Project-Team IntuiDoc

# *Intuitive user interaction for document*

*Rennes*

*Activity Report*

*2013*

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# 2 Overall Objectives

The IntuiDoc project is an evolution from the previous Imadoc team.

The project IntuiDoc carries out research on the Human-Document Interaction by associating the issues of fields of Pattern Recognition and Human-Machine Interaction. The objective is to find solutions to design an efficient, robust and intuitive Human-Document communication based on a continuum between the document under its paper format and the same document as its digital interpreted form (figure 1).

The project lies to the domain convergence of the analysis and recognition of complex handwritten documents ( manuscript, printed paper, form, graph, sketches, composite documents, etc.), and of the pen- and gesture-based interaction for touch or pen capable devices such as smartphones, tablets and multitouch surfaces.

IntuiDoc aims to investigate new approaches to analyze, recognize, compose or interpret complex documents by introducing an interactive process. The originality is to explicitly integrate the user

in the process of analysis and decision making, both in the recognition of complex documents and in the "on-the-fly" interpretation of on-line hand- drawn sketches. This strategy aims to address the limitations of current approaches that are based on non-interactive treatments. The concept is to strengthen the decision processes based on implicit or explicit correction of a final user to avoid the propagation of errors of interpretation throughout the analysis.

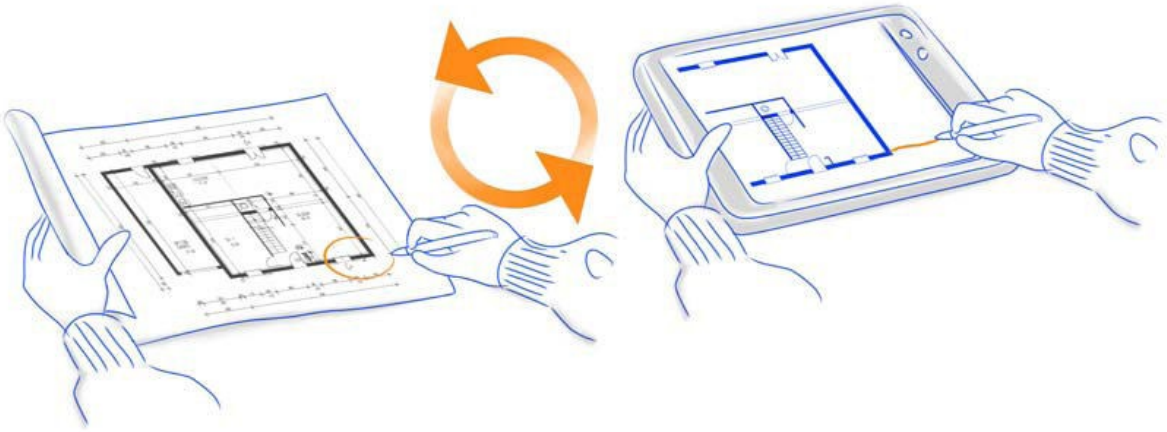


Figure 1: Continuum from paper document to digital interpreted document

# 3 Scientific Topics

## 3.1 Bidimensional visual languages integrating the user-interaction concept

The knowledge associated with the structure of the documents are modeled using bidimensional grammars and visual languages, and by studying new approaches based on constraint multiset grammars. The aim is to design generic methods for structured document analysis and composition.

The introduction of the user in structured document recognition process requires to model this interaction to be able to describe what are the possible interactions for the user, in association with the structural modeling of the document (bidimensional grammars). With the introduction of the user in the analysis process we need to control the requests for the user. If the user interaction occurs on one isolated document, the interaction can be synchronous. On the other hand, during the treatment of a large collections of document, the challenge consists for the analyzer to collect requests and postpone the interaction with the user, to build an asynchronous interaction. To elaborate evolving systems for structured document recognition we explore grammatical inference. This objective, that is already a real challenge for mono-dimensional grammars, is very complex for bidimensional grammars. Our strategy is to perform this inference with the help of user interaction and by focusing inference for the physical structure analysis.

## 3.2 Combining points of view for image interpretation

Combinig several ways of interpreting the content of a document can improve its recognition [6]. Thus we study some mechanisms of knowledge fusion to combine the results various document analysis techniques that are usually studied separately. The knowledge fusion must be as flexible as possible, and if necessary in an asynchronous way.

First, we study different levels of analysis of the image : the analysis of multiresolution images enables to inspire from the human perceptive vision that detects salient objets in a document without specific knowledge.

Secondly, we explore some low level image processing techniques to extract some local primitives: line segment extraction with Kalman filtering, use of particle filter for text line extraction, word spotting using interest point detector, texture analysis... We also introduce some knowledge coming from other processes, such as the result of commercial OCR. All these kinds of contents have to be combined, depending on the studied kind of document, to process the best results.

At last, the originality of our work is to combine a structural analysis with the introduction of statistical data. This combination enables to exploit the expression power of a structural analysis while benefiting from the large range of statistical approaches.

## 3.3 Incremental learning and evolving fuzzy classifiers

To develop a robust and contextual recognition of the elements which form a printed or handwritten document, we design hybrid recognition methods (statistical / structural) which relies in particular on the theory of fuzzy logic to manage the inaccuracy of handwritten strokes.

Traditionally, a classification system is trained using a learning dataset under the supervision of an expert that controls and optimizes the learning process. The system performance is fundamentally related to the learning algorithm and the learning dataset. The classification system is delivered to the final user to be used in real applicative contexts. Typically, no learning algorithms are available at the user side. The main weakness in the above-mentioned conception paradigm is that the knowledge base is constrained by the learning dataset available on the expert side and cannot be extended by the data provided on the user side. These drawbacks increase the need for new type of classification systems that can learn, adapt and evolve in a lifelong continuous manner. For example, in the framework of on the fly composition of documents, it is interesting to allow user to choose its own set of gestures to assign them to different symbols or commands. In the context of interactive document recognition, it is essential to learn from the user interactions, the unknown symbols by integrating dynamically new classes of these symbols in the recognition system.

In evolving systems, incremental learning algorithms are used to learn from the data samples provided by the user after sending a validation or a correction signal in order to confirm or change the label suggested by the classifier. Contrary to the traditional paradigm, there is no separation between the learning phase and the operation phase in evolving classification systems. One of the key features in evolving classifiers is that incoming samples may bring in new unseen classes that are learned by the classifier without destroying its knowledge base or forgetting the existing classes. IntuiDoc designs new incremental approaches for the learning of classification models based on first-order Takagi-Sugeno fuzzy inference systems [1]. This approach includes, on the one hand, the adaptation of consequences of the fuzzy rules using the recursive least-squares method, and, on the other hand, an incremental learning of the antecedent of these rules according to the evolution of data density in the input space.

## 3.4 Pen- and Gesture-Based Interaction

Accuracy and robustness of developed systems are key elements for the User Acceptance. To cope with these requirements, the recognition systems have to be adjustable during their use in the application. We design an evolving recognition engine with an online, incremental, and lifelong learning process.

Portable, touch or pen capable devices such as smartphones, tablets and multitouch surfaces become more and more ubiquitous. Such devices allow for natural interaction via handwriting and gestures. For this sort of usage we designed personalisable gesture recognition engine. We aim to provide the user the possibility to define his own gesture library for various activities. For instance, we work on intuitive

mechanism to get user feedback on recognizer answers, which allows the latter to continuously enhance its performance. We also design direct object manipulation such as rotation, zoom or translation...

Some complex applications need a lot of commands thus the definition of gesture commands and the gesture memorization becomes an important task. Our objective is to obtain natural fluid gestures and to help the user to learn as quickly as possible. The key point is to obtain a complete and customizable set of gestural commands to interact with applications: this induces to be able to design an auto-evolutional gesture recognition system and, in the same time, a framework to help the user to memorize his gestural command set.

The main approaches of gesture learning help are based on Marking Menus which propose two ways of utilization: a novice mode where the user has menus displayed to help him to finalize his gesture and an expert mode where he only needs to draw the required gesture and the recognizer will try to understand which command is invoked. All these approaches help the users to memorize gestures by making them practice drawing. Obviously, the final form of gestures strongly depends on the menu ergonomics.

In this way, we design the Customizable Gesture Menus which combine the advantages of marking menus and personalization capability to give the user an optimal memorization help with customizable set of gestures.

In this scientific area, it is vital to take into account the user and therefore the uses. This is why IntuiDoc actively collaborates with the multidisciplinary research platform LOUSTIC to assist the experiments on gestural commands and on the learning strategies which explicitly involves the final user.

# 4 Application Domains

## 4.1 Paper document analysis: batch or interactive interpretation

Applications of our research in the context of paper document analysis are very wide. Indeed, the generic approaches we have developed (the DMOS-P and IMISKETCH method) allow a quite fast adaptation to new types of documents. Documents we have already worked on are:

- Architectural floor plan interpretation;
- Orchestra scores with polyphonic staves;
- Mathematical formulae;
- Table structures, forms with recognition of the hierarchical organization;
- Archives documents: more or less structured old forms [3].

With the help of handwriting recognition, those systems can be used in many ways:

- Retroconversion of paper documents, to avoid a manual input to get a usable electronic version. It can, for example, be used for a new edition, or to produce a Braille document;
- Kind of document identification, to make, for example, an automatic management of faxes;
- Automatic production of indices and annotations for an automatic access by content to documents;
- Detection of specific areas in a document to improve its access.

## 4.2 Evolving pen- and touch- based interaction

One target application is the use of online handwritten gesture classifiers to facilitate user interactions on pen- and touch- based interfaces like tablet, smartphones, whiteboards, multitouch surfaces, etc. The challenge is to developp applications for these devices with personalization capacity so that user can define his own set of gesture and add new gestures at any moment. Gestures, Symbols or letters can be drawn differently from one user to another, and users may want to add or remove gestures, as long as they use the application. Moreover, users would often change progressively the manner by which they draw gestures. Novice users start drawing carefully and slowly their gestures, while they do them in a more fluid and rapid manner as they become expert. The classifier hence needs to evolve and follow the changes in the data flow. If most users will use a common subset of gestures, each user will need some specific gestures classes for his own usage but that others won't use. In addition, classifier usage may change with time, and the end user may need to add, remove or change gestures classes to fit his needs. That is why the classifier needs to be customisable by end users.

Several applications are developed and experimented using gesture commands, intuitive editing commands, handwritten letter or symbol recognition:

- touch- or pen- based composition: musical score, graph, architectural floor plan...
- annotating documents (photo, archive) for indexing (digital library),
- personalizing Gesture-Based Interaction for Touch-Sensitive Screens.

## 4.3 Handwriting, hand-drawn symbol, and gesture recognition systems

Recently, there has been a new increase in the applications of handwriting recognition [9] in the domains of automatic processing of paper documents (*off-line recognition*) as well as in the new modality of man-machine interaction (graphical gesture recognition), based on the use of a pen and a touch-screen (*on-line recognition*).

To date, in *off-line recognition*, industrial needs are huge and for this reason the design of robust and accurate recognition systems is highly needed. The application domain range is very large. It concerns the problem of the automatic processing of every kind of paper documents, e.g. order lists, social security forms or faxes. In this domain, we have mainly concentrated our efforts to guarantee a high degree of robustness and confidence in the results to be obtained on automatic processing of handwriting. This was done to avoid any risk of error.

In *on-line recognition*, a huge market has arisen due to recent cheap availability of the following devices:

- smartphone (*Iphone, Galaxy note...*),
- tabletPCs (*Surface, Ipda...*),
- multitouch table (*Microsoft PixelSense*).

As future user-centered interaction systems will offer more flexibility and give more liberty to the final user(ability to choose his personal gestures and customize the system),the recognition methods will have to be extensible and to deal with new unpredictable symbols.

To date, the "ResifCar" and "Evolve Touch" software were embedded in such devices (cf. subsections 5.1, 5.2).

# 5 Software

All the presented softwares have been deposit in APP. More details on those softwares can be found on Intuidoc web site (http://www.irisa.fr/intuidoc).

## 5.1 RESIF: Handwriting recognition by hierarchical fuzzy inference systems

**Contact:** Eric Anquetil

**Keywords**: Handwriting Recognition, smartphone, fuzzy logic.

RESIF technology is today composed of three main software to analyze, model and recognize handwritten characters and words:

- RESIFCar is specialized to recognize isolated handwritten characters: Latin alphabet, digits and special symbols.
- RESIFMot is the software for unconstrained cursive handwritten word recognition.
- RESIFApp is the automatic learning process that generates from a handwritten character database the hierarchical fuzzy models used by the recognition systems: RESIFCar and RESIFMot.

RESIFCar and RESIFApp are already in their five version. Through industrial collaborations, RESIFCar has been successfully integrated into mobile devices (smartphones) which are characterized by their limited computing and memory resources.

ResifCar has been integrated in the educational software *Toutaki* of Evodia/Script&Go Company. This Tablet PC software helps the young children to learn how to write. Toutaki has been licensed to HITACHI Company to be embedded to their Electronic Whiteboards.

## 5.2 EVOLVE++ / EVOLVE TOUCH: Evolving recognition engine

**Contact:** Eric Anquetil

**Keywords**: Incremental recognition, Evolving system, Gestures and Symbols Recognition.

*Evolve++* is an evolving recognition engine, that can be trained incrementally, starting from few data samples. Evolve++ is based on a fuzzy inference systems that learn incrementally and cope with class adding.

*Evolve-Touch* is a derived sofware based on Evolve++ for the application domain of graphical gesture recognition for multitouch devices. *Evolve-Touch* offer a complete framwork to allow user to manage and customize his gesture sets for different application contexts in simple and user-friendly manner. An intuitive mechanism is adopted to get user feedback on recognizer answers, which allows the latter to continuously enhance its performance. To demonstrate the main features of Evolve-Touch system, a showcase application is presented in this video : *http://youtu.be/qOx4IY6uYf8*. This work is supported by a *European Regional Development Fund* (FEDER), and protected by a *European patent* (N°1258803).

## 5.3 Varchitect: Windows Store application based on Evolve++/EvolveTouch

**Contact:** Eric Anquetil

**Keywords**: Incremental recognition, Evolving system, Gestures and Symbols Recognition, Interior design, Tablet, Windows Store.

*Varchitect* is a Windows Store application that was developped as part of the effort to port the *Evolve++/EvolveTouch* system to current tablet operating systems. It is available for free at http://apps.microsoft.com/windows/en-us/app/aa0889d0-2097-4a91-aa28-2a74df7e206c

With Varchitect, users can define their own set of gesture commands to insert furniture or architectural elements in a plan, and then design their interior with a stylus or fingers. The users can use a picture (taken from the tablet's builtin camera) as a base and set the scale of their plan to be sure everything fits. Plans made using Varchitect can be shared or printed.

This work is supported by a development fund from *SATT Ouest Valorisation*.

## 5.4 DALI: a framework for the design of pen-based document sketching systems

**Contact:** Eric Anquetil

**Keywords**: Sketch recognition, pen-based interaction, visual language theory, industrial transfer.

*DALI* is a framework for the interpretation of hand-drawn sketches drawn on tablet PCs. The first property of the *DALI* method is its genericity, which means that it can be used to design pen-based software to sketch various natures of documents. It is based on the visual language and grammar theory that makes it possible to model bidimensional symbols and documents [7, 8]. *DALI* interprets the user strokes *on-the-fly*, directly during the design of the document; it means that each time the user draws a stroke, the system analyses it and produces a visual feedback, showing how it is interpreted.

This way, the user is an actor of the interpretation process, because he can progressively correct the errors of the system. Thus, the interpretation process can rely on the information given by the user to better interpret the following strokes. The coupling of these two properties increases significantly the efficiency and the robustness of the sketch interpretation process.

The *DALI* method has been used to design several pen-based prototypes, for instance for the sketching of musical scores, electrical sketches, UML class diagrams, architectural floor plans, etc.

It has been transferred to the Script&Go society, which led to the design of *Script&Go Electrical Sketches* for electrical sketches and *Script&Go Plans* for architectural floor plan sketching. These softwares are today commercialized and used daily by hundreds of technicians in France. *Script&Go Electrical Sketches* has been rewarded with the "Trophées de l'innovation" 2008 for uses, applications and communicating solutions for enterprises", in the category named "Solutions Métiers".

## 5.5 IMISKETCH: interactive off-line sketches recognition

**Contact:** Eric Anquetil

**Keywords**: interactive off-line Recognition, sketches, 2D architectural floor plan.

*IMISketch* is a new generic method for interactive *interpretation* of image of sketches (structured document). The goal is the mapping of technical paper document to numerical ones. IMISketch has been used to deal with off-line handwritten 2D architectural floor plan recognition [15].

## 5.6 DocRead : an automatic generator of recognition systems on structured documents

**Contact:** Bertrand Coüasnon

**Keywords**: Recognition, structured document, musical scores, mathematical formulae, table structures, forms, archives.

DocRead is an automatic generator of recognition systems on structured documents. It has been developed thanks to the DMOS-P method [4]. It is made of a compiler of the EPF language (with which it is possible to describe a document), a parser associated to this language, an early vision module (binarization and line segments detection) and a classifier having also a reject option.

This generator allows us a fast adaptation to a new type of document. Indeed, it is only necessary to define a new grammar in EPF, which describes the new type of document. Then, if necessary, a new learning of the classifier is done to make it able to recognize new symbols. The new recognition system adapted to a new structured document is produced by compilation.

With this generator, we already have been able to produce recognition systems of structured documents:

- ScoRead: a prototype for musical scores recognition;
- MathRead: a prototype for mathematical formulae recognition;
- TennisRead: a prototype for tennis court detection in videos;
- TabRead: a prototype for table structures recognition;
- JournRead: a prototype for newspaper structure recognition;
- FormuRead: a software for reading military forms of the 19th century recognition despite their deterioration. This software has been successfully tested on more than 480,000 pages of the *Archives de la Mayenne* and *Archives des Yvelines*;
- NatuRead: a software for recognition of naturalization decree registers from 1883 to 1930. This software has been applied on 85,088 pages of the *Centre Historique des Archives Nationales*;
- LettRead: a software for extracting structure of mail documents. It has been applied on 1150 images provided by the French project RIMES.
- BanglaRead: a software for extracting headline in Bangla script. This extraction represent a pre-processing tool for handwritting recognition. This work has been realized in collaboration with University of Kolkata and applied on 1922 words from 26 writers.
- FlowRead: a sofwtare for on-line flow-chart segmentation and structure recognition.

## 5.7 Precoce: Library to extract visual indices

**Contact:** Jean Camillerapp

**Keywords**: Early vision, adaptative binarization, vectorization, Kalman filtering, squeletonization, multi-resolution.

It is the library on which the DocRead software described in the section 5.6 is based.

This library is composed of various methods of adaptive binarization. Those use either local determinations of threshold or edge detection and region growing cooperation. Some of these methods can provide results with a sub-pixel resolution.

Using Kalman filters this library carries out detection of rectilinear segments in complex images.

It also contains a skeletonization method from gray level images.

The selected resolution for the digitalization of the documents is not always adapted at best to the recognition of all the structures. This is why the library also provides possibilities of multi-resolution processing.

## 5.8 LIMO : an isolated handwriting word recognizer

**Contact:** Bertrand Coüasnon

**Keywords**: Offline Handwriting Recognition, HMM, SVM, rejection.

The LIMO software purposes is to realize isolated handwriting word recognition. It takes as input an image of the word and produces a list of N-best hypotheses. It can be used to recognize words belonging to a finite dictionary or an open dictionary (with n-gram language model). The recognizer has a two stages architecture :

- A HMM-based recognition that generates a list of N-best hypotheses,
- A SVM-based verification to rescore the N-best hypotheses using SVM character classifiers and to select the best one.

The recognizer also has an integrated rejection feature which combines the HMM and SVM recognition scores to accept or reject the analyzed sample.

## 5.9 iLib: a feature extraction library

**Contact:** Yann Ricquebourg

**Keywords**: Feature extraction.

Concerning the studies of efficient classification and recognition methods, the team lacks its own library of low-level extraction of information that should feed the developed classifiers. Therefore, we decided to federate our works and join our algorithms extracting and computing features from images in a common framework.

Those main purposes have been achieved and the library now proposes in a generic and stable way “classical” features often cited as required by common recognition systems (as surface, gravity center, curvature...), as well as more original or promising characteristic functions as Zernike moments, (concerning plain pixel images), elliptic Fourier descriptors (concerning contour curves), or holes and hollows determination based on chanfrein distance and convex envelope.

Moreover, through a generic approach of our implementation, any extractor functions can be involved in a useful classical “zoning” computation, without requiring complementary programming of the extractor itself.

Additionally, the library also includes auxiliary data structures that are required by some feature extractors (Freeman chains, run-length representation...) as well as utility algorithms (adaptative binarisation, connected region labelling...).

# 6 New Results

## 6.1 Evolving Classification System for Handwritten Gesture Recognition

**Participants**: Manuel Bouillon, Eric Anquetil.

Evolving classification systems have appeared in the last decade to meet the need for recognizers that work in changing environments. They use incremental learning to adapt to the data flow and cope with class adding (or removal) at runtime. The goal of this work is to obtain an on-line handwriting gesture classifier that can learn from very few data (two or three sample per class). Such a recognizer can be used to facilitate interactions on computers with touch sensitive interface (like smartphones, tablets, whiteboards, etc.) by associating commands to gestures (see section 6.5 for more details on gesture commands). In this context, we are studying several aspects of the incremental learning process to improve the performances of our classifier.Our baseline system – namely *Evolve* – is an on-line recognizer based on an evolving fuzzy inference system (with a first order conclusion structure).


Figure 2: Incremental Gesture Recognition with Evolve++ Classifier

First, we have extended our evolving classification system *Evolve* by integrating decremental learning techniques. We have developed two new approaches to introduce decremental learning in the optimization of fuzzy rule conclusions, both relying on a sliding window of data samples. The first one uses this window to unlearn completely old data – so-called downdating – whereas the second strategy uses the window to cut down old data weight in the optimization process – so-called (directional) forgetting. We have shown that decremental learning is necessary to maintain the system learning capacity over time and to correctly adapt to concept drifts. Decremental learning is hence essential for the life-time use of an evolving classification system. These results have lead to the following publications [19][18].

Second, we have studied how confusion reject can be used to help users during the definition of their gesture commands. The use of gesture commands give rise to a cross-learning situation where the user has to learn and memorize the gestures, and the classifier has to learn and recognize drawn gestures. Enabling customization of the gesture commands is essential for users' memorization. On the other hand, enabling users to choose their own gestures may lead to commands with similar or strange gestures that are hard to recognize by the classifier. In order to facilitate this cross-learning situation, we developed a conflicting class detection mechanism to help users during the command gesture definition step. Our goal is to highlight similar classes that the recognition engine will tend to confuse and not recognize well. It allows the user to change his gestures if he has define similar classes, or to draw more gesture samples until classes are no longer confused. This conflict detection mechanism uses confusion reject principles to detect conflicting classes. This aspect has been published in [20].

Third, we are currently working on incremental reject to be able to incrementally improve *Evolve*

rejection capacity. In the same way that recognition models evolve with time, rejection model should adapt to run-time data to improve the error/rejection trade-off. Such a rejection capacity can be used by the gesture command system to ask the user to provide gesture true label instead of (probably) making a wrong action when the classifier's confidence is very low. This incremental reject feature can also be used by the *IMISketch* plan analyzer to improve its performances (see section 6.4 for more details on *IMISketch*).

## 6.2 Fusion of structural and statistical analysis: application to flow-chart recognition

**Participants**: Cérès Carton, Aurélie Lemaitre, Bertrand Coüasnon.

We have improved our work for handwritten on-line flowchart recognition. It has been published in [21].

A critical step of on-line handwritten flowchart recognition is the segmentation between text and symbols. It is still an open problem in several approaches of the literature. However, for a human operator, text/symbol segmentation is an easy task and does not even need understanding diagram semantics. It is done thanks to the use of both structural knowledge and statistical analysis. A human operator knows what is a symbol and how to distinguish a good symbol from a bad one in a list of candidates. We propose to reproduce this perceptive mechanism by introducing some statistical information inside of a grammatical method for document structure recognition, in order to combine both structural an statistical knowledge. This approach is applied to flowchart recognition on a freely available database. The results demonstrate the interest of combining statistical and structural information for perceptive vision in diagram recognition.

## 6.3 Interactive extraction of knowledge in ground truth

**Participants**: Cérès Carton, Bertrand Coüasnon, Aurélie Lemaitre.

A critical step of syntactical method for document image analysis is the adaptation of a system to a new kind of documents. This adaptation is time-consuming as it is done manually by the grammar writer. We work on exhaustive analysis of ground truth data set to help the user through the automatic learning of positioning. This work has been published in [22]. In this paper, we present LearnPos which is a new generic tool that models and evaluates positioning from a learning set of documents.

With the use of this new tool, the grammar writer is helped to define the physical structure of the document. He can then concentrate his efforts on the definition of the logical structure of documents. The presented method can handle spatial relations compose of distinct zones and is able to furnish appropriate order and point of view to minimize errors. The experiments were conducted on RIMES dataset of handwritten business letters. We prove that resulting models can be successfully used for structured document recognition, while reducing the manual exploration of the data set of documents.

We are currently working on an approach that proposes an interactive extraction of knowledge in an annotated ground truth. This approach is composed of three main steps: the automatic structuring phase of the knowledge by the system, the visualization phase of the results by the user and finally the interaction phase where the user can ask questions to the system to obtain further analysis. With this automatic extraction of knowledge, the user has an exhaustive vision of the data set, detecting both the global and the rare cases. This approach will help the user for the description of a new type of document by making it easier and by reducing the time required for a new description.

## 6.4 Architectural floor plan recognition

**Participants**: Achraf Ghorbel, Eric Anquetil, Aurélie Lemaitre.

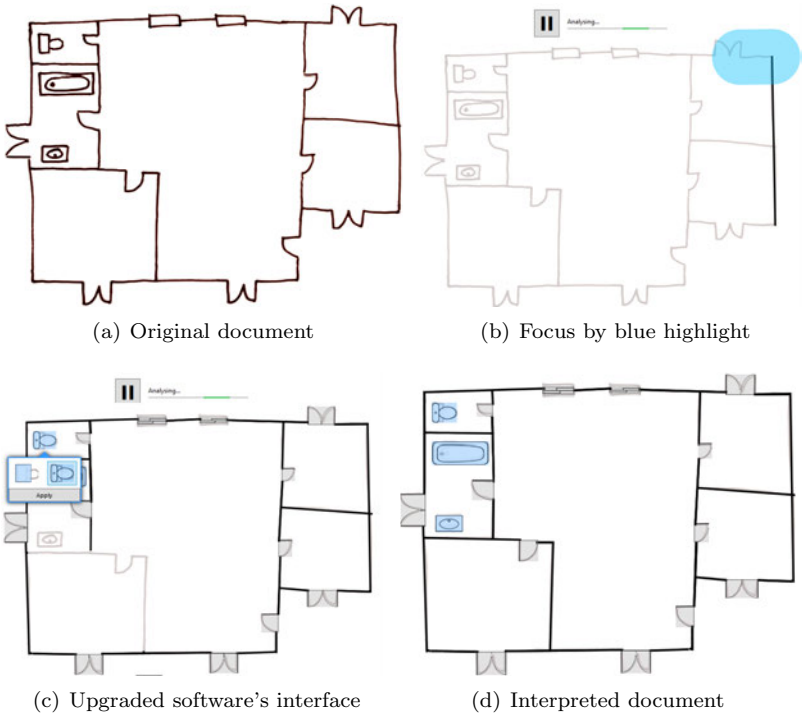
In the context of the MobiSketch ANR research project (http://mobisketch.irisa.fr/), we are working on the recognition of technical paper documents to digital ones. The principle is to offer a complete and homogeneous solution to unify paper document recognition and pen-based sketch interpretation (for instance: with Tablet PC). Our work is to develop a new generic method (referred as IMISketch) for an interactive interpretation of sketches to avoid a fastidious verification phase [15].

We have validated the criteria of acceptability and usability of the system by doing usage tests based on collaboration with experts from the laboratory uses Loustic (http://www.loustic.net/rennes)[23].

Many experiences are applied to centred design of IMISketch method. The aim of these tests is to determine the best way to present the results to the user interpretation and the best manner to interact with the user. The experiments, made on more than 100 persons, have shown that displaying the interpretation results of documents in a progressive manner is most appreciated by the participants. In addition, other experiments recommend interacting with the user by soliciting her if needed.

As shown on Figures 3(a) and 3(d), the current interface displays the interpretation superimposed on the manuscript plan (sequential, integrated). In addition, the interpretation appears gradually on the screen.

The interface contains a pause button (Figures 3(b) and 3(c)) as recommended by the test. The Mobisketch project is finished at the end of May 2013.



(a) Original document (b) Focus by blue highlight

(c) Upgraded software's interface (d) Interpreted document

Figure 3: IMISKetch : Analysis process screenshots

## 6.5 User System Cross-learning of gestural commands

**Participants**: Peiyu Li, Grégoire Richard, Eric Anquetil,.

In this work, we analyzed user system cross-learning of gestural commands through several new concepts. We reported in [27, 26] several experiments, to justify our approach for designing pen-based interfaces for complex application needing more than ten gestural commands: first concept is to offer user the possibility to personalize his gestures; second concept is to use Customizable Gesture Menus to help user memorize gestures; third concept is to help user during the definition of his gestures avoid too similar gesture definition. The results show that using an evolving gesture recognition engine that learns incrementally, starting from few data samples, is a really promising strategy to induce a cross-learning of user and recognition engine. We summarize that personalized gestures can offer an easier way to manipulate software. The handover of software offering the gestures personalization should be separated into two steps: the help on definition of gestures and the help on manipulation during the utilization. Besides these new concepts, we know that Marking Menus can offer more advantages on interactive devices compared to traditional way with either menu bar or tabular menu, like entering text or parameters. Integration of these extension concepts will be our future work.

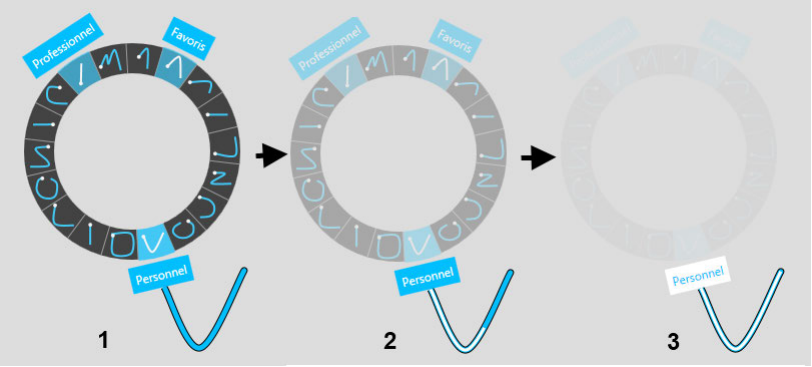



Figure 4: Selection of gesture on Customizable Gesture Menus.

## 6.6 Varchitect

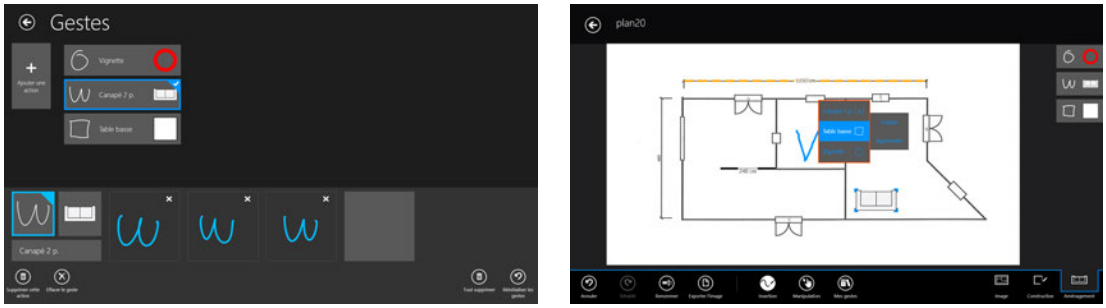
**Participants**: Grégoire Richard, Eric Anquetil.

The development project "EvolveTouch" from *SATT Ouest Valorisation* has for goal to port the *Evolve++/EvolveTouch* gesture regonition framework to Windows 8, Android and iOS tablets.

As part of this effort we published in december 2013 an application on the Windows Store, making the engine and its interaction principles available on Windows 8.1 tablets. The app aims to showcase the *Evolve++/EvolveTouch* gesture regonition framework, while appealing to the general public of tablet users.

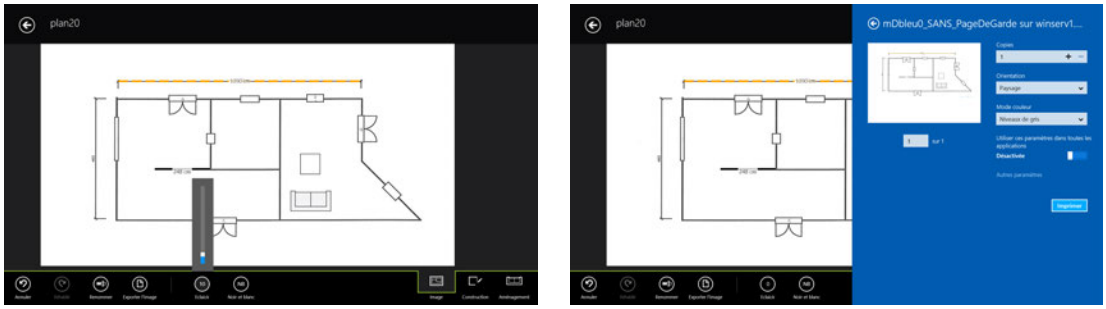
The application is named Varchitect and allows users to design their home interior using gesture commands. Users can take a picture with the device's camera to use it as a base, set its scale and from there add furniture to scale using Evolve++/EvolveTouch. The created documents can then be shared or printed.

Based on previous work done for *Evolve Showcase*, which targeted Windows 7+ desktops, we adapted the engine and the associated graphical framework as reusable WinRT components. The-




(a) (b)

Figure 5: Define your own set of gesture commands to insert furniture or architectural elements in a plan. Design your interior with your stylus or fingers.




(a) (b)

Figure 6: Use a picture as a base and set the scale of your plan. Share your creations or print them.

ses components are EvolveTouch.WinRT and EvolveTouch.WinRTToolkit, have been tested on x86, x64 and ARM achitectures and are used by Varchitect.

Varchitect is available for free on all Windows 8.1 platforms since december 2013 :
*http://apps.microsoft.com/windows/en-us/app/aa0889d0-2097-4a91-aa28-2a74df7e206c*

## 6.7 Heterogeneous and multi-language document recognition

**Participants**: Baptiste Poirriez, Aurélie Lemaitre, Bertrand Coüasnon, Jean Camillerapp.

In the context of the Cassidian - PEA DGA project (see section 7.6), we have participated to the two rounds of the Maurdor campaign (http://www.maurdor-campaign.org). The campaign goal is to evaluate the capabilities for automatic documents analysis. The task is split in five modules. We have worked on the segmentation module (module 1), the script identification module (module 2) and the logical structure extraction module (module 5). The other modules were language detection (module 3) and text transcription (module 4).

The segmentation module segments the document in various zones : table, text regions, form fields... Due to the task splitting, the module needs to produce homogeneous zones. We defined in EPF the different type of zones. To ensure that the zones are homogeneous, we combine those rules with a classifier. The first set of rules describe the structural elements of the documents : table, frame and separators. These are then erased from the document. The next set of rules describe printed latin text blocs. We need to stop the bloc when we encounter any hand-script or Arabic text. The description recognize the alignment (right, left, justified). We use an OCR (ABBYFinereader) to detect potential word. Those hypothesis are then verified with a classifier printed text/other. Text line are constructed and merged to form a homogeneous bloc. The resulting blocs are erased, and we process in the same way the Arabic blocs, without the support of the OCR but with a classifier Arabic text/other. After a new erasing step, the hand-scripted text-line are found, confirmed with an other classifier and text blocs created. The last step produce graphics (signature, drawing, ...) zones. Each classifier is a bonzaiboost classifier with different models (section 6.11).

The script identification module uses a word segmentation based on the line segmentation (section 6.9). Each word is then send to a bonzaiboost classifier. The decision at the zone scale is taken with a majority vote weighted by each word score.

For the logical structure extraction we have used the interactive analysis of ground truth (section 6.3) to create a set of unitary EPF rules. Each rule aims to give a great accuracy, eventually with a poor recall. The use of this tool provide the possibility to develop easily a large set of rules, to increase the recall rate.

The campaign final results are not yet published.

## 6.8 Processing old newspapers

**Participants**: Eric Le Lay, Bertrand Coüasnon, Aurélie Lemaitre.

This development project from *SATT Ouest Valorisation* applies the DMOS-P multiresolution grammatical analysis to French newspapers from the 19th and 20th centuries. It spans from the begining of September 2013 to the end of August 2014. Its goal is to provide a robust system for extracting headlines, articles with their title and author, as well as tables and graphics from a large amount ($> 100000$ pages) of scanned newspapers.

The system performs a recursive segmentation of the page content based on rulings. It handles damaged and double rulings, recognizes frames and processes their contents but it lacks support of graphics and tables for the moment. Textual content is extracted via the Abbyy FineReader OCR

software and grouped into paragraphs, then into articles. Articles may flow from column to column but may not cross horizontal rulings.

## 6.9 Handwritten text segmentation using blurred image

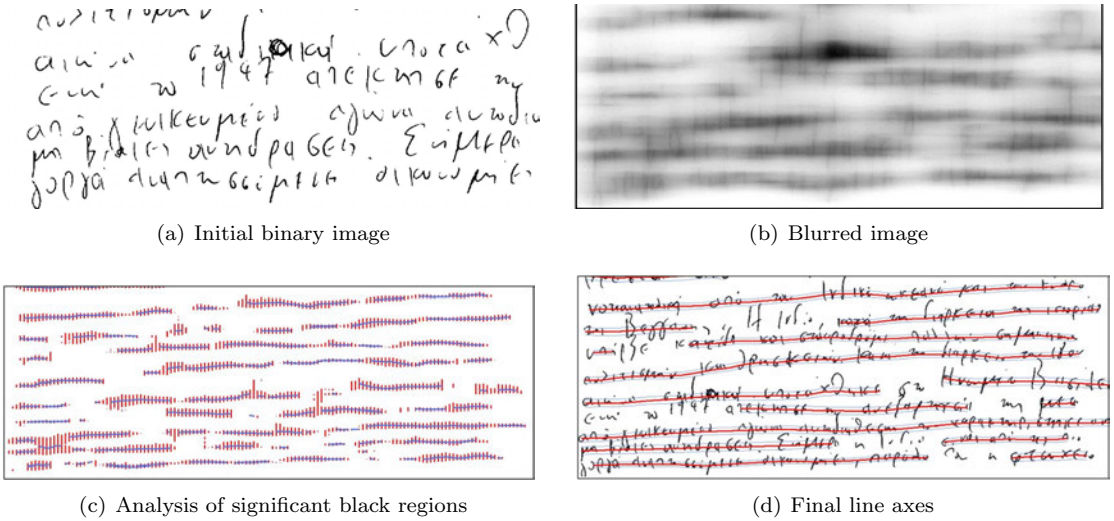
**Participants**: Aurélie Lemaitre, Jean Camillerapp,.

We have proposed a new method for the segmentation of handwritten text pages into lines, which has been submitted to ICDAR'2013 handwritten segmentation competition[SGL+13].

This method is based on two levels of perception of the image: a rough perception based on a blurred image, and a precise perception based on the presence of connected components. The combination of those two levels of perception enables to deal with the diffculties of handwritten text segmentation: curvature, irregular slope and overlapping strokes. Thus, the analysis of the blurred image is effcient in images with high density of text, whereas the use of connected components enables to connect the text lines in the pages with low text density.

The combination of those two kinds of data is implemented with a grammatical description, which enables to externalize the knowledge linked to the page model. The page model contains a strategy of analysis that can be associated to an applicative goal. Indeed, the text line segmentation is linked to the kind of data that is analysed: homogeneous text pages, separated text blocks or unconstrained text.

The algorithm is separated on two steps: a low level image analysis described on figure 7 and a grammatical description of page model (figure 8).



(a) Initial binary image

(b) Blurred image

(c) Analysis of significant black regions

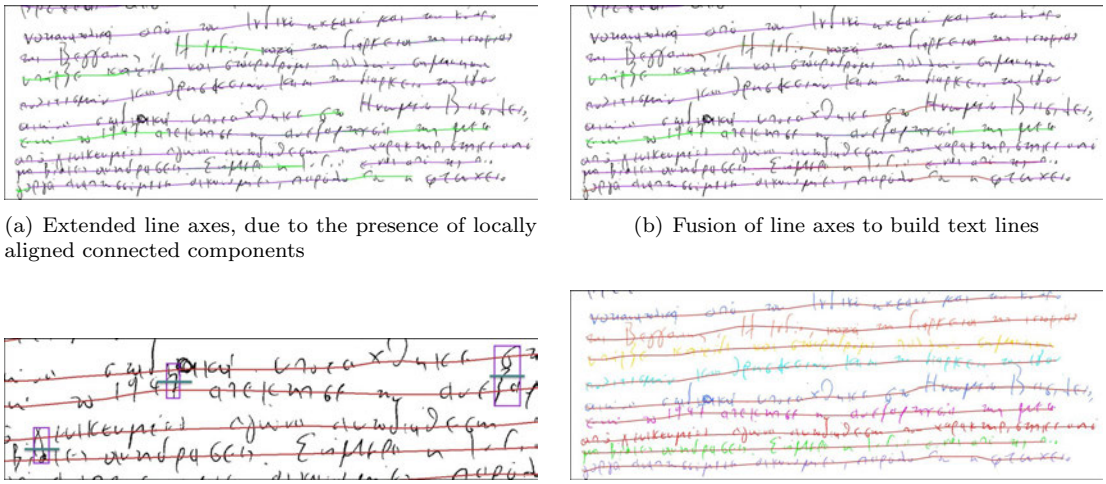
(d) Final line axes

Figure 7: Low level image analysis

This method obtained a recognition rate of more than 98% on last ICDAR'2013 competition [SGL+13]. It places our method in the 5 best methods, over 13 presented methods. A paper describing this method will be published next year in DRR'2014 [LCC14].

[SGL+13] N. Stamatopoulos, B. Gatos, G. Louloudis, U. Pal, A. Alei, "ICDAR 2013 Handwriting Segmention Contest", *in : 12th International Conference on Document Analysis and Recognition*, 2013.

[LCC14] A. Lemaitre, J. Camillerapp, B. Coüasnon, "Handwritten text segmentation using blurred image", *in : Document Recognition and Retrieval XXI*, 2014. to appear.



(a) Extended line axes, due to the presence of locally aligned connected components

(b) Fusion of line axes to build text lines

(c) Re-segmentation of connected components when touching two text lines

(d) Final segmentation result

Figure 8: Application of the grammatical description of page model

## 6.10 Use of Points Of Interests for the analysis of Mexican marriage records

**Participants**: Aurélie Lemaitre, Jean Camillerapp,.

This work has been realized for ICDAR'2013 HIP Family Search Competition. This competition focuses on Mexican marriage records that are used by the genealogists. In those printed forms, the genealogists are interested in several handwriten fields: month and year of the record, origins of the attendees.

The work for the competition can be separated into two tasks. First, we must localize in documents the handwritten fields, called Regions Of Interest (ROI), inside of the records, that contains month, year, and origins of the two attendees. Secondly, for each kind of field, we must gather the ROI that contain the same text. It is not asked to recognize the content of the regions.

This method has obtained the second price at ICDAR'2013 HIP Family Search Competition. It has been published in [25].

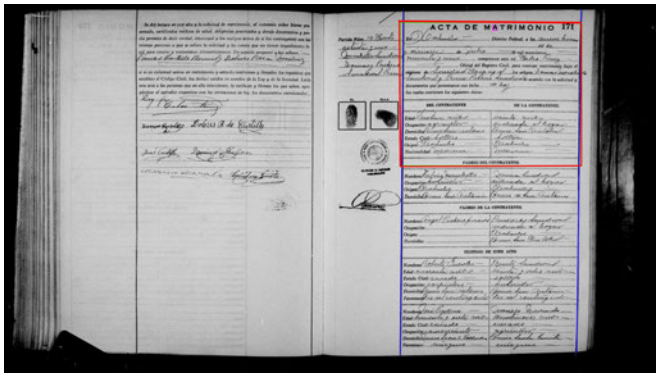
This method is based on the study of the arrangement of local descriptors called Points of Interest (POI) [Low04]. The points of interest are used in this context to realize some word spotting. Then, the word spotting is exploited at two levels in the competition: the localization of regions of interest in the document and the clustering of similar text regions.

## 6.11 Experiments on Boosting bonsai trees as classification system

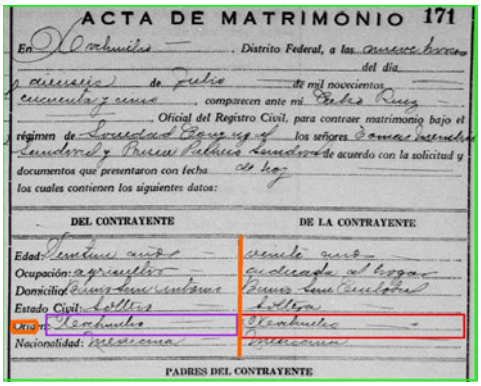
**Participants**: Yann Ricquebourg, Bertrand Coüasnon.

Boosting over decision-stumps proved its efficiency in Natural Language Processing essentially with symbolic features, and its good properties (fast, few and un-critical parameters, not sensitive to over-fitting) could be of great interest in the numeric world of pixel images.

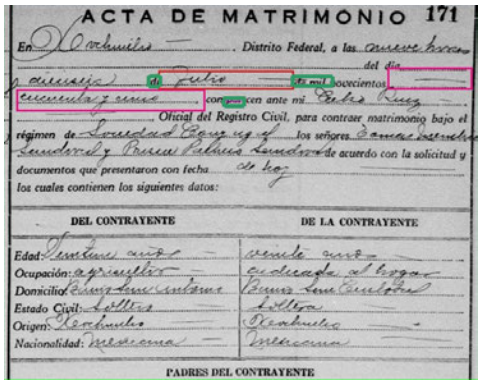
[Low04] D. G. Lowe, "Distinctive image features from scale-invariant keypoints", *International Journal of Computer Vision, IJCV 60*, 2, 2004, p. 91–110.




(a) Delimitation of the interest zone, at the beginning of the record, thanks to two vertical segments (in blue) and a letter *A* from the title




(b) Localization of the origin ROI, thanks to the printed word *origen* and a vertical line segment




(c) Localization of the year and month ROI, thanks to the printed words *de*, *de mil novecientos* and *comparecen*

Figure 9: Steps of analysis for the localisation of regions of interest

| SVM (without tuning) | | | | | | |
|---|---|---|---|---|---|---|
| Label | Prec.% | Rec.% | F1% | ER% | Train | Test |
| hand | 79.57 | 55.31 | 65.26 | 44.69 | | |
| printed | 90.57 | 96.80 | 93.58 | 10.08 | | |
| All | 89.16 | 89.16 | 89.16 | 10.84 | 10hrs | 64min |
| **SVM (with tuning)** | | | | | | |
| hand | 91.15 | 86.09 | 88.55 | 13.91 | | |
| printed | 96.90 | 98.12 | 97.51 | 3.14 | | |
| All | 95.90 | 95.90 | 95.90 | 4.10 | 13days | 64min |
| **bonzaiboost** | | | | | | |
| hand | 88.81 | 85.05 | 86.89 | 14.95 | | |
| printed | 96.66 | 97.58 | 97.12 | 3.37 | | |
| All | 95.28 | 95.28 | 95.28 | 4.72 | 56hrs | 1min30 |

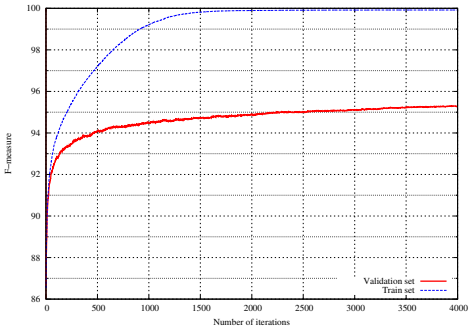



Figure 10: (a) Tables of performance (precision, recall, F-measure, error-rate) and process time (training and prediction testing) for each compared system. (b) Curves of F-measure for bonzaiboost. It illustrates the unsensivity to over-fitting: whilst the train reached a maximum result after 2000 iterations, further training iterations still improve the validation results

In this study we proposed bonzaiboost[1], to implement and test the use of boosting over small decision trees of depth around 2-4 (not only decision-stumps, in order to capture deeper information while avoiding over-training typical of full trees). We first used this approach for the image classification problem of discrimination of handwritten/printed text.

Thus, we conducted experiments to compare it to usual SVM-based classification revealing convincing results with very close performance, but without necessary tuning, with faster predictions and behaving far less as a black-box. Those promising results tend to make use of this classifier in more complex recognition tasks like multiclass problems.

# 7 Contracts and Grants with Industry

## 7.1 SCRIPT and GO

**Participant**: Eric Anquetil.

- Partners: *SCRIPT&GO company*
- Contract: INSA

The IntuiDoc team has close links with the SCRIPT&GO company for transferring its industrial research results. This partnership is now based on more than six licensing agreements. They cover various technologies of the Intuidoc team such as handwriting recognition, document analysis and on the fly diagrams and plans recognition. Since the creation of SCRIPT&GO companies, several technologies (Resif, Dali, Evolve) have been transferred indirectly, to companies such as Thales, Apave, Hitachi...

This partnership is also supported by several collaborative projects: in particular the ANR project "MobiSketch" (http://mobisketch.irisa.fr/) which is labeled by the "Images et Reseaux" cluster.

## 7.2 MobiSketch ANR project

**Participants**: Eric Anquetil, Achraf Ghorbel, Aurélie Lemaitre.

[1] `http://bonzaiboost.gforge.inria.fr`

- Partners: *SCRIPT&GO company,CRPCC Rennes 2 University*
- Contract: INSA (leadership of the project)
- 42 months (2009-2013).

MobiSketch (http://mobisketch.irisa.fr/) is an ANR project (November 2009) from the "content and interaction" programme. It aims at developing generic pen-based software for structured document analysis, design and editing in a mobility context (on the field). The project deals with technical documents such as architectural floor plans. The principle is to offer a complete and homogenous solution from paper document recognition to pen-based document sketching with Table PC. The originality of the project is to explicitly integrate the user in a uniform assessment process to both recognize a paper document and hand-drawn design/edit a new document. To achieve this, we will focus both on new document analysis processes based on visual language and grammar theory but also on the usages to design a new "man-document" interaction based on pen or gesture interaction. The end of the MobiSketch project is fixed to may 2013. Mobisketch has achieved the design of IMISketch framework that has been used to deal with off-line handwritten 2D architectural floor plan recognition [15, 23].

## 7.3 Evolve project : European Regional Development Fund(FEDER)

**Participants**: Eric Anquetil, Grégoire Richard.

- Contract: INSA (leadership of the project)
- 18 months (2011-2013).
- *Evolve-Touch* is protected by a *European patent* (Ref 1258803).
- Industrial transfers : Excense and SCRIPT&GO compagnies.

The goal of the *European Regional Development Fund* (FEDER) project "Evolve" is to accelerate the industrial transfer of "Evolve" technology [1]. This project achieves this year the design of *Evolve-Touch* framework, a derived sofware based on Evolve technolgy : the application domain is graphical gesture recognition for multitouch devices. *Evolve-Touch* offers a complete logical and graphical framework to allow users to manage and customize their gesture sets for different application contexts in simple and user-friendly manner. To demonstrate the main features of Evolve-Touch system, a showcase application is presented in this video : *http://youtu.be/qOx4IY6uYf8*. This work has been protected by a *European patent* (Ref 1258803). "Evolve-Touch" has been tranferred to Excense and SCRIPT&GO compagnies.

## 7.4 EvolveTouch project : SATT Ouest Valorisation development fund

**Participants**: Eric Anquetil, Grégoire Richard.

- Partner: SATT Ouest Valorisation
- Contract: INSA
- 15 months (2013-2014).
- Port for current tablet OSes.

The goal of the *SATT Ouest Valorisation* development fund "EvolveTouch" is to port the results of the development of the *EvolveTouch* technology and framework to the three major operating systems for tablets : Windows 8, Android and iOS. An application will be developed for each of these platforms as an illustration of the features and capabilities of *EvolveTouch*.

This project achieves this year the port of the *EvolveTouch* framework as a *WinRT* component and the *Varchitect* application.

### 7.5 Old Newspaper project : SATT Ouest Valorisation development fund

**Participants**: Bertrand Coüasnon, Aurélie Lemaitre, Eric Le Lay.

- Partner: SATT Ouest Valorisation
- Contract: INSA
- 12 months (2013-2014)

The goal of the *SATT Ouest Valorisation* development fund "Old Newspaper" is to develop a document recognition system for old newspapers from the 19th and 20th centuries. This system is build with the DMOS-PI method and will extract the newspaper content structured in headlines, articles with title and author, graphics and tables (see section 6.8).

### 7.6 Cassidian - PEA DGA project

**Participants**: Bertrand Coüasnon, Aurélie Lemaitre, Baptiste Poirriez, Yann Ricquebourg.

- Partners: Cassidian (an EADS company)
- Contract: INSA
- 31 months (2012-2014)

This project is done in the context of a PEA (Programme d'Etude Amont - upstream study program) from the DGA (French Ministry of Defense) which involve Elda, LNE, and different research partners (A2iA, Irisa/Insa, Lip6, Litis) leaded by Cassidian, an EADS company, to build a prototype of an automatic document recognition system.

We work on the structure recognition of heterogeneous and multi-language documents, which can be handwritten, printed or mixed. The objective is to define a document structure recognition system able to deal with this large variety of documents, to extract and identify the different types of elements found on those documents. This is done by building a generic description of the document structure with the DMOS-P method. Two international competitions will be organized in this PEA, to evaluate the different modules of document recognition.

## 8 Other Grants and Activities

### 8.1 National initiatives

#### 8.1.1 Experiments on interactive gestural commands using a digital pen or touch screen.

**Participants**: Eric Anquetil, PeiYu Li.

- Partner: *LOUSTIC laboratory of Rennes (laboratoire d'obervation des usages des technologies de l'information et de la communication)*
- 2011-2013.

This project has been labeled by the LOUSTIC laboratory of Rennes (laboratoire d'observation des usages des technologies de l'information et de la communication). The objective is to make several experiments on interactive gesture commands using a digital pen or touch screen(6.5). This new mode of interaction is designed to offer the user the ability to define at the same time by a graphic gesture: the type of command, the area targeted by the command and its parameters. Defining, modeling and recognizing these gesture commands is a challenge considering the following objectives: to integrate a large family of gestures within the same application, allowing the user to select and configure its control actions, make the gesture recognition engine self-evolving to suit the current user ( incremental learning). To design efficient interactive gestural commands, it is necessary to place the user at the center of the development process by implementing several experimental tests.

### 8.1.2 IMPACT - Brittany and Pays de la Loire region Grant (ARED)

**Participants**: Eric Anquetil, ZhaoXin Chen.

- Partners: Brittany and Pays de la Loire region
- Contract: INSA
- 36 months (2013-2016)

This project funds (Brittany and Pays de la Loire region/Insa grant) the Ph.D. of ZhaoXin Chen on Recognition and interpretation of structured documents with multi-touch interactions. It aims to extend the composition capability of complex structured documents (architectural plan, diagram, mathematical expressions ...) with multipoint interaction on touchpad. This project is supervised by Prof. C. Viard-Gaudin (Univ. of Nantes) and Prof. E. Anquetil (INSA of Rennes).

### 8.1.3 Igidoc - Brittany region Grant (ARED)

**Participants**: Bertrand Coüasnon, Aurélie Lemaitre, Cérès Carton.

- Partners: Brittany region
- Contract: INSA
- 36 months (2012-2015)

This project funds (Brittany region/Insa grant) the Ph.D. of Cérès Carton on Interactive Grammatical Inference in Visual Grammars for Structured Documents Recognition. The objective is to simplify the definition of knowledge on a new kind of document, by integrating grammatical inference. It is a very challenging task in mono-dimensional grammars, and it is even more in bi-dimensional grammars like we have for document analysis. However, to reduce the complexity of this task, we will work on grammatical inference with a human interaction and we will in a first step, focus inference more on the physical structure, which is easier to do than on the logical part.

## 8.2 International initiatives

#### 8.2.1 Polytechnique Montréal: Synthetic Handwritten Gesture Generation Using Sigma-Lognormal Model for Evolving Handwriting Classifiers

**Participants**: Eric Anquetil, Abdullah Almaksour.

- Partner: Ecole Polytechnique de Montréal - SCRIBENS laboratory
- Contract: INSA research collaboration

We started this collaboration in 2009 with Professor Réjean Plamondon at SCRIBENS laboratory from Ecole Polytechnique Montreal. In the context of handwritten gesture recognition, Evolve adapts continuously with the special writing styles (personalization of existing symbols) and the new needs of the users (adding new symbols). In this specific domain, we propose to accelerate learning of new symbols by automatic generation of artificial data. The generation technique is based on Sigma-lognormal theory, developed by prof. Plamondon, which proposes a new representation space of handwritten forms based on a neuromuscular modeling of writing mechanism. By applying some deformations on the Sigma-lognormal parameters of a given gesture, we obtain synthetic handwritten gestures that are realistic and close to human deformation. Integrating this data generation technique in our systems has accelerated the learning process and has significantly improved the overall performance. [17]

# 9 Dissemination

## 9.1 Leadership within scientific community

### 9.1.1 Program Chair and Committee

- E. Anquetil is Program Chair of the 17th Conference of the International Graphonomics Society (IGS 2015).
- E. Anquetil is Guest Editor of the Special Issue on Frontiers in Handwriting Processing of the Pattern Recognition Letters journal.
- E. Anquetil is member of the program committee of the International Conference on Frontiers in Handwriting Recognition (ICFHR 2014).
- E. Anquetil and B. Coüasnon are members of the program committee of the International Conference on Document Analysis and Recognition (ICDAR 2013).
- E. Anquetil and B. Coüasnon are members of the program committee of the International Conference on Pattern Recognition (ICPR 2014).
- E. Anquetil and B. Coüasnon are members of the program committee of the "Colloque International Francophone sur l'Écrit et le Document" (CIFED 2014).
- B. Coüasnon is members of the program committee of the International Conference on Computer Analysis of Images and Patterns (CAIP 2013).
- B. Coüasnon is Conference Co-Chair (with Richard Zanibbi, USA) of the international conference DRR 2013, 20th Document Recognition and Retrieval Conference, conference IS&T/SPIE of the Electronic Imaging Symposium in San Francisco.
- B. Coüasnon is Conference Co-Chair (with Eric Ringger, USA) of the international conference DRR 2014, 21th Document Recognition and Retrieval Conference, conference IS&T/SPIE of the Electronic Imaging Symposium in San Francisco.

#### 9.1.2 Reviewing

- E. Anquetil is a reviewer in 2013 of:
  - IJDAR (International Journal on Document Analysis and Recognition);
  - PR (Pattern Recognition);
  - DN (Document Numérique).
- B. Coüasnon is a reviewer of DN (Document Numérique) in 2013.
- A. Lemaitre is reviewer of PRL (Pattern Recognition Letters) in 2013.

#### 9.1.3 Member of scientific society

- E. Anquetil is a member of the executive committee of the society GRCE : " Groupe de Recherche en Communication Écrite ".
- E. Anquetil and B. Coüasnon take part in the animation structure " SA 5.2-Écrit " of the Pôle 2: ICC (Interaction coopération et communication), Axe 5: " Communication orale, écrite et visuelle " du GDR-PRC CNRS $I^3$ (Information, Interaction, Intelligence).
- E. Anquetil, B. Coüasnon, J. Camillerapp and A. Lemaitre, take part in the activities of the society GRCE : " Groupe de Recherche en Communication Écrite ".
- E. Anquetil is a member of the steering committee of LOUSTIC laboratory of Rennes (laboratoire d'observation des usages des technologies de l'information et de la communication).
- E. Anquetil is an elected member of the laboratory council of IRISA.

#### 9.1.4 Participation to Phd defenses

- E. Anquetil was a member of the PhD committee of the Phd of Sylvain Fleury, Le rôle de l'utilisateur dans les systèmes de traitements automatiques, Université de Rennes 2, Janv. 2014.
- B. Coüasnon was a reviewer for the PhD of David Hebert, Champs aléatoires conditionnels pour l'extraction de structures dans les images de documents, Université de Rouen, Juin 2013.
- B. Coüasnon was a reviewer for the PhD of Sofiane Medjkoune, Stratégies de fusion pour des signaux écrits et sonores. Application à la reconnaissance d'expressions mathématiques, Université de Nantes Angers Le Mans, Nov. 2013.
- B. Coüasnon was a reviewer for the PhD of Fattah Zirari, Segmentation et indexation d'images de documents, Université de Rouen, Université de Ibn Zohr Agadir, Déc. 2013.

### 9.2 University education

The team is mainly made up of teachers who are very implied in activities of teaching. But a majority of lectures are not rattached to this research topic, so they are not mentioned here.

- E. Anquetil is program manager of the Master of Science *"Innovation Entrepreunership"* of INSA and ESC School of business of Rennes.
- E. Anquetil and B. Coüasnon give lectures at Master-Research *d'informatique* of University of Rennes 1.

- E. Anquetil is in charge of the module "Analyse des documents et des flux audiovisuels pour l'indexation" (FAV) of the Master-Research *d'informatique* of University of Rennes 1.
- B. Coüasnon is in charge of the module on professionalization adapted to research (PROF) of the Master-Research *d'informatique* of University of Rennes 1.
- B. Coüasnon was invited for a course at Master-Research "New technologies applied to History" of the Ecole nationale des Chartes on : "Automatic Access to Old Documents", Paris, France.
- A. Lemaitre was invited for a course at Master *PRANET of Information and Communication* of University of Rennes 2.

# 10 Bibliography

## Major publications by the team in recent years

[1] A. Almaksour, E. Anquetil, "Improving premise structure in evolving Takagi-Sugeno neuro-fuzzy classifiers", *Evolving Systems 2*, 2011, p. 25–33, 10.1007/s12530-011-9027-0, `http://dx.doi.org/10.1007/s12530-011-9027-0`.

[2] A. Almaksour, E. Anquetil, "ILClass: Error-Driven Antecedent Learning For Evolving Takagi-Sugeno Classification Systems", *Applied Soft Computing*, 0, 2013, `http://www.sciencedirect.com/science/article/pii/S1568494613003414`.

[3] B. Coüasnon, J. Camillerapp, I. Leplumey, "Access by Content to Handwritten Archive Documents: Generic Document Recognition Method and Platform for Annotations", *International Journal on Document Analysis and Recognition, IJDAR 9*, 2-4, 2007, p. 223–242, `http://springerlink.com/content/5843461264501u81/`.

[4] B. Coüasnon, "DMOS, a Generic Document Recognition Method: Application to Table Structure Analysis in a General and in a Specific Way", *International Journal on Document Analysis and Recognition, IJDAR 8*, 2-3, June 2006, p. 111–122.

[5] A. Delaye, E. Anquetil, "HBF49 feature set: A first unified baseline for online symbol recognition", *Pattern Recognition 46*, 1, 2013, p. 117 – 130.

[6] A. Lemaitre, J. Camillerapp, B. Coüasnon, "Multiresolution Cooperation Improves Document Structure Recognition", *International Journal on Document Analysis and Recognition (IJDAR) 11*, 2, November 2008, p. 97–109.

[7] S. Macé, E. Anquetil, "Eager interpretation of on-line hand-drawn structured documents: The DALI methodology", *Pattern Recognition 42*, 12, 2009, p. 3202 – 3214, New Frontiers in Handwriting Recognition.

[8] S. Macé, E. Anquetil, "Exploiting on-the-fly interpretation to design technical documents in a mobile context", *Journal on Multimodal User Interfaces 4*, 2011, p. 129–145.

[9] S. Quiniou, M. Cheriet, E. Anquetil, "Error handling approach using characterization and correction steps for handwritten document analysis", *International Journal on Document Analysis and Recognition (IJDAR) 15*, 2012, p. 125–141.

## Doctoral dissertations and "Habilitation" theses

[10] J. Chazalon, *Interprétation contextuelle et assistée de fonds d'archives numérisés : application à des registres de vente du XVIIIe siècle*, PhD Thesis, INSA de Rennes, jan 2013.

## Articles in referred journals and book chapters

[11] A. Almaksour, E. Anquetil, "ILClass: Error-Driven Antecedent Learning For Evolving Takagi-Sugeno Classification Systems", *Applied Soft Computing*, 0, 2013, p. –, `http://www.sciencedirect.com/science/article/pii/S1568494613003414`.

[12] A. Delaye, E. Anquetil, "HBF49 feature set: A first unified baseline for online symbol recognition", *Pattern Recognition 46*, 1, 2013, p. 117 – 130.

[13] S. Fleury, E. Jamet, E. Loup-Escande, A. Ghorbel, A. Lemaitre, E. Anquetil, "Towards Specifications for Automatic Recognition Software: An Example of a User-Centred Design", *Journal of Software Engineering and Applications 6*, 2013, p. 1–4.

[14] A. Ghorbel, A. Almaksour, A. Lemaitre, E. Anquetil, *Incremental learning for interactive sketch recognition*, *LNCS 7423*, Springer Berlin / Heidelberg, 2013, p. 108–118.

[15] A. Ghorbel, E. Anquetil, J. Camillerapp, A. Lemaitre, "IMISketch: an interactive method for sketch recognition", *Pattern Recognition Letters 35*, 2014, p. 78–90.

[16] A. Lemaitre, H. Mouchère, J. Camillerapp, B. Coüasnon, *Interest of syntactic knowledge for on-line flowchart recognition*, *LNCS 7423*, Springer Berlin / Heidelberg, 2013, p. 89–98.

[17] R. Plamondon, C. O'Reilly, J. Galbally, A. Almaksour, E. Anquetil, "Recent Developments in the Study of Rapid Human Movements with the Kinematic Theory: Applications to Handwriting and Signature Synthesis.", *Pattern Recognition Letters 35*, 2014, p. 225–235.

## Publications in Conferences and Workshops

[18] M. Bouillon, E. Anquetil, A. Almaksour, "Decremental Learning of Evolving Fuzzy Inference Systems, Application to Handwritten Gestures Recognition", *in : International Conference on Machine Learning and Data Mining (MLDM'2013)*, *Lecture Notes in Computer Science*, Springer Berlin Heidelberg, p. 115–129, New-York, USA, 2013.

[19] M. Bouillon, E. Anquetil, A. Almaksour, "Étude des techniques d'oubli dans les moindres carrés récursifs pour l'apprentissage de classifieurs évolutifs : application à la reconnaissance de formes", *in : 13e Conférence Francophone sur l'Extraction et la Gestion des Connaissances*, Herman, p. 15–24, Toulouse, France, January 2013.

[20] M. Bouillon, P.-Y. Li, E. Anquetil, G. Richard, "Using Confusion Reject to Improve (User and) System (Cross-)Learning of Gesture Commands", *in : Intenational Conference on Document Analysis and Recognition (ICDAR'13)*, p. 1017–1021, 2013.

[21] C. Carton, A. Lemaitre, B. Coüasnon, "Fusion of statistical and structural information for perceptive vision", *in : Intenational Conference on Document Analysis and Recognition (ICDAR'13)*, p. 1242–1246, 2013.

[22] C. Carton, A. Lemaitre, B. Coüasnon, "LearnPos: a new tool for interactive learning positioning", *in : Document Recognition and Retrieval XXI*, 2014. to appear.

[23] S. Fleury, A. Ghorbel, A. Lemaitre, E. Anquetil, E. Jamet, "User-centred design of an interactive off-line handwritten architectural floor plan recognition", *in : Intenational Conference on Document Analysis and Recognition (ICDAR'13)*, 2013.

[24] A. Lemaitre, J. Camillerapp, B. Coüasnon, "Handwritten text segmentation using blurred image", *in : Document Recognition and Retrieval XXI*, 2014. to appear.

[25] A. Lemaitre, J. Camillerapp, "HIP 2013 FamilySearch Competition - Contribution of IRISA", *in : ICDAR Historical Image Processing Workshop (HIP2013)*, 2013.

[26] P. Li, E. Anquetil, "Graphical Gesture Commands[U+0092] learning with the help of Customizable Gesture Menus", *in : 16th International Graphonomics Society Conference (IGS 2013)*, p. 74–77, 2013.

[27] P. Li, M. Bouillon, E. Anquetil, G. Richard, "User and System Cross-Learning of Gesture Commands on Pen-Based Devices", *in : Human-Computer Interaction – INTERACT*, *Lecture Notes in Computer Science*, Springer Berlin Heidelberg, p. 337–355, Cape Town, South Africa, 2013.

[28] Y. Ricquebourg, B. Coüasnon, L. Guichard, "Evaluation of lexicon size variations on a verification and rejection system based on SVM, for accurate and robust recognition of handwritten words", *in : Document Recognition and Retrieval XX*, 2013.

[29] Y. Ricquebourg, C. Raymond, B. Poirriez, A. Lemaitre, B. Coüasnon, "Boosting bonsai trees for handwritten-printed text discrimination", *in : Document Recognition and Retrieval XXI*, 2014. to appear.

[30] R. Sekkal, F. Pasteau, M. Babel, B. Brun, I. Leplumey, "Simple Monocular door detection and tracking", *in : IEEE Int. Conf. on Image Processing, ICIP'13*, Melbourne, Australie, September 2013, http://hal.inria.fr/hal-00845459.