INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE

Project-Team Qgar

Querying Graphics Through Analysis and Recognition

Lorraine

THEME COG

Activity Report

2006

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1. Team

QGAR *is a research project-team of* LORIA.

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2. Overall Objectives

2.1. Overall Objectives

Our project-team works on the conversion of weakly structured information—an image of a paper document, or a PDF file, for example—into "enriched" information, structured in such a way that it can be directly handled within information systems. Our research belongs to the document analysis field, and more precisely to the graphics recognition community. However, as the semantics (or domain knowledge) of the processed information cannot be fully taken into account, this community is well aware of the fact that recognition alone will not lead to completely automated back-conversion.

We study the use of graphics recognition methods to index and structure weakly structured graphical information, contained in *graphics-rich documents*, such as technical documentation. In this context, we experiment the capacity of pattern recognition methods to compute useful features for indexing and information retrieval. It appears that text-based retrieval (based on annotations or textual references, for instance) must be complemented with the handling of purely graphical information, such as symbols or drawing parts.

3. Scientific Foundations

3.1. Introduction

Our scientific foundations belongs in the domain of image analysis and pattern recognition. For many years, the main contributions of our project-team were in the area of algorithms and methods for image analysis and segmentation, with a specific thrust on images of graphics-intensive documents. In the last years, while keeping a regular activity in this domain, we have moved our main effort towards pattern recognition methods, especially for symbol recognition and spotting. But, of course, recognition tasks also require the prior extraction of features, using image processing and segmentation methods.

3.2. Feature extraction and segmentation

Keywords: *Binarization*, *image processing*, *text-graphics segmentation*, *vectorization*.

As conversion from pixels to features raises a great deal of problems, our project-team had to design several algorithms and methods for binarization, vectorization or text-graphics segmentation. However, designing new methods, or variants of older ones, is not enough. We also must be able to characterize and to evaluate the performances of the methods we use, to study their robustness and reliability, and to get stable implementations for them (hence, the focus on software, cf. § 5.1).

Too often, feature extraction methods rely on parameters which must be fine-tuned from one application to another. We aim at designing robust and stable methods, with as few parameters as possible, by studying the relationship between parameter values, data to be processed, and results obtained. We are particularly concerned with *text-graphics segmentation*, to separate image parts supposed to be of textual nature from parts supposed to be graphics. Most existing methods are based on the analysis of connected components. We have improved some of them to achieve higher-quality segmentation, including steps to recover textual parts touching graphics [37].

Vectorization is the conversion of a binary image into a series of graphical primitives, mainly line segments and arcs of circle, generically called “vectors”, which are a good representation of the original graphics. Existing methods generally suffer from two major drawbacks, over-segmentation and poor geometric precision, especially at the junctions between vectors. We have worked for many years on this matter and proposed several techniques to overcome these limitations. In particular, the RANVEC raster-to-vector conversion software developed during Xavier Hilaire’s thesis in our project-team [14] won the first prize at the 2005 International Arc Detection Contest [35] and is considered as one of the most advanced state-of-the-art methods for vectorization.

Performance evaluation is a major concern in document analysis, and more generally in image processing, pattern recognition and computer vision. A way of approaching the problem considers a method to be evaluated as a completely separate module, which is fed with synthetic or real data. Evaluation is then carried out by comparing the results supplied by the module with some ground-truth. The performances of a segmentation method may also be evaluated according to the observed qualities of recognition steps, using the features provided by the method. This is sometimes called “goal-oriented performance evaluation”.

We are actively involved in the organization of performance evaluation campaigns for symbol recognition, at national and international levels. More particularly, our project-team is leader of the Épeires project (cf. § 8.1.1), affiliated to the Techno-Vision program. This project aims at providing a complete environment of performance evaluation, for our own needs—as organizers—but also for the needs of any team working on symbol recognition or using recognition methods.

Performance evaluation of graphics recognition methods is related to a number of open scientific questions, including intricate problems such as defining simple and non-biased metrics and matching procedures between the ground-truth and the output of recognition methods, when the answer is more complex than a simple "recognized" or "not recognized" label (a good example is the evaluation of a vectorization method). Another potential problem is the generation of large sets of training or benchmarking data, using image degradation models. Such models have to be realistic and as interchangeable as possible with real data.

3.3. Symbol recognition and spotting

Symbol recognition is the localization and identification of symbols which are present in a document [17] and which constitute natural features to be used in indexing and retrieval applications. Whereas it has ancient and solid foundations, and has proved to be mature for character recognition, for instance, symbol recognition still remains an open question when dealing with complex symbols having large variations. Our attention is focused on the weaknesses of the existing recognition methods, which make them difficult to use:

- In querying and browsing applications, it is often impossible to work with a database of reference symbols *a priori* known. It is more often the case that the user delineates an arbitrary symbol in a drawing and queries for similar symbols in the set of available documents. We therefore have to design methods able to recognize, or at least to spot "on the fly", without prior learning or precompilation of models.
- We are interested in coping with cases when a prior segmentation of the image is difficult or even impossible, *i.e.* when it is necessary to design segmentation-free recognition methods or methods which simultaneously perform segmentation and recognition.
- Efficient methods for recognizing a symbol among 10 or 20 different models are currently available. They work even when the symbol to be recognized is distorted, for example by noise or by touching graphics. However, they do not scale well to the recognition of a number of symbols an order of magnitude larger. There are both computational complexity issues and open questions about the discrimination power of the methods chosen for recognition.

Signatures are often used for indexing and retrieval purposes, but most work has concentrated on text-based or image-based signatures. Nevertheless, we think that there is also room for graphics-specific signatures to achieve an efficient localization and recognition of symbols, and we currently work in two directions:

- Quick and robust symbol localization through image-based signatures: we propose to combine a feature descriptor method with a structural representation of symbols. We define a robust structural representation based on key points, which allows a quick localization of candidate symbols within documents. Each candidate is then recognized using a combination of shape descriptors. To improve the recognition steps, the processing is directly performed on the grey-level image of the document, without any previous segmentation.
- Vector-based signatures: direct work on the raw image data is not always necessary as, in many cases, vector data can be obtained from available CAD files or similar electronic representations, or can be captured through raster-to-vector conversion. It is therefore interesting to use signatures directly computed on such data.

Ultimately, our idea is to find features which can provide signatures for efficient symbol spotting and identification of broad hypotheses [16]. This will probably be enough for good retrieval performance in many cases. If finer recognition is needed, the preliminary use of such signatures can eliminate a number of hypotheses and help segmenting out candidate regions. Usual pattern recognition methods can then be applied with more efficiency.

When dealing with a large number of symbols, both signatures and structural recognition methods may not be powerful enough to discriminate. They could be used as preclassification steps, before recognition based on usual classification methods appropriate to the family identified by the signature.

4. Application Domains

4.1. Application Domains

Keywords: *Documentation*, *document analysis*, *graphics*, *indexation*, *navigation*.

Our main application domain is the processing and analysis of *documents*—i.e. information produced by humans for communicating with other humans—which convey a huge amount of information in very "poor" formats: paper documents, or low-level, poorly structured digital formats such as Postscript, PDF or DXF.

We are more specifically interested in graphics-rich documents, typically technical documents containing text mixed with a lot of graphics. The usual text-based indexing and retrieval methods are still of interest, but we also need additional ways of accessing the information conveyed by the documents: recurring symbols, connections between textual descriptions and drawing parts, etc. Within this general application area, we work on two major kinds of document analysis applications:

- Specific documentation referring to a well-known framework of technical knowledge: a good knowledge about the type of information which has to be extracted from the documents is usually available, in terms of models of the symbols to be recognized. This is the case of electrical wiring diagrams in aircrafts, like those of the European FRESH project (cf. § 7.2), in which we participate.
- Open documentation: few or even no strong assumptions are made on the kind of information to handle. This is typically the case of applications for browsing large sets of heterogeneous documents, when the user provides "on the fly" information about the symbols or structures he is looking for. We are currently working with France Télécom R&D on this topic (cf. § 7.1).

The growing inclusion of cameras in mobile devices provides significant potential for new computing applications. We recently started a collaboration with Netlor Concept (cf. § 7.3), to develop a prototype system to identify city buildings from still images captured by a camera: a central computer system receives images captured by users' mobile devices and identifies them from a large image database including a wide range of viewpoints of each building.

5. Software

5.1. Qgar Software

Participants: Gérald Masini, Jan Rendek.

Overview. Since several years, the QGAR project-team has devoted much effort to the construction of a software environment, to be able to reuse whole or part of software implemented during previous work, as well as collected experience. This environment includes three main parts:

- *QgarLib*, a library of C++ classes implementing basic graphics analysis and recognition methods,
- *QgarApps*, an applicative layer, including high-level applications (binarization, edge detection, text-graphics separation, thick-thin separation, vectorization, etc.),
- *QgarGUI*, a graphical interface to design and run applications, providing data manipulation and display capabilities.

The Qgar system is registered with the French agency for software protection (APP) and may be freely downloaded from its web site (http://www.qgar.org). The whole system is written in C++ and includes about 100,000 lines of code, including unit-testing procedures. A particular attention has been paid to the support of "standard" formats (PBM+, DXF, SVG), high-quality documentation, configuration facilities (using autoconf/automake), and support of Unix/Linux and Windows operating systems.

Application management is plugin-based. Each executable binary file is paired with a XML description file which is parsed when the user interface is launched: the corresponding application is then dynamically integrated into the menus of the interface, and dialog boxes to access the documentation and run the application are dynamically generated. In this way, any application may be easily coupled with a remote system based on a similar approach. Conversely, as the integration (or removal) of an application does not imply any modification of the user interface, the installation of remote applications, provided by partners for testing for example, is easy. This is particularly useful when comparing different methods performing the same task, in the context of performance evaluation, a topic which is part of our current research work, as previously mentioned. For these reasons, the system has been and is used within the context of several cooperation projects, like the FRESH European project (cf. § 7.2).

New results. As the system reached a stable and matured architecture at the end of 2004, most of our effort is now devoted to the improvement of the quality of its components, especially library QgarLib and applications QgarApps. Unit-testing procedures of new tools are systematically implemented so that the correctness of available tools may be guaranteed in case of minor or major modification of any module. A continuing work of documentation writing is simultaneously done.

A number of tools were reengineered, mainly to increase their extendability, reusability and efficiency. In particular, the input/output system has been completely revised to make it easier to implement new file formats, most image processing tools have been optimized, and new geometrical operations (intersections, angles, etc.) have been implemented.

At a higher level, the method to compute connected components has been refactored to be best suited to the needs of current ongoing research, descriptors based on shape context [36] have been implemented as part of a joint project with the CVC Barcelona (cf. § 6.4), and a new prototype application for text-graphics separation is being developed to take primitives like dashed lines into account.

Within the INRIA Software Development Operation (ODL), an engineer will be recruited at the beginning of 2007 to develop the next version of the software: the code will compile on Linux and Windows platforms using the same scripts in both cases, and complete installation packages on these platforms will be automatically generated when issuing each new version of the software. The workspace will be hosted by an external collaborative development environment so that local developers and users as well as remote partners can effectively work together.

5.2. The Épeires environment

Participants: Philippe Dosch, Yamina Smail.

In the context of the Épeires performance evaluation project (cf. § 8.1.1), we have built up a complete information system, capable of managing all required data related to performance evaluation of symbol recognition methods. It includes the management of data themselves, but also of their classification, of the automatic degradation processes, of the participants profiles, and of the available tests and result storage. The development of this environment is still ongoing work, using the Ruby on Rails framework (http://www.rubyonrails.org/), but the first version is available at the web site of the project, hosted at http://www.epeires.org.

The web site is also the location where all resources related to the project are freely available for the scientific community. In this way, users are able to manage their methods, to generate testing evaluations for specific purposes or to download existing ones, and to send and analyze their results. The same functionalities will be provided to the organizers (Épeires Consortium).

We also developed a collaborative ground-truth managing software, called Picvert, coded in Java and hosted at http://gforge.inria.fr/. It is used to create, review and validate the labelling of test images with respect to reference symbols (ground-truth). Its architecture is based on a client/server model connected to the information system.

The web site will be fully operational at the end of 2006, and it will be used to organize testing campaigns as they are planned in the definition of the Épeires project. It will be also used to organize the next International Symbol Recognition Contest, which will be held during GREC 2007 in Curitiba, Brazil.

6. New Results

6.1. Combination of classifiers and shape descriptors

Participants: Jan Rendek, Jean-Pierre Salmon, Oriol Ramos Terrades, Salvatore Tabbone, Laurent Wendling.

Combining outputs of classifiers is one of the strategies used to improve classification rates in common classification applications [24]. Related techniques most often rely on a Bayesian probabilistic approach. We tackled the problem of using a non-Bayesian framework for the same purpose, considering both two-class and multi-class classifiers [10]. A classifier is assimilated to a random variable and finding the best classifier combination is expressed as solving an optimization problem. The method produces an optimal linear combination of the classifier outputs satisfying constraints of independency and distribution. The optimal weight of each classifier is computed according to its success rate during the learning stage.

We also proposed an improvement of classifier combination using the Choquet integral [26], defined on fuzzy measures. A degree of trust, *i.e.* a weight, is assigned to sources and subsets of sources, making it possible to take the positive and negative interaction between sources into account. Our contribution to the improvement of the usual applications of the Choquet integral is twofold. On one hand, we improved the learning algorithm proposed by Grabisch [34]. On the other hand, we added a selection mechanism to discard classifiers which are considered as inappropriate at the end of consecutive phases of combination. Experimental studies demonstrate the usefulness of the approach, especially when few data is available to train classifiers separately and the fusion operator.

Simultaneously, we continued our work on the combination of shape descriptors based on a behavior study of a learning set [15]. Each descriptor is computed on several clusters of symbols. For each cluster and for each descriptor, an appropriate mapping is directly carried out from the learning database. Then, existing conflicts are assessed and integrated into a map. This method substantially improves the recognition when dealing with real data.

6.2. Scaling of symbol recognition methods

Participants: Sabine Barrat, Bart Lamiroy, Jean-Pierre Salmon, Salvatore Tabbone, Karl Tombre, Laurent Wendling.

The FRESH project (cf. § 7.2) gives a new dimension to the recognition/classification problem as it mainly aims at distinguishing between roughly 500 different symbols either very similar, only differing by slight details, or completely dissimilar from a visual point of view, or even composed of other known and significant symbols, possibly not connected. Furthermore, the applicative framework of the project requires the analysis of a very large number of very large images. The main difficulty is the preservation of the scalability with respect to a substantial increase of the amount of data: structural relationships between symbols and parts of symbols should be available to perform semantical interpretation as well as electric simulations from wiring diagrams, robustness should be tuned so that image noise does not perturb recognition but fine details are captured as well, fine details should not hinder scalability, etc.

Global signal-based shape descriptors present many drawbacks in this context. They do not accommodate well to connected symbols and composition, and they are generally not very suitable to the capture of small detail changes, though this tends to make them fault tolerant to image distortions. They nevertheless scale very well and allow easy insertion of new symbols in the database. Structural shape descriptors are very segmentation-dependent and do not scale easily when they are based on graph representations. They also lack robust expressive power when hierarchically organized. However, they capture details very well and provide interesting hooks for semantic interpretation.

Our contribution consists in designing a composite descriptor, robust and compact, with a low computational complexity. It is composed of smaller elementary descriptors, yielding integer or boolean values, which are thoroughly evaluated with respect to robustness and reliability. They express information like the number of small occlusions, the occurrence of text, the number of connected components, the presence of symmetrical extensions, full circles or rectangles, etc.

Besides full scale evaluation, we are currently studying metrics suited to descriptor comparison. Since several components of a composite descriptor convey correlated information and since the behavior of components differ according to known image perturbations and segmentation errors, a statistical analysis helps to correctly compare two descriptors. As the main goal is scalability, we are now focusing on a second stage operating disambiguation on the remaining candidates. We improved a pattern recognition scheme based on genetic algorithms, by integrating circular arc features and by adding the ability to take feature topology into account. The comparison of few degraded models gave promising results. We are now investigating ways to deal with larger, vectorized databases.

As learning is likely to appreciably improve recognition, we adapted a progressive learning method to symbol recognition, which increases its own recognition rate when new symbols are successfully recognized [19]. A discriminant analysis provides allocation rules from learning samples belonging to known classes. However, such a method is efficient only if learning samples and data are defined in the same conditions, which is seldom the case in real cases. A conditional vector is therefore added to each observation, to take parasitic effects between data and learning samples into account.

6.3. On-the-fly recognition and symbol spotting

Participants: Philippe Dosch, Bart Lamiroy, Joan Mas Romeu, Oanh Nguyen, Marçal Rusiñol, Salvatore Tabbone, Wan Zhang, Daniel Zuwala.

In most recognition problems which are satisfactorily solved, data are matched with a set of known models, provided that it has been possible to construct these models beforehand, or to perform some learning to get them instead. We are interested in what we call "on the fly symbol recognition" and might also call "dynamic" or "unsupervised" recognition: a user is given the possibility to delineate a region of interest— that is to say a symbol—in a document and to simply ask the system to locate other instances of this symbol. We called this general problem "symbol spotting" because of its similarities with other problems in document image analysis, such as word spotting, table spotting, etc.

Daniel Zuwala's PhD thesis [12] proposes a system for browsing a set of graphical documents without prior knowledge of their content. A new structural method locates regions potentially embedding a symbol, using an unsupervised reconstruction of the document from the skeletons (*i.e.* chains of points) of the regions. A querying mechanism retrieves regions which are the most similar to a given input symbol. A combined filtering and indexing method, well-suited to high-dimensional data in large databases, makes the search itself efficient. It allows a user to browse a set of scanned documents in a very timesaving way. The derived implementation supplies excellent promising results, in terms of response time and precision [31].

The SYMBOLREC associated team with CVC of Barcelona (cf. § 8.2.1) also gave rise to the opportunity of studying on-the-fly recognition. Subsequent stays of Joan Mas at LORIA allowed the joint development of a new method for on-the-fly model generation [20], [21]. This work falls within the domains of syntactical and sketch-based symbol recognition, and is related to grammatical inference. Once topological properties of symbols are expressed using an adjacency grammar, a set of local geometric invariants is produced by the grammar rules which are triggered by the recognition process, in order to further disambiguate topologically similar configurations. The combination of both steps results in a very robust and efficient recognition method well-suited to user-drawn sketches. We show that the same approach can be easily adapted to the generation of adjacency grammars, or can be used as an interface for navigation and querying based on hand-drawn examples.

This leads to the more general topic of *symbol spotting*, to quickly determine which zones of a given image of a document have a high probability to contain a queried symbol. Since the purpose is the indexation of large image databases, it requires a method able to tackle symbol discrimination and segmentation at the same time.

In his PhD thesis work in Barcelona, Marçal Rusiñol is designing an indexing method working with the components of a graphical symbol, in fact polylines (*i.e.* chains of connected line segments). The components of a queried symbol and the components of the known symbols are compared using a string matching scheme which is able to match same-shaped components independently of their number of segments. An indexing table of polyline clusters allows regions of interest, where the queried symbol can be found, to be spotted. During his visit to the QGAR project-team, Marçal Rusiñol worked jointly with Philippe Dosch on comparing polylines, taking the idea of a split-and-merge operation. A polyline is described by the accumulated histogram of the lengths of its segments and of the angles between them. This method is less time-consuming than the whole string matching scheme, and the spotting of graphical symbols appearing in real-case images proves its robustness to noise.

6.4. Evaluation and benchmarking

Participants: Philippe Dosch, Gérald Masini, Jan Rendek, Salvatore Tabbone, Karl Tombre, Wan Zhang, Daniel Zuwala.

Since the end of 2004, our project-team is leader of the Épeires project affiliated to the Techno-Vision campaign. The objective is the construction of a complete environment for performance evaluation of symbol recognition and localization methods. This topic has gained increasing interest in the last years, as demonstrated by the creation of two international contests on symbol recognition methods [13]. In addition, we are working with the other Épeires partners on the definition of the related metrics and protocols required by evaluation campaigns. This also includes the development of an open source collaborative ground-truth management software for dataset labelling purpose (cf. § 5.2).

In collaboration with CVC at University of Barcelona as part of the SYMBOLREC associated team (cf. § 8.2.1), we also started a new project about characterization of shape descriptors, in order to define a "genetic map" of a number of selected descriptors, that is to say a list of properties some families among them share. These properties must not be dataset-dependent. We hope that such a map will lead to the definition of usage profiles, so that a user facing a practical pattern recognition problem can get help in choosing the most appropriate family of descriptors.

Such a protocol must be independent of datasets to be of general use. Evaluation models are easy to implement when they are dataset-driven, as they just require the computation of some recognition rates on a given dataset. However, they do not give much information about the behavior of a descriptor on a different dataset. Our aim is the design of dataset-independent models, which is more complicated.

We are interested both in pixel-based descriptors, computed on all pixels of the shape or on a subset of these pixels (contours, or regions, for example), and in structural descriptors, computed from the components of the shape and from the relationships between them. Each descriptor must be evaluated in terms of computational complexity, of robustness to geometric transformations and image degradations, of genericity, and of separability and compactibility. The last two criteria give a measure of the discrimination power of a descriptor when the number of classes and the variability of the shapes grow.

Evaluation is also the matter of our collaboration with City University Hong Kong. During her visit to LORIA, Wan Zhang integrated a descriptor developed by her team [38] in the shape descriptor characterization project, in order to evaluate its discrimination power and its efficiency using different databases. The Hong Kong group is developing an online symbol recognition system, which improves the efficiency and effectiveness of the user's input by presenting him/her with possible candidates dynamically selected from the symbol database. Wan Zhang worked on applying this idea to help annotating the ground-truth in the Épeires environment.

7. Contracts and Grants with Industry

7.1. France Télécom R&D

Participants: Bart Lamiroy, Jan Rendek, Karl Tombre, Laurent Wendling.

We have a long-lasting partnership with France Télécom R&D (FT R&D) on various issues within document image analysis. From 2001 to 2003, we were members of the RNTL DocMining project led by FT R&D. Since the end of 2004, we have a new partnership on the topic of on-the-fly symbol recognition (cf. § 6.3). More specifically, FT R&D pays the salary of Jan Rendek, a PhD student, under a CIFRE contract.

7.2. The Fresh project and Algo'tech

Participants: Bart Lamiroy, Laurent Fritz, Jean-Pierre Salmon, Karl Tombre, Laurent Wendling.

Algo'tech Informatique is a French company based in Biarritz, which develops CAD solutions in electrical design and, more particularly, a vectorization and document analysis system for electrical wiring drawings. We contribute to the improvement of this system in the context of the European STREP project FRESH[1] (FRom Electric cabling plans to Simulation Help). Its objective is the reduction of the time required to design aircraft electrical harnesses, as well as the construction of an intelligent system to maintain and overhaul electric cabling.

We contribute to the recapture of electrical wirings diagrams, with a particular focus on recognition methods for complex symbols. More precisely, we are developing a hierarchical symbol recognition method to progressively "zoom in" on a few models out of several hundred possible ones, by computing a set of simple geometric descriptors and the relationships between them. We have also improved a pattern recognition scheme based on a genetic algorithm by adding the ability to take arcs of circle and connected components into account. Promising results were achieved to compare degraded symbols. We are now investigating ways to deal with larger, vectorized databases.

The partners of the project are: Algo'tech Informatique (France), ESTIA (France), Euro Inter (France), ECM Drawings (France), CEIT (Spain), Rector (Poland), Tekever (Portugal), and Zenon (Greece).

7.3. Netlor Concept

Participants: Sabine Barrat, Salvatore Tabbone.

Netlor Concept is a French company located in Nancy, which develops web services for the optimization of company management and the dynamization of information exchange. It pays the salary of Sabine Barrat, a PhD student under a CIFRE contract, who works on a navigation system in urban environment (cf. § 4.1).

8. Other Grants and Activities

8.1. National actions

8.1.1. Techno-Vision ÉPEIRES

Participants: Philippe Dosch, Gérald Masini, Karl Tombre.

Techno-Vision is a French national program to fund projects related to performance evaluation of vision algorithms in computer science. We are leaders of the Épeires project[2] on performance evaluation of symbol spotting and recognition (2005–2007) and, as such, in charge of the scientific animation, of the creation of the information system related to the project, and of the creation of the testing data which will be used during an evaluation campaign opened to all interested participants at the end of 2006.

The funded partners are the universities of La Rochelle (L3i laboratory), Rouen (PSI laboratory) and Tours (LI laboratory), and the Algo'Tech company. The non-funded partners are the City University of Hong Kong, the DAG team of the Computer Vision Center of Barcelona, and the ONE laboratory of France Télécom R&D.

8.1.2. Navidomass

We submitted in 2006 a research proposal to the ANR call on Data Masses (ARA MDCA). The corresponding project, entitled NAVIDOMASS, was accepted by the scientific committee of ANR in Fall 2006 and should start in the first months of 2007. The general purpose is the construction of a framework to digitally preserve and provide universal access to heritage document collections in libraries, museums and public archives. The main focus is the problem concerning navigation in large archives databases containing text, images, illustrations and schemas, through the extraction of knowledge from images of documents.

[1] http://www.aero-scratch.net/fresh.html
[2] http://www.epeires.org/

Our partners in this projects are the IMADOC group at IRISA in Rennes, Centre d'Études Supérieures de la Renaissance in Tours (CESR, UMR 6576), and the universities of La Rochelle, Tours, Rouen and Paris 5.

8.2. International cooperation

8.2.1. CVC Barcelona

In 2006, we intensified our long-lasting scientific cooperation with the Computer Vision Center at *Universitat Autònoma de Barcelona*, including joint PhD supervisions, student, regular researcher and post-doc exchanges, collaboration in the Techno-Vision Épeires project, INRIA associated team SYMBOLREC[3], funding through PAI Picasso for joint work, joint European proposal, and joint organization of international symbol recognition contests.

Various symbol recognition problems have been studied through research collaborations:

- Oriol Ramos' jointly supervised PhD thesis [10], defended in October 2006, proposes a classifier combination scheme of multiresolution descriptors (cf. § 6.1).
- Marçal Rusiñol, Josep Lladós and Philippe Dosch tackled the problem of recognizing and segmenting at the same time. They worked on querying symbols by shape in large databases, to provide a list of regions of interest where the queried symbol has a high probability to be found. More specifically, the collaboration relates to vectorial signatures, *i.e.* descriptors for indexing symbols based on vectorial data (cf. § 6.3).
- Joan Mas, Bart Lamiroy, Gemma Sánchez and Josep Lladós address the syntactical approaches for symbol representation, and more particularly the use of adjacency grammars for sketch recognition. The joint work focused on the inference of a grammar representing a symbol class from hand-drawn examples [20], [21].
- Agnès Borràs, Josep Lladós and Bart Lamiroy study content-based image retrieval by shape features. Once image contours are polygonally approximated, symbols are described in terms of geometrical attributes and then located in scenes using a voting approach.
- Several PhD students had research stays in the partner institution.

We also launched a new joint project on the characterization and evaluation of shape descriptors (cf. § 6.4), and organized two joint workshops. The first, held in Nancy on April 20–21, gave a starter to the new joint project, while the second, held in Barcelona on October 19–20, examined the progress of the work and planned work for 2007.

The SYMBOLREC associated team has been granted funding for continuing operation in 2007.

8.2.2. City University of Hong Kong

In 2006, we intensified our research collaboration with Wenyin Liu's group at the City University of Hong Kong (CityU). Our scientific objective is a common work on symbol recognition for information retrieval in technical documentation, through the construction of a reference database and the study of performance evaluation of graphics recognition methods. The project is partially funded by PAI Procore and by *Région Lorraine*, and also includes a collaboration within the Techno-Vision Épeires project (§ 8.1.1).

Wenyin Liu visited Nancy in May 2006 to work with Karl Tombre and Philippe Dosch on performance evaluation of symbol recognition and to define the participation of CityU to the Techno-Vision Épeires led by LORIA. In August 2006, Karl Tombre and Laurent Wendling visited CityU in Hong Kong and had exchanges with Wenyin Liu, Wan Zhang and PhD and master students about symbol recognition and construction of a reference database.

[3] http://www.cvc.uab.es/dag/

From September to December, Wan Zhang, a PhD student at CityU, stayed in Nancy and took part in our work on performance characterization and evaluation (cf. § 6.4). She also worked on the design of a graph of spatial relations between basic geometric shapes, to make the best possible use of the respective contributions of LORIA to the decomposition of a symbol into basic geometric shapes, and of CityU to the hierarchical representation of the relations between basic geometric shapes.

8.2.3. Miscellaneous

Karl Tombre is working with University of Yaoundé 1 and *École Polytechnique de Yaoundé* (Cameroon), helping in the supervision of two PhD students on the topics of geographical information systems and map analysis.

9. Dissemination

9.1. Animation of scientific community

9.1.1. Journals

Karl Tombre is editor in chief of the "International Journal on Document Analysis and Recognition" (IJDAR), member of the advisory board of "Electronic Letters on Computer Vision and Image Analysis" (ELCVIA), and member of the editorial board of "Machine Graphics & Vision" and of "ARIMA".

9.1.2. Associations

Karl Tombre was elected president of the International Association for Pattern Recognition (IAPR, see http://www.iapr.org/) in August 2006, for a two-years term. In the previous term (2004–2006), he was first vice-president of the IAPR.

Karl Tombre is the president of the French Association for Pattern Recognition and Image Processing (AFRIF, *Association Française pour la Reconnaissance et l'Interprétation des Formes*).

9.1.3. Other responsibilities

- Bart Lamiroy is elected to the administration council of INPL, and is the elected representative of INPL at the CIRIL administration council.

  He is a member of *Comité de suivi de l'espace transfert* at LORIA. This committee follows and evaluates spin-offs and start-ups created by LORIA members.

  He is an active member of the Education Commission of the Information Technology Service Management Forum.
- Gérald Masini is responsible for the commission of users of computing means (COMIN) at LORIA. He is also a member of the Operational Committee (*Comité Opérationnel*) and of the Management Committee (*Comité de Pilotage*) of the computing means departments at LORIA.
- Karl Tombre heads the Department for Computer Science of the IAEM Doctoral School, common to the four universities in Lorraine.

  He is elected to the studies council (CEVU) of INPL.
- Laurent Wendling is a member of the council of LORIA and is elected to the studies council (CEVU) of Université Henri Poincaré Nancy 1.

9.2. Collaborations within INRIA

A cooperation with Isabelle Debled-Rennesson (project-team ADAGIO) is ongoing. We have proposed a new way to extract arcs of circle and line segments from curvature profiles by defining adapted filters in the splitting process [27].

We also regularly work with the IMADOC group at IRISA, a partner of our new NAVIDOMASS project (cf. § 8.1.2) on heritage documents.

9.3. Teaching

Most members of the QGAR project-team are university faculty members and, as such, have a statutory teaching service in their respective universities. In addition, several of them have major organizational and administrative responsibilities. They have teaching positions in various institutions:

- Suzanne Collin, at ESIAL (engineering school, master of engineering level).
- Philippe Dosch, at Université Nancy 2, at bachelor level.

  He is the director of studies for the bachelor degree "Administration of open source systems, networks and applications". He is also a member of the recruitment committee in computer science (*Commission de Spécialistes, 27e section*) at Université Nancy 2.
- Bart Lamiroy, at *École des Mines de Nancy/Institut National Polytechnique de Lorraine* (engineering school, master of engineering level).

  He is responsible for one option at the Department of Computer Science, and is the technical coordinator of the IPISO specialized degree. He is also a member of the recruitment committee in computer science (*Commission de Spécialistes, 27e section*) at Institut National Polytechnique de Lorraine.
- Salvatore Tabbone, at Université Nancy 2, at bachelor and master level.

  He is head of the Department of Computer Science at Université Nancy 2.
- Karl Tombre, at *École des Mines de Nancy/Institut National Polytechnique de Lorraine* (engineering school, master of engineering level).

  He is head of the Department of Computer Science at *École des Mines de Nancy* and also heads the recruitment committee in computer science (*Commission de Spécialistes, 27e section*) at Institut National Polytechnique de Lorraine.
- Laurent Wendling, at ESIAL (engineering school, master of engineering level).

  He is director of studies at ESIAL.

9.4. Conference and workshop committees

- Salvatore Tabbone was/is member of the program committees of ACM-SAC 2006 (Dijon, France), CIFED 2006 (Fribourg, Switzerland), ICPR 2006 (Hong Kong), ACM-SAC 2007 (Seoul, Korea), ORASIS 2007 (Obernai, France), and TAIMA 2007 (Hammamet, Tunisia).
- Karl Tombre was/is member of the program committee for CARI 2006 (Cotonou, Benin), CIFED 2006 (Fribourg, Switzerland), DAS 2006 (Nelson, New Zealand), ICPR 2006 track 2 (Hong Kong), RFIA 2006 (Tours, France), SSPR 2006 (Hong Kong), IbPRIA 2007 (Girona, Spain), ICDAR 2007 (Curitiba, Brazil), ICIAP 2007 (Modena, Italy), MVA 2007 (Tokyo, Japan), and DAS 2008 (Nara, Japan).
- Laurent Wendling is member of the program committee of ORASIS 2007 (Obernai, France).

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