, conference attendees, students following the same course, tourists visiting a region, mobile experts on the field, etc. Examples of collaboration and applied projects include: Kolflow, OCKTOPUS, ISICIL, SAP Convention.

ZENITH Project-Team

4. Application Domains

4.1. Data-intensive Scientific Applications

The application domains covered by Zenith are very wide and diverse, as they concern data-intensive scientific applications, i.e., most scientific applications. Since the interaction with scientists is crucial to identify and tackle data management problems, we are dealing primarily with application domains for which Montpellier has an excellent track record, i.e., agronomy, environmental science, life science, with scientific partners like INRA, IRD, CIRAD and IRSTEA. However, we are also addressing other scientific domains (e.g. astronomy, oil extraction) through our international collaborations (e.g. in Brazil).

Let us briefly illustrate some representative examples of scientific applications on which we have been working on.

- **Management of astronomical catalogs**. An example of data-intensive scientific applications is the management of astronomical catalogs generated by the Dark Energy Survey (DES) project on which we are collaborating with researchers from Brazil. In this project, huge tables with billions of tuples and hundreds of attributes (corresponding to dimensions, mainly double precision real numbers) store the collected sky data. Data are appended to the catalog database as new observations are performed and the resulting database size is estimated to reach 100TB very soon. Scientists around the globe can query the database with queries that may contain a considerable number of attributes. The volume of data that this application holds poses important challenges for data management. In particular, efficient solutions are needed to partition and distribute the data in several servers. An efficient partitioning scheme should try to minimize the number of fragments accessed in the execution of a query, thus reducing the overhead associated to handle the distributed execution.
- **Personal health data analysis and privacy** The "Quantified Self" movement has gained a large popularity these past few years. Today, it is possible to acquire data on many domains related to personal data. For instance, one can collect data on her daily activities, habits or health. It is also possible to measure performances in sports. This can be done thanks to sensors, communicating devices or even connected glasses (as currently being developped by companies such as Google, for instance). Obviously, such data, once acquired, can lead to valuable knowledge for these domains. For people having a specific disease, it might be important to know if they belong to a specific category that needs particular care. For an individual, it can be interesting to find a category that corresponds to her performances in a specific sport and then adapt her training with an adequate program. Meanwhile, for privacy reasons, people will be reluctant to share their personal data and make them public. Therefore, it is important to provide them solutions that can extract such knowledge from everybody's data, while guaranteeing that their private data won't be disclosed to anyone.
- **Botanical data sharing**. Botanical data is highly decentralized and heterogeneous. Each actor has its own expertise domain, hosts its own data, and describes them in a specific format. Furthermore, botanical data is complex. A single plant's observation might include many structured and unstructured tags, several images of different organs, some empirical measurements and a few other contextual data (time, location, author, etc.). A noticeable consequence is that simply identifying plant species is often a very difficult task; even for the botanists themselves (the so-called taxonomic gap). Botanical data sharing should thus speed up the integration of raw observation data, while providing users an easy and efficient access to integrated data. This requires to deal with social-based data integration and sharing, massive data analysis and scalable content-based information retrieval. We address this application in the context of the French initiative Pl@ntNet, with CIRAD and IRD.

- **Deepwater oil exploitation**. An important step in oil exploitation is pumping oil from ultra-deepwater from thousand meters up to the surface through long tubular structures, called risers. Maintaining and repairing risers under deep water is difficult, costly and critical for the environment. Thus, scientists must predict risers fatigue based on complex scientific models and observed data for the risers. Risers fatigue analysis requires a complex workflow of data-intensive activities which may take a very long time to compute. A typical workflow takes as input files containing riser information, such as finite element meshes, winds, waves and sea currents, and produces result analysis files to be further studied by the scientists. It can have thousands of input and output files and tens of activities (e.g. dynamic analysis of risers movements, tension analysis, etc.). Some activities, e.g. dynamic analysis, are repeated for many different input files, and depending on the mesh refinements, each single execution may take hours to complete. To speed up risers fatigue analysis requires parallelizing workflow execution, which is hard to do with existing systems. We address this application in collaboration with UFRJ, and Petrobras.

These application examples illustrate the diversity of requirements and issues which we are addressing with our scientific application partners. To further validate our solutions and extend the scope of our results, we also want to foster industrial collaborations, even in non scientific applications, provided that they exhibit similar challenges.

ALICE Project-Team

4. Application Domains

4.1. Numerical simulation

flow simulation for oil exploration: we co-advised three Ph.D. theses with the Gocad Consortium, that develops modeling algorithms for oil and gas exploration. We developed specialized meshing algorithms, well suited to represent geological layers at various resolutions [27], [19].

optimal transport: this is an active research topics in the mathematics community. Given two measures μ and ν, optimal transport defines a distance between μ and ν, as the minimum cost of "morphing" μ into ν. This distance (called the *Wasserstein distance*) structures the space of measures and offers new ways of solving some highly non-linear PDEs (Monge-Ampere, Fokker-Plank ...). This requires a numerical way of computing the Wasserstein distance and its gradients. We studied a semi-discrete technique [21] (conditionally accepted to ESAIM J. M2AN) that optimizes power diagrams. This is to our knowledge the first numerical implementation of optimal transport for volumetric densities (computes the Wasserstein distance between a sum of Dirac masses and a piece-wise linear density supported on a tetrahedral mesh).

Bose-Einstein condensates: Xavier Antoine (prof. in mathematics at the Université de Lorraine) joined the team on a "delegation" position (Sept. 2013 - Sept. 2014) to explore some common research topics. We are members of the BECASIM project, funded by the ANR ("French NSF"). In a certain sense, a Bose-Einstein condensate is a "Schroedinger cat" made of a few hundred atoms. By special physical means (low temperature and lasers), the probability waves of these atoms are intermixed, thus forming an alternative state of matter. The BECASIM project aims at developing numerical simulation methods for these complicated phenomena (that intermix fluid dynamics, electromagnetics and quantum physics).

4.2. Fabrication

Our work around fabrication and additive manufacturing finds applications in different fields. Our algorithms for fast geometric computations on solids (boolean operations, morphological operations) are useful to model a variety of shapes, from mechanical engineering parts to prosthetics for medical applications. Our techniques allow for simpler modelling and processing of very intricate geometries and therefore also find applications in art and design, for unusual shapes that would be very difficult to obtain otherwise.

AVIZ Project-Team

4. Application Domains

4.1. Panorama

Research in visual analytics can profit from the challenges and requirements of real-world datasets. Aviz develops active collaboration with users from a range of application domains, making sure it can support their specific needs. By studying similar problems in different domains, we can begin to generalize our results and have confidence that our solutions will work for a variety of applications.

We apply our techniques to important medical applications domains such as bioinformatics and brain studies. In particular, we are interested in helping neuroscientists make sense of evolving functional networks, in the form of weighted and/or dynamic graphs.

Other application domains include:

- *Digital Humanities* in general, and in particular with the Cendari European project with historians from most European countries, and the joint project with Microsoft Research and Inria on Graph Visualization;
- *Genealogy*, in cooperation with North Carolina State University;
- *Digital Libraries*, in cooperation with the French National Archives and the Wikipedia community.

HYBRID Project-Team

4. Application Domains

4.1. Overview

The research program of Hybrid team aims at next generations of virtual reality and 3D user interfaces which could possibly address both the “body” and “mind” of the user. Novel interaction schemes are designed, for one or multiple users. We target better integrated systems and more compelling user experiences.

The applications of our research program correspond to the applications of virtual reality technologies which could benefit from the addition of novel body-based or mind-based interaction capabilities:

- **Industry**: with training systems, virtual prototyping, or scientific visualization;
- **Medicine**: with rehabilitation and reeducation systems, or surgical training simulators;
- **Entertainment**: with 3D web navigations, video games, or attractions in theme parks,
- **Construction**: with virtual mock-ups design and review, or historical/architectural visits.

IMAGINE Project-Team

4. Application Domains

4.1. Domain

This research can be applied to any situation where users need to create new, imaginary, 3D content. Our work should be instrumental, in the long term, for the visual arts, from the creation of 3D films and games to the development of new digital planning tools for theatre or cinema directors. Our models can also be used in interactive prototyping environments for engineering. They can help promoting interactive digital design to scientists, as a tool to quickly express, test and refine models, as well as an efficient way for conveying them to other people. Lastly, we expect our new methodology to put digital modeling within the reach of the general public, enabling educators, media and other practitioners to author their own 3D content.

Our current application domains are:

- Visual arts
  - Modeling and animation for 3D films and games.
  - Virtual cinematography and tools for theatre directors.
- Engineering
  - Industrial design.
  - Mechanical & civil engineering.
- Natural Sciences
  - Virtual functional anatomy.
  - Virtual plants.
- Education and Creative tools
  - Sketch-based teaching.
  - Creative environments for novice users.

The diversity of users these domains bring, from digital experts to other professionals and novices, gives us excellent opportunities to validate our general methodology with different categories of users. Our ongoing projects in these various application domains are listed in Section 6.

IN-SITU Project-Team

4. Application Domains

4.1. Application Domains

InSitu works on general problems of interaction in multi-surface environments as well as on challenges associated with specific research groups. The former requires a combination of controlled experiments and field studies; the latter involves participatory design with users. We are currently working with highly creative people, particularly designers and music composers, to explore interaction techniques and technologies that support the earliest phases of the design process. We are also working with research scientists, particularly neuroscientists and astrophysicists, in our explorations of interaction in multisurface environments, and with doctors and nurses to support crisis management situations.

MANAO Project-Team (section vide)

MAVERICK Project-Team (section vide)

MIMETIC Project-Team

4. Application Domains

4.1. Autonomous Characters

Autonomous characters are becoming more and more popular has they are used in an increasing number of application domains. In the field of special effects, virtual characters are used to replace secondary actors and generate highly populated scenes that would be hard and costly to produce with real actors. In video games and virtual storytelling, autonomous characters play the role of actors that are driven by a scenario. Their autonomy allows them to react to unpredictable user interactions and adapt their behavior accordingly. In the field of simulation, autonomous characters are used to simulate the behavior of humans in different kind of situations. They enable to study new situations and their possible outcomes.

One of the main challenges in the field of autonomous characters is to provide a unified architecture for the modeling of their behavior. This architecture includes perception, action and decisional parts. This decisional part needs to mix different kinds of models, acting at different time scale and working with different nature of data, ranging from numerical (motion control, reactive behaviors) to symbolic (goal oriented behaviors, reasoning about actions and changes).

In the MimeTIC team, we focus on autonomous virtual humans. Our problem is not to reproduce the human intelligence but to propose an architecture making it possible to model credible behaviors of anthropomorphic virtual actors evolving/moving in real time in virtual worlds. The latter can represent particular situations studied by psychologists of the behavior or to correspond to an imaginary universe described by a scenario writer. The proposed architecture should mimic all the human intellectual and physical functions.

4.2. Biomechanics and Motion Analysis

Biomechanics is obviously a very large domain. This large set can be divided regarding to the scale at which the analysis is performed going from microscopic evaluation of biological tissues' mechanical properties to macroscopic analysis and modeling of whole body motion. Our topics in the domain of biomechanics mainly lie within this last scope.

The first goal of such kind of research projects is a better understanding of human motion. The MimeTic team addresses three different situations: everyday motions of a lambda subject, locomotion of pathological subjects and sports gesture.

In the first set, Mimetic is interested in studying how subjects maintain their balance in highly dynamic conditions. Until now, balance havec nearly always been considered in static or quasi-static conditions. The knowledge of much more dynamic cases still has to be improved. Our approach has demonstrated that first of all, the question of the parameter that will allow to do this is still open. We have also taken interest into collision avoidance between two pedestrian. This topic includes the research of the parameters that are interactively controlled and the study of each one's role within this interaction.

When patients, in particular those suffering from central nervous system affection, cannot have an efficient walking it becomes very useful for practicians to benefit from an objective evaluation of their capacities. To propose such help to patients following, we have developed two complementary indices, one based on kinematics and the other one on muscles activations. One major point of our research is that such indices are usually only developed for children whereas adults with these affections are much more numerous.

Finally, in sports, where gesture can be considered, in some way, as abnormal, the goal is more precisely to understand the determinants of performance. This could then be used to improve training programs or devices. Two different sports have been studied: the tennis serve, where the goal was to understand the contribution of each segments of the body in ball's speed and the influence of the mechanical characteristics of the fin in fin swimming.

After having improved the knowledge of these different gestures a second goal is then to propose modeling solutions that can be used in VR environments for other research topics within MimeTic. This has been the case, for exemple, for the colision avoidance.

4.3. Crowds

Crowd simulation is a very active and concurrent domain. Various disciplines are interested in crowds modeling and simulation: Mathematics, Cognitive Sciences, Physics, Computer Graphics, etc. The reason for this large interest is that crowd simulation raise fascinating challenges.

At first, crowd can be first seen as a complex system: numerous local interactions occur between its elements and results into macroscopic emergent phenomena. Interactions are of various nature and are undergoing various factors as well. Physical factors are crucial as a crowd gathers by definition numerous moving people with a certain level of density. But sociological, cultural and psychological factors are important as well, since crowd behavior is deeply changed from country to country, or depending on the considered situations. On the computational point of view, crowd push traditional simulation algorithms to their limit. An element of a crowd is subject to interact with any other element belonging the same crowd, a naive simulation algorithm has a quadratic complexity. Specific strategies are set to face such a difficulty: level-of-detail techniques enable scaling large crowd simulation and reach real-time solutions.

MimeTIC is an international key contributor in the domain of crowd simulation. Our approach is specific and based on three axis. First, our modeling approach is founded on human movement science: we conducted challenging experiment on the motion of groups. Second: we developed high-performance solutions for crowd simulation. Third, we develop solutions for realistic navigation in virtual world to enable interaction with crowds in Virtual Reality.

4.4. Motion Sensing

Recording human activity is a key point of many applications and fundamental works. Numerous sensors and systems have been proposed to measure positions, angles or accelerations of the user’s body parts. Whatever the system is, one of the main is to be able to automatically recognize and analyze the user’s performance according to poor and noisy signals. Human activity and motion are subject to variability: intra-variability due to space and time variations of a given motion, but also inter-variability due to different styles and anthropometric dimensions. MimeTIC has addressed the above problems in two main directions.

Firstly, we have studied how to recognize and quantify motions performed by a user when using accurate systems such as Vicon (product of Oxford Metrics) or Optitrack (product of Natural Point) motion capture systems. These systems provide large vectors of accurate information. Due to the size of the state vector (all the degrees of freedom) the challenge is to find the compact information (named features) that enables the automatic system to recognize the performance of the user. Whatever the method is used, finding these relevant features that are not sensitive to intra-individual and inter-individual variability is a challenge. Some researchers have proposed to manually edit these features (such as a Boolean value stating if the arm is moving forward or backward) so that the expertise of the designer is directly linked with the success ratio. Many proposals for generic features have been proposed, such as using Laban notation which was introduced to encode dancing motions. Other approaches tend to use machine learning to automatically extract these features. However most of the proposed approaches were used to seek a database for motions which properties correspond to the features of the user’s performance (named motion retrieval approaches). This does not ensure the retrieval of the exact performance of the user but a set of motions with similar properties.

Secondly, we wish to find alternatives to the above approach which is based on analyzing accurate and complete knowledge on joint angles and positions. Hence new sensors, such as depth-cameras (Kinect, product of Microsoft) provide us with very noisy joint information but also with the surface of the user. Classical approaches would try to fit a skeleton into the surface in order to compute joint angles which, again, lead to large state vectors. An alternative would be to extract relevant information directly from the raw data, such as the surface provided by depth cameras. The key problem is that the nature of these data may be very different from classical representation of human performance. In MimeTIC, we try to address this problem in specific application domains that require picking specific information, such as gait asymmetry or regularity for clinical analysis of human walking.

4.5. VR and Sports

Sport is characterized by complex displacements and motions. These motions are dependent on visual information that the athlete can pick up in his environment, including the opponent's actions. The perception is thus fundamental to the performance. Indeed, a sportive action, as unique, complex and often limited in time, requires a selective gathering of information. This perception is often seen as a prerogative for action, it then takes the role of a passive collector of information. However, as mentioned by Gibson in 1979, the perception-action relationship should not be considered sequential but rather as a coupling: we perceive to act but we must act to perceive. There would thus be laws of coupling between the informational variables available in the environment and the motor responses of a subject. In other words, athletes have the ability to directly perceive the opportunities of action directly from the environment. Whichever school of thought considered, VR offers new perspectives to address these concepts by complementary using real time motion capture of the immersed athlete.

In addition to better understanding sports and interaction between athletes, VR can also be used as a training environment as it can provide complementary tools to coaches. It is indeed possible to add visual or auditory information to better train an athlete. The knowledge found in perceptual experiments can be for example used to highlight the body parts that are important to look at to correctly anticipate the opponent's action.

4.6. Interactive Digital Storyrelling

Interactive digital storytelling, including novel forms of edutainment and serious games, provides access to social and human themes through stories which can take various forms and contains opportunities for massively enhancing the possibilities of interactive entertainment, computer games and digital applications. It provides chances for redefining the experience of narrative through interactive simulations of computer-generated story worlds and opens many challenging questions at the overlap between computational narratives, autonomous behaviours, interactive control, content generation and authoring tools.

Of particular interest for the Mimetic research team, virtual storytelling triggers challenging opportunities in providing effective models for enforcing autonomous behaviours for characters in complex 3D environments. Offering both low-level capacities to characters such as perceiving the environments, interacting with the environment and reacting to changes in the topology, on which to build higher-levels such as modelling abstract representations for efficient reasonning, planning paths and activities, modelling cognitive states and behaviours requires the provision of expressive, multi-level and efficient computational models. Furthermore virtual storytelling requires the seamless control of the balance between the autonomy of characters and the unfolding of the story story through the narrative discourse. Virtual storytelling also raises challenging questions on the conveyance of a narrative through interactive or automated control of the cinematography (how to stage the characters, the lights and the cameras). For example, estimating visibility of key subjects, or performing motion planning for cameras and lights are central issues for which have not received satisfactory answers in the litterature.

4.7. VR and Ergonomics

The design of workstations nowadays tends to include assessment steps in a Virtual Environment (VE) to evaluate ergonomic features. This approach is more cost-effective and convenient since working directly on the Digital Mock-Up (DMU) in a VE is preferable to constructing a real physical mock-up in a Real Environment (RE). This is substantiated by thefact that a Virtual Reality (VR) set-up can be easily modified, enabling quick adjustmentsofthe workstation design.Indeed, the aim of integrating ergonomics evaluation tools inVE is to facilitate the design process, enhance the design efficiency, and reduce the costs.

The development of such platforms ask for several improvements in the field of motion analysis and VR: the interactions have to be as fidelistic as possible to properly mimic the motions performed in real environments, the fidelity of the simulator need also to be correctly evaluated, and motion analysis tools have to be able to provide in real-time biomechanics quantities usable by ergonomists to analyse and improve the working conditions.

MINT Project-Team

4. Application Domains

4.1. Next-generation desktop systems

The term *desktop system* refers here to the combination of a window system handling low-level graphics and input with a window manager and a set of applications that share a distinctive look and feel. It applies not only to desktop PCs but also to any other device or combination of devices supporting graphical interaction with multiple applications. Interaction with these systems currently rely on a small number of interaction primitives such as text input, pointing and activation as well as a few other basic gestures. This limited set of primitives is one reason the systems are simple to use. There is, however, a cost. Most simple combinations being already used, few remain to trigger and control innovative techniques that could facilitate task switching or data management, for example. Desktop systems are in dire need of additional interaction primitives, including gestural ones.

4.2. Ambient Intelligence

Ambient intelligence (AmI) refers to the concept of being surrounded by intelligent systems embedded in everyday objects [49]. Envisioned AmI environments are aware of human presence, adapt to users' needs and are capable of responding to indications of desire and possibly engaging in intelligent dialogue. Ambient Intelligence should be unobtrusive: interaction should be relaxing and enjoyable and should not involve a steep learning curve. Gestural interaction is definitely relevant in this context.

4.3. Serious Games

Serious game refers to techniques extensively used in computer games, that are being used for other purposes than gaming. Fields such as learning, use of Virtual Reality for rehabilitation, 3D interactive worlds for retail, art-therapy, are specific context with which the MINT group has scientific connection, and industrial contacts. This field of application is a good opportunity for us to test and transfer our scientific knowledge and results.

POTIOC Project-Team

4. Application Domains

4.1. Popularization of science, education, art, entertainment

Or project aims at providing 3D digital worlds to all, including the general public, to stimulate understanding, learning, communication and creation. Our scope of applications encompasses

- popularization of science
- education
- art
- entertainment

See "Objective 3: Exploring new applications and usages" for the detailed description 3.4 .

REVES Project-Team

4. Application Domains

4.1. Domain

The application domain is vast. It ranges from audiovisual production, which typically requires long, offline computation to obtain high quality results, all the way to real-time applications such as computer games or virtual reality, for which the main consideration is to guarantee 60 frames per second frame rates, or, in general the reduction of latency to user reaction. The process of generation of images and sound, generally called *rendering* is our primary interest; our second main interest are virtual environments (VE's) as well as augmented (AE's) or mixed environments (ME's), that is scenes containing both real objects (often digitized) as well as purely synthetic objects. We are interested in both the generation and the interaction with these environments. We use the term virtual environments for scenes with a certain degree of interactivity, potentially in a semi-immersive (stereo and tracking, workbench) or immersive (CAVE, RealityCenter) context.

TITANE Project-Team

4. Application Domains

4.1. Domains

In addition to tackling scientific challenges, our research on geometric modeling and processing is motivated by applications to computational engineering, reverse engineering, digital mapping and urban planning. The main deliverables of our research are algorithms with theoretical foundations. Ultimately we wish to contribute making geometry modeling and processing routine for practitioners who deal with real-world data. Our contributions may also be used as a sound basis for future software and technology developments.

Our ambition for technology transfer is to consolidate the components of our research experiments in the form of new software components for the CGAL (Computational Geometry Algorithms Library) library. Through CGAL we wish to contribute to the "standard geometric toolbox", so as to provide a generic answer to application needs instead of fragmenting our contributions. We already cooperate with the Inria spin-off company Geometry Factory, which commercializes CGAL, maintains it and provide technical support.

We also started increasing our research momentum with companies through advising Cifre Ph.D. theses and postdoctoral fellows.

ALPAGE Project-Team

4. Application Domains

4.1. Overview

NLP tools and methods have many possible domains of application. Some of then are already mature enough to be commercialized. They can be roughly classified in four groups:

Human-computer interaction : mostly speech processing and text-to-speech, often in a dialogue context; today, commercial offers are limited to restricted domains (train tickets reservation...);

Language writing aid : spelling, grammatical and stylistic correctors for text editors, controlled-language writing aids (e.g., for technical documents), memory-based translation aid, foreign language learning tools, as well as vocal dictation; related to this group lies the automatic correction of the output of OCR systems;

Access to information : tools to enable a better access to information present in huge collections of texts (e.g., the Internet): automatic document classification, automatic document structuring, automatic summarizing, information acquisition and extraction, text mining, question-answering systems, as well as surface machine translation. Information access to speech archives through transcriptions is also an emerging field.

Experimental linguistics : tools to explore language in an objective way (this is related, but not limited to corpus linguistics).

Alpage focuses on applications included in the three last points, such as information extraction and (linguistic and extra-linguistic) knowledge acquisition (4.2), text mining (4.3), spelling correction (4.5) and experimental linguistics (4.6).

4.2. Information extraction and knowledge acquisition

Participants: Éric Villemonte de La Clergerie, Benoît Sagot.

The first domain of application for Alpage parsing systems is information extraction, and in particular knowledge acquisition, be it linguistic or not, and text mining.

Knowledge acquisition for a given restricted domain is something that has already been studied by some Alpage members for several years. Obviously, the progressive extension of Alpage parsing systems or even shallow processing chains to the semantic level increase the quality of the extracted information, as well as the scope of information that can be extracted. Such knowledge acquisition efforts bring solutions to current problems related to information access and take place into the emerging notion of *Semantic Web*. The transition from a web based on data (textual documents,...) to a web based on knowledge requires linguistic processing tools which are able to provide fine grained pieces of information, in particular by relying on high-quality deep parsing. For a given domain of knowledge (say, news wires or tourism), the extraction of a domain ontology that represents its key concepts and the relations between them is a crucial task, which has a lot in common with the extraction of linguistic information.

In the last years, such efforts have been targeted towards information extraction from news wires in collaboration with the Agence France-Presse (Rosa Stern was a CIFRE PhD student at Alpage and at AFP, and worked in 2013 within the ANR project EDyLex).

These applications in the domain of information extraction raise exciting challenges that require altogether ideas and tools coming from the domains of computational linguistics, machine learning and knowledge representation.

4.3. Processing answers to open-ended questions in surveys: vera

Participants: Benoît Sagot, Valérie Hanoka.

Verbatim Analysis is a startup co-created by Benoît Sagot from Alpage and Dimitri Tcherniak from Towers Watson, a world-wide leader in the domain of employee research (opinion mining among the employees of a company or organization). The aim of its first product, *vera*, is to provide an all-in-one environment for editing (i.e., normalizing the spelling and typography), understanding and classifying answers to open-ended questions, and relating them with closed-ended questions, so as to extract as much valuable information as possible from both types of questions. The editing part relies in part on SxPipe (see section 5.5) and Alexina morphological lexicons. Several other parts of *vera* have been co-developed by Verbatim Analysis and by Inria.

4.4. Multilingual terminologies and lexical resources for companies

Participant: Éric Villemonte de La Clergerie.

Lingua et Machina is a small company now headed by François Brown de Colstoun, a former Inria researcher, that provides services for developing specialized multilingual terminologies for its clients. It develops the WEB framework Libellex for validating such terminologies. A formal collaboration with ALPAGE has been set up, with the recruitment of Mikaël Morardo in 2012 as an engineer, funded by Inria's DTI. He pursued his work on the extension of the web platform *Libellex* for the visualization and validation of new types of lexical resources. In particular, he has integrated a new interface for handling monolingual terminologies, lexical networks, and bilingual wordnet-like structures, including the WOLF.

4.5. Automatic and semi-automatic spelling correction in an industrial setting

Participants: Kata Gábor, Pierre Magistry, Benoît Sagot, Éric Villemonte de La Clergerie.

NLP tools and resources used for spelling correction, such as large n-gram collections, POS taggers and finite-state machinery are now mature and precise. In industrial setting such as post-processing after large-scale OCR, these tools and resources should enable spelling correction tools to work on a much larger scale and with a much better precision than what can be found in different contexts with different constraints (e.g., in text editors). Moreover, such industrial contexts allow for a non-costly manual intervention, in case one is able to identify the most uncertain corrections. Alpage is working within the "Investissements d'avenir" project PACTE, headed by Numen, a company specialized in text digitalization, and three other partners. Kata Gábor and Pierre Magistry are doing post-docs funded by PACTE (see 6.3)

4.6. Experimental and quantitative linguistics

Participants: Benoit Crabbé, Benoît Sagot, Alexandra Simonenko, Sarah Beniamine, Kristina Gulordava.

Alpage is a team that dedicates efforts in producing ressources and algorithms for processing large amounts of textual materials. These ressources can be applied not only for purely NLP purposes but also for linguistic purposes. Indeed, the specific needs of NLP applications led to the development of electronic linguistic resources (in particular lexica, annotated corpora, and treebanks) that are sufficiently large for carrying statistical analysis on linguistic issues. In the last 10 years, pioneering work has started to use these new data sources to the study of English grammar, leading to important new results in such areas as the study of syntactic preferences [62], [139], the existence of graded grammaticality judgments [86].

The reasons for getting interested for statistical modelling of language can be traced back by looking at the recent history of grammatical works in linguistics. In the 1980s and 1990s, theoretical grammarians have been mostly concerned with improving the conceptual underpinnings of their respective subfields, in particular through the construction and refinement of formal models. In syntax, the relative consensus on a generative-transformational approach [72] gave way on the one hand to more abstract characterizations of the language faculty [72], and on the other hand to the construction of detailed, formally explicit, and often implemented, alternative formulation of the generative approach [61], [103]. For French several grammars have been implemented in this trend, such as the tree adjoining grammars of [65], [76] among others. This general movement led to much improved descriptions and understanding of the conceptual underpinnings of both linguistic competence and language use. It was in large part catalyzed by a convergence of interests of logical, linguistic and computational approaches to grammatical phenomena.

However, starting in the 1990s, a growing portion of the community started being frustrated by the paucity and unreliability of the empirical evidence underlying their research. In syntax, data was generally collected impressionistically, either as ad-hoc small samples of language use, or as ill-understood and little-controlled grammaticality judgements [121]. This shift towards quantitative methods is also a shift towards new scientific questions and new scientific fields. Using richly annotated data and statistical modelling, we address questions that could not be addressed by previous methodology in linguistics.

In this line, at Alpage we have started investigating the question of choice in French syntax with a statistical modelling methodology. In the perspective of better understanding which factors influence the relative ordering of post verbal complements across languages and through language evolution.

On the other hand we are also collaborating with the Laboratoire de Sciences Cognitives de Paris (LSCP/ENS) where we explore the design of algorithms towards the statistical modelling of language acquisition (phonological acquisition). This is currently supported by one PhD project.

In parallel, quantitative methods are applied to computational morphology, in particular in the context of Sarah Beniamine's PhD, co-supervized by Benoît Sagot (Alpage) and Olivier Bonami (LLF, CNRS, U. Paris Diderot and U. Paris Sorbonne). Collaborative work in this area is also conducted in collaboration with descriptive linguists from CRLAO (CNRS and Inalco; Guillaume Jacques) and HTL (CNRS, U. Paris Diderot and U. Sorbonne Nouvelle; Aimée Lahaussois) and formal linguists from DDL (CNRS and Université Lyon 2; Géraldine Walther).

MULTISPEECH Team

4. Application Domains

4.1. Introduction

Approaches and models developed in the MULTISPEECH project are intended to be used for facilitating oral-based communication in various situations through enhancements of the communication channels, either directly via automatic speech recognition or speech production technologies, or indirectly, thanks to computer assisted language learning. Applications also include the usage of speech technologies for helping people in handicapped situations or for improving their autonomy. Foreseen application domains are related to computer assisted learning, health and autonomy (more precisely aided communication and monitoring), annotation and processing of spoken documents, and multimodal computer interaction.

4.2. Computer assisted learning

Although speaking seems quite natural, learning foreign languages, or learning the mother tongue for people with language deficiencies, represent critical cognitive stages. Hence, many scientific activities have been devoted to these issues either from a production or a perception point of view.

The general guiding principle with respect to computer assisted mother or foreign language learning is to combine modalities or to augment speech to make learning easier. Also, the system should provide indications on what should be corrected, a guidance which is considered as necessary by specialists in the oral aspects of language learning. Consequently, based upon a comparison of the learner's production to a reference, automatic diagnoses of the learner's production can be considered, as well as perceptual feedback relying on an automatic transformation of the learner's voice. For example, with respect to prosody, the diagnosis provided through both a text and a visual display, comes from an evaluation of the melodic curve and of the phoneme durations of the learner's realization; and the perceptual feedback consists in a replacement of the learner's prosodic cues by those of the reference; i.e., the signal of the learner's utterance is modified in order to reflect the prosodic cues (duration and F0) of the reference in order to make the learner aware of the expected prosodic cues. The diagnosis step strongly relies on the studies on categorization of sounds and prosody in the mother tongue and in the second language, and also depends on the influence between them. Furthermore, reliable diagnosis on individual utterances is still a challenge, and elaboration of advanced automatic feedback requires a temporally accurate segmentation of speech utterances into phones and this explains why accurate segmentation of native and non-native speech is also an important topic in the field of acoustic speech modeling.

4.3. Aided communication and monitoring

Speech technologies provide ways of helping people in handicapped situations or improving their autonomy. The following applications are considered in the project.

The first one is related to the tuning of speech recognition technology for providing a means of communication between a speaking person and a hard-of-hearing or a deaf person, through an adequate display of the recognized words and/or syllables, which takes also into account the reliability of the recognized items.

The second application aims at improving pathological voices. In this context, the goal is typically to transform the pathological voice signal in order to make it more intelligible. Ongoing work deals with esophageal voices, i.e., substituted voice learned by a laryngectomized patient who has lost his/her vocal cords after surgery. Voice conversion techniques will be studied further to enhance such voice signals, in order to produce clean and intelligible speech signals in replacement of the pathological voice.

The third application aims at improving the autonomy of elderly or disabled people, and fit with smartrooms. In a first step, source separation techniques could be tuned and should help for locating and monitoring people through the detection of sound events inside apartments. In a longer perspective, adapting speech recognition technologies to the voice of elder people should also be useful for such applications, but this requires the recording of adequate databases. Sound monitoring in other application fields (security, environmental monitoring) could also be envisaged.

4.4. Annotation and processing of spoken documents

The first type of annotation consists in transcribing a spoken document in order to get the corresponding sequences of words, with possibly some complementary information, such as the structure (punctuation) or the modality (affirmation/question) of the utterances to make the reading and understanding easier. Typical applications of the automatic transcription of radio or TV shows, or of any other spoken document, include making possible their access by deaf people, as well as by text-based indexing tools.

The second type of annotation is related to speech-text alignment, which aims at determining the starting and ending times of the words, and possibly of the sounds (phonemes). This is of interest in several cases as for example, for annotating speech corpora for linguistic studies, and for synchronizing lip movements with speech sounds, for example for avatar-based communications. Although good results are currently achieved on clean data, automatic speech-text alignment needs to be improved for properly processing noisy spontaneous speech data and needs to be extended to handle overlapping speech.

Finally, there is also a need for speech signal processing techniques in the field of multimedia content creation and rendering. Relevant techniques include speech and music separation, speech equalization, prosody modification, and speaker conversion.

4.5. Multimodal computer interactions

Speech synthesis has tremendous application in facilitating communication in a human-machine interaction context to make machines more accessible. For example, it started to be widely common to use acoustic speech synthesis in smartphones to make possible the uttering of all the information. This is valuable in particular in the case of handicap, as for blind people. Audiovisual speech synthesis, when used in an application such as a talking head, i.e., virtual 3D animated face synchronized with acoustic speech, is beneficial in particular for hard-of-hearing individuals. This requires an audiovisual synthesis that is intelligible, both acoustically and visually. A talking head could be an intermediate between two persons communicating remotely when their video information is not available, and can also be used in language learning applications as vocabulary tutoring or pronunciation training tool. Expressive acoustic synthesis is of interest for the reading of story, such as audiobook, to facilitate the access to literature (for instance for blind people or illiterate people).

PANAMA Project-Team

4. Application Domains

4.1. Acoustic scene capture

Acoustic fields carry much information about audio sources (musical instruments, speakers, etc.) and their environment (e.g., church acoustics differ much from office room acoustics). A particular challenge is to capture as much information from a complete 3D+t acoustic field associated with an audio scene, using as few sensors as possible. The feasibility of compressive sensing to address this challenge was shown in certain scenarii, and the actual implementation of this framework will potentially impact practical scenarii such as remote surveillance to detect abnormal events, e.g. for health care of the elderly or public transport surveillance.

4.2. Audio signal separation in reverberant environments

Audio signal separation consists in extracting the individual sound of different instruments or speakers that were mixed on a recording. It is now successfully addressed in the academic setting of linear instantaneous mixtures. Yet, real-life recordings, generally associated to reverberant environments, remain an unsolved difficult challenge, especially with many sources and few audio channels. Much of the difficulty comes from the estimation of the unknown room impulse response associated to a matrix of mixing filters, which can be expressed as a dictionary-learning problem. Solutions to this problem have the potential to impact, for example, the music and game industry, through the development of new digital re-mastering techniques and virtual reality tools, but also surveillance and monitoring applications, where localizing audio sources is important.

4.3. Multimedia indexing

Audiovisual and multimedia content generate large data streams (audio, video, associated data such as text, etc.). Manipulating large databases of such content requires efficient techniques to: segment the streams into coherent sequences; label them according to words, language, speaker identity, and more generally to the type of content; index them for easy querying and retrieval, etc. As the next generation of online search engines will need to offer content-based means of searching, the need to drastically reduce the computational burden of these tasks is becoming all the more important as we can envision the end of the era of wasteful datacenters that can increase forever their energy consumption. Most of today's techniques to deal with such large audio streams involve extracting features such as Mel Frequency Cepstral Coefficients (MFCC) and learning high-dimensional statistical models such as Gaussian Mixture Models, with several thousand parameters. The exploration of a compressive learning framework is expected to contribute to new techniques to efficiently process such streams and perform segmentation, classification, etc., in the compressed domain. A particular challenge is to understand how this paradigm can help exploiting truly multimedia features, which combine information from different associated streams such as audio and video, for joint audiovisual processing.

4.4. Brain source imaging

Epilepsies constitute a common neurological disorder that affects about 1% of the world population. As the epileptic seizure is a dynamic phenomenon, imaging techniques showing static images of the brain (MRI, PET scan) are frequently not the best tools to identify the brain area of interest. Electroencephalography (EEG) is the technique most indicated to capture transient events directly related to the underlying epileptic pathology (like interictal spikes, in particular). EEG convey essential information regarding brain (patho-)physiological activity. In addition, recording techniques of surface signals have the major advantage of being noninvasive. For this reason, an increased use in the context of epilepsy surgery is most wanted. However, to reach this objective, we have to solve an electromagnetic inverse problem, that is to say to estimate the current generators underlying noisy EEG data. Theoretically, a specific electromagnetic field pattern may be generated by an infinite number of current distributions. The considered inverse problem, called "brain source imaging problem", is then said to be ill-posed.

SEMAGRAMME Project-Team

4. Application Domains

4.1. Introduction

Our applicative domains concern natural language processing applications that rely on a deep semantic analysis. For instance, one may cite the following ones:

- textual entailment and inference,
- dialogue systems,
- semantic-oriented query systems,
- content analysis of unstructured documents,
- text transformation and automatic summarization,
- (semi) automatic knowledge acquisition.

However, if the need for semantics seems to be ubiquitous, there is a challenge in finding applications for which a deep semantic analysis results in a real improvement over non semantic-based techniques.

4.2. Text Transformation

Text transformation is an application domain featuring two important sub-fields of computational linguistics:

- parsing, from surface form to abstract representation,
- generation, from abstract representation to surface form.

Text simplification or automatic summarization belong to that domain.

We aim at using the framework of Abstract Categorial Grammars we develop to this end. It is indeed a reversible framework that allows both parsing and generation. Its underlying mathematical structure of λ-calculus makes it fit with our type-theoretic approach to discourse dynamics modeling. The ANR project Polymnie (see section 7.2.1.1) is especially dedicated to this aim.

E-MOTION Project-Team

3. Application Domains

3.1. Introduction

The main applications of our research are those aiming at introducing advanced and secured robotized systems into human environments. In this context, we are focusing onto the following application domains: Future cars and transportation systems, Service and Human assistance robotics, and Potential spin-offs in some other application domains.

3.2. Future cars and transportation systems

Thanks to the introduction of new sensor and ICT technologies in cars and in mass transportation systems, and also to the pressure of economical and security requirements of our modern society, this application domain is quickly changing. Various technologies are currently developed by both research and industrial laboratories. These technologies are progressively arriving at maturity, as it is witnessed by the results of large scale experiments and challenges (e.g., Darpa Urban Challenge 2007) and by the fast development of ambitious projects such as the Google's car project. Moreover, the legal issue starts to be addressed (see for instance the recent laws in Nevada and in California authorizing autonomous vehicles on roads).

In this context, we are interested in the development of *ADAS*[0] systems aimed at improving comfort and safety of the cars users (e.g., ACC, emergency braking, danger warnings), and of *Fully Autonomous Driving* functions for controlling the displacements of private or public vehicles in some particular driving situations and/or in some equipped areas (e.g., automated car parks or captive fleets in downtown centers or private sites).

3.3. Service, intervention, and human assistance robotics

This application domain is currently quickly emerging, and more and more industrials companies (e.g., IS-Robotics, Samsung, LG) are now commercializing service and intervention robotics products such as vacuum cleaner robots, drones for civil or military applications, entertainment robots . . .). One of the main challenges is to propose robots which are sufficiently robust and autonomous, easily usable by non-specialists, and marked at a reasonable cost. A more recent challenge for the coming decade is to develop robotized systems for assisting elderly and/or disabled people. We are strongly involved in the development of such technologies, which are clearly tightly connected to our research work on robots in human environments.

3.4. Potential spin-offs in some other application domains

Our *Bayesian Programming* tools (including the functions for decision making under uncertainty) are also impacting a large spectrum of application domains such as autonomous systems, surveillance systems, preventive maintenance for large industrial plants, fraud detection, video games, etc. These application domains are covered by our start-up *Probayes*.

[0] Advanced Driver Assistance Systems

FLOWERS Project-Team

4. Application Domains

4.1. Applications

Personal robotics. Many indicators show that the arrival of personal robots in homes and everyday life will be a major fact of the 21st century. These robots will range from purely entertainment or educative applications to social companions that many argue will be of crucial help in our aging society. For example, UNECE evaluates that the industry of entertainment, personal and service robotics will grow from $5.4Bnto$17.1Bn over 2008-2010. Yet, to realize this vision, important obstacles need to be overcome: these robots will have to evolve in unpredictable homes and learn new skills while interacting with non-engineer humans after they left factories, which is out of reach of current technology. In this context, the refoundation of intelligent systems that developmental robotics is exploring opens potentially novel horizons to solve these problems.

Human-Robot Collaboration. Robots play a vital role for industry and ensure the efficient and competitive production of a wide range of goods. They replace humans in many tasks which otherwise would be too difficult, too dangerous, or too expensive to perform. However, the new needs and desires of the society call for manufacturing system centered around personalized products and small series productions. Human-robot collaboration could widen the use of robot in this new situations if robots become cheaper, easier to program and safe to interact with. The most relevant systems for such applications would follow an expert worker and works with (some) autonomy, but being always under supervision of the human and acts based on its task models. Video games. In conjunction with entertainment robotics, a new kind of video games are developing in which the player must either take care of a digital creature (e.g. Neopets), or tame it (e.g. Nintendogs), or raise/accompany them (e.g. Sims). The challenges entailed by programming these creatures share many features with programming personal/entertainment robots. Hence, the video game industry is also a natural field of application for FLOWERS.

Environment perception in intelligent vehicles. When working in simulated traffic environments, elements of FLOWERS research can be applied to the autonomous acquisition of increasingly abstract representations of both traffic objects and traffic scenes. In particular, the object classes of vehicles and pedestrians are if interest when considering detection tasks in safety systems, as well as scene categories ("scene context") that have a strong impact on the occurrence of these object classes. As already indicated by several investigations in the field, results from present-day simulation technology can be transferred to the real world with little impact on performance. Therefore, applications of FLOWERS research that is suitably verified by real-world benchmarks has direct applicability in safety-system products for intelligent vehicles.

Automated Tutoring Systems. Optimal teaching and efficient teaching/learning environments can be applied to aid teaching in schools aiming both at increase the achievement levels and the reduce time needed. From a practical perspective, improved models could be saving millions of hours of students' time (and effort) in learning. These models should also predict the achievement levels of students in order to influence teaching practices.

HEPHAISTOS Team

4. Application Domains

4.1. Application Domains

While the methods developed in the project can be used for a very broad set of application domains (for example we have an activity in CO2 emission allowances), it is clear that the size of the project does not allow us to address all of them. Hence we have decided to focus our applicative activities on *mechanism theory*, where we focus on *modeling*, *optimal design* and *analysis* of mechanisms. Along the same line our focus is *robotics* and especially *service robotics* which includes rescue robotics, rehabilitation and assistive robots for elderly and handicapped people. Although these topics were new for us when initiating the project we have spent two years determining priorities and guidelines by conducting about 200 interviews with field experts (end-users, praticians, family and caregivers, institutes), establishing strong collaboration with them (e.g. with the CHU of Nice-Cimiez) and putting together an appropriate experimental setup for testing our solutions. A direct consequence of setting up this research framework is a reduction in our publication and contract activities. But this may be considered as an investment as assistance robotics is a long term goal.

LAGADIC Project-Team

4. Application Domains

4.1. Application Domains

The natural applications of our research are obviously in robotics. In fact, researches undertaken in the Lagadic group can apply to all the fields of robotics implying a vision sensor. They are indeed conceived to be independent of the system considered (and the robot and the vision sensor can even be virtual for some applications).

Currently, we are mostly interested in using visual servoing for aerial and space application, micromanipulation, autonomous vehicle navigation in large urban environments or for disabled or elderly people.

We also address the field of medical robotics. The applications we consider turn around new functionalities of assistance to the clinician during a medical examination: visual servoing on echographic images, needle insertion, compensation of organ motion, etc.

Robotics is not the only possible application field to our researches. In the past, we were interested in applying visual servoing in computer animation, either for controlling the motions of virtual humanoids according to their pseudo-perception, or for controlling the point of view of visual restitution of an animation. In both cases, potential applications are in the field of virtual reality, for example for the design of video games, or virtual cinematography.

Applications also exist in computer vision and augmented reality. It is then a question of carrying out a virtual visual servoing for the 3D localization of a tool with respect to the vision sensor, or for the estimation of its 3D motion. This field of application is very promising, because it is in full rise for the realization of special effects in the multi-media field or for the design and the inspection of objects manufactured in the industrial world.

RITS Team

4. Application Domains

4.1. Introduction

While the preceding section focused on methodology, in connection with automated guided vehicles, it should be stressed that the evolution of the problems which we deal with, remains often guided by the technological developments.We enumerate three fields of application, whose relative importance varies with time and which have strong mutual dependencies: driving assistance, new transportation systems and fully automated vehicles (cybercars).

4.2. Driving assistance

Several techniques will soon help drivers. One of the first immediate goal is to improve security by alerting the driver when some potentially dangerous or dangerous situations arise, i.e. collision warning systems or lane tracking could help a bus driver and surrounding vehicle drivers to more efficiently operate their vehicles. Human factors issues could be addressed to control the driver workload based on additional information processing requirements. Another issue is to optimize individual journeys. This means developing software for calculating optimal (for the user or for the community) paths. Nowadays, path planning software is based on a static view of the traffic: efforts have to be done to take the dynamic component into account.

4.3. New transportation systems

The problems related to the abusive use of the individual car in large cities led the populations and the political leaders to support the development of public transport. A demand exists for a transport of people and goods which associates quality of service, environmental protection and access to the greatest number. Thus the Tram and the light subways of VAL type recently introduced into several cities in France conquered the populations, in spite of high financial costs. However, these means of mass transportation are only possible on lines on which there is a keen demand. As soon as one moves away from these “lines of desire” or when one deviates from the rush hours, these modes become expensive and offer can thus only be limited in space and time. To give a more flexible offer, it is necessary to plan more individual modes which approach the car as we know it. However, if one wants to enjoy the benefits of the individual car without suffering from their disadvantages, it is necessary to try to match several criteria: availability anywhere and anytime to all, lower air and soils pollution as well as sound levels, reduced ground space occupation, security, low cost. Electric or gas vehicles available in self-service, as in the Praxitèle system, bring a first response to these criteria. To be able to still better meet the needs, it is however necessary to re-examine the design of the vehicles on the following points:

- ease empty car moves to better distribute them;
- better use of information systems inboard and on ground;
- better integrate this system in the global transportation system.

These systems are now operating (i.e. in La Rochelle). The challenge is to bring them to an industrial phase by transferring technologies to these still experimental projects.

4.4. Automated vehicles

The long term effort of the project is to put automatically guided vehicles (cybercars) on the road. It seems too early to mix cybercars and traditional vehicles, but data processing and automation now make it possible to consider in the relatively short term the development of such vehicles and the adapted infrastructures. RITS aims at using these technologies on experimental platforms (vehicles and infrastructures) to accelerate the technology transfer and to innovate in this field. Other application can be precision docking systems that will allow buses to be automatically maneuvered into a loading zone or maintenance area, allowing easier access for passengers, or more efficient maintenance operations. Transit operating costs will also be reduced through decreased maintenance costs and less damage to the braking and steering systems. Regarding technical topics, several aspects of Cybercars have been developed at RITS this year. First, we have stabilized a generic Cycab architecture involving Inria SynDEx tool and CAN communications. The critical part of the vehicle is using a real-time SynDEx application controlling the actuators via two Motorola's MPC555. Today, we have decided to migrate to the new dsPIC architecture for more efficiency and ease of use. This application has a second feature, it can receive commands from an external source (Asynchronously this time) on a second CAN bus. This external source can be a PC or a dedicated CPU, we call it high level. To work on the high level, in the past years we have been developing a R&D framework called (Taxi) which used to take control of the vehicle (Cycab and Yamaha) and process data such as gyro, GPS, cameras, wireless communications and so on. All our developments and demonstrations on our cybercars (cycabs, Yamaha AGV and new Cybus platforms) are using the RTMaps SDK development platform. These demonstrations include: reliable SLAMMOT algorithm using 2 to 4 laser sensors simultaneously, automatic line/road following techniques, PDA remote control, multi sensors data fusion, collaborative perception via ad-hoc network. The second main topic is inter-vehicle communications using ad-hoc networks. We have worked with the HIPERCOM team for setting and tuning OLSR, a dynamic routing protocol for vehicles communications. Our goal is to develop a vehicle dedicated communication software suite, running on a specialized hardware. It can be linked also with the Taxi Framework for getting data such GPS information's to help the routing algorithm.

AYIN Team

4. Application Domains

4.1. Remote sensing

With the development and launch of new instruments (for instance, GeoEye, Ikonos, Pleiades, COSMO-SkyMed, TerraSAR-X, and future missions EnMAP, PRISMA, HYPXIM, ...) capturing Earth images at very high spatial, spectral, and temporal resolutions, numerous new applications arise, such as precision agriculture, natural disaster management, monitoring of urban environments, and mineralogy. We apply our new methodologies to the analysis of SAR, multi- and hyper-spectral remote sensing images and temporal sequences. In particular, we address image segmentation and classification, change detection, the extraction of structures, and object tracking.

4.2. Skin care

The most recent sensors used in dermatology and cosmetology produce images with very high spatial, spectral, and temporal resolutions. As with remote sensing, numerous applications then arise that can make use of the new information. In the application to dermatology, we are particularly interested in hyperpigmentation detection and the evaluation of the severity of various disorders (for instance, for melasma, vitiligo, acne, melanoma, etc.). In the application to cosmetology, our main goals are the analysis, modeling, and characterization of the condition of human skin, especially as applied to the evaluation of methods designed to influence that condition.

LEAR Project-Team

4. Application Domains

4.1. Application Domains

A solution to the general problem of visual recognition and scene understanding will enable a wide variety of applications in areas including human-computer interaction, retrieval and data mining, medical and scientific image analysis, manufacturing, transportation, personal and industrial robotics, and surveillance and security. With the ever expanding array of image and video sources, visual recognition technology is likely to become an integral part of many information systems. A complete solution to the recognition problem is unlikely in the near future, but partial solutions in these areas enable many applications. LEAR's research focuses on developing basic methods and general purpose solutions rather than on a specific application area. Nevertheless, we have applied our methods in several different contexts.

Semantic-level image and video access. This is an area with considerable potential for future expansion owing to the huge amount of visual data that is archived. Besides the many commercial image and video archives, it has been estimated that as much as 96% of the new data generated by humanity is in the form of personal videos and images [0], and there are also applications centering on on-line treatment of images from camera equipped mobile devices (e.g. navigation aids, recognizing and answering queries about a product seen in a store). Technologies such as MPEG-7 provide a framework for this, but they will not become generally useful until the required mark-up can be supplied automatically. The base technology that needs to be developed is efficient, reliable recognition and hyperlinking of semantic-level domain categories (people, particular individuals, scene type, generic classes such as vehicles or types of animals, actions such as football goals, etc).

Visual (example based) search. The essential requirement here is robust correspondence between observed images and reference ones, despite large differences in viewpoint or malicious attacks of the images. The reference database is typically large, requiring efficient indexing of visual appearance. Visual search is a key component of many applications. One application is navigation through image and video datasets, which is essential due to the growing number of digital capture devices used by industry and individuals. Another application that currently receives significant attention is copyright protection. Indeed, many images and videos covered by copyright are illegally copied on the Internet, in particular on peer-to-peer networks or on the so-called user-generated content sites such as Flickr, YouTube or DailyMotion. Another type of application is the detection of specific content from images and videos, which can, for example, be used for finding product related information given an image of the product.

Automated object detection. Many applications require the reliable detection and localization of one or a few object classes. Examples are pedestrian detection for automatic vehicle control, airplane detection for military applications and car detection for traffic control. Object detection has often to be performed in less common imaging modalities such as infrared and under significant processing constraints. The main challenges are the relatively poor image resolution, the small size of the object regions and the changeable appearance of the objects.

[0] http://www.sims.berkeley.edu/research/projects/how-much-info/summary.html

LINKMEDIA Project-Team

4. Application Domains

4.1. Asset management in the entertainement business

Regardless of the ingestion and storage issues, media asset management—archiving, describing and retrieving multimedia content—has turned into a key factor and a huge business for content and service providers. Most content providers, with television channels at the forefront, rely on multimedia asset management systems to annotate, describe, archive and search for content. So do archivists such as the Institut National de l'Audiovisuel, the Nederlands Instituut voor Beeld en Geluid or the British Broadcast Corporation, as well as media monitoring companies, such as Yacast in France. Protecting copyrighted content is another aspect of media asset management.

4.2. Multimedia Internet

One of the most visible application domains of linked multimedia content is that of multimedia portals on the Internet. Search engines now offer many features for image and video search. Video sharing sites also feature search engines as well as recommendation capabilities. All news sites provide multimedia content with links between related items. News sites also implement content aggregation, enriching proprietary content with user-generated content and reactions from social networks. Most public search engines and Internet service providers offer news aggregation portals.

4.3. Multiscreen TV

The convergence between television and the Internet has accelerated significantly over the past few years, with the democratization of TV on-demand and replay services and the emergence of social TV services and multiscreen applications. These evolutions and the ever growing number of innovative applications incurred offer a unique playground for multimedia technologies. Recommendation plays a major role in connected TV. Enriching multimedia content, with explicit links targeting either multimedia material or knowledge databases, appears as a key feature in this context, at the core of rich TV and second screen applications.

4.4. E-learning

On-line courses are rapidly gaining interest with the recent movement for massive open on-line courses (MOOCs). Such courses usually aggregate multimedia material, such as a video of the course with handouts and potentially text books, exercises and other related resources. This setting is very similar to that of the media aggregation sites though in a different domain. Automatically analyzing and describing video and textual content, synchronizing all material available across modalities, creating and characterizing links between related material or between different courses are all necessary features for on-line courses authoring.

MAGRIT Project-Team

4. Application Domains

4.1. Augmented reality

We have a significant experience in AR that allowed good progress in building usable, reliable and robust AR systems. Our contributions cover the entire process of AR: matching, pose initialization, 3D tracking, in-situ modeling, handling interaction between real and virtual objects....

4.2. Medical Imaging

For 15 years, we have been working in close collaboration with University Hospital of Nancy and GE Healthcare in interventional neuroradiology. Our common aim is to develop a multimodality framework to help therapeutic decisions and interventional gestures. Contributions of the team focus about the developments of AR tools for neuro-navigation as well as the development of simulation tools of the interventional act for training or planning. Laparoscopic surgery is another field of interest with the development of methods for tracking deformable organs based on bio-mechanical models. Some of these projects are developed in collaboration with the EPC SHACRA.

4.3. Applied mechanics

In experimental solid mechanics, an important problem is to characterize properties of specimen subject to mechanical constraints, which makes it necessary to measure tiny strains. Contactless measurement techniques have emerged in the last few years and are spreading quickly. They are mainly based on images of the surface of the specimen on which a regular grid or a random speckle has been deposited. We are engaged since June 2012 in a transdisciplinary collaboration with Institut Pascal (Clermont-Ferrand Université). The aim is to characterize the metrological performances of these techniques limited by, e.g., the sensor noise, and to improve them by several dedicated image processing tools.

MORPHEO Project-Team

4. Application Domains

4.1. 4D modeling

Modeling shapes that evolve over time, analyzing and interpreting their motion has been a subject of increasing interest of many research communities including the computer vision, the computer graphics and the medical imaging communities. Recent evolutions in acquisition technologies including 3D depth cameras (Time-of-Flight and Kinect), multi-camera systems, marker based motion capture systems, ultrasound and CT scans have made those communities consider capturing the real scene and their dynamics, create 4D spatio-temporal models, analyze and interpret them. A number of applications including dense motion capture, dynamic shape modeling and animation, temporally consistent 3D reconstruction, motion analyzes and interpretation have therefore emerged.

4.2. Shape Analysis

Most existing shape analysis tools are local, in the sense that they give local insight about an object's geometry or purpose. The use of both geometry and motion cues makes it possible to recover more global information, in order to get extensive knowledge about a shape. For instance, motion can help to decompose a 3D model of a character into semantically significant parts, such as legs, arms, torso and head. Possible applications of such high-level shape understanding include accurate feature computation, comparison between models to detect defects or medical pathologies, and the design of new biometric models or new anthropometric datasets.

4.3. Human Motion Analysis

The recovery of dense motion information enables the combined analyses of shapes and their motions. Typical examples include the estimation of mean shapes given a set of 3D models or the identification of abnormal deformations of a shape given its typical evolutions. The interest arises in several application domains where temporal surface deformations need to be captured and analysed. It includes human body analyses for which potential applications are anyway numerous and important, from the identification of pathologies to the design of new prostheses.

4.4. Interaction

The ability to build models of humans in real time allows to develop interactive applications where users interact with virtual worlds. The recent Kinect proposed by Microsoft illustrates this principle with game applications using human inputs perceived with a depth camera. Other examples include gesture interfaces using visual inputs. A challenging issue in this domain is the ability to capture complex scenes in natural environments. Multi-modal visual perception, e.g. depth and color cameras, is one objective in that respect.

PERCEPTION Project-Team (section vide)

PRIMA Project-Team (section vide)

SIROCCO Project-Team

4. Application Domains

4.1. Introduction

The application domains addressed by the project are:

- Compression with advanced functionalities of various image modalities (including multi-view, medical images such as MRI, CT, WSI, or satellite images);
- Networked multimedia applications via their various needs in terms of image and 2D and 3D video compression, or in terms of network adaptation (e.g., resilience to channel noise);
- Content editing and post-production.

4.2. Compression with advanced functionalities

Compression of images and of 2D video (including High Definition and Ultra High Definition) remains a widely-sought capability for a large number of applications. This is particularly true for mobile applications, as the need for wireless transmission capacity will significantly increase during the years to come. Hence, efficient compression tools are required to satisfy the trend towards mobile access to larger image resolutions and higher quality. A new impulse to research in video compression is also brought by the emergence of new formats beyond High Definition TV (HDTV) towards high dynamic range (higher bit depth, extended colorimetric space), super-resolution, formats for immersive displays allowing panoramic viewing and 3DTV.

Different video data formats and technologies are envisaged for interactive and immersive 3D video applications using omni-directional videos, stereoscopic or multi-view videos. The "omni-directional video" set-up refers to 360-degree view from one single viewpoint or spherical video. Stereoscopic video is composed of two-view videos, the right and left images of the scene which, when combined, can recreate the depth aspect of the scene. A multi-view video refers to multiple video sequences captured by multiple video cameras and possibly by depth cameras. Associated with a view synthesis method, a multi-view video allows the generation of virtual views of the scene from any viewpoint. This property can be used in a large diversity of applications, including Three-Dimensional TV (3DTV), and Free Viewpoint Video (FTV). The notion of "free viewpoint video" refers to the possibility for the user to choose an arbitrary viewpoint and/or view direction within a visual scene, creating an immersive environment. Multi-view video generates a huge amount of redundant data which need to be compressed for storage and transmission. In parallel, the advent of a variety of heterogeneous delivery infrastructures has given momentum to extensive work on optimizing the end-to-end delivery QoS (Quality of Service). This encompasses compression capability but also capability for adapting the compressed streams to varying network conditions. The scalability of the video content compressed representation and its robustness to transmission impairments are thus important features for seamless adaptation to varying network conditions and to terminal capabilities.

4.3. Networked visual applications

3D and Free Viewpoint TV: The emergence of multi-view auto-stereoscopic displays has spurred a recent interest for broadcast or Internet delivery of 3D video to the home. Multiview video, with the help of depth information on the scene, allows scene rendering on immersive stereo or auto-stereoscopic displays for 3DTV applications. It also allows visualizing the scene from any viewpoint, for scene navigation and free-viewpoint TV (FTV) applications. However, the large volumes of data associated to multi-view video plus depth content raise new challenges in terms of compression and communication.

Internet and mobile video: Broadband fixed (ADSL, ADSL2+) and mobile access networks with different radio access technologies (RAT) (e.g. 3G/4G, GERAN, UTRAN, DVB-H), have enabled not only IPTV and Internet TV but also the emergence of mobile TV and mobile devices with internet capability. A major challenge for next internet TV or internet video remains to be able to deliver the increasing variety of media (including more and more bandwidth demanding media) with a sufficient end-to-end QoS (Quality of Service) and QoE (Quality of Experience).

Mobile video retrieval: The Internet has changed the ways of interacting with content. The user is shifting its media consumption from a passive to a more interactive mode, from linear broadcast (TV) to on demand content (YouTubes, iTunes, VoD), and to user-generated, searching for relevant, personalized content. New mobility and ubiquitous usage has also emerged. The increased power of mobile devices is making content search and retrieval applications using mobile phones possible. Quick access to content in mobile environments with restricted bandwidth resources will benefit from rate-efficient feature extraction and description.

Wireless multi-camera vision systems: Our activities on scene modelling, on rate-efficient feature description, distributed coding and compressed sensing should also lead to algorithmic building blocks relevant for wireless multi-camera vision systems, for applications such as visual surveillance and security.

4.4. Medical Imaging (CT, MRI, Virtual Microscopy)

The use of medical imaging has greatly increased in recent years, especially with *magnetic resonance images (MRI) and computed tomography (CT)*. In the medical sector, lossless compression schemes are in general used to avoid any signal degradation which could mask a pathology and hence disturb the medical diagnosis. Nevertheless, some discussions are on-going to use near-lossless coding of medical images, coupled with a detection and segmentation of region-of interest (ROIs) guided by a modeling stage of the image sensor, by a precise knowledge of the medical imaging modalities and by the diagnosis and expertise of practitioners. New application domains using these new approaches of telemedecine will surely increase in the future. The second aspect deals with the legal need of biomedical images storage. The legacy rules of such archives are changing and it could be interesting to propose adaptive compression strategies, i.e to explore reversible lossy-to-lossless coding algorithms and new storage modalities which use, in a first stage, the lossless representation and continuously introduce controlled lossy degradations for the next stages of archives. Finally, it seems promising to explore new representation and coding approaches for 3D biological tissue imaging captured by *3D virtual microscopy*. These fields of interest and scientific application domains commonly generate terabytes of data. Lossless schemes but also lossy approaches have to be explored and optimized, and interactive tools supporting scalable and interactive access to large-sized images such as these virtual microscopy slides need to be developed.

4.5. Editing and post-production

Video editing and post-production are critical aspects in the audio-visual production process. Increased ways of “consuming” video content also highlight the need for content repurposing as well as for higher interaction and editing capabilities. Content captured at very high resolutions may need to be repurposed in order to be adapted to the requirements of actual users, to the transmission channel or to the terminal. Content repurposing encompasses format conversion (retargeting), content summarization, and content editing. This processing requires powerful methods for extracting condensed video representations as well as powerful inpainting techniques. By providing advanced models, advanced video processing and image analysis tools, more visual effects, with more realism become possible. Other applications such as video annotation/retrieval, video restoration/stabilization, augmented reality, can also benefit from the proposed research.

STARS Project-Team

4. Application Domains

4.1. Introduction

While in our research the focus is to develop techniques, models and platforms that are generic and reusable, we also make effort in the development of real applications. The motivation is twofold. The first is to validate the new ideas and approaches we introduce. The second is to demonstrate how to build working systems for real applications of various domains based on the techniques and tools developed. Indeed, Stars focuses on two main domains: **video analytics** and **healthcare monitoring**.

4.2. Video Analytics

Our experience in video analytics [6], [1], [8] (also referred to as visual surveillance) is a strong basis which ensures both a precise view of the research topics to develop and a network of industrial partners ranging from end-users, integrators and software editors to provide data, objectives, evaluation and funding.

For instance, the Keeneo start-up was created in July 2005 for the industrialization and exploitation of Orion and Pulsar results in video analytics (VSIP library, which was a previous version of SUP). Keeneo has been bought by Digital Barriers in August 2011 and is now independent from Inria. However, Stars continues to maintain a close cooperation with Keeneo for impact analysis of SUP and for exploitation of new results.

Moreover new challenges are arising from the visual surveillance community. For instance, people detection and tracking in a crowded environment are still open issues despite the high competition on these topics. Also detecting abnormal activities may require to discover rare events from very large video data bases often characterized by noise or incomplete data.

4.3. Healthcare Monitoring

We have initiated a new strategic partnership (called CobTek) with Nice hospital [67], [85] (CHU Nice, Prof P. Robert) to start ambitious research activities dedicated to healthcare monitoring and to assistive technologies. These new studies address the analysis of more complex spatio-temporal activities (e.g. complex interactions, long term activities).

4.3.1. Topics

To achieve this objective, several topics need to be tackled. These topics can be summarized within two points: finer activity description and longitudinal experimentation. Finer activity description is needed for instance, to discriminate the activities (e.g. sitting, walking, eating) of Alzheimer patients from the ones of healthy older people. It is essential to be able to pre-diagnose dementia and to provide a better and more specialised care. Longer analysis is required when people monitoring aims at measuring the evolution of patient behavioral disorders. Setting up such long experimentation with dementia people has never been tried before but is necessary to have real-world validation. This is one of the challenge of the European FP7 project Dem@Care where several patient homes should be monitored over several months.

For this domain, a goal for Stars is to allow people with dementia to continue living in a self-sufficient manner in their own homes or residential centers, away from a hospital, as well as to allow clinicians and caregivers remotely proffer effective care and management. For all this to become possible, comprehensive monitoring of the daily life of the person with dementia is deemed necessary, since caregivers and clinicians will need a comprehensive view of the person's daily activities, behavioural patterns, lifestyle, as well as changes in them, indicating the progression of their condition.

4.3.2. Ethical and Acceptability Issues

The development and ultimate use of novel assistive technologies by a vulnerable user group such as individuals with dementia, and the assessment methodologies planned by Stars are not free of ethical, or even legal concerns, even if many studies have shown how these Information and Communication Technologies (ICT) can be useful and well accepted by older people with or without impairments. Thus one goal of Stars team is to design the right technologies that can provide the appropriate information to the medical carers while preserving people privacy. Moreover, Stars will pay particular attention to ethical, acceptability, legal and privacy concerns that may arise, addressing them in a professional way following the corresponding established EU and national laws and regulations, especially when outside France. Now, Stars can benefit from the support of the COERLE (Comité Opérationnel d'Evaluation des Risques Légaux et Ethiques) to help it to respect ethical policies in its applications.

As presented in 3.1 , Stars aims at designing cognitive vision systems with perceptual capabilities to monitor efficiently people activities. As a matter of fact, vision sensors can be seen as intrusive ones, even if no images are acquired or transmitted (only meta-data describing activities need to be collected). Therefore new communication paradigms and other sensors (e.g. accelerometers, RFID, and new sensors to come in the future) are also envisaged to provide the most appropriate services to the observed people, while preserving their privacy. To better understand ethical issues, Stars members are already involved in several ethical organizations. For instance, F. Bremond has been a member of the ODEGAM - "Commission Ethique et Droit" (a local association in Nice area for ethical issues related to older people) from 2010 to 2011 and a member of the French scientific council for the national seminar on "La maladie d'Alzheimer et les nouvelles technologies - Enjeux éthiques et questions de société" in 2011. This council has in particular proposed a chart and guidelines for conducting researches with dementia patients.

For addressing the acceptability issues, focus groups and HMI (Human Machine Interaction) experts, will be consulted on the most adequate range of mechanisms to interact and display information to older people.

WILLOW Project-Team

4. Application Domains

4.1. Introduction

We believe that foundational modeling work should be grounded in applications. This includes (but is not restricted to) the following high-impact domains.

4.2. Quantitative image analysis in science and humanities

We plan to apply our 3D object and scene modeling and analysis technology to image-based modeling of human skeletons and artifacts in anthropology, and large-scale site indexing, modeling, and retrieval in archaeology and cultural heritage preservation. Most existing work in this domain concentrates on image-based rendering—that is, the synthesis of good-looking pictures of artifacts and digs. We plan to focus instead on quantitative applications. We are engaged in a project involving the archaeology laboratory at ENS and focusing on image-based artifact modeling and decorative pattern retrieval in Pompeii. Application of our 3D reconstruction technology is now being explored in the field of cultural heritage and archeology by the start-up Iconem, founded by Y. Ubelmann, a Willow collaborator.

4.3. Video Annotation, Interpretation, and Retrieval

Both specific and category-level object and scene recognition can be used to annotate, augment, index, and retrieve video segments in the audiovisual domain. The Video Google system developed by Sivic and Zisserman (2005) for retrieving shots containing specific objects is an early success in that area. A sample application, suggested by discussions with Institut National de l'Audiovisuel (INA) staff, is to match set photographs with actual shots in film and video archives, despite the fact that detailed timetables and/or annotations are typically not available for either medium. Automatically annotating the shots is of course also relevant for archives that may record hundreds of thousands of hours of video. Some of these applications will be pursued in our MSR-Inria project.