# Progress report of
# EPITA Research and Development Laboratory (LRDE)

1998 – 2010

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# Contents

# 1 Introduction

The EPITA Research and Development Laboratory (LRDE) is a research laboratory under the tutelage of EPITA, Graduate School of Computer Science. At the end of the year 2010 it is composed of 8 researchers, 1 system administrator, 1 administrative assistant, 3 PhD students and 6 research students. Its funding is covered at 90% by EPITA, the remaining 10% by industrial contracts and by academic research projects.

Belonging to a private university, the LRDE is an exception in an environment where academic scientific research is almost exclusively the responsibility of public bodies. Building on its solid scientific production and academic collaborations, the LRDE presents in this progress report the results of 12 years of activity, in order to provide a stage of reflection and guidance on one hand and a communication tool for the scientific community on the other hand.

## 1.1 Historical background

The LRDE was founded in 1998 at the initiative of Joël Courtois, director of EPITA, who wanted to equip his university with a real academic laboratory in order both to attract high-quality teaching staff and to contribute to EPITA's recognition by peers. At the same time, the laboratory could allow the university's best students to be involved in research while participating in research projects.

### The genesis

Right from the beginning the laboratory has hosted students starting from their 3rd year of studies (1st year of EPITA's 3-year engineering cycle) allowing them to discover research while participating in the development of projects. These projects are or used to be (cf `http://projects.lrde.epita.fr/`):

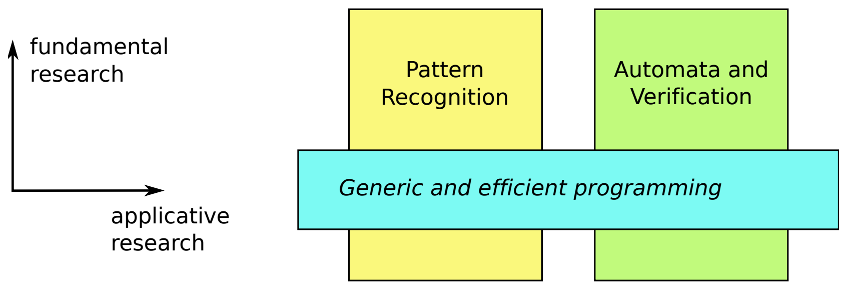
- Olena (98–...), an image processing library that aims to combine user-friendliness and high-performance,
- Urbi et Orbi (99–02), a distributed environment for virtual worlds,
- Tiger (99-...), an educational project for learning programming techniques based on compiler construction,
- Vaucanson (01–...), a finite state machine manipulation platform,
- Transformers (02 –09), a library transforming source code of naive C++ into optimized C++,
- APMC (04–06), a distributed probabilistic *model checker*,
- SPOT (07–...), a deterministic *model checker*.

In addition to these projects, research has been undertaken in the fields of speaker recognition, functional programming, geopolitics of the internet or numerical simulation of granular particle movement.

The variety of these research fields is due to the diversity of the LRDE-members.

### The maturation

In 2005, at the instigation of EPITA's brand new Scientific Council, it became necessary to organize the laboratory within well defined research areas in order to succeed in the academic and industrial world. It was difficult to define a main research area. The most visible feature all the lab's projects have in common was, and still is, the issue of *genericity and performance*. It is definitely the lab's trademark that one can find in various projects and that has resulted in over a dozen publications, cf section 2.3. Currently, the laboratory's seminar focusses on this aspect, cf appendix C. But this way of programming is considered as a tool serving the research projects that are the real principal activities of the researchers. Among these activities image processing has always been the lab's main area, but it was submerged among the other activities. After a long reflection process the LRDE has chosen two main areas: Image and pattern recognition, cf section 2.1 and Automata and verification, cf section 2.2.




Today new research staff, associate professors or PhD students are recruited only if they work in these fields.

## 1.2 Staff

The current staff includes the following researchers:

| Name | Born in | Education | Status | Arrived in |
|---|---|---|---|---|
| Ala-Eddine Ben-Salem | 1980 | M2 SLCP (INP Toulouse) | PhD-student | 2010 |
| Roland Levillain[1] | 1980 | EPITA / M2 SIRF (ENST) | PhD-student | 2005 |
| Yongchao Xu | 1986 | M2 (Paris XI) | PhD-student | 2010 |
| Guillaume Lazarra | 1985 | EPITA | research engineer | 2008 |
| Réda Dehak | 1975 | PhD ENST | associate professor | 2002 |
| Akim Demaille | 1970 | X / PhD ENST | associate professor | 1999 |
| Alexandre Duret-Lutz | 1978 | EPITA / PhD Paris VI | associate professor | 2007 |
| Thierry Géraud | 1969 | ENST / PhD ENST | associate professor | 1998 |
| Jonathan Fabrizio | 1978 | PhD Paris VI | associate professor | 2009 |
| Olivier Ricou | 1966 | PhD Paris VI | associate professor – Director of LRDE | 2002 |
| Didier Verna | 1970 | ENST / PhD ENST | associate professor | 2000 |

Table 1: Researchers at the LRDE

All PhDs hold a PhD in Computer Science, except Olivier Ricou who has a PhD in Mathematics (Numerical Analysis).

The team is assisted by Daniela Becker for administrative matters and by Geoffroy Fouquier for system administration. In the past, certain members of the LRDE have continued their career in the field of research:

| Name | Education | Status | Present at LRDE | Current position |
|---|---|---|---|---|
| Jérôme Darbon | EPITA | PhD-student/ass. prof. | 2001–2006 | CNRS |
| Fabien Freling | EPITA | research engineer | 2009–2010 | R&D Engineer |
| Alexandre Hamez | M2 Paris VI | PhD-student | 2005–2009 | Postdoc Toulouse |
| Alban Linard | M2 Paris VI | PhD-student | 2005–2009 | Postdoc Geneva |
| D. Papadopoulos -Orfanos | PhD ENST | Postdoc | 1999 | CEA |
| Sylvain Peyronnet | PhD Paris XI | ass. prof. | 2004–2006 | ass.prof. Paris XI |
| Heru Xue | PhD (China) | Researcher | 2001–2002 | ass.prof. in China |

The past and present staff of the LRDE has always been completed by research students (cf below).

### 1.2.1 A work of transmission

A unique feature of the LRDE is education by research: we offer to a handful of EPITA students to integrate the research community right from the first year of the engineering cycle. This work situated between teaching and research generates pre-doctoral students and is presented as such in this progress report.

[1] Roland used to be a research engineer at the lab from 2005 to 2007, year when he started his PhD thesis.

104 students have thereby integrated the LRDE in eleven years. Each of them has had his desk next to his/her supervisor, each has participated in the research activities of the latter and some of them have even been able to present their work results at international conferences. Many of the students have done their final internship at research labs in France or abroad. 43 have continued with a Master's degree (M2 research), 14 hold their PhD degree and 15 are currently PhD students. Today one LRDE alumnus works at CNRS (French Centre for Scientific Research) and three alumni are assistant professors:

- Jérôme Darbon, (class of 2001): CNRS researcher at Center for Mathematical Studies and their Applications CMLA (ENS Cachan),
- Alexandre Duret-Lutz (class of 2001): assistant professor at LRDE (EPITA),
- Yann Régis-Gianas (class of 2003): assistant professor at Proofs, Programs and Systems Lab PPS (University Paris VII),
- Jean-Baptiste Mouret (class of 2004): assistant professor at Institute for Intelligent Systems and Robotics ISIR (University Paris VI).

### 1.3 Infrastructure

The LRDE is located at EPITA's campus at Kremlin-Bicêtre, Porte d'Italie.

It has its own facilities of about 200 $m^2$ which include several staff and student offices, a library and a machine room. These facilities allow us to welcome temporary staff, students, interns, PhD-students, invited professors in excellent conditions.

The laboratory has of course access to EPITA's infrastructures, especially to the lecture halls for its seminars.

The computer-based resources include, besides the machines of the permanent staff, a computing cluster and several servers hosting the lab's services, for instance the automatic services for code validation developed by the LRDE, cf section 3.2. The lab's network is independent from EPITA's network except for the Internet connection.

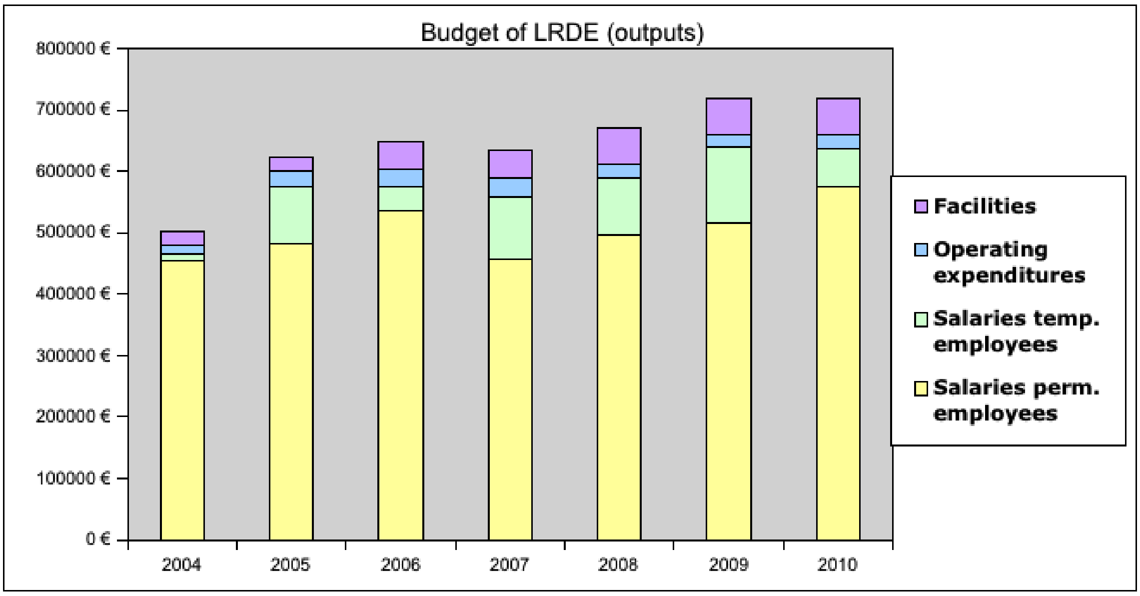
### 1.4 Budget

The summary of the LRDE budget of the past years is presented in figure 1.

The costs include primarily the salaries of its members. Even though the number of fixed-term contracts has increased in the past four years, they should make room for indefinite contracts, mainly for PhD-students.

Concerning the funding of the LRDE, it is covered at 90% by EPITA, while the rest comes from academic and industrial projects.

The researchers spend about a third of their time on teaching and on the proper functioning of the school, another third on research and the last third varies from one person to the other. Teaching loads are comparable to those at universities.



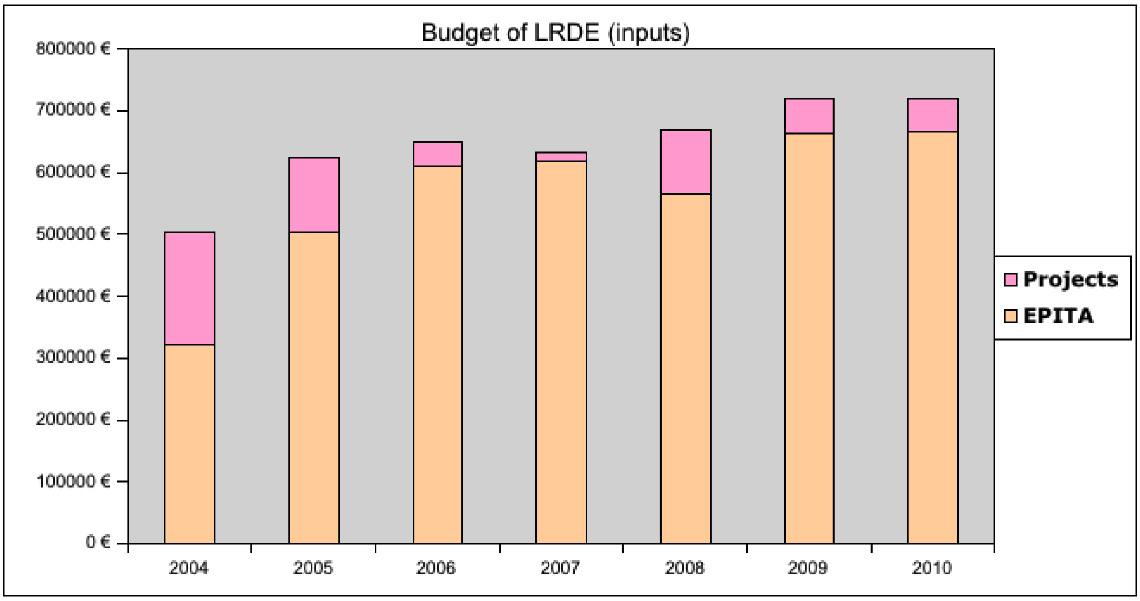




Figure 1: LRDE's budget breakdown

# 2 Research report

The LRDE aims at developing new concepts within its research fields reaching from theory to reusable implementations. This last point is characteristic of the laboratory that includes as much as possible its academic research activities in open libraries. So everyone can download them and measure the significance of the research conducted at the LRDE, and use it in order to go further. In addition to their effectiveness as tools these libraries are most helpful communication tools as well, allowing to build relationships with academic and industrial partners.

The LRDE's main libraries are Olena for image processing, Vaucanson for finite state machines and Spot for *model checking*. Nowadays Olena is the most complete one and is already used for various academic and industrial projects. Spot, already recognized in the academic community is being developed for industrial applications. Vaucanson is a tool for researchers who have received funding from the French National Research Agency ANR in 2010 in order to make it fully exploitable. These libraries are presented at section 3.2 and at the sections dedicated to their respective research fields.

However this important work on the creation of libraries has an important impact on the production of scientific articles. It takes much more time to build a solid and efficient library allowing to integrate the new research results than to program a prototype for each idea that generates a scientific article.

## 2.1 Theme 1 – Image and pattern recognition

### 2.1.1 Image processing

Image processing at LRDE consists mainly in writing morphological algorithms. The principal fields of application are document image analysis and medical image processing.

Some parts of the state of the art of these fields as well as all the results of the Image-team's research have been integrated in Olena, a high performance generic image processing library.

**A generic and efficient library**

Developing the Olena library is part of our objective that aims at building a platform dedicated to this research field. The fundamental concepts are described in Duret-Lutz (2000). To be able to process efficiently a huge amount of data, we have to guarantee good performances for the library's algorithms. Thus we use a static paradigm that contrasts with the dynamic nature of the satellite tools available on the platform (environment with a graphic interface, shell, executables from the command line, *etc.*). Roland Levillain's PhD thesis in partnership with ESIEE deals with the issue of bridging these two worlds.

Concerning the library at the core of our platform, we have demonstrated that it is possible to reconcile performance et genericity (postdoc stay of Dimitri Papadopoulos-

Orfanos) (Géraud et al., 1999). In concrete terms it is about writing a single algorithm, knowing that the input data can be of different types, while preserving the efficiency thanks to static programming (Géraud et al., 2001). In particular, we have shown that C++ allows static translations of classic object oriented models (Burrus et al., 2003). Further, we have proposed a solution to support the notion of *concepts*[1] directly in the language (Géraud and Levillain, 2008).

From the point of view of software engineering, the *design patterns* can be reused, but rely on a dynamic paradigm. First we have defined a redesign model (Géraud and Duret-Lutz, 2000), then we have formalized the static translations of the most common models (Duret-Lutz et al., 2001).

*Translation "image → concepts"*

Setting up computer programs for entities in the field of image processing must preserve the abstract nature of these entities without sacrificing performance. For this, it was necessary to define these entities through their respective interfaces and to implement in an effective manner algorithms based on these interfaces. We have given preliminary solutions for writing generic algorithms with these abstract interfaces in Géraud et al. (2000). Since then we have simplified the writing of algorithms and increased the level of abstraction. More flexible definitions allowed us to develop more general algorithms: in particular, we have shown that it is possible to process "classical" images as well as graphs or meshes (Levillain et al., 2010a).

After having developed several prototypes that served as proof of concepts and enabled us to refine our specifications, the first version of our Olena platform was released in 2009.

**Algorithms and mathematical morphology**

Writing generic algorithms leads to better readability of the code of these algorithms; the translation into programming languages becomes almost literal (Darbon et al., 2002). A further step in writing algorithms appears when more than one operator processing algorithms share a common framework. It is then possible to write code with gaps, *canvases*, and decline the different "versions" of operators by providing a functor defining the variable parts (gaps).

We have studied the Tarjan *union-find* algorithm for the implementation of connected filters (Géraud, 2005b). We also discussed the implementation of mathematical morphology operators based on algorithmic canvases, kind of meta-algorithms (Géraud et al., 2010b,a).

Generic writing also affects the structure of the data and allows to manipulate specific topologies such as meshes or complexes. Thus in the project Mélimage, see 3.1.1, we discussed the functional $2D+t$ MRI images in order to segment a tumor in several regions of homogeneous functional behavior. Instead of considering that the image was $3D$, we represented the $2D$ image with a cubic *complex* and the pixel values (2-faces of the complex) were therefore functions of time. A segmentation with a watershed line allowed

[1]System of constraints on the parameterized types that should someday integrate the C++ standard.

to separate the regions by positioning the contours on the 0-face and 1-face (geometric objects with inter-pixel boundaries).

It was necessary to introduce the structure of a cell *complex*. This structure results from an approach becoming more and more common in image processing which consists in considering not only the pixels (2-faces) of an image, but also the data *between* these pixels (edges or 1-face) and data between the sides (points or 0-face). Such structures can best represent the topology of discrete images. The generic approach in image processing allows to write unique algorithms running as naturally on images based on complexes as on "classical" images. We showed that this approach was effective in mathematical morphology (Levillain et al., 2009) and in discrete geometry (Levillain et al., 2010b).

Another example is about the tree components allowing to identify the objects in an image. For this purpose, the images are described by the topological structure of cubical complexes, the 1-face allowing to represent the boundaries of components. Yongchao Xu's PhD thesis, started in October 2010 in partnership with Laurent Najman (A3SI, LIGM, University Paris-Est) is about possibilities that offers the self-dual structure of the tree of shapes expressed on cell complexes for object recognition and segmentation.

### Applications

The main application of research in image processing at the LRDE concerned the issue of content extraction in documents. The results have been applied in several contexts: *intelligent* scanners while working with the French company SWT; processing press photos in collaboration with the French news agency AFP; supporting data management via a document indexing system within the project called Scribo.

*Text extraction in natural images*

We have tried two approaches for the text location in an image: a slow (about one minute) but robust method and a less robust but extremely fast method (less than one second per image).


(a) Original photograph (b) Result

Figure 2: Text detection in photographs

The first method is the result of a joint effort between the Centre of Mathematical Morphology (Mines ParisTech), the Laboratoire d'Informatique de Paris VI (Pierre et Marie Curie University) and the LRDE (Minetto et al., 2010). It is divided into two parts: location and validation. During the text location phase, the image is segmented following a method of mathematical morphology (the TMMS), then the letters are extracted by a classifier and combined to form text areas. During the validation phase, the text areas are checked by another classifier to eliminate false positives.

The second method is more refined: the image is initially segmented by a multiscale adaptation of the Sauvola method, then components with similar characteristics are grouped together to form the text areas.

*Structured documents*

Processing structured documents at the LRDE has started with the collaboration with the French company SWT (now EMC Captiva) and led to a European and an American patent that were about an algorithm allowing to detect the type of a document. This work resulted also in an award, the European IST Prize 2004.

Subsequently we have participated in the project called SCRIBO, see 3.1.1, whose goal is to provide free tools to make semi-automatic indexing of documents. In this context, we have developed tools to segment and reconstruct initially structured documents as images.

Our method, based on a component-based approach, identifies text components and by deduction those of another nature. *Finally* we identify and locate different objects in the documents (3a and 3b). An important step upstream is the binarization. For this we use the Sauvola algorithm, which unfortunately does not handle objects of various sizes in the same document. So we developed a solution that we used in a binarization contest for old documents.

A guest-worker program may brighten the outlook for Mexico's internal illegals, but observers say the compassionate rhetoric is not just for domestic consumption. Calderón, who is meeting this month with U.S. President Bush to talk about how Mexican migrants are treated in the U.S., seems to be following a simple maxim: Do unto others as you would have them do unto you. **—By Nathan Thornburgh. Reported by Dolly Mascareñas/Mexico City**

battle in the south, don't expect the Taliban to start digging trenches. It's an insurgency, stupid. A Taliban spokesman has declared that he has 2,000 suicide bombers ready to act once the snow melts. While it's hard to believe that they have the wherewithal, or even the explosives, to outfit such a large number (Taliban math rule of

**Taliban fighters have learned from the Iraqi insurgency**

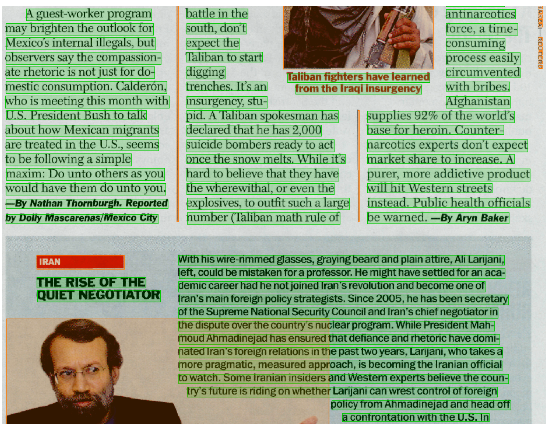
antinarcotics force, a time-consuming process easily circumvented with bribes. Afghanistan supplies 92% of the world's base for heroin. Counternarcotics experts don't expect market share to increase. A purer, more addictive product will hit Western streets instead. Public health officials be warned. **—By Aryn Baker**

IRAN

**THE RISE OF THE QUIET NEGOTIATOR**

With his wire-rimmed glasses, graying beard and plain attire, Ali Larijani, left, could be mistaken for a professor. He might have settled for an academic career had he not joined Iran's revolution and become one of Iran's main foreign policy strategists. Since 2005, he has been secretary of the Supreme National Security Council and Iran's chief negotiator in the dispute over the country's nuclear program. While President Mahmoud Ahmadinejad has ensured that defiance and rhetoric have dominated Iran's foreign relations in the past two years, Larijani, who takes a more pragmatic, measured approach, is becoming the Iranian official to watch. Some Iranian insiders and Western experts believe the country's future is riding on whether Larijani can wrest control of foreign policy from Ahmadinejad and head off a confrontation with the U.S. In

(a) Example of a scanned document.



(b) Result. The green boxes correspond with text lines, the orange boxes with images.

Figure 3: Segmentation of scanned documents.

It has to be noted that, in accordance with our principle of genericity, all the developed tools can be applied to other use cases without major modifications. They will be distributed as modules with our image processing library in 2011. Some are also available as online demo on our website[2].

Finally this work has been integrated in the *smart* office software Nepomuk for the KDE environment of Linux. It has already resulted in the integration of Olena in the Linux distribution of Mandriva.

### 2.1.2 Speaker recognition and speech processing

The LRDE works on statistical methods to deal with speaker and channel variabilities for speaker recognition systems. We propose new representations for speaker voiceprint.

This work was conducted in collaboration with the speech recognition team of the Computer Research Institute of Montreal (CRIM, Canada) and the Spoken Language Systems Group of the MIT Computer Science and Artificial Intelligence Laboratory.

#### SVM based methods for Speaker Recognition

Speaker recognition methods can be devided into two classes depending on how they deal with speaker's parameters: the generative approaches are essentially based on parametric probalistic models generally represented by a *Gaussian Mixture Model* (GMM). Other approaches use discriminant methods in order to learn how to distinguish one speaker within a set of impostors. The most commonly used approaches in this case are based on the *Support Vector Machine* (SVM) Methods.

One of the main obstacles for the use of SVM methods for speaker verification is related to the length variability of the audio recording. There are two different approaches for extracting a vector of fixed size from the sequence of acoustic vectors: the first approach uses directly the acoustic vectors as a set of features for the SVM training. The decision scores are averaged over all acoustic vectors.

The second group uses the GMM to project the variable lenght audio speech into a fixed dimension space representing the Baum Welch statistics for each gaussian component.

We have studied the linear kernel, which is based on a scalar product between two mean vectors and the Gaussian kernel defined using the Kullback-Leibler (LB) distance between two GMMs. We have shown the importance of model parameters normalization using the GMM-UBM parameters (M-NORM) to improve the system performances (Dehak et al., 2007). We tested also the *Nuisance Attribute Projection* (NAP) to deal with channel variability in GMM parameters space.

One advantage of the SVM methods is their scoring speed. This advantage has motivated us to explore the possibilities of combination with the JFA method (*Joint Factor Analysis*) which allows a better representation of the channel and speaker variabilities. So we proposed a comparison between the two approaches in Dehak et al. (2008a), then

[2] cf `http://www.lrde.epita.fr/cgi-bin/twiki/view/Olena/Demos`

we proposed a cosine distance based kernel for SVM methods used directly in JFA parameter space (Dehak et al., 2009b). The resulting performances are similar to the JFA method with a significant gain in computation time.

In parallel, we proposed to use a fusion method in the SVM kernel space using *Multiple Kernel Learning* (MKL) approaches (Dehak et al., 2008a, 2009b). This approach has the advantage of learning the fusion parameters using the same speaker-training database. The obtained fusion SVM system of a linear kernel, a Gaussian kernel and a GLDS kernel had similar or better performances than a linear score fusion approach.

#### I-Vector: a simplified representation of the speaker's identity

In order to improve the performance of the JFA method we proposed a new set of parameters to represent a speaker voiceprint (I-Vector: Identity Vector) (Dehak et al., 2009a; **?**). This set includes both variabilities (channel and speaker) in the same *Total Variability space* (TV space). We use techniques of pattern recognition: *linear Discriminant Analysis* (LDA) and *Within Class Covariance Normalization* (WCCN) in a TV space to eliminate the variability of the channel and the speaker. The score is obtained by calculating a cosine distance between the test I-Vector and the training I-Vector. This approach provides nowadays the best performance, especially in the case of short duration of training and testing samples.

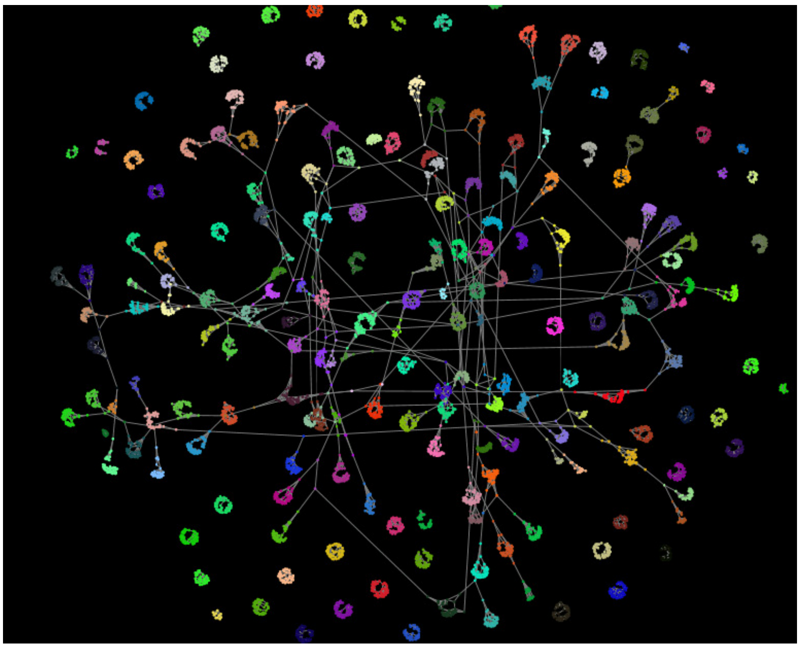


Figure 4: Visualization of the adjacency graph of the different speakers of the NIST- SRE 2010 base

We can see in Figure 4 the result of the display of the adjacency graph of all speakers of NIST- SRE 2010 databases (Dehak et al., 2011). The grouping of samples from the same speaker shows the performances obtained by this approach.

We have simplified the normalization of scores (Z-Norm, T-Norm and S-Norm) by integrating it directly into cosine distance (Dehak et al., 2010; Shum et al., 2010). This helped reduce the computation time.

### Evaluation campaign of the NIST-SRE speaker verification systems

We have participated in the evaluation campaign of speaker verification systems organized by NIST [3] since the beginning of the project (Dehak et al., 2006; Perrot et al., 2006; Dehak et al., 2008b; Dehak and N.Dehak, 2010).

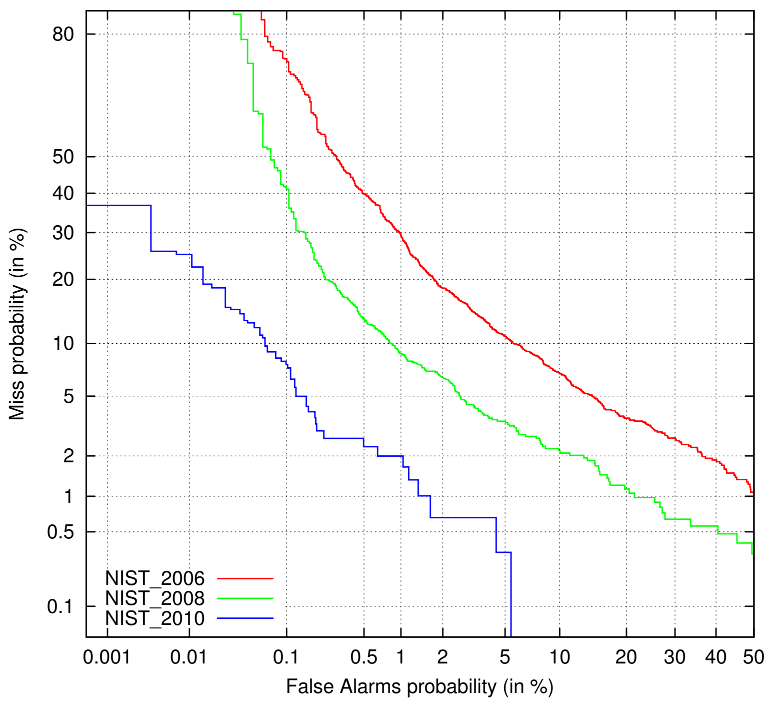



Figure 5: Evolution of the performances of the LRDE system in NIST-SRE competitions

The system proposed in 2006 was based on a simple GMM and SVM system based on the Gaussian kernel but without the use of channel compensation techniques.

In 2008, we proposed a fusion of several systems: we fuse the two systems based on SVM methods with a linear kernel and a non-linear kernel with three systems using prosodic parameters allowing a representation of long-term characteristics of the speech signal.

In 2010, the proposed system uses the I-Vectors to represent the speaker and the techniques described in the previous section for the compensation of the channel. We participated for the first time in the task 10sec-10sec.

In Figure 5, we can see the DET [4] curves describing the performances of the main systems

[3] The National Institute of Standards and Technology organizes competitions in various fields both to stimulate research and to define new standards, cf `http://www.itl.nist.gov/iad/mig/tests/sre/`

[4] Detection Error Tradeoff

submitted to the NIST competition for the required job. We managed to improve the performance of our system every time.

## 2.2 Theme 2 – Automata and verification

The LRDE's Automata-team works on the manipulation of finite-state machines with multiplicities following two approaches. The first approach is about algorithms for finite-state machines (or weighted finite-state machines) in a generic framework that can specialize on specific machines. The second is the use of $\omega$-automata (capable of recognizing infinite words) for formal verification. These two axes, although both dealing with automata, are in fact two different communities, with little interaction.

### 2.2.1 Finite-state machines with multiplicities

Our ambition regarding this research project is to develop a platform for the manipulation of finite-state machines with multiplicities in order to provide genericity, efficiency, respect of the theory and multipurpose tools.

Genericity because it should directly support various types of finite state machines, in the broadest sense, finite-state machines or transducers (the manipulated words being defined in any monoid, that is not necessarily free, and the weights in a semiring).

Efficiency because it should be able to work on large automata.

Respect of the theory because it should provide the users with an expressiveness of the algorithms as close as possible to their mathematical description.

Last but not least, multipurpose tools in order to allow students and senior researchers, academics and industrials, the natural language processing community and the formal verification community to use our platform naturally.

This work, initiated in 2001 by Jacques Sakarovitch (LTCI/ENST) and Sylvain Lombardy (at that time at LIAFA, now at IGM), currently includes four partners with the arrival in 2007 of Professeur Hsu-Chun Yen's team of the University of Taipei. The results of this collaboration have been recognized by the ANR and its counterpart in Taiwan who gave funding in 2010 in order to continue the project.

**Advancement**

The first versions of this platform called Vaucanson have been presented at CIAA'03 (Lombardy et al., 2003) and CIAA'05 (Claveirole et al., 2005). At that state it was a simple library without any user interface.

A control interface (called TAF-Kit) has been added in 2006, followed by two prototypes for a graphical interface (the first one in Java, the second in C++); the Taiwanese team has rewritten a large part of the first prototype and continues to develop it today.

In 2008, we have presented to the community an XML format allowing to represent any type of finite-state machines with multiplicities with their corresponding regular expressions (Vaucanson group, 2004; Demaille et al., 2008a).

Today, the stable version of Vaucanson exists since November 2009, cf 3.2. It should be the last one of the generation, since after an in-depth analysis we have entirely redefined the different interfaces. We want in particular to be able to distinguish four types of automata: automata labeled by letters, others labeled by atomic propositions (letter or empty word), others labeled by words, and others labeled by regular expressions (up to now Vaucanson has known only the last two types). Over the years it became more and more obvious that changes were necessary. They should lead to the release of a new version, Vaucanson 2.0. This project has received the support of the French National Research Agency (ANR), see above.

### 2.2.2 Formal verification

The other aspect of studied automata is about $\omega$-automata for the formal verification or *model checking*.

To verify that a model $M$ verifies a behavioral property $\varphi$, we proceed in four steps. (1) The state space of the model is developed in the form of an automaton $A_M$ whose language represents a series of possible execution scenarios. (2) The property is transformed into an automaton $A_{\neg\varphi}$ whose language is the set of behaviors violating the property. (3) We construct the synchronized product of two automata: that is to say an automaton whose language $\mathscr{L}(A_M \otimes A_{\neg\varphi}) = \mathscr{L}(A_M) \cap \mathscr{L}(A_{\neg\varphi})$ represents all the scenarios of the model that violates $\varphi$. (4) Finally we check that the language of this product is empty using an algorithm called *emptiness check*.

For that we use our Spot library, cf 3.2. The "library nature" of Spot distinguishes it from conventional *model checkers* which are more "frozen", i.e. wired to perform a series of operations and nothing else. In our case we pay attention to the possibility to use, substitute, alter, the whole or parts of the verification chain.

Eventually, we would like to be able to compose a chain of processes dynamically adapted to the system and to the properties that you want to check, which leads to an adaptive *model checking* (PhD thesis in progress).

In the short term, Spot serves as an evolving environment that we expand by developing new algorithms, which allows us to test new ideas.

Currently the work focuses on strong fairness assumptions, on state aggregation and the translation of properties.

#### Strong fairness assumptions

Strong fairness assumptions are properties of the type *if an event occurs infinitely often, then another event occurs infinitely often*.

Integrating several similar hypotheses into the verification process involves a significant additional cost. Typically, Büchi automata which model $n$ fairness assumptions have about $2n \times 3^n$ states. We have shown that using generalized automata with acceptance conditions on transitions, the number of states could be reduced to $2^n + 1$. This change of automata type comes without any extra cost on the algorithms that are then used (in particular the *emptiness check*), and the reduction of the number of states is directly reflected by saving time. We have also shown how the *emptiness check* algorithm used on these automata could be slightly modified in order to work on Streett automata. Thus the *emptiness check* on $n$ fairness assumptions is $n$ times slower, but $n$ assumptions can be represented by a 1-state deterministic Streett automaton. So we swap an exponential cost increase for a linear cost increase (Duret-Lutz et al., 2009).

**State aggregation and alternative products**

A *model checker* spends most of its time building the automaton product of $A_M \otimes A_{\neg\varphi}$ while checking that the automaton thus built has an empty language. The computation time is thus directly proportional to the size of this product. Various techniques have been developed to reduce the size of $A_{\neg\varphi}$, other techniques exist to reduce the size of $A_M$. Some techniques even reduce the size of $A_M$ depending on the property to check for example by aggregating $A_M$ states that are similar in terms of the property. We are working on similar ideas, but which are defined at the product level by considering not the property in its entirety, but only the suffix of the property that remains to be verified. We have defined two new product operations between automata. The results we obtain with these two techniques show a significant performance gain compared to similar techniques used before the product. The paper presenting these two products is in preparation.

**Translation of properties**

We have seen the importance of the size of the $A_{\neg\varphi}$ automaton for limiting the explosion of the product. Spot is known for its algorithm for translating formulas expressed in Linear Temporal Logic (LTL) into automata, which is considered being one of the best in the field. This did not stop us from improving several aspects of the translation. The last two versions of Spot incorporate such improvements, which are often rather technical implementation details but which can be a gain in terms of orders of magnitude in time or space. Thus we worked on the generalization of this algorithm in order to cover the linear part of PSL (*Process Spécification Language*, an industry standard).

We also implemented two other algorithms for the translation of LTL formulas taken from the literature. The first one is for translating properties expressed in ELTL, that is to say a linear-time temporal logic equipped with operators specified in the form of automata. The second translates an LTL formula into a Büchi automaton via an intermediate *alternant* automaton. This algorithm had never been implemented so far. We have seen that neither of these translations is better than the translation algorithm already used by default in Spot, but their integration has highlighted several ideas, and the formalism of alternating automata has shown other applications that we will explore later.

Finally, a technique developed by Christian Dax (at ETHZ) is the minimization of automata representing obligation formulas. Obligations are a subclass of LTL formulas for which there is a weak deterministic Büchi automaton that can be minimized with the same algorithm as finite automata (the calculation of all parties). Following an invitation to work at ETHZ on this technique, we have integrated it into Spot in 2010.

## 2.3 Transverse research axis – Genericity and performance

Given the previous sections, it appears that if all the projects the LRDE members work on involve various application areas, a common underlying problem is how to reconcile two aspects usually contradictory: performance and genericity.

### 2.3.1 Programming paradigms and expressive languages

**Motivation**

This issue has led the lab's teams, starting with that of the Olena project, to develop a long-term software engineering based on technical C + + with many templates. If the LRDE demonstrates today an undeniable expertise in the field, the initial language bias remains. An alternative approach is therefore to get rid of this bias, in order to explore the possibilities offered by other languages.

Concerning to reconciliation of the aspects of performance and genericity, the chosen language does not only offer advantages. Disadvantages include the fact that C + + is a heavy language with an extremely complex and ambiguous syntax, that the template system is actually a completely different language from "standard" C + + , and finally that it is a static language. This last point has significant implications on the application, insofar as it imposes a strict chain of Compilation $\rightarrow$ Development $\rightarrow$ Execution $\rightarrow$ Debugging, making for example rapid prototyping or human-machine interfacing activities difficult. It becomes therefore essential to equip the involved projects with a third language infrastructure that is rather based on scripting languages.

Facing these problems, another team of the laboratory has chosen to focus on the persistent question of "performance and genericity" with a transversal approach, that is to say focused on alternative languages rather than on a particular application domain. The purpose of this research is therefore to examine the solutions offered by languages other than C + +, especially dynamic languages, and we chose Common Lisp.

**Performance**

From the perspective of performance, the choice of an alternative language has meaning only if one is able to prove that this new approach can at least stay in the same orders of magnitude in terms of efficiency. It is therefore necessary to start with a performance evaluation of this new language, provided that the choice of a dynamic language is inherently controversial.

At first glance, it seems paradoxical indeed to use, for performance issues, a language which is legitimately expected to *deteriorate* them. By definition, a dynamic language does less at compile-time and more at run-time (eg, type checking). Most "modern" dynamic languages like Python and Ruby match these preconceived notions. Common Lisp has however the unknown particularity to enable static typing of *variables*, instead of the traditional dynamic typing of *objects*. A compiler that is properly informed about the type of a piece of code (you can freely combine static and dynamic typing) is then free to perform any optimizations you want, even to produce a weakly typed executable like the one produced by a C compiler.

One goal of this research focuses therefore on comparing the performances obtained by some Common Lisp compilers with those of equivalent programs written in C or C++. This work involves a substantial set of performance measurements on micro-benchmarks to evaluate the cost of some basic operations (arithmetic, object instantiation, access to their members, dynamic dispatch, *etc.*). Two publications have already been produced on the subject Verna (2006, 2009), demonstrating indeed the expected results.

**Genericity**

Once the issue of performance is resolved, we still have to demonstrate the benefits of a dynamic language for genericity. The basis of this approach lies in a fact that is this time widely recognized: dynamic languages are more expressive. By eliminating especially the static typing, and consequently, by expanding the scope of polymorphism, dynamic languages provide paradigms that are impossible or difficult to obtain in static languages. This is for example clearly demonstrated in Verna (2008) and Verna (2010). If we take simply the paradigm of object-oriented programming, Common Lisp goes further than other (static or dynamic) languages if the object layer is based on a protocol called "meta-object": a reflexive architecture that implements the object layer in itself, and that also allows to modify or extend it. Thus, far from the classical object approach of common languages, the object-oriented expressivity of Common Lisp includes natively multimethods, and allows the use of traditional classes or the model based on the notion of prototype, a context-oriented approach *etc.*.

The second line of research in this work consists in the study of all these new programming paradigms in terms of what they bring to the notion of genericity. To do this, we have chosen to "clone" one of the oldest projects of the laboratory (Olena) and to express the same issues following an axis of dynamic genericity. Eventually, we hope to get a clearer picture of the contribution of these paradigms, but also of their complementarity.

Finally, a longer-term perspective will be to reconcile these aspects of dynamic genericity with the performances of a dedicated code. This step should also be made significantly easier than the manipulation of C + + templates because of the *structural* reflexivity of Lisp (code and data are represented in the same way). The system of "macros" in Common Lisp is unique because it can perform any function written in Lisp itself during the compilation, these functions themselves having access to the code to compile. This allows in particular to rewrite the code on the fly and an easy *just in time* compilation.

### 2.3.2 Workshop for C++ Programs Transformation

#### Embedded Domain-Specific Languages

We can distinguish roughly two types of programming languages:

- general-purpose languages (like C, Java, Lisp, CAML, Ada, *etc.*) designed to allow the installation of any programs
- domain-specific languages, or specialized languages, designed to provide the perfect level of abstraction for specific jobs (like COBOL or SQL for databases, MatLab for mathematics, PostScript or PDF or SVG for vector images, *etc.*).

Domain-specific languages always end up integrating the functionality of a general-purpose language (loops, data structures, input / output, *etc.*), without ever having been designed to do this properly.

Domain-specific languages embedded in general-purpose languages (EDSL, Embedded Domain Specific Languages) offer the best of both environments. After all, most general-purpose languages embed a specific language: that of mathematics. Nowadays, who would ever want to write something else than `f(x)+g(y)*h(z)`?

It is among other things due to the possibility for programmers to specialize the operators (`+`, `*`, *etc.*) that the C++ language fits well with mathematical domains: the formula `f(x)+g(y)*h(z)` could refer to matrices and quaternions.

But what can we do for people doing image processing? How can we contribute to the design of graphical user interfaces? What can we offer for manipulating automata? For transforming XML documents?

#### High-Level Optimizations

The two main tasks of a compiler are

- validity checking (typically "Is this relevant?")
- optimization: without altering the visible behavior, change the user code to improve certain aspects ( typically the execution speed, but one can also be interested in a size reduction or in a low power consumption).

Some optimizations can only be done at the highest level, where we can take advantage of the laws of the field of our study. Thus, some properly exploited algebraic properties (associativity, commutativity, neutrality, *etc.*) enable faster computations. It is still algebra that allows spectacular optimizations for queries in databases.

This level of knowledge cannot be treated in a general-purpose language, since knowledge is really specific to a domain. Unfortunately, there is no satisfactory environment allowing to communicate the compiler equations legitimizing high-level optimizations, so that today the programmers write complex programs, not only because they implant a solution to a problem, but they implement it in an optimized way.

In the same vein, the object-oriented modeling is well suited to the design of such libraries like Olena and Vaucanson (image processing and manipulation of finite automata), but only at the cost of writing complex programs the maximum of performances can be achieved.

We would like to have a way to optimize a "naive" but readable program and transform it into a complex but efficient program. Such an environment would also express specific semantic rules to diagnose consistency problems during the compilation.

**C++++**

For high-level optimizations you must have an environment allowing Program Transformation in the host language (take a program written in this language, and produce another in the same language). For supporting domain-specific languages you must also have the ability to extend the grammar of the language and the transforming environment. All in a modular way, so that we can embed several domain-specific languages.

We still have to choose the host language.

For better or for worse, C++ is a major language for the design of scientific libraries. Some of the reasons include a large community of programmers, its acceptance by the industry, a good range of tools (development workshops, compilers, literature, websites, initial training, *etc.*), excellent execution performances, support of different paradigms (e.g. object vs. genericity) allowing it to cover problems ranging from embedded actions to very large projects ... For these reasons, and with the intention of providing support to the Olena and Vaucanson teams of the LRDE, the aim of the Transformers project was to create a workshop for C++ Program Transformation.

**Transformers**

The Transformers project is no longer maintained by the LRDE. A former student has exported it to Norway where he did his PhD thesis. This project consisted of writing a modular C++ grammar, and of the provision of a library with methods for C++ program transformation.

During the project, many tasks have been completed. Because we wanted at all costs modularity, we had to develop original tools (not specific to C++) for manipulation of attribute grammars (David et al., 2005; Borghi et al., 2005; David et al., 2006; Demaille et al., 2008b). This workshop for computational linguistics also included debugging tools, and fusion of language, tools for AST extraction, for synthesis of pretty-printing rules, *etc.* (Demaille et al., 2005).

Some extensions of C/C++ have been implemented (e.g., Borghi et al. (2006)). However, the full coverage of C++ was not achieved when the project was closed in 2009.

It should be noted that this project was watched closely by the most influential personalities in the C++ community, because they saw the opportunity to experiment easily various extensions to the language.

# 3 Results of the LRDE's activities

Like any research laboratory, our activity is measured by the number and quality of publications. It can also be measured by our projects and collaborations with our peers. Finally, concerning the LRDE, it can as well be measured by the progression of the libraries developed at the laboratory.

The following table provides an overview of the first two criteria.

| Year | Publications (book / journal / int conf / nat conf) | | | | Projects (academic / industrial) | |
|---|---|---|---|---|---|---|
| 2010 | 2⋆ | 3 | 9 | 0 | 2 | 1 |
| 2009 | 0 | 1 | 8 | 0 | 3 | 0 |
| 2008 | 0 | 1 | 15 | 0 | 2 | 1 |
| 2007 | 0 | 1 | 13 | 0 | 2 | 2 |
| 2006 | 0 | 6 | 14 | 0 | 1 | 2 |
| 2005 | 0 | 2 | 10 | 0 | 1 | 1 |
| 2004 | 0 | 2 | 7 | 0 | 1 | 1 |
| 2003 | 0 | 1 | 9 | 0 | 0 | 1 |
| 2002 | 0 | 0 | 2 | 0 | 0 | 5 |
| 2001 | 0 | 0 | 8 | 0 | 0 | 6 |
| 2000 | 0 | 0 | 8 | 0 | 0 | 1 |
| 1999 | 0 | 0 | 1 | 1 | 0 | 1 |

Table 2: Publications and projects per year
⋆ book chapter in French and English

It turns out that the activity within the academic and industrial projects significantly influence the rate of publications. The full list of publications is presented in Appendix B.

## 3.1 Research projects

Even if industrial and academic projects are not always *profitable* in terms of publications, they are no less essential both because of the financial contribution and the links they allow to weave between laboratories. Aware of its youth and its small size, the laboratory has grown slowly among different calls for proposals and participates today in projects of all types funded by: ANR, European projects, Business Clusters, the French Single Inter-Ministry Fund (FUI), the national Cancer Institute and OSEO.

### 3.1.1 Publicly funded projects

**Interactive autonomous agents – ROBEA – 2002**

This project focused on computer modeling and experimental study in cognitive psychology of decision-making action of a group of interacting agents, based on the interpretation of actions performed by others.

Besides the LRDE, the project partners were:

- University of Paris VIII, laboratory for "Cognition & Finalized Activities"
- University of Barcelona, Department of Methodology of the Behavioural Sciences
- University Paris Nord, LIPN

The contribution of the LRDE was the realization of the "simulation" software. It was about replacing the existing platform StarLogo (developed by MIT) in order to facilitate the integration of the agents' behaviors as well as the behavioral changes of the agents. One of the goals justifying this replacement was to provide intensive simulations.

**EFIGI – ANR – 2004-2008** `http://terapix.iap.fr/rubrique.php?id_rubrique=151`

EFIGI (Extraction of idealized forms of Galaxies in Image Processing) was a project whose main objective was to provide the community of astrophysicists with robust and efficient software tools for measuring and classifying the shapes of galaxies using astronomical images.

Besides the LRDE, the project partners were:

- Paris Institute of Astrophysics, IAP (UMR 7095),
- Laboratory for data processing and communication of information, LTCI (UMR 5141, GET/Telecom Paris),
- Laboratory of Astronomy in Marseille, LAM (UMR 6110)
- Laboratory of Astrophysics of the Observatory Midi-Pyrénées, LAOMP (UMR 5572)
- Astronomical Research Centre in Lyon, CRAL (UMR 5574)
- Service of Astrophysics of the Atomic Energy and Alternative Energies Commission, Sap

EFIGI code version 2.6.2 started on 2007-09-21 at 18:52:49 with 1 thread (run time: 43 s)

FITS extension #1: 3 / 12 sources fitted

| # | x | y | mag | bulge $r_e$ | bulge b/a | bulge θ (°) | Sersic n | disk $r_h$ | disk b/a | disk θ (°) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 124.234 | 126.101 | -14.0932 | 6.58 | 0.92 | 37.50 | 1.09 | 16.10 | 0.83 | 72.18 |
| 2 | 227.064 | 84.165 | -7.6800 | 1.46 | 0.50 | -26.80 | 2.04 | 1.13 | 0.25 | -16.67 |
| 3 | 79.365 | 218.899 | -9.9778 | 2.60 | 0.50 | -42.48 | 1.29 | 3.17 | 0.85 | -62.86 |

Figure 6: Feature extraction of galaxy images

The LRDE has contributed both in the processing of galaxy images and in the upscaling by parallelizing the tasks. This project has generated the following publications with LRDE members: Baillard et al. (2005, 2007); Berger et al. (2007); Ricou et al. (2007).

**Mélimage – INCa – 2006-2009** `http://www.ir4m.u-psud.fr/spip.php?article134`

This project for medical image processing in oncology has focused on the functional characterization and quantification of response to treatment using multimodality imaging (MRI 2D+t / ultrasonography / PET / CT scan) associated with histological tumor markers.

Besides the LRDE, the project partners were:

- IGR : Institut Gustave Roussy,
- IR4M : UMR8081 CNRS - University Paris Sud XI,
- TRIBVN.

The LRDE has developed some fusion and image registration methods along with methods for the segmentation of structures allowing to analyze parameters describing tumor activity.

**Scribo – FUI – 2007-2010** `http://www.scribo.ws/`

Scribo was an applied research project in the fields of Computational Linguistics and Knowledge Engineering. It proposed free algorithms and tools for the semi-automatic and collaborative annotation of digital documents. The approach is based on the extraction of knowledge from texts and images.


Figure 7: Text extraction from photographs of AFP

Besides the LRDE, the project partners were:

- The French News Agency AFP,
- CEA LIST
- the ALPAGE team of INRIA
- Mandriva
- Nuxeo
- Proxem
- Tagmatica
- XWiki

This project has been supported by the Business Cluster Systematic via a French Single Inter-Ministry Fund (FUI).

Our part in this project involved the extraction of text areas in images (photos) and the separation of text / images in documents like magazines. A description of our work is presented in Section 2.1.1, Part *Applications*.

This project has generated the following publications with LRDE members: Levillain et al. (2009, 2010a,b).

**OpenSE – European project – 2009-2012** `http://www.opense.net/`

The OpenSE project aims at setting up an open infrastructure for teaching, and therefore for learning, of computer science through free software and its spirit and concept of sharing. It is about gathering students of diverse backgrounds in order to make them build on what their predecessors have done rather than constantly repeat the same exercises. In addition to the interactive aspect between student generations, it allows to enrich the knowledge base and educational materials addressing the needs of students.

Besides the LRDE, the project partners are:

- Aristotle University of Thessaloniki (Greece),
- Open University (United Kingdom),
- University Rey Juan Carlos (Spain),
- Tampere University of Technology (Finland),
- Oxford University (United Kingdom),
- Sociedada Portuguesa de Inovação (Portugal)
- the Free Knowledge Institute (Netherlands)
- UNU-MERIT of Maastricht University (Netherlands)

Still in progress, this project is already visible through its website, `http://www.opense.net/`, where courses are given. A partnership with the Apache Software Foundation starts in order to test the possibility of coaching in field of free software development.

### 3.1.2 Privately financed projects

The LRDE has also conducted research projects with industrial partners and has run consulting assignments within its research areas. Here are some significant examples.

**CEA-DIF – 1999-2002**

In the context of two contracts awarded directly by the CEA-DIF, we designed a tool for semi-automatic extraction of signals from digitized oscillograms. This method based on mathematical morphology, has been the subject of three publications: Géraud (2003c,b,a).

**SWT – 1999-2006**

Our collaboration with EMC CAPTIVA (formerly SWT) between 1999 and 2006 focused on the recognition of types of scanned documents. The aim was to process, after scanning, incoming surface mail (letters, invoices, forms). To do this, relying on similarity measures, we developed a classifier that automatically reveals the different types of received documents. A statistical study can then extract descriptors for each type of document in the form of relevant sub-sections (thumbnails). We finally developed a recognition engine based on the theory of evidence to sort and dispatch incoming mail on the fly (Géraud et al., 2003).

This work has resulted in two patents Géraud (2005a, 2008) and led to a European award for innovation IST 2004.

#### AM$^2$ Systems – 2006-2007

For AM$^2$ Systems, a provider for Bouygues Telecom, we conducted a study on the implementation of a distributed repository of mapping systems. This study was also the occasion to supervise two M2 internships of the Science and technology of software specialization STL (University Paris VI).

The results were integrated by AM$^2$ Systems in their product.

#### Morpho (formerly Sagem Sécurité) – 2010

This project focused on the evaluation of commercial systems for speaker recognition. This allowed us to thoroughly test the systems of the company's competitors (the NIST competition mixes industrial and academic systems) and compare them with our system.

A report with the state of the art, the requested assessments and a comparison with the system of the LRDE has been delivered. This report is not open to the public.

## 3.2 Internal libraries

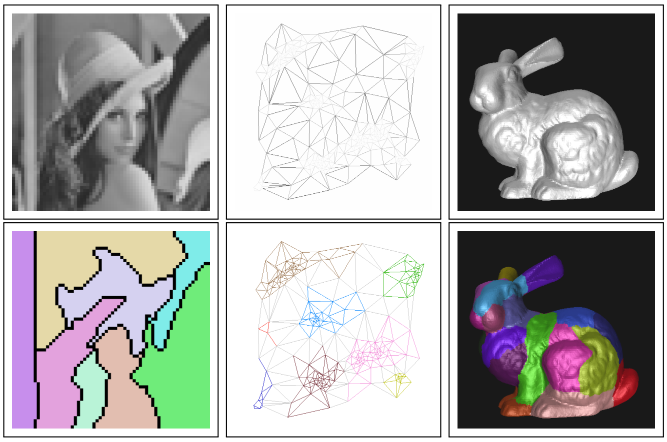
The LRDE has three flagship projects, three generic and efficient libraries written in C++, all of them under a free software license[5]. These libraries are an integral part of our research and can be used in projects and services. Currently only Olena, the laboratory's oldest and most advanced library, is used in projects and has allowed us to contract with industrial partners.

#### Olena – `http://olena.lrde.epita.fr/`

Olena is a generic and efficient platform dedicated to image processing. The purpose of this library is to allow to write unique algorithms knowing that the entries of these algorithms can be of different nature. Indeed possible inputs are 1D-images (signals),

[5] Our libraries are distributed under the conditions of the GNU GPL v2 license, even though not in the point of view of the linker. Having the copyright we can change the license or define a dual license for industrial collaborations for example. Anyway we do not envisage not to freely distribute these libraries. This would go against the reproducible research we stand for.

2D-images (regular images), 3D-images (volumes), or graph-based images and their generalizations (cell complexes). In addition, the values stored in these images are of various types: Boolean for binary images, grayscale with different encodings, floats or other. Olena's force is to preserve the abstract nature of algorithms without sacrificing performance.



Three examples of using the *same* generic segmentation algorithm. Top line: input images (2D grayscale image, graph with valued edges, 3D mesh with curvature information) Bottom line: segmentation results (colored regions).

The first major version of Olena, the version 1.0, was released in 2009. It is integrated into the Mandriva Linux distribution (and freely downloadable on our website). The next stable release, the version 1.1, will be released in early 2011 with the developments made in the project Scribo. This version is already included in the *Smart* Desktop Nepomuk distributed by Mandriva.

The main users of Olena except the Scribo project members are the Institut Gustave Roussy (IGR) and the Institut Gaspard Monge (University Paris-Est Marne la Vallée).

The list of publications, including internal reports, about the Olena project is available at: `http://www.lrde.epita.fr/cgi-bin/twiki/view/Olena/Publications`.

**Vaucanson** – `http://vaucanson.lrde.epita.fr/`

The Vaucanson project consists of three important parts:

- a generic library in which are defined
  - different types of automata representation (graphs or hash tables) and regular expressions

  - different types of monoids and semigroups
  - different algorithms that manipulate them

- A command line interface called TAF-Kit, which allows you to name the main features of the library without having to write in C++. Due to the generic approach used in the library, TAF-Kit must be instantiated for a particular type (that is to say a choice of automata representation, FIXME monoid and semigroup). A dozen of such instances are built for predefined types.
- A graphical user interface whose development was taken over by the team of Prof. Chun-Yen Hsu in Taiwan

This library is developed following a generic programming paradigm and allows to

1. write algorithms once, regardless of the data structure used to represent automata or regular expressions, and regardless of the monoid and semigroup used by this object.
2. not pay the price of this abstraction able to (in theory) run as fast as an algorithm that was designed specifically for a particular type of data.

The latest stable version of Vaucanson, version 1.3.2, was released in September 2009.

Vaucanson is co-developed by the LRDE, the LTCI / ENST, IGM / Paris Est and the University of Taipei.

The list of publications, including internal reports, about the Vaucanson project is available at: `http://www.lrde.epita.fr/Vaucanson/Papers`.

**Spot** – `http://spot.lip6.fr/`

Spot is a *model checking* library. It provides useful algorithms for the construction of a *model checker* according to an approach based on automata.

Compared to other tools, we distinguish ourselves by using automata with generalized acceptance conditions on transitions, while most research is done on automata with non-generalized acceptance conditions on states. Both formalisms have the same expressiveness, but the first one is much more concise and can perform the basic operations of the automata based approach to LTL *model checking* more efficiently:

- translation form LTL gives more compact automata, so the product is (usually) also smaller
- the use of generalized acceptance conditions makes it easier to represent weak fairness assumptions
- research of an accepting cycle in a generalized automaton can be done as quickly as in a non-generalized automaton

Spot is already known among the *model checking* community. The following use cases have generated publications citing Spot:

- Tauriainen (Finland) has used Spot to test several variations of emptiness-check that he has developed; his doctoral advisor Heljenko still uses Spot for translations.
- Sebastiani (Italy) has used it to translate LTL formulas.
- Li et al. (China) have used it to test variations of emptiness-check.
- Vardi, Rozier, and Tabakov (USA) use Spot to translate LTL formulas, and in a certain way promote it more effectively than we do.
- Staats et al. (USA) have integrated Spot in a tool for generated code verification, knowing that its role is once again to translate properties.
- Ehlers (Germany) also uses Spot for translations, and some exchanges have improved the result of Spot on certain formulas.
- Cichoń (Poland) compared Spot and LTL2BA on 5 classes of LTL formulas.

We appreciate that Spot is used by international users, but most of them use Spot only as a translator for LTL formulas into classical Büchi automata, that is to say without trying to use the generalized automata with their associated algorithms, which is the strength of Spot.

Model checking naturally having industrial applications and Spot being recognized for high quality, it seems normal that we try to see how we could help industrial partners to solve their problems. For this we have contacted several industry partners and we have applied for funding from OSEO to develop the parts of Spot that are necessary for its industrialization. This request has been accepted.

The list of publications, including internal reports, about the Spot project is available at: `http://www.lrde.epita.fr/Spot/Papers`.

Note about Spot's history: Spot has been started by Alexandre Duret-Lutz during his PhD thesis at LIP6. It is today co-developed by LRDE and LIP6.

**Build farm**

The development of heavy libraries demand mechanisms with high quality automatic validation. The build farm is one of these mechanisms.

Built on the platform Buildbot[6], the build farm is not a project of the LRDE, even if the LRDE brought its contributions, but it contributes greatly to the quality of the LRDE's libraries. It allows to check directly that changes in one of the libraries do not do any damage to the existing. For this reason, whenever a person changes something, a battery

[6] `http://trac.buildbot.net/`

of tests is automatically initiated and an alert system lets you know if the change has a negative impact somewhere.

This system coupled with a version control system allows to safely integrate new participants into the project teams. It is not surprising that the most important open source projects[7] use it where the number of participants is high and stability is vital.

The heavy investment of the installation of such an infrastructure, which is due to the configuration that must be able to adapt to particular cases, is quickly profitable and is even essential for any large project.

## 3.3 Participation in conference and journal committees

Certain laboratory members are involved in the organization of scientific conferences and journals.

### 3.3.1 Conference organizing committee

The following LRDE members are involved in the organization of conferences:

- Didier Verna for
  - ELS – European Lisp Symposium
  - ELW (ECOOP) – European Lisp Workshop
- Akim Demaille for RIVF

The following members have participated in the organization of conferences:

- Roland Levillain for ITiCSE'09
- Olivier Ricou for the first edition of the Open World Forum (2008)

### 3.3.2 Conference program committee

The following LRDE members are involved in conference program committees:

- Didier Verna for
  - ILC – International Lisp Conference
  - DLS (SPLASH) – Dynamic Languages Symposium

[7] OpenOffice.org, Mozilla and therefore Firefox, Google Chrome, Apache...

  - SAC – ACM Symposium on Applied Computing
  - ELS – European Lisp Symposium / Chairman
  - ELW (ECOOP) – European Lisp Workshop / Chairman
  - COP (ECOOP) – Context Oriented Programming Workshop
- Akim Demaille for RIVF
- Thierry Géraud for International Symposium on Mathematical Morphology (**ISMM**).

Thierry Géraud was also a member of the program of the International Conference in Central Europe on Computer Graphics, Visualization and Computer Vision (**WSCG**) from 2001 to 2006.

#### 3.3.3 Peer review committees in scientific journals

The following LRDE members are reviewers of scientific journal papers:

- Didier Verna for
  - JUCS – Journal of Universal Computer Science
- Thierry Géraud for
  - IEEE Signal Processing Letters
  - IEEE Transactions on Fuzzy Sets and System
  - IEEE Transactions on Image Processing
  - Pattern Recognition Letters
  - Software - Practice and Experience
- Réda Dehak for
  - IEEE Signal Processing Letters
  - IEEE Transactions on Information Forensics and Security

## 4 Perspectives

The LRDE is an academic laboratory in a private school that has the autonomy of a public laboratory and the responsiveness of a private organization. At the same time it is a small lab with the associated risks of isolation.

Even if the increase in permanent staff recruitment is limited by the financial capacity of the school, fortunately, there are opportunities for external funding. One of the possibilities that we have already experienced is to set up funded projects. We want to continue and develop this activity. Another possibility is to set up research partnerships with industry partners. Integration into academic structures such as a PRES (Center for Research and Higher Education) and Doctoral schools is also an important aspect that will help us recruit or finance PhD-students.

The recruitment of a large number of PhD-students at the LRDE is indeed the priority for the next years. They should allow us to significantly increase our strength in our core research themes.

The life of a small laboratory also involves collaborations, which the LRDE maintains carefully. More PhD-students and integration into a PRES could also strengthen ties with our partners and create new ones.

Research at LRDE in future years is divided into two areas: development of our strengths in areas where we are recognized and opening new related fields. Briefly, these strengths are document image analysis, speaker recognition, translation by Spot from LTL formulas to Büchi automata, static generic programming. The novelties that we want to deal with are the discrete / continuous transition in image processing, speech recognition, integration of *Kind* into the automata of the Vaucanson project, the slowness of the *model checking*, and the continuation of the SCOOP paradigm in dynamic languages.

The following sections clarify these issues.

## 4.1 Pattern recognition

Pattern recognition is the major research theme of the LRDE. It includes image and signal processing with different levels of analysis. In addition to the specific research outlined in the following sections, a work of fusion of these skills is envisaged on the one hand to address new areas such as video documents, and on the other hand to have a more extensive analysis in all areas.

### 4.1.1 Image processing

The main innovative purpose is a new interpretation of images that combines discrete with continuous models: a digital image represented by a multivalued discrete function on a cell complex can have continuity properties. Research areas opened by this representation include the re-expression of existing morphological filters (watershed transform, reconstructions, levelings) by correcting aberrations related to discrete representations, and the generalization of topological operators (thinning, closures, etc.) for grayscale images.

In applied research, our work on dematerialized documents allowed us to become recognized as experts. However the work is not yet finished. We now have to manage object types that have not yet been taken into account (tables, frames and advertising inserts) and to make robust the *layout* analysis. For text localization and recognition in natural images, we have to extend the developed techniques to video documents and, in particular, to those acquired from mobile devices (phones, tablets, and assistants). This requires the definition of evaluation methods for text detection. We consider three applications for these methods: assistance for disabled individuals, automatic removal of subtitles and enriching the index of search engines by the extracted text.

Finally, this research has culminated in the image processing platform Olena that should continue to provide an adapted framework for the addressed issues. We will have to make progress on the methodology allowing to decorrelate genericity and performance and we will have to bridge the gap between the static and dynamic worlds. A formalization work is also necessary. We need to define the taxonomy of domain entities, indicating the possible properties and corresponding interfaces; this concerns not only the types of images, but also the auxiliary types like sites, site collections, functions, accumulators and values. A second formalization task concerns canvases for algorithms (or meta-algorithms) which should allow us to exploit the genericity offered by the library to transcend existing algorithms and open up further research.

### 4.1.2 Speaker recognition

Future research in the field of speaker recognition follows three objectives.

The first short-term objective focuses on different methods allowing to remove the channel-effect used in our approach by using I-Vectors. Currently, we use LDA and WCCN based on Euclidean distance, assuming a Gaussian distribution of the speakers' parameters. Other approaches are possible, for example by taking into account the cosine distance used to measure the distance between two individuals. We will study the effect of the projection in the hypersphere of radius 1 on the distribution of I-Vector parameters of a speaker.

The second medium-term objective is to expand our scope to the field of language recognition. Systems are based on similar methods in speaker recognition, the difference being limited to the used parameters and the number of classes to be separated. In the case of language recognition, there are very few classes to separate and furthermore we have more examples for the training of the different language models. The similarities are strong enough for us to consider addressing this new class of problems, even if we are aware that our tools used to remove the intra-class variability and increase inter-class variability may not be appropriate in this case. As for speaker recognition, we will submit our research within the framework of the NIST-LRE evaluation.

Finally as a very long-term objective, we plan to address the area of speaker segmentation (Speaker Diarization). The problem of the presence of multiple speakers in the same audio recording is very common, for example in the case of meetings, radio broadcasts etc.. but significantly increases the complexity of speaker recognition. Currently, our methods are based on the assumption of the presence of a single identity in the audio recording. Therefor we must build a speaker segmentation method that retains the properties of our recognition system of the current speaker. This should also improve the robustness and performance of our methods.

## 4.2 Automata and verification

With the retirement of the principal leader of the Vaucanson project on automata and given the rise of the part of research on *model checking* at the LRDE, it is possible that the verification field takes precedence over the area of automata in the coming years. In the meantime, the Vaucanson project received the support of the ANR with the stated goal of making it become a tool for the academic community.

### 4.2.1 Automata

The future of the Vaucanson library is Vaucanson 2. We want to go beyond the limits of version 1 (the current implementation) through a redesign of the platform. This reorganization covers three aspects:

- change the core of the Vaucanson project, so that the automata have the type of information about the transitions they store (this will be detailed later)
- improve the usability of the provided tools to make them more user friendly for an academic audience
- develop the GUI which is done primarily by our Taiwanese partners.

Vaucanson 1 is a generic programming library built around a design pattern called *Element*. This pattern is a double bridge to decouple the implementation behavior of any object. It gives the possibility to specialize algorithms according to their nature or their implementation.

With this pattern, the automata of Vaucanson are defined in a very general sense by their mathematical nature (e.g. an automaton defined by an alphabet of letters and integer weight) and their implementation (e.g. a graph implemented by adjacency list). However, a forgotten parameter is the label expression of these automata. Besides using letters, we sometimes want to label the automata with words (possibly empty), or with rational expressions. The current implementation suffers from this in many ways. For this reason the notion of "*Kind*" will be added to Vaucanson 2: an automaton will be defined not only by its mathematical nature and by its implementation, but also by its "*Kind*", that is to say the type of its labels. This change affects the entire architecture of the library and the implementation of algorithms that will be more efficient.

### 4.2.2 *Model checking*

Today model checking is slow, very slow regarding the needs. This slowness has several origins:

1. the model itself, the indeterminism and asynchronism of which are the source of a large combinatorial explosion

2. the property to check: we know that some properties are more difficult than others to verify
3. the different techniques used to verify a property of a model: the automata-theoretic approach provides only a framework, it is possible to implement it in many ways. One step of the approach can be solved by several algorithms, and it is not always easy to predict which algorithm is the best.

So our approach follows two complementary ways: the creation of more efficient algorithms for certain points and automatic selection of the combination of algorithms that provides the best performance.

Verifying properties of a model implies that we must express these properties, select the automata type for the model, for the properties, for the type of product to be made between the automata, the type of emptiness check... All these choices are issues on which we are working right now, but there are immense possibilities.

The analysis of the properties appears promising. We know property classes that simplify the verification process.

Another sub-issue is the translation of LTL formulas into Büchi automata. This is the highlight of Spot which made its reputation, but possible significant improvements remain allowing to translate more quickly to smaller automata.

Finally, parallel programming is of course a strong temptation even if the sticking points are very important. In addition, our library has not been developed in this sense and parallelizing it requires a major overhaul. Anyway, we do not rule out this possibility which has almost become mandatory due to the evolution of computers.

## 4.3 Transverse research axis -– Genericity and performance

The exploration of alternative approaches mentioned in Section 2.3 led us to tackle the problems addressed by the SCOOP paradigm in static programming in terms of dynamic languages like Common Lisp.

The current basis for this new approach is a first draft of stable software, with a predefined set of generic algorithms and a well documented expansion interface. Now that the result of this work is at a satisfactory level of maturity, many opportunities are available to us.

### 4.3.1 Performances

Performance aspects of course include algorithms and software engineering. In the first case we have to investigate existing algorithms and adapt them to our case if necessary. Concerning the software, we have to analyze the performance of the current implementation in order to obtain a profiled global vision, detect bottlenecks *etc*. This analysis will then re-evaluate our implementation of critical passages.

The language axis is the most innovative approach. It is about studying the relative performances of different available data structures, functions, macros and idioms. Since we deal with a dynamic language, another important optimization axis is to allow static information of the types whenever this is possible. Common Lisp has indeed the property to mix dynamic and static/weak typing.

### 4.3.2 Paradigms

Along with the optimization work, another longer-term perspective is considered: the study of alternative programming paradigms. This research is the heart of the project.

The dynamic approach offered by Common Lisp, the structural reflexivity of the language and ultimately the existence of a meta-object protocol defining the object-oriented layer itself make it a leading language for the exploration of new programming paradigms. Indeed, it is particularly easy to produce extensions to the language as simple function libraries, where a real change in the compiler would be required in a more traditional language.

Among the recent paradigms whose exploration is planned, we include context-oriented programming, the filtered dispatch and prototype-based programming. In each of these three cases, the study will not only focus on compared expressiveness of these paradigms (following the issue of genericity), but also on their level of performance.

# A EPITA's Scientific Council

The work of the LRDE is presented twice a year to EPITA's Scientific Council. The members of the council are:

- Fabrice Kordon (LIP6, University Paris VI)
- Henri Maître (Telecom Paristech)
- Yves Ruggeri (France Telecom)
- Jean-Francois Perrot (LIP6, University Paris VI) – President
- Jean-Luc Stehlé (Jean Luc Stehlé Conseil SARL) – Vice-President
- Fanny Bellone (Mind Technologies)
- Philippe Jacquet (INRIA)
- Stéfane Fermigier (Nuxeo)
- Vincent Bouatou ( Sagem)
- Jacques Sakarovitch (CRNS / Telecom Paristech)
- Pierre-Louis Xech (Microsoft)

## B Publications of the LRDE

The list of publications of the LRDE and some publications are available on our website, cf `http://publis.lrde.epita.fr`. They are presented year by year differentiating between book chapters, journal articles, articles in international conferences and articles in national conferences.

The red numbers refer to the page where the article is quoted.

## Publications from 1999

### International conferences with peer review

Géraud, Th., Bloch, I., and Maître, H. (1999). Atlas-guided recognition of cerebral structures in MRI using fusion of fuzzy structural information. In *Proceeding of CIMAF Symposium on Artificial Intelligence*, pages 99–106, La Havana, Cuba. EPITA as current address.

### National conferences with peer review

Géraud, Th., Fabre, Y., Papadopoulos-Orfanos, D., and Mangin, J.-F. (1999). Vers une réutilisabilité totale des algorithmes de traitement d'images. In *Proceedings of the 17th Symposium on Signal and Image Processing (GRETSI)*, volume 2, pages 331–334, Vannes, France. In French. 10

## Publications from 2000

### International conferences with peer review

Duret-Lutz, A. (2000). Olena: a component-based platform for image processing, mixing generic, generative and OO programming. In *Proceedings of the 2nd International Symposium on Generative and Component-Based Software Engineering (GCSE)—Young Researchers Workshop; published in "Net.ObjectDays2000"*, pages 653–659, Erfurt, Germany. 9

Fabre, Y., Pitel, G., Soubrevilla, L., Marchand, E., Géraud, Th., and Demaille, A. (2000a). An asynchronous architecture to manage communication, display, and user interaction in distributed virtual environments. In Mulder, J. and van Liere, R., editors, *Virtual Environments 2000, Proceedings of the 6th Eurographics Workshop on Virtual Environments (EGVE)*, Computer Science / Eurographics Series, pages 105–113, Amsterdam, The Netherlands. Springer-Verlag WienNewYork.

Fabre, Y., Pitel, G., Soubrevilla, L., Marchand, E., Géraud, Th., and Demaille, A. (2000b). A framework to dynamically manage distributed virtual environments. In Heudin, J.-C., editor, *Proceedings of the 2nd International Conference on Virtual Worlds (VW)*, volume LNAI 1834 of *Lecture Notes in Computer Science Series*, pages 54–64, Paris, France. Springer Verlag.

Fabre, Y., Pitel, G., and Verna, D. (2000c). Urbi et Orbi: unusual design and implementation choices for distributed virtual environments. In *Proceedings of the 6th International Conference on Virtual Systems and MultiMedia (VSMM)—Intelligent Environments Workshop*, pages 714–724, Gifu, Japan. IOS Press, USA.

Géraud, Th. and Duret-Lutz, A. (2000). Generic programming redesign of patterns. In *Proceedings of the 5th European Conference on Pattern Languages of Programs (EuroPLoP)*, pages 283–294, Irsee, Germany. UVK, Univ. Verlag, Konstanz. 10

Géraud, Th., Fabre, Y., Duret-Lutz, A., Papadopoulos-Orfanos, D., and Mangin, J.-F. (2000). Obtaining genericity for image processing and pattern recognition algorithms. In *Proceedings of the 15th International Conference on Pattern Recognition (ICPR)*, volume 4, pages 816–819, Barcelona, Spain. IEEE Computer Society. 10

Verna, D. (2000). Action recognition: how intelligent virtual environments can ease human-machine interaction. In *Proceedings of the 6th International Conference on Virtual Systems and MultiMedia (VSMM)—Intelligent Environments Workshop*, pages 703–713, Gifu, Japan. IOS Press, USA.

### National conferences with peer review

Géraud, Th., Bloch, I., and Maître, H. (2000). Reconnaissance de structures cérébrales à l'aide d'un atlas et par fusion d'informations structurelles floues. In *Actes du 12ème Congrès Francophone AFRIF-AFIA de Reconnaissance des Formes et Intelligence Artificielle (RFIA)*, volume 1, pages 287–295, Paris, France. EPITA as current address.

## Publications from 2001

### International conferences with peer review

Angelidis, A. and Fouquier, G. (2001). Visualization issues in virtual environments: from computer graphics techniques to intentional visualization. In Skala, V., editor, *Proceedings of the 9th International Conference in Central Europe on Computer Graphics, Visualization and Computer Vision (WSCG)*, volume 3, pages 90–98, Plzen, Czech Republic.

Darbon, J., Sankur, B., and Maître, H. (2001). Error correcting code performance for watermark protection. In *Proceedings of the 13th Symposium SPIE on Electronic Imaging—-Security and Watermarking of Multimedia Contents III (EI27)*, volume 4314, pages 663–672, San Jose, CA, USA.

Duret-Lutz, A. (2001). Expression templates in Ada 95. In *Proceedings of the 6th International Conference on Reliable Software Technologies (Ada-Europe)*, volume 2043 of *Lecture Notes in Computer Science Series*, pages 191–202, Leuven, Belgium. Springer-Verlag. Best Paper Award.

Duret-Lutz, A., Géraud, Th., and Demaille, A. (2001). Generic design patterns in C++. In *Proceedings of the 6th USENIX Conference on Object-Oriented Technologies and Systems (COOTS)*, pages 189–202, San Antonio, TX, USA. USENIX Association. 10

Géraud, Th., Fabre, Y., and Duret-Lutz, A. (2001a). Applying generic programming to image processing. In Hamsa, M., editor, *Proceedings of the IASTED International Conference on Applied Informatics (AI)—Symposium on Advances in Computer Applications*, pages 577–581, Innsbruck, Austria. ACTA Press. 10

Géraud, Th., Strub, P.-Y., and Darbon, J. (2001b). Color image segmentation based on automatic morphological clustering. In *Proceedings of the IEEE International Conference on Image Processing (ICIP)*, volume 3, pages 70–73, Thessaloniki, Greece.

Géraud, Th., Strub, P.-Y., and Darbon, J. (2001c). Segmentation d'images en couleur par classification morphologique non supervisée. In *Proceedings of the International Conference on Image and Signal Processing (ICISP)*, pages 387–394, Agadir, Morocco. Faculty of Sciences at Ibn Zohr University, Morocco. In French.

Verna, D. (2001). Virtual reality and tele-operation: a common framework. In *Proceedings of the 5th World Multi-Conference on Systemics, Cybernetics and Informatics (SCI)—Emergent Computing and Virtual Engineering*, volume 3, pages 499–504, Orlando, Florida, USA.

## Publications from 2002

### International conferences with peer review

Carlier, S. (2002). Polar type inference with intersection types and $\omega$. In *Proceedings of the 2nd Workshop on Intersection Types and Related Systems (ITRS), published in: Electronic Notes in Theoretical Computer Science*, volume 70, Copenhagen, Denmark. Elsevier.

Darbon, J., Géraud, Th., and Duret-Lutz, A. (2002). Generic implementation of morphological image operators. In *Mathematical Morphology, Proceedings of the 6th International Symposium (ISMM)*, pages 175–184, Sydney, Australia. CSIRO Publishing. 10

# Publications from 2003

## Journal papers

Bloch, I., Géraud, Th., and Maître, H. (2003). Representation and fusion of heterogeneous fuzzy information in the 3D space for model-based structural recognition—application to 3D brain imaging. *Artificial Intelligence*, 148(1-2):141–175.

## International conferences with peer review

Burrus, N., Duret-Lutz, A., Géraud, Th., Lesage, D., and Poss, R. (2003). A static C++ object-oriented programming (SCOOP) paradigm mixing benefits of traditional OOP and generic programming. In *Proceedings of the Workshop on Multiple Paradigm with Object-Oriented Languages (MPOOL)*, Anaheim, CA, USA. 10

Géraud, Th. (2003a). Fast road network extraction in satellite images using mathematical morphology and MRF. In *Proceedings of the EURASIP Workshop on Nonlinear Signal and Image Processing (NSIP)*, Trieste, Italy. 27

Géraud, Th. (2003b). Segmentation d'objets curvilignes à l'aide des champs de markov sur un graphe d'adjacence de courbes issu de l'algorithme de la ligne de partage des eaux. In *Proceedings of the International Conference on Image and Signal Processing (ICISP)*, volume 2, pages 404–411, Agadir, Morocco. Faculty of Sciences at Ibn Zohr University, Morocco. In French. 27

Géraud, Th. (2003c). Segmentation of curvilinear objects using a watershed-based curve adjacency graph. In Springer-Verlag, editor, *Proceedings of the 1st Iberian Conference on Pattern Recognition and Image Analysis (IbPRIA)*, volume 2652 of *Lecture Notes in Computer Science Series*, pages 279–286, Mallorca, Spain. Springer-Verlag. 27

Géraud, Th., Fouquier, G., Peyrot, Q., Lucas, N., and Signorile, F. (2003). Document type recognition using evidence theory. In *Proceedings of the 5th IAPR International Workshop on Graphics Recognition (GREC)*, pages 212–221, Computer Vision Center, UAB, Barcelona, Spain. 28

Lombardy, S., Poss, R., Régis-Gianas, Y., and Sakarovitch, J. (2003). Introducing Vaucanson. In Springer-Verlag, editor, *Proceedings of Implementation and Application of Automata, 8th International Conference (CIAA)*, volume 2759 of *Lecture Notes in Computer Science Series*, pages 96–107, Santa Barbara, CA, USA. 16

Maes, F. (2003). Program templates: expression templates applied to program evaluation. In Striegnitz, J. and Davis, K., editors, *Proceedings of the Workshop on Declarative Programming in the Context of Object-Oriented Languages (DP-COOL; in conjunction with PLI)*, number FZJ-ZAM-IB-2003-10 in John von Neumann Institute for Computing (NIC), Uppsala, Sweden.

Régis-Gianas, Y. and Poss, R. (2003). On orthogonal specialization in C++: dealing with efficiency and algebraic abstraction in Vaucanson. In Striegnitz, J. and Davis, K., editors, *Proceedings of the Parallel/High-performance Object-Oriented Scientific Computing (POOSC; in conjunction with ECOOP)*, number FZJ-ZAM-IB-2003-09 in John von Neumann Institute for Computing (NIC), Darmstadt, Germany.

Xue, H., Géraud, Th., and Duret-Lutz, A. (2003). Multi-band segmentation using morphological clustering and fusion application to color image segmentation. In *Proceedings of the IEEE International Conference on Image Processing (ICIP)*, volume 1, pages 353–356, Barcelona, Spain.

## Publications from 2004

### Journal papers

Géraud, Th. and Mouret, J.-B. (2004). Fast road network extraction in satellite images using mathematical morphology and Markov random fields. *EURASIP Journal on Applied Signal Processing*, 2004(16):2503–2514. Special issue on Nonlinear Signal and Image Processing - Part II.

Lombardy, S., Régis-Gianas, Y., and Sakarovitch, J. (2004). Introducing Vaucanson. *Theoretical Computer Science*, 328:77–96.

### International conferences with peer review

Darbon, J., Géraud, Th., and Bellot, P. (2004). Generic algorithmic blocks dedicated to image processing. In *Proceedings of the ECOOP Workshop for PhD Students*, Oslo, Norway.

Darbon, J. and Sigelle, M. (2004). Exact optimization of discrete constrained total variation minimization problems. In *Proceedings of the 10th International Workshop on Combinatorial Image Analysis (IWCIA)*, volume 3322 of *Lecture Notes in Computer Science Series*, pages 548–557, Auckland, New Zealand. Springer-Verlag.

Duflot, M., Fribourg, L., Herault, Th., Lassaigne, R., Magniette, F., Messika, S., Peyronnet, S., and Picaronny, C. (2004). Probabilistic model checking of the CSMA/CD, protocol using PRISM and APMC. In *Proceedings of the 4th International Workshop on Automated Verification of Critical Systems (AVoCS)*, volume 128 of *Electronic Notes in Theoretical Computer Science Series*, pages 195–214.

Géraud, Th., Palma, G., and Van Vliet, N. (2004). Fast color image segmentation based on levellings in feature space. In Publishers, K. A., editor, *Computer Vision and Graphics—International Conference on Computer Vision and Graphics (ICCVG), Warsaw, Poland, September 2004*, volume 32 of *Computational Imaging and Vision*, pages 800–807. On CD.

Grosicki, E., Abed-Meraim, K., and Dehak, R. (2004). A novel method to fight the non line of sight error in AOA measurements for mobile location. In *Proceedings of the IEEE International Conference on Communications (ICC)*, volume 5, pages 2794–2798, Paris, France.

Maes, F. (2004). Metagene, a C++ meta-program generation tool. In *Proceedings of the Workshop on Multiple Paradigm with OO Languages (MPOOL; in conjunction with ECOOP)*, Oslo, Norway.

Yoruk, E., Konukoglu, E., Sankur, B., and Darbon, J. (2004). Person authentication based on hand shape. In *Proceedings of 12th European Signal Processing Conference (EUSIPCO)*, Vienna, Austria.

## Publications from 2005

### Journal papers

Bloch, I., Colliot, O., Camara, O., and Géraud, Th. (2005). Fusion of spatial relationships for guiding recognition, example of brain structure recognition in 3D MRI. *Pattern Recognition Letters*, 26(4):449–457.

Dehak, R., Bloch, I., and Maître, H. (2005). Spatial reasoning with relative incomplete information on relative positioning. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 27(9):1473–1484.

### International conferences with peer review

Baillard, A., Bertin, E., Mellier, Y., McCracken, H. J., Géraud, Th., Pelló, R., LeBorgne, J.-F., and Fouqué, P. (2005). Project EFIGI: Automatic classification of galaxies. In Gabriel, C., Arviset, Ch., Ponz, D., and Solano, E., editors, *Astronomical Data Analysis Software and Systems XV*, volume 351 of *Conference*, pages 236–239. Astronomical Society of the Pacific. 25

Claveirole, Th., Lombardy, S., O'Connor, S., Pouchet, L.-N., and Sakarovitch, J. (2005). Inside Vaucanson. In Springer-Verlag, editor, *Proceedings of Implementation and Application of Automata, 10th International Conference (CIAA)*, volume 3845 of *Lecture Notes in Computer Science Series*, pages 117–128, Sophia Antipolis, France. 16

Darbon, J. (2005). Total variation minimization with $l^1$ data fidelity as a contrast invariant filter. In *Proceedings of the 4th International Symposium on Image and Signal Processing and Analysis (ISPA 2005)*, pages 221–226, Zagreb, Croatia.

Darbon, J. and Akgül, C. B. (2005). An efficient algorithm for attribute openings and closings. In *Proceedings of the 13th European Signal Processing Conference (EUSIPCO)*, Antalya, Turkey.

Darbon, J. and Peyronnet, S. (2005). A vectorial self-dual morphological filter based on total variation minimization. In *Proceedings of the First International Conference on Visual Computing*, volume 3804 of *Lecture Notes in Computer Science Series*, pages 388–395, Lake Tahoe, Nevada, USA. Springer-Verlag.

Darbon, J. and Sigelle, M. (2005). A fast and exact algorithm for total variation minimization. In *Proceedings of the 2nd Iberian Conference on Pattern Recognition and Image Analysis (IbPRIA)*, volume 3522, pages 351–359, Estoril, Portugal. Springer-Verlag.

Demaille, A. (2005). Making compiler construction projects relevant to core curriculums. In *Proceedings of the Tenth Annual Conference on Innovation and Technology in Computer Science Education (ITICSE'05)*, pages 266–270, Universidade Nova de Lisboa, Monte da Pacarita, Portugal.

Géraud, Th. (2005). Ruminations on Tarjan's Union-Find algorithm and connected operators. volume 30 of *Computational Imaging and Vision*, pages 105–116, Paris, France. Springer. 10

Guirado, G., Herault, Th., Lassaigne, R., and Peyronnet, S. (2005). Distribution, approximation and probabilistic model checking. In *Proceedings of the 4th international workshop on Parallel and Distributed Model Checking (PDMC)*.

Lassaigne, R. and Peyronnet, S. (2005). Probabilistic verification and approximation. In *Proceedings of 12th Workshop on Logic, Language, Information and Computation (Wollic)*, volume 143 of *Electronic Notes in Theoretical Computer Science*, pages 101–114.

# Publications from 2006

## Book chapters

Duflot, M., Kwiatkowska, M., Norman, G., Parker, D., Peyronnet, S., Picaronny, C., and Sproston, J. (2006). Practical application of probabilistic model checking to communication protocols. In Gnesi, S. and Margaria, T., editors, *FMICS Handbook on Industrial Critical Systems*, chapter 7. To appear.

## Journal papers

Borghi, A., David, V., and Demaille, A. (2006). C-Transformers — A framework to write C program transformations. *ACM Crossroads*, 12(3). `http://www.acm.org/crossroads/xrds12-3/contractc.html`. 22

Darbon, J. and Sigelle, M. (2006). Image restoration with discrete constrained Total Variation—part I: Fast and exact optimization. *Journal of Mathematical Imaging and Vision*, 26(3):261–276.

Verna, D. (2006a). 2006(3).

Verna, D. (2006b). How to make lisp go faster than C. *IAENG International Journal of Computer Science*, 32(4).

Yörük, E., Konukoglu, E., Sankur, B., and Darbon, J. (2006). Shape-based hand recognition. *IEEE Transactions on Image Processing*, 15(7):1803–1815.

### International conferences with peer review

Cadilhac, M., Hérault, Th., Lassaigne, R., Peyronnet, S., and Tixeuil, S. (2006). Evaluating complex MAC protocols for sensor networks with APMC. In *Proceedings of the 6th International Workshop on Automated Verification of Critical Systems (AVoCS)*, volume 185 of *Electronic Notes in Theoretical Computer Science Series*, pages 33–46.

Chekroun, M., Darbon, J., and Ciril, I. (2006). On a polynomial vector field model for shape representation. In *Proceedings of the International Conference on Image Analysis and Recognition (ICIAR)*, Povoa de Varzim, Portugal. Springer-Verlag.

Darbon, J., Lassaigne, R., and Peyronnet, S. (2006). Approximate probabilistic model checking for programs. In *Proceedings of the IEEE 2nd International Conference on Intelligent Computer Communication and Processing (ICCP'06)*, Technical University of Cluj-Napoca, Romania.

Darbon, J. and Sigelle, M. (2006). Fast and exact discrete image restoration based on total variation and on its extensions to levelable potentials. In *SIAM Conference on Imaging Sciences*, Minneapolis, USA.

David, V., Demaille, A., and Gournet, O. (2006). Attribute grammars for modular disambiguation. In *Proceedings of the IEEE 2nd International Conference on Intelligent Computer Communication and Processing (ICCP'06)*, Technical University of Cluj-Napoca, Romania. 22

Dehak, R., Deledalle, C.-A., and Dehak, N. (2006). LRDE system description. In *NIST SRE'06 Workshop: speaker recognition evaluation campaign*, San Juan, Puerto Rico. 15

Demaille, A., Peyronnet, S., and Hérault, Th. (2006a). Probabilistic verification of sensor networks. In *Proceedings of the Fourth International Conference on Computer Sciences, Research, Innovation and Vision for the Future (RIVF'06)*, Ho Chi Minh City, Vietnam.

Demaille, A., Peyronnet, S., and Sigoure, B. (2006b). Modeling of sensor networks using XRM. In *Proceedings of the 2nd International Symposium on Leveraging Applications of Formal Methods, Verification and Validation (ISoLA'06)*, Coral Beach Resort, Paphos, Cyprus.

Denise, A., Gaudel, M.-C., Gouraud, S.-D., Lassaigne, R., and Peyronnet, S. (2006). Uniform random sampling of traces in very large models. In *Proceedings of the 1st international workshop on Random Testing 2006 (RT06)*, ACM digital library, pages 10–19.

Hérault, T., Lassaigne, R., and Peyronnet, S. (2006). APMC 3.0: Approximate verification of discrete and continuous time markov chains. In *Proceedings of Qest 2006*, pages 129–130.

Lesage, D., Darbon, J., and Akgül, C. B. (2006). An efficient algorithm for connected attribute thinnings and thickenings. In *Proceedings of the second International Conference on Visual Computing*, volume 4292 of *Lecture Notes in Computer Science Series*, pages 393–404, Lake Tahoe, Nevada, USA. Springer-Verlag.

Perrot, P., Dehak, R., and Chollet, G. (2006). ENST-IRCGN system description. In *NIST SRE'06 Workshop: speaker recognition evaluation campaign*, San Juan, Puerto Rico. 15

Verna, D. (2006a). Beating C in scientific computing applications. In *Third European Lisp Workshop at ECOOP*, Nantes, France. Best paper award. 20

Verna, D. (2006b). How to make lisp go faster than C. In *Proceedings of the International MultiConference of Engineers and Computer Scientists*, Hong Kong. International Association of Engineers.

## Publications from 2007

### Journal papers

Laplante, S., Lassaigne, R., Magniez, F., Peyronnet, S., and de Rougemont, M. (2007). Probabilistic abstraction for model checking: an approach based on property testing. *ACM Transactions on Computational Logic*, 8(4).

### International conferences with peer review

Baillard, A., Berger, Ch., Bertin, E., Géraud, Th., Levillain, R., and Widynski, N. (2007). Algorithme de calcul de l'arbre des composantes avec applications à la reconnaissance des formes en imagerie satellitaire. In *Proceedings of the 21st Symposium on Signal and Image Processing (GRETSI)*, Troyes, France. 25

Berger, Ch., Géraud, Th., Levillain, R., Widynski, N., Baillard, A., and Bertin, E. (2007). Effective component tree computation with application to pattern recognition in astronomical imaging. In *Proceedings of the IEEE International Conference on Image Processing (ICIP)*, volume 4, pages IV–41–IV–44, San Antonio, TX, USA. 25

Darbon, J. (2007). A note on the discrete binary Mumford-Shah model. In *Proceedings of the international Computer Vision / Computer Graphics Collaboration Techniques and Applications (MIRAGE 2007)*, Paris, France.

Darbon, J., Sigelle, M., and Tupin, F. (2007). The use of levelable regularization functions for MRF restoration of SAR images. In *Proceedings of the 19th Symposium SPIE on Electronic Imaging*, San Jose, CA, USA.

Dehak, R., Dehak, N., Kenny, P., and Dumouchel, P. (2007). Linear and non linear kernel GMM supervector machines for speaker verification. In *Proceedings of the European Conference on Speech Communication and Technologies (Interspeech'07)*, Antwerp, Belgium. 13

Fouquier, G., Atif, J., and Bloch, I. (2007a). Local reasoning in fuzzy attribute graphs for optimizing sequential segmentation. In Escolano, F. and Vento, M., editors, *Proceedings of the 6th IAPR TC-15 Workshop on Graph-based Representations in Pattern Recognition (GBR)*, volume LNCS 4538, pages 138–147, Alicante, Spain. Springer Verlag.

Fouquier, G., Likforman, L., Darbon, J., and Sankur, B. (2007b). The biosecure geometry-based system for hand modality. In *Proceedings of the 32nd IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP)*, volume I, pages 801–804, Honolulu, Hawaii, USA.

Hamez, A., Kordon, F., and Thierry-Mieg, Y. (2007). libDMC: a library to operate efficient distributed model checking. In *Workshop on Performance Optimization for High-Level Languages and Libraries — associated to IPDPS'2007*.

Quoc, C. L., Bellot, P., and Demaille, A. (2007a). On the security of quantum networks: a proposal framework and its capacity. In *Proceedings of the 2007 International Conference on New Technologies, Mobility and Security (NTMS'07)*, Paris, France.

Quoc, C. L., Bellot, P., and Demaille, A. (2007b). Stochastic routing in large grid-shaped quantum networks. In *Proceedings of the Fifth International Conference on Computer Sciences, Research, Innovation and Vision for the Future (RIVF'07)*, Hanoi, Vietnam.

Ricou, O. (2007). 10 years of confrontation between French Internet users and their successive governments. In *Proceedings of the 7th European Conference on e-Government (ECEG)*.

Ricou, O., Baillard, A., Bertin, E., Magnard, F., Marmo, C., and Mellier, Y. (2007). Web services at TERAPIX. In *Proceedings of the XVII conference on Astronomical Data Analysis Software & Systems (ADASS)*. 25

Verna, D. (2007). CLOS solutions to binary methods. In *Proceedings of the International MultiConference of Engineers and Computer Scientists*, Hong Kong. International Association of Engineers.

## Publications from 2008

### Journal papers

Verna, D. (2008). Binary methods programming: the CLOS perspective (extended version). *Journal of Universal Computer Science*, 14(20):3389–3411. 20

### International conferences with peer review


Darbon, J. (2008). Global optimization for first order Markov random fields with submodular priors. In *Proceedings of the twelfth International Workshop on Combinatorial Image Analysis (IWCIA'08)*, Buffalo, New York, USA.

Dehak, N., Dehak, R., Kenny, P., and Dumouchel, P. (2008a). Comparison between factor analysis and GMM support vector machines for speaker verification. In *Proceedings of the Speaker and Language Recognition Workshop (IEEE-Odyssey 2008)*, Stellenbosch, South Africa. 13, 14

Dehak, R., Dehak, N., and Kenny, P. (2008b). The LRDE systems for the 2008 NIST speaker recognition evaluation. In *NIST-SRE 2008*, Montréal, Canada. 15

Dehak, R., Dehak, N., Kenny, P., and Dumouchel, P. (2008c). Kernel combination for SVM speaker verification. In *Proceedings of the Speaker and Language Recognition Workshop (IEEE-Odyssey 2008)*, Stellenbosch, South Africa.

Demaille, A., Duret-Lutz, A., Lesaint, F., Lombardy, S., Sakarovitch, J., and Terrones, F. (2008a). An XML format proposal for the description of weighted automata, transducers, and regular expressions. In *Proceedings of the seventh international workshop on Finite-State Methods and Natural Language Processing (FSMNLP'08)*, Ispra, Italia. 17

Demaille, A., Durlin, R., Pierron, N., and Sigoure, B. (2008b). Semantics driven disambiguation: A comparison of different approaches. In *Proceedings of the 8th workshop on Language Descriptions, Tools and Applications (LDTA'08)*. 22

Demaille, A., Levillain, R., and Perrot, B. (2008c). A set of tools to teach compiler construction. In *Proceedings of the Thirteenth Annual Conference on Innovation and Technology in Computer Science Education (ITICSE'08)*, pages 68–72, Universidad Politécnica de Madrid, Spain.

Géraud, Th. and Levillain, R. (2008). Semantics-driven genericity: A sequel to the static C++ object-oriented programming paradigm (SCOOP 2). In *Proceedings of the 6th International Workshop on Multiparadigm Programming with Object-Oriented Languages (MPOOL)*, Paphos, Cyprus. 10

Hamez, A., Thierry-Mieg, Y., and Kordon, F. (2008). Hierarchical set decision diagrams and automatic saturation. In *Petri Nets and Other Models of Concurrency –ICATPN 2008*.

Hémon, S., de Rougemont, M., and Santha, M. (2008). Approximate Nash equilibria for multi-player games. In *1st International Symposium on Algorithmic Games Theory*, Paderborn, Germany.

Kenny, P., Dehak, N., Dehak, R., Gupta, V., and Dumouchel, P. (2008). The role of speaker factors in the NIST extended data task. In *Proceedings of the Speaker and Language Recognition Workshop (IEEE-Odyssey 2008)*, Stellenbosch, South Africa.

Quoc, C. L., Bellot, P., and Demaille, A. (2008). Towards the world-wide quantum network. In *Proceedings of the 4th Information Security Practice and Experience Conference (ISPEC'08)*, Sydney, Australia.

Ricou, O. (2008). A survey of French local e-democracy. In *Proceedings of the 8th European Conference on e-Government (ECEG)*.

Verna, D. (2008). Binary methods programming: the CLOS perspective. In *Proceedings of the First European Lisp Symposium*, pages 91–105, Bordeaux, France.

Verna, D., Herzeel, C., Rhodes, C., and Hübner, H. (2008). Report on the 5th workshop ELW at ECOOP 2008. In Eugster, P., editor, *Object-Oriented Technology. ECOOP 2008 Workshop Reader.*, volume 5475 of *Lecture Notes in Computer Science*, pages 1–6. Springer.

## Publications from 2009

### Journal papers

Hamez, A., Thierry-Mieg, Y., and Kordon, F. (2009). Building efficient model checkers using hierarchical set decision diagrams and automatic saturation. *Fundamenta Informaticae*.

### International conferences with peer review

Dehak, N., Dehak, R., Kenny, P., Brummer, N., Ouellet, P., and Dumouchel, P. (2009a). Support vector machines versus fast scoring in the low-dimensional total variability space for speaker verification. In *Interspeech*. 14

Dehak, N., Kenny, P., Dehak, R., Glember, O., Dumouchel, P., Burget, L., Hubeika, V., and Castaldo, F. (2009b). Support vector machines and joint factor analysis for speaker verification. In *IEEE-ICASSP*, Taipei - Taiwan. 14

Demaille, A., Levillain, R., and Sigoure, B. (2009). TWEAST: A simple and effective technique to implement concrete-syntax AST rewriting using partial parsing. In *Proceedings of the 24th Annual ACM Symposium on Applied Computing (SAC'09)*, pages 1924–1929, Waikiki Beach, Honolulu, Hawaii, USA.

Dumouchel, P., Dehak, N., Attabi, Y., Dehak, R., and Boufaden, N. (2009). Cepstral and long-term features for emotion recognition. In *Interspeech*. Open Performance Sub-Challenge Prize.

Duret-Lutz, A., Poitrenaud, D., and Couvreur, J.-M. (2009). On-the-fly emptiness check of transition-based Streett automata. In Liu, Z. and Ravn, A. P., editors, *Proceedings of the 7th International Symposium on Automated Technology for Verification and Analysis (ATVA'09)*, volume 5799 of *Lecture Notes in Computer Science*, pages 213–227. Springer-Verlag. 18

Levillain, R., Géraud, Th., and Najman, L. (2009). Milena: Write generic morphological algorithms once, run on many kinds of images. In Wilkinson, M. H. F. and Roerdink, J. B. T. M., editors, *Mathematical Morphology and Its Application to Signal and Image Processing – Proceedings of the Ninth International Symposium on Mathematical Morphology (ISMM)*, volume 5720 of *Lecture Notes in Computer Science*, pages 295–306, Groningen, The Netherlands. Springer Berlin / Heidelberg. 11, 26

Verna, D. (2009a). CLOS efficiency: Instantiation. In *Proceedings of the International Lisp Conference*, pages 76–90. Association of Lisp Users. 20

Verna, D. (2009b). Revisiting the visitor: the just do it pattern. In *Proceedings of the ACCU Conference 2009*, Oxford. Accepted.

# Publications from 2010

## Book chapters

Géraud, Th., Talbot, H., and Droogenbroeck, M. V. (2010a). Algorithms for mathematical morphology. In Najman, L. and Talbot, H., editors, *Mathematical Morphology—From Theory to Applications*, pages 323–353. Wiley-ISTE. 10

Géraud, Th., Talbot, H., and Droogenbroeck, M. V. (2010b). Morphologie et algorithmes. In Najman, L. and Talbot, H., editors, *Morphologie mathématique 2 : estimation, choix et mise en œuvre*, IC2 signal et image, chapter 6, pages 151–180. Hermès Science Publications. 10

## Journal papers

Dolstra, E., Löh, A., and Pierron, N. (2010). NixOS: A purely functional linux distribution. *Journal of Functional Programming*. Published online by Cambridge University Press 15 Oct 2010.

Verna, D. (2010). Revisiting the visitor: the just do it pattern. *Journal of Universal Computer Science*, 16:246–271. 20

## International conferences with peer review

Dehak, N., Dehak, R., Glass, J., Reynolds, D., and Kenny, P. (2010). Cosine Similarity Scoring without Score Normalization Techniques. In *Odyssey The Speaker and Language Recognition*, Brno, Czech Republic. 15

Dehak, R. and N.Dehak (2010). Lrde Speaker Recognition System for NIST-SRE 2010. In *NIST 2010 Speaker Recognition Evaluation*, Brno, CZ. 15

Levillain, R., Géraud, Th., and Najman, L. (2010a). Why and how to design a generic and efficient image processing framework: The case of the Milena library. In *Proceedings of the IEEE International Conference on Image Processing (ICIP)*, pages 1941–1944, Hong Kong. 10, 26

Levillain, R., Géraud, Th., and Najman, L. (2010b). Writing reusable digital geometry algorithms in a generic image processing framework. In *Proceedings of the Workshop on Applications of Digital Geometry and Mathematical Morphology (WADGMM)*, pages 96–100, Istanbul, Turkey. 11, 26

Linard, A., Paviot-Adet, E., Kordon, F., Buchs, D., and Charron, S. (2010). polyDD: Towards a framework generalizing decision diagrams. In *Proceedings of the 10th International Conference on Application of Concurrency to System Design (ACSD)*, pages 124–133, Braga, Portugal. IEEE Computer Society.

Minetto, R., Thome, N., Cord, M., Fabrizio, J., and Marcotegui, B. (2010). Snoopertext: A multiresolution system for text detection in complex visual scenes. In *Proceedings of the IEEE International Conference on Image Processing (ICIP)*, pages 3861–3864, Hong Kong. 12

Shum, S., Dehak, N., Dehak, R., and Glass, J. (2010). Unsupervised Speaker Adaptation based on the Cosine Similarity for Text-Independent Speaker Verification. In *Odyssey The Speaker and Language Recognition*, Brno, Czech Republic. 15

Verna, D. (2010a). Classes, styles, conflicts: the biological realm of LaTeX. In Beeton, B. and Berry, K., editors, *TUGboat*, volume 31, pages 162–172.

Verna, D. (2010b). CLoX: Common Lisp objects for XEmacs. In *Proceedings of the 3rd European Lisp Symposium*, Lisbon, Portugal.

## C LRDE Seminar on Performance and Genericity

In chronological order:

**2008**

- Romain Lerallut (A2iA) and Raffi Enficiaud (DxO Labs) – Morph-M and generic image processing
- Sylvain Pion (INRIA Sophia Antipolis) – Robustness, efficiency and genericity in the CGAL library
- Vitor Vasconcelos Araujo Silva (LORIA Nancy) – Performance and genericity in Qgar
- Pascal Costanza (Vrije Universiteit, Bruxelles, Belgium) – Context-oriented Programming with ContextL
- Anya Helene Bagge (Institutt for Informatikk, Universitetet i Bergen, Norway) – Aspect-oriented Programming
- Anya Helene Bagge (Institutt for Informatikk, Universitetet i Bergen, Norway) – High-Level Abstractions and Optimization
- Magne Haveraaen (Institutt for Informatikk, Universitetet i Bergen, Norway) – Mouldable Programming
- Frédéric Loulergue (LIFO, University of Orleans) – Certified Parallel Programming
- Frédéric Gava (LACL, University Paris-Est, Créteil) – The BSML language
- Joël Falcou (IEF, University Paris-Sud, Orsay) – Tools for parallelism: contributions of generative programming
- Gaétan Hains (LACL, University Paris-Est, Créteil) – Systems, algorithms and applications: Efficiency and effectiveness of parallel systems
- Samuel Tardieu (TELECOM ParisTech) – Build a robust application without exploding costs
- Thomas Quinot (AdaCore) – Effective representation of complex data in a schizophrenic middleware
- Wilfried Kirschenmann (EDF R&D) – A multi-target generic library for linear algebra
- Laurent Plagne (EDF R&D Clamart) – Performance and genericity measurement at EDF R&D

**2009**

- Louis Mandel (University Paris-Sud 11, LRI) – ReactiveML: an extension of OCaml for programming synchronous reactive systems
- Luc Maranget (Inria) – Programming in JoCaml
- Pierre-Etienne Moreau (INRIA Nancy - Grand Est) – Programming with rules: application for the tree transformation in Java
- Patrick Viry (Ateji) – Implementation and application of language extensions
- Yann Régis-Gianas (PPS Laboratory - Univ. Paris Diderot, $\pi r^2$ team - INRIA) – What is hiding behind this type?
- Benoit Sonntag (ICPS - LSIIT) – Lisaac/IsaacOS: The power of prototype-based object-oriented languages
- Dominique Colnet (SmartEiffel - LORIA) – A guided tour of SmartEiffel : software engineering in practice
- Gaël Thomas (REGAL/Lip6/Inria) – AutoVM: pushing the boundaries of genericity
- Nicolas Geoffray (Lip6/INRIA/REGAL) – VMKit, LLVM and Clang: he next generations of compilers
- Yannick Allusse (independant consultant) and Patrick Horain (Télécom SudParis) – GpuCV: Acceleration using graphics processors for image processing and computer vision
- David Tschumperlé (GREYC Uni Caen) – CImg and G'MIC: Free toolkits for image processing at different levels
- Pierre Fortin (PEQUAN, LIP6) – The fast multipole method on the Cell processor: Calculation of the near field
- Jean-Luc Lamotte (PEQUAN, LIP6) – The Cell processor: architecture and programming

**2010**

- Raffi Enficiaud (INRIA Paris-Rocqencourt, IMEDIA project team) – Yayi: A generic library for morphological image processing
- Bertrand Meyer (ETH Zurich, Switzerland) – Genericity and inheritance in Eiffel
- Jean-Baptiste Fasquel (University of Angers, LISA) – Genericity in image processing: algorithmic level and software
- Roland Levillain (LRDE) – Software architecture for generic image processing tools

- Alban Linard (University of Geneva, ”Software Modeling and Verification” team, Switzerland) – Decision Diagrams on Demand (DdoD)
- Yann Cointepas (CEA/LNAO, NeuroSpin/IFR 49) – Interface générique pour la parallélisation d'applications de recherche en imagerie biomédicale
- Julien Lamy (University of Strasbourg) – Genericity and discrete topology in C++
- David Picard (ENSEA, Cergy-Pontoise) – Image search and content-based multimedia indexing
- Vincent Tariel (Ecole Polytechnique) – Property programming: application to image processing
- Rémi Forax (LIGM, University Paris Est Marne-la-Vallée) – PHP.Reboot: A script language using the JSR 292.

## D The former research-students of the LRDE

Here is the list of EPITA students who have been at the LRDE during their studies. Among the 94 students, 41 did a Master degree (DEA/M2 Research) (44%), 22 hold a PhD today (23%) and 8 are PhD-students (8,5%).

### Class of 2000

- Amilcar Baptista (Manager at Accenture, Paris, France)
- Yoann Fabre (R&D Director at Epiphyte, Paris, Master Degree DEA)
- Arnaud Flutre (Software Development Engineer 2 at Microsoft, Seattle, USA)
- Emmanuel Marchand (Consultant Engineer at Intelsys)
- Guillaume Pitel (R&D Project Manager at Epiphyte, Paris, PhD)
- Laurent Soubrevilla (CEO, Epiphyte, Paris)

### Class of 2001

- Alexis Angelidis (Technical Director at Pixar Animation Studios, USA, PhD)
- Vincent Berruchon (Design/Development Engineer at PROLOGISM, Paris)
- Maxime Colas-Des-Francs (RIQ, Réseau Internet Québec Inc., Canada)
- Jérôme Darbon (CNRS researcher at CMLA, ENS Cachan, France, PhD)
- Alexandre Duret-Lutz (associate professor at LRDE, France, PhD)
- Geoffroy Fouquier (Postdoc at Telecom Paristech, PhD)
- Renaud François (System Engineer at Cisco, Paris, France)
- Valentine Ogier-Galland (Technical Communicator at NexWave Solutions, Montpellier, France)
- Sébastien Uzeel (Consultant at AUSY, France)
- Anthony Pinagot (Network Engineer at Cogitis, Montpellier, France)
- Mickaël Strauss (at HORIZON SOFTWARE, France)
- Sebastien Thellier (Project Manager at Atos Worldline)

### Class of 2002

- Jean Chalard (Development Engineer at WeatherNews, Japon)
- Rémi Coupet (Software Engineer at HSBC Private Bank, Geneva)
- Ludovic Perrine
- Christophe Kiciak (Manager of the penetration testing activity at Provadys, Paris)
- Josselin Lebret (Design Engineer at Blue Infinity, Geneva, Switzerland)
- Jean-Marie Santoni-Costantini (Gameplay Programmer at Dancing Dots, Paris, France)
- Pierre-Yves Strub (Postdoc at INRIA / Microsoft Joint Center, Orsay, France, PhD)
- Nicolas Waniowski (Consultant at Niji, Issy les Moulineaux, France)

### Class of 2003

- Robert Anisko (Consultant at Murex, France)
- Clément Faure (EADS CCR researcher, Toulouse, PhD)
- Ignacy Gawedzki (Postdoc at LRI, Orsay, France, PhD)
- Jean-Sébastien Mouret (Roaming Gameplay Programmer at Ubisoft, Singapore)
- Quoc Peyrot (Medical extern, Hôpitaux de Paris, Master Degree M2)
- Raphaël Poss (associated professor at University of Amsterdam, Netherlands, Master degree, PhD-student)
- Yann Régis-Gianas (associated professor University Paris 7, PhD)
- Emmanuel Turquin (Director Technical Studies & Research at The Bakery, Gémenos, France, PhD)

### Class of 2004

- Sylvain Berlemont (Postdoc at Harvard Medical School, USA, PhD)
- Nicolas Burrus (Postdoc at University Carlos III of Madrid, Spain, PhD)
- David Lesage (Engineer in the industry sector, PhD)
- Francis Maes (Postdoc at University of Liège, Belgium, PhD)
- Jean-Baptiste Mouret (associated professor at University Paris 6, ISIR, PhD)
- Benoît Perrot (Product Manager at Dassault Systèmes, France)
- Maxime Rey (Engineer at Thémis)

- Nicolas Tisserand (Lead Developer at MixVibes, Gennevilliers, France)
- Astrid Wang (R&D Project Manager at Gemalto, Singapore)

**Class of 2005**

- Thomas Claveirole (Engineer at LRI at University Paris XI, PhD)
- Valentin David (University of Bergen, PhD)
- Loïc Fosse (Development Engineer at Eugen Systems, Paris, France)
- Giovanni Palma (Research Engineer at General Electrics Healthcare, Paris, PhD)
- Julien Roussel (Director of the Development at Wevod, Paris, France, Master Degree DEA)
- Niels van Vliet (at Mitsubishi UFJ Securities, London, UK)
- Clément Vasseur (Engineer at Freebox)

**Class of 2006**

- Nicolas Despres (R&D Director at Mobile Devices Ingénierie)
- Olivier Gournet (Developer at Freebox)
- Sarah O'Connor (Asset Manager at Société Générale, Paris)
- Simon Odou (PhD LRI at University Paris-Sud XI, PhD)
- Louis-Noël Pouchet (Postdoc at Ohio State University, Columbus, USA, PhD)
- Nicolas Pouillard (PhD-student in the Gallium team, INRIA Roquencourt, France, Master degree M2)
- Damien Thivolle (PhD-student in the VASY team, INRIA Rhône-Alpes, France, Master degree M2)

**Class of 2007**

- Christophe Berger (Consultant IT Security at Devoteam, France, Master degree M2)
- Robert Bigaignon (Software Engineer at Syncsort, New York, USA)
- Alexandre Borghi (PhD-student at LRI at University Paris-Sud 11, Master degree M2)
- Michael Cadilhac (PhD-student at University of de Montreal, Canada, Master degree M2)

- Guillaume Guirado (Engineer at Thalès ?, France, Master degree M2)
- Thomas Largillier (PhD LRI at University Paris-Sud XI, PhD)
- Johan Oudinet (Postdoc at Karlsruhe Institute of Technology, Karlsruhe, Germany, PhD)
- Florent Terrones (Software Engineer at Prosodie, Lyon, France)
- Nicolas Widynski (PhD ENST, ParisTech Télécom, France, PhD)

### Class of 2008

- Samuel Charron (R&D Engineer at Twenga, Paris, France)
- Charles-Alban Deledalle (PhD-student at TelecomParisTech, France, Master degree M2)
- Renaud Durlin (R&D Engineer at Dassault Systèmes, France)
- Jean-Philippe Garcia-Ballester (University Institute for Teachers Training IUFM, Grenoble, France)
- Quentin Hocquet (R&D Engineer at Gostai, Paris, France)
- Guillaume Lazzara (R&D Engineer at LRDE, France)
- Guillaume Leroi (Design Engineer at Key Consulting, France)
- Thomas Moulard (PhD-student, LAAS-CNRS, Toulouse, France, Master degree M2)
- Nicolas Neri (Intern at Emerald Vision, Paris, France)
- Nicolas Pierron (PhD-student, LIP6/Gostai, Paris, France, Master degree M2)
- Geoffroy Querol (IT/Quant Engineer at Lunalogic, Paris, France)
- Benoît Sigoure (Reliability Engineer at StumbleUpon, San Francisco, USA)

### Class of 2009

- Alexandre Abraham (Intern at Thales Systèmes Aéroportés, France, Master degree M2)
- Nicolas Ballas (PhD-student, CEA Saclay, France, Master degree M2)
- Vivien Delmon (PhD-student at Elekta, Issy Les Moulineaux, France, Master degree M2)
- Matthieu Garrigues (Research Engineer at ENSTA, Paris, France)
- Ugo Jardonnet (Intern at INRIA, Paris, France, Master degree M2)

- Antoine Leblanc (Research Engineer at Altribe, Paris, France)
- Florian Lesaint (legal studies at University Paris I, France, Master degree M2)
- Jimmy Ma (Engineer at Syllabs, Paris, France, Master degree M2)
- Florian Quèze (Developer at Instantbird.org, France)
- Maxime Van-Noppen (Research Engineer at Altribe, Paris, France)

**Class of 2010**

- Florent D'Halluin (Developer at Stevens Institute of Technology, Hoboken, USA)
- Jérôme Galtier (?)
- Damien Lefortier (Software Engineer at Exalead, Paris, France)
- Vincent Ordy (Intern at Siemens Corporate Research, New York, USA)
- Guillaume Sadegh (R&D Engineer at Exalead, Paris, France)
- Warren Seine (Technical Director, Aerys, Paris, France)