Project-Team IntuiDoc

Intuitive user interaction for document

Rennes

Activity Report

2015

Contents

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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.

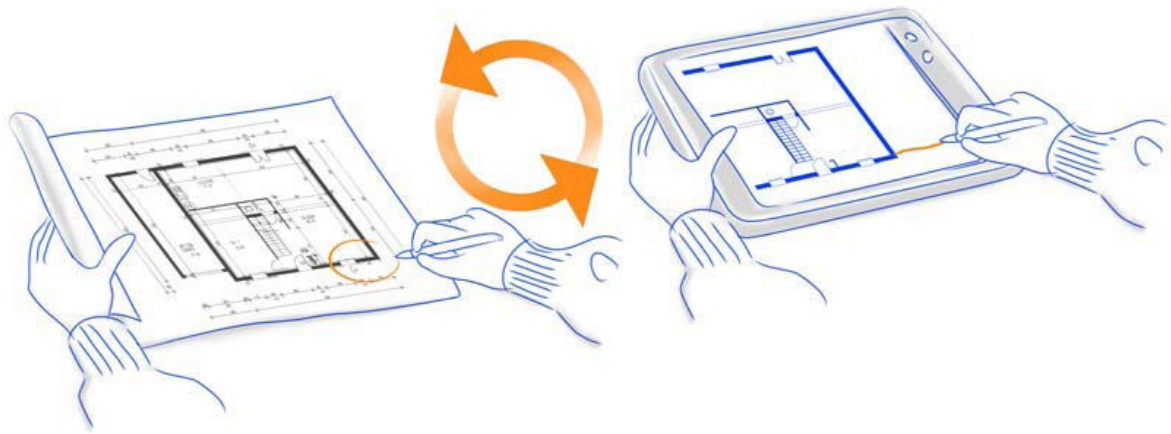

Figure 1: Continuum from paper document to digital interpreted document

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, Ipad...*),
- 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 software based on Evolve++ for the application domain of graphical gesture recognition for multi-touch devices. *Evolve-Touch* offer a complete framework 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. In 2014 we focused on bringing a qualitative evaluation of gestures. 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 and US patents* (N° 2995704 / 14/429,649). In 2014, EvolveTouch was made available for *Android*, *WinRT* and *iOS* tablet systems.

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*.

In 2015, Varchitect was downloaded more than 7000 times

5.4 Vscript: Android tablet application based on Evolve++/EvolveTouch

Contact: Eric Anquetil

Keywords: Incremental recognition, Evolving system, Gestures and Symbols Recognition, Learning, Handwriting, Tablet, Android..

Vscript is an Android application that was developped as part of the effort to port the *Evolve++/EvolveTouch* system to current tablet operating systems. It is available on the Android's Play Store at https://play.google.com/store/apps/details?id=fr.irisa.intuidoc.vscript

Vscript is a handwriting learning application for children. It is meant to be used on android tablets with a stylus, although touch input is supported. In this application the children are following a series of exercises of increasing challenge from identifying shapes for reproducing symbols (shapes, letters, numbers) and ultimately composing pictures and words. EvolveTouch is used to interpret the handwriting by recognizing symbols and giving indications of quality.

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

5.5 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".

5.6 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 [13] [12].

5.7 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;
- 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.
- JournRead: a software for the recognition of old newspaper content structured in headlines, articles with title and author, graphics and tables. This software has been developed with a *SATT Ouest Valorisation* development fund;
- MaurdorRead: a software for the structure recognition of heterogeneous and multi-language documents, with handwritten, printed or mixed content. This software has been developed in the context of a PEA (Programme d'Etude Amont - upstream study program) from the DGA (French Ministry of Defense).

5.8 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 5.7 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.

5.9 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.

5.10 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...).

Finally, motivated by our current perspective of experimenting CRFs on images, we are facing the difficulty to find implementations for general CRF use and able to process in the continuous domain of numerical data needed by image processing (whilst not theoretically compulsory, usual recommended implementations are restricted to symbolic data). To handle images, some implementations propose a workaround using a neuronal system to handle numeric data from images. But the CRF system is only on top of outputs of this subsystem, as a superior layer and as a posterior processing (RNNSharp from Microsoft, Hidden-Unit Conditional Random Fields, ...) Thus we work to add a fully numerical implementation of CRFs, from existing generic symbolic implementations (like CRF++ or Wapiti).

6 New Results

6.1 Eyes Wide Open: an interactive learning method for the design of rule-based systems

Participants: Cérès Carton, Aurélie Lemaitre, Bertrand Coüasnon.

A critical step of syntactical methods for document image analysis is the adaptation of a system to a new kind of documents. As a matter of fact, this learning step is harder to do if no annotated learning database is available for the design of the document recognition system. We propose a new general method to extract knowledge and infer rules from non annotated documents. The analysis is based on the study of redundancies of extracted elements from documents in large databases.

One of the major properties of these automatically extracted elements is that they are not completely reliable. To be able to use them for the inference of the rules, we propose the introduction of a data reliability enhancement step which allows us to create a pseudo ground truth. This step is based on the use of clustering techniques and interaction with the user that brings sense to the data. The pseudo ground truth is then used in the Eyes Wide Open method for the learning of rules for syntactical recognition systems.

This method has been validated by producing a grammatical description for the recognition of the structure of Mexican marriage records from the FamilySearch HIP2013 competition database. The results demonstrate that we successfully automatically infer rules from non annotated documents using the redundancy of extracted elements of the documents. This work has been published in [15].

6.2 Strategies of analysis for field extraction in Mexican marriage records

Participants: Aurélie Lemaitre, Jean Camillerapp, Cérès Carton, Bertrand Coüasnon

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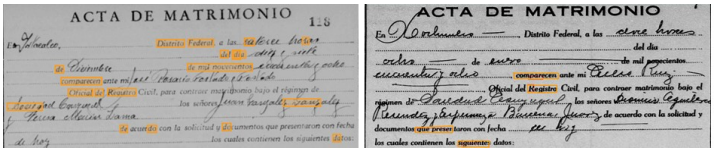
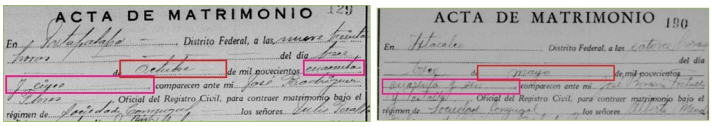
We worked on a database proposed in ICDAR'2013 HIP Family Search Competition. This competition focuses on Mexican marriage records that are used by the genealogists. We focus on the first task of this competition that aims at locating in documents the handwritten fields, called Regions Of Interest (ROI), inside of the records, that contains month and year.

Our analysis is based on the extraction of printed words. Those words are extracted by the study of the arrangement of local descriptors called Points of Interest (POI) [Low04].

However, we have to face with two difficulties of this database: (1) the bad quality of the documents and the interactions between printed and handwritten text makes difficult the extraction of printed keywords in the documents, even with the POI method. Consequently, we have to face with the lack of extracted keywords (figure 2(a));(2) the database contains many versions of pre-prints for registers (figure 2(b)). Consequently, it is not possible to directly apply a mask for the detection of fields, and we have to be able to adapt to any pre-print.



(a) Some printed keywords are not detected



(b) The preprint forms can vary a lot

Figure 2: Two main difficulties of the database

In this synthesis work, we have implemented and compared four approaches. Their properties are summerized in table 1

The *empirical method* is based on a manual analysis of the database: we have manually estimated that there was about 4 kinds of preprints in the collection of documents. We manually produced 4 grammatical descriptions corresponding to the 4 pre-prints. This method obtains good results but cannot be adapted to new kinds of preprints.

The *logical method* aims at describing the logical configuration of the elements in text blocks. It has a good faculty of adaptation to new kinds of models, but cannot infer the missed keywords.

The *statistical method* has been proposed in the thesis of Cérès Carton (see section 6.1). The system of analysis has been generated after a statistical analysis of the collection. This system automatically produced 11 templates of pre-prints. It is able to deal with the absence of keywords, but cannot infer new kinds of models, if they were not in the learning database.

The *mixed method* takes the advantage of the two previous methods. The logical method is applied if enough keywords are found. Otherwise, the statical method is applied.

The results of table 1 shows that the mixed version obtains the better results. Indeed, the fusion of logical information and statistical analysis enable to improve the localisation rates. A journal paper has been submitted to the IJDAR on this topic.

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

Method	Ability to deal with missed keywords	Ability to deal with variable preprints	Recognition rate at field level	False recognition
Empirical	+	-	90.2%	5.8%
Logical	-	++	88.4%	9.8%
Statistical	++	+	90.1%	4.7 %
Mixed	++	++	92.6%	3.8%

Table 1: Comparative results of the four approaches: the best results are obtained by the fusion of statistical and logical information in the mixed version.

6.3 Extraction of new visual clues

Participants: Jean Camillerapp, Bertrand Coüasnon.

The DMOS method was proposed by Bertrand Coüasnon in his Phd-thesis in 1996. It was based on two kinds of visual clues:

- Line segments, even distorted,
- Connected components of black pixels.

Thereafter these visual clues have been increased. Presently we worked on two new kinds of clues:

- Specific clues for music,
- Clues extracted from PDF files.

Clues suited to music scores

When the print quality of a document is good enough, the different elements are well segmented. Otherwise it is necessary to introduce specific knowledge for detecting segmentation errors and correct them.

At first we worked on the beams detection. The image (figure 3(a)) shows a group of notes as it appears in the image after the detection and the erasing of staff lines.

(a) Notes whitout staff lines (b) Extracted horizontal segments (c) New connected components

Figure 3: Segments and connected components

We extract horizontal segments by the classical method used by DMOS (figure 3(b)) and we build a new set of connected components by eliminating all horizontal run-length too short (figure 3(c)).

The major part of extracted segments correspond to the beams, allowing to estimate the thickness of a beam in this image. The image (figure 4(a)) shows this segments: some segment has been eliminated.

The combination of segments (figure 4(a)) and components (figure 3(c)) enables to detect the components that define a group. Splitting these components according to their thickness in each

(a) Segments of a group (b) Number of beams (c) Beams proposed

Figure 4: Extraction of beams

column, is used to estimate the number of beams. Figure 4(b) shows, in red the part that must contain two beams, in blue those that must contain three, and in green those that do not contain enough segments. This allows to achieve the proposed segmentation (figure 4(c)).

Clues extracted from PDF files

If for old documents, the image remains the usual source, for recent documents it is possible to have a digital-born PDF version. We know, of course, to generate an image from PDF file and it could be possible to recognize the structure of the document from this image. But in that case some information is degraded or lost.

PDF is a description language of the visual appearance of the page. In some applications it is advantageous to extract the logical structure of the document: breaking down in columns for the press, extracting tabular structures, understanding outlines.

We experiment to extract clues from PDF files. Those clues become some complementary information to visual clues extracted from the image or may replace them.

Depending on the used font, it is possible to extract text strings with their positions on the page. The PDF splitting a text into substrings is somewhat arbitrary. In particular, it depends from the text alignement. It must be possible to provide to DMOS which looks like the output of an OCR but without recognition error.

Graphical primitives inside PDF are not numerous, but they allow to generate very complex drawings. It should be investigated, according to the application, what groupings are significant.

6.4 Processing old newspapers

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

This development project from *SATT Ouest Valorisation* extended with a founding of *Rennes Métropole*, applies the DMOS-P multiresolution grammatical analysis to French newspapers from the 19th and 20th centuries. It started in September 2013 and ended in February 2015 (see section 7.4). We developed a robust system for extracting headlines, articles with their title and author, as well as tables and graphics in scanned old 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. To enhance text recognition rate, we combined in DMOS-P the grammatical description of the page with the use of the Abbyy FineReader OCR software at two image resolutions. Tables are recognized and included in the article contents.

Reading order is detect in articles, the title is extracted, based on typography, layout and textual clues. Recurring sections of newspapers (sports, columns, etc.) are discovered using clustering and

textual distance, and injected into the system to refine the analysis. Title pages are recognized and segmented accordingly. Advertisements (pictures interlaced with text) are recognized and tagged.

New results in 2015 were focused on global improvements of the system.

6.5 Transcription of whole words using CRFs

Participants: Yann Ricquebourg, Christian Raymond (IRISA/LinkMedia), Bertrand Coüasnon.

Convinced by the interest of CRFs (that became state of the art tools in Natural Language Processing particularly with their good property to handle the whole sequential aspect of a text, we experiment it to get transcriptions of isolated word images (extracted from documents), facing two usual difficulties to adapt it to image domain:

- The problem of segmentation necessary to get the sequences to train the system;
- The problem of usual implementations of CRFs restricted to symbolic data (that is to say non numeric data) not adapted to features extracted from images.

We have a discretization algorithm of numeric data allowing to feed non numeric CRF implementations "on the shelf" (e.g. Wapiti) related to an over-segmentation of the input word pixels with a sliding window of regular size along the word (proportionnal to its height).

Arbitrary over-segmenting being not satisfying to correctly train a system, but the the process chain remaining promising, we modify the first step to resort to manually segmented data (using an efficient helper UI) or segmentations outputed by an previous system of word recognition in our team using HMM (+SVM). The main goal is take benefit of such a paradigm natively integrating sequential context in the recognition, while not resorting to recurrent neuronal approaches currently outperforming among others, while being tricky to tune and long to train.

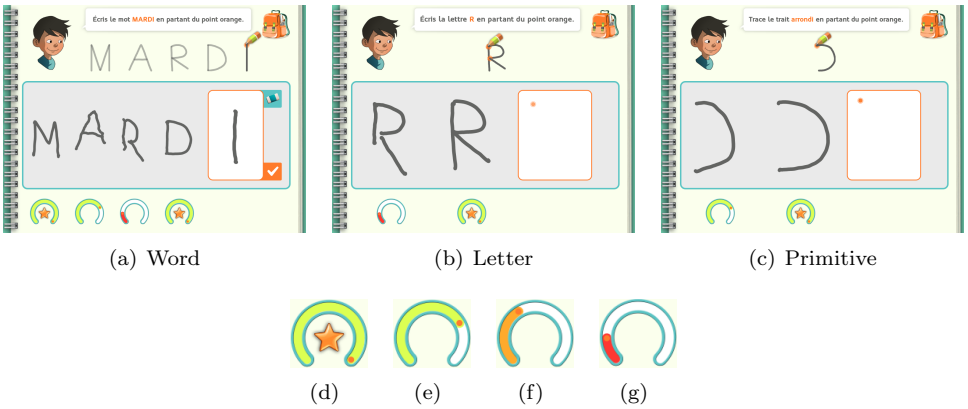
6.6 Online Active Learning of an Evolving classifier

Participants: Manuel Bouillon, Eric Anquetil.

Using gesture commands is a new way of interacting with touch sensitive interfaces. In order to facilitate user memorization of several commands, it is essential to let the user customize the gestures. This applicative context gives rise to a cross-learning situation, where the user has to memorize the set of commands and the system has to learn and recognize the different gestures.

This situation implies several requirements, from the recognizer (*Evolve* ∞) and from the system that supervises its learning process (*IntuiSup*). For instance, the recognizer has to be able to learn from few data samples, to keep learning during its use and to follow indefinitely any change of the data flow. The supervisor has to optimize the cooperation between the recognizer and the system to minimize user interactions while maximizing recognizer learning.

Online active supervisor: *IntuiSup* This year, we have finalized the design of the online active supervisor *IntuiSup*. *IntuiSup* optimizes user interactions to train a classifier when the user is in the training loop, for instance, during customized gesture command use. The proportion of data that is labeled by the user evolves to adapt to problem difficulty and to follow environment evolution (concept drifts). The use of a boosting method optimizes the timing of user interactions to maximize their impact on classifier learning process.



(a) Word (b) Letter (c) Primitive

(d) (e) (f) (g)

Figure 5: Hierarchical methodology that enables children to be autonomous by first analysing letters of a word (a), and then working on letters (b) and primitives (c) if it is required. On-line feedback is given with a colour scale indicator drawn under each gesture with the following colouring code: very good (green with yellow star) (d), good (green) (e), average (orange) (f) and incorrect (red) (g).

Evolving recognition system: *Evolve* ∞ The classifier *Evolve* ∞ has been used for handwriting quality analysis [14], in the context of the IntuiScript project (cf. section 6.9 and section 7.3). The IntuiScript project aims at developing a digital workbook to help with teaching children how to handwrite. To do so, we must be able to analyse their handwriting, to evaluate if the letters are correctly written, and to detail what aspects of the child symbols – letters, numbers, and geometric forms - do not correspond to the teacher models. We use an online fuzzy model to easily build target models, and to automatically evaluate the adequacy of children letters to these reference models, with respect to different aspects: symbol shape, drawing direction and stroke order for example (see Figure 5).

This new results have been presented in the 17th Conference of the International Graphonomics Society (IGS'15) and obtained the best student paper award [14].

6.7 Direct and Indirect multi-touch gesture pre-recognition and multi-user detection problem

Participants: Zhaoxin Chen, Eric Anquetil, Christian Viard Gaudin (IRCCYN NANTES), Harold Mouchère (IRCCYN NANTES).

This work is funded by the Impact ARED project:(Brittany and Pays de la Loire region/Insa grant - cf. section 8.1.1). This project is the result of the collaboration between IRISA/IntuiDoc and IRCCYN laboratories. The goal is to design a new process to recognize and interpret multi-touch interactions. It aims to extend the composition capability of complex structured documents (architectural plan, diagram, mathematical expressions ...) with multipoint interaction on touch-screen.

For the multi-touch gesture recognition problem, we develop a modelling and recognition method to interpret a multi-touch gesture for command shortcut purpose(see Figure 6). A graph modelling approach is used to represent the multi-touch gesture by extracting its shape features and inner-stroke spatial and temporal relation features. The recognition process is a graph matching problem and we explore specific graph embedding approach. The first results of this work has been published in the 17th Conference of the International Graphonomics Society [16]. Moreover, since multi-touch gesture are usually used as direct manipulation in the common sense, we try to explore how can the multi-touch

gestures be used both for command shortcut and manipulation in a same context. It requires a very sensitive recognition system that should be able to reject the incomplete command purpose gesture and accept manipulation purpose gesture in the very early stage of a multi-touch gesture. To this end, we develop a multi-classifier reject/accept algorithm which dynamically recognizes a multi-touch gesture during its performing and determines if it should be accept or reject.

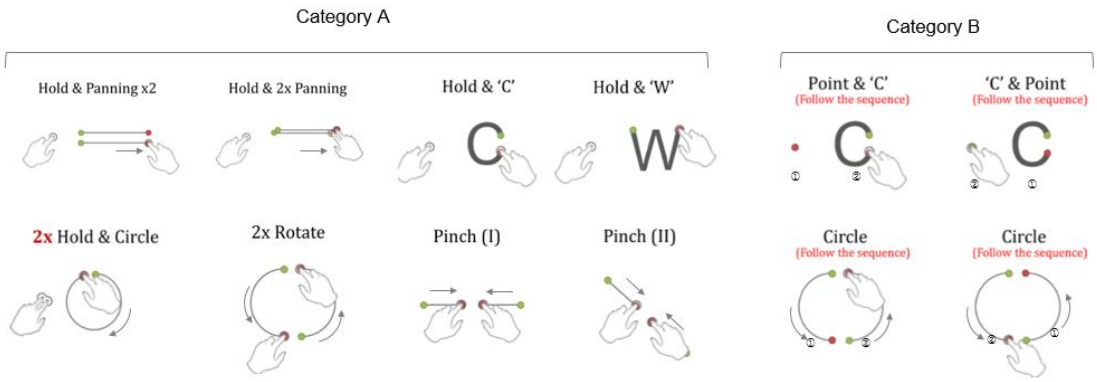


Figure 6: Samples from the gesture database. Category A contains gestures in which the trajectories are synchronously performed. B consists of two sequential mono-touch gestures which are distinguished from written order.

This year, we start a new collaboration with Excence company (cf. section 7.1) to explore a new dimension of this work: the multi-user interaction. The goal is to segment and recognize on the fly the multi-touch gestures perform by several users in the same time and on a same device such as interactive widescreen. This year, we design and collect an new and original multi-user and multi-touch gesture dataset for this research based on a collaborative mind-map application.

6.8 The *IntuiScript* project: Handwriting Quality Analysis with Online Fuzzy Models

Participants: Damien Simonnet, Eric Anquetil, Mickael Renault.

IntuiScript (*http://intuiscript.com/*) is a three years research project founded by the French government as part of innovative projects (BPI) in the e-education field It targets the introduction of innovative services and digital contents in the development of fundamental skills at school (see section 7.3).

The main objective of the *IntuiScript* project is to offer an advanced digital writing learning experience at school by using tablet and tactile digital devices (with finger touch and stylus).

After publishing first results in the international conference IGS about block letter analysis in [14], the *IntuiScript* project has extended results by firstly submitting a research paper entitled *Multi-Criteria Handwriting Quality Analysis with Online Fuzzy Models* to the journal *IEEE Transactions on Human-Machine Systems* and secondly applying the analysis approach to cursive letters.

6.8.1 Multi-Criteria Handwriting Quality Analysis with Online Fuzzy Models

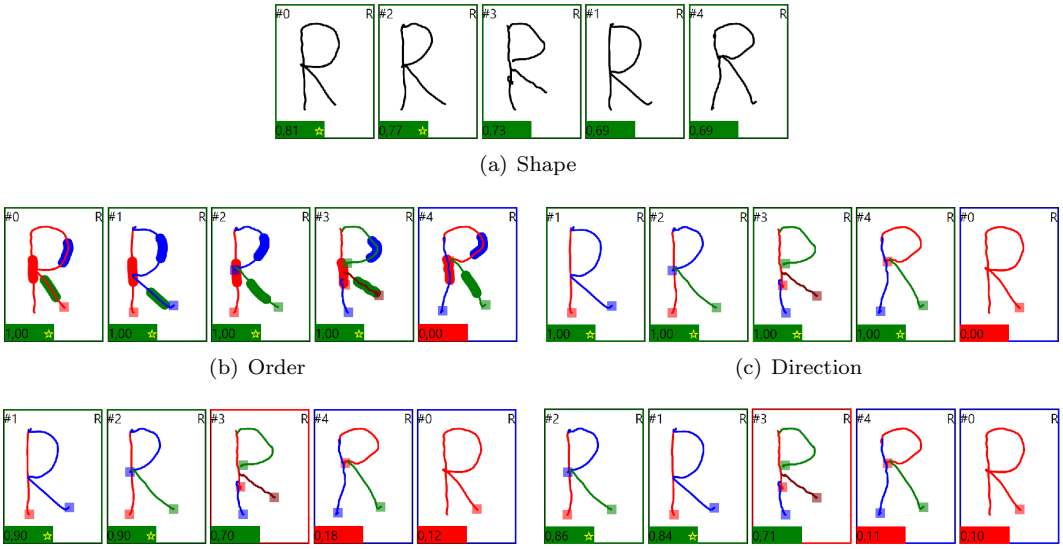
In the context of the development of a digital workbook providing feedback during the handwriting learning process, this work presents an approach to analyse handwriting quality with regards four different aspects: *global*, *shape*, *order* and *direction* and introduces a *multi-criteria* architecture with

hierarchical dependencies (*e.g. order* and *direction* depend on *shape*) and a precise characterisation of each criteria with specific features.

This work has shown significant improvements of the results on a dataset collected in four preschools with 171 children:

- *multi-criteria* : the analysis error of negative gestures decreases of 33% without changing analysis rate of positive gestures (*i.e.* 99%).
- *shape* : the analysis error for positive and negative gestures decreases of 33% and 27% (analyses rates on positive and negative samples are respectively 96% and 92%).
- *order* : the analysis error for positive and negative gestures decreases of 96% and 97% (analyses rates on positive and negative samples are respectively 98% and 99%).
- *direction* : the analysis error for positive and negative gestures decreases of 67% and 98% (analyses rates on positive and negative samples are respectively 98% and 99%).

Qualitative results are presented in Figure 7 and show a continuous degradation of the final score (*i.e. multi-criteria*) with the degradation of the letter, and the ability to detect specific errors (*e.g. order* and *direction*).



(a) Shape

(b) Order

(c) Direction

(d) Global

(e) Multi Criteria

Figure 7: Qualitative results on the five criteria with positive shapes and where strokes are coloured from the first to the fourth with red, blue, green and brown (the end of each stroke being represented with an alpha colour rectangle). In (b) median strokes are represented with thicker lines.

In-class experiments conducted with the *global* classifier have shown that children get quickly familiar with the application and try to improve the evaluation score that is well understood. Moreover, the personalised feedback allows children to progress with autonomy at their own speed, and to stay concentrated during the whole session of 20 minutes which is difficult for young children.

New criteria introduced in this paper (*i.e. multi-criteria*, *shape*, *order* and *direction*) will be used in the next in-class experiments.

6.8.2 Handwriting Analysis of Cursive Letters

This work takes place in the second stage of experiments conducted by the *IntuiScript* project about the cursive handwriting analysis, and concentrates on the development of an analyser providing a *global* feedback to children. Therefore, the approach used for block letters has been improved by adding features related to descending areas which is a stable part in the cursive writing. Experiments illustrated by Figure 8 are still done with week words, therefore specific models have been trained for all letters, couple of letters and triplet of letters associated to those words.

The next step consists of including a word segmentation approach previously developed by IntuiDoc (cf. section 5.1) to extract from a gesture the set of characters, and then to use the previous letter classifier to analyse the word recognised. Consequently, the approach will be more flexible and practical for any set of words as there is no need to train models for couples and triplets associated.

(a) Letter (b) Letter couple (c) Letter triplet

Figure 8: Qualitative results about the cursive handwriting on letters (a), couples (b) and triplets (c)

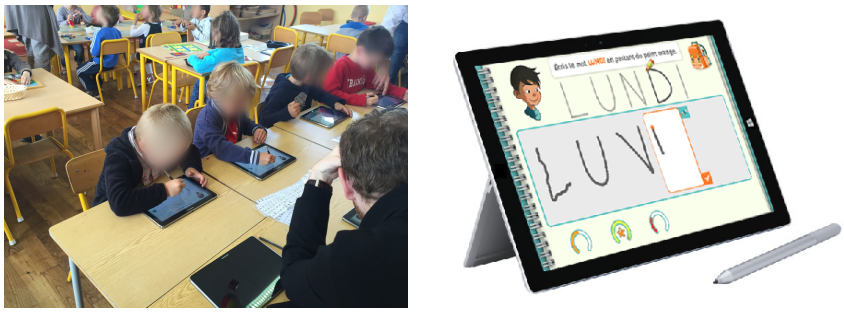
6.9 Digital workbook for the handwriting learning

Participants: Mickael Renault, Eric Anquetil, Damien Simonnet.

In the context of the *IntuiScript* (*http://intuiscript.com/*) project (cf. section 7.3), we have designed in collaboration with SCRIPT&GO company, a digital workbook (see Figure 9). The goal is to help teachers and children from three to seven years old during the handwriting learning process, by giving direct on-line and off-line feedback. This digital workbook includes today four categories of exercises (see Figure 10):

- The first two exercises deal with Block letters and cursive letters handwriting learning. These two exercises focused on the handwriting learning. The digital workbook integrate the automatic handwriting analysis process developed in our research team. The goal is to provide a direct feedback to the children during the handwriting process. We analyse handwriting quality with regards of different aspects: *shape*, *order* and *direction*. This process is based on the work described in section 6.8.1.

- The two other categories of exercises focused on word and shape identification and drawing. Children have to identify in a first step the geometrical shapes in a image (such as a square or a circle) and they have to draw these geometrical shapes using the pen-based interface of the digital workbook. The drawing precision is automatically evaluated to give a direct on-line feedback to the chidren.



(a) (b)

Figure 9: First in-class (a) experiment of the *IntuiScript* project with pen-based tablet devices (b).

(a) (b)

(c) (d)

Figure 10: Categories of exercices developed: block letters (a), words recognition (b), cursive letters (c) and shape recognition (d).

6.10 Transposal of handwriting techniques for 3D skeleton-based action recognition

Participants: Said-Yacine Boulahia, Eric Anquetil, Richard Kulpa, Franck Multon, Manuel Bouillon.

Human action recognition attracts increasing attention among researchers in computer vision. We are currently working on an approach to recognize human actions given sequences of 3D joint positions. Different from most previous skeleton-based approaches, our work does not consist of proposing a new set of features or an original learning method. The approach is rather based on the study of handwriting recognition work in order to explore its transposal to the recognition of 3D actions.

Several studies have been conducted during the last twenty years on the recognition of handwriting trajectories (writing, drawing, 2D gestures, etc.). It seems therefore promising to capture this knowledge and to transpose it to the 3D skeleton gestures which by nature are an extension of gestures produced on a 2D tablet.

In particular, we selected an efficient set of handwriting features, namely HBF49 [5], and proposed to model an action as a modified 2D writing symbol. This approach which we refer to as 3D Multistroke Mapping (3DMM) follows a straightforward recognition strategy since the aim is to measure the potential of such transposal. Figure 11 illustrates the major steps constituting the proposed action recognition approach.

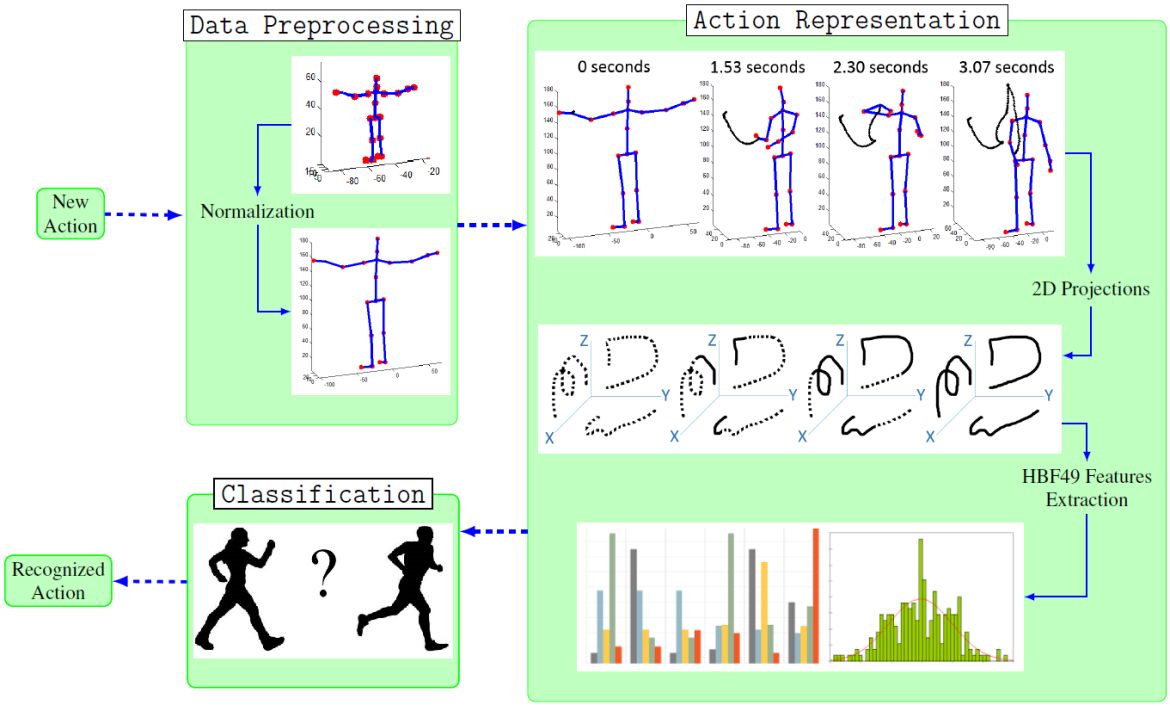


Figure 11: Illustration of the major steps constituting the 3DMM skeleton-based approach (This figure appears in the submitted journal paper (JVCIR)

The effectiveness of the 3DMM approach is evaluated by means of two classical classifiers, namely

Support Vector Machine (SVM) and Multilayer Perceptron (MLP), on three challenging 3D action datasets captured by commodity depth cameras. To illustrate this performance we give in table 2 the obtained results on one of these datasets.

Method	**Recognition rate (%)**
HMIJ + SVM [Ofli, 2014]	84.40
HMIJ + Nearest neighbour [Ofli, 2014]	80.73
SMIJ +Nearest neighbour [Ofli, 2014]	81.65
SMIJ +SVM [Ofli, 2014]	82.57
Dynamic Temporal Warping [Reyes, 2011]	82.08
MIJA/MIRM + LCSS [Pazhoumand, 2015]	85.23
3DMM approach + SVM + 100 best features	91,74
3DMM approach + MLP + 20 best features	**92.66**

Table 2: Comparisons between 3DMM approach and previous approaches by means of two classifiers.

The experimental evaluations attest the validity of this transposal since the introduced approach achieves better results compared to other state of the art algorithms. A journal paper have been submitted to JVCIR on this topic.

7 Contracts and Grants with Industry

7.1 Industrial collaboration contract with Excence company

Participant: Eric Anquetil, Zhaoxin Chen.

- Partners: *Excence*, *IRCCYN NANTES*
- 25 months (2015-2016).
- Contract: INSA

This new contract with Excence company is based on the collaboration between IRISA/IntuiDoc and IRCCYN laboratories with the PhD student Chen Zhaoxin (see section 8.1.1). The PhD topic is to design a new process to recognize and interpret multi-touch interactions. This industrial collaboration is focused on a new dimension of this work: the multi-user interaction. The goal is to segment and recognize on the fly the multi-touch gestures perform by several users in the same time and on a same device such as interactive widescreen.

7.2 Industrial software licensing with SCRIPT&GO company

Participant: Eric Anquetil.

- Partners: *SCRIPT&GO company*
- since 2014
- 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/) and the *IntuiScript* Project (http://intuiscript.com/) which are labelled by the "Images et Réseaux" cluster.

7.3 IntuiScript: National Innovative BPI Project

Participants: Eric Anquetil, Mickael Renault, Damien Simonnet.

- Partners: *SCRIPT&GO company*, *Microsoft*, *Academy of Brittany*, *Region of Brittany*, *LOUSTIC laboratory of Rennes (laboratoire d'obervation des usages des technologies de l'information et de la communication)*
- 32 months (2014-2017).
- 2 resources for IntuiDoc: 1 Research Engineer and 1 Post-Doc .
- Contract: INSA

IntuiScript (*http://intuiscript.com/*) is a three years research project founded by the French government as part of innovative projects (BPI) in the e-education field targeting the introduction of innovative services and digital contents in the development of fundamental skills at school.

The main objective of the *IntuiScript* project is to offer an advanced digital writing learning experience at school by using tablet and tactile digital devices (with finger touch and stylus). This project is structured around the conception of a digital workbook to help teachers and children from three to seven years old during the handwriting learning process, by giving on-line and off-line feedback. The former gives a personalised feedback to children to help them to learn from their mistakes with autonomy by presenting them adapted pedagogic content. The latter is a detailed analysis for teachers to evaluate the content of the digital workbook composed of the historic of all letters written by a children.

A user-centered design approach is used in the development of this digital workbook: modules are designed by educational experts followed by experiments in school to use feedback from children and teacher to improve the pedagogical approach of exercises performed on tactile digital devices.

The validation of this research project is based on experiments performed in school from half day to a month with a large number of French primary school students in Brittany. Currently, two sessions of experiments have been conducted, the first one occured in june 2015 in Rennes area, the second one which have opened the project to other schools from brittany (Brest, Quimper, Saint Brieuc,...) took place in december 2015. During these experimentations, more than 1000 children distributed in 18 schools have participated.

The Intuiscript project has been featured in several french television news bulletin:

- TV France 3 Bretagne (12/10/2015) : https://vimeo.com/142233890
- TV 12h45 de M6 (28/09/2015) : https://vimeo.com/140660028

7.4 Old Newspaper project 2: Rennes Métropole development fund

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

- Partner: Rennes Métropole
- Contract: INSA
- 6 months (2014-2015)

This project continues the *SATT Ouest Valorisation* development fund "Old Newspaper", started in 2013, with a funding from Rennes Métropole, 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 extract the newspaper content structured in headlines, articles with title and author, graphics and tables. Results are presented in section 6.4.

8 Other Grants and Activities

8.1 National initiatives

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

Participants: Eric Anquetil, ZhaoXin Chen, Christian Viard Gaudin (IRCCYN NANTES), Harold Mouchère (IRCCYN NANTES).

- 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 touch screen (see section 6.7). This project is supervised by Prof. E. Anquetil (INSA of Rennes) and Prof. C. Viard-Gaudin (Univ. of Nantes) in collaboration with assistant Prof. Harold Mouchère(Univ. of Nantes).

8.1.2 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 (see section 6.1).

8.2 International initiatives

9 Dissemination

9.1 Leadership within scientific community

9.1.1 Program Chair and Committee

- B. Coüasnon is Organizing Chair of the International Workshop on Historical Document Imaging and Processing (HIP 2015) [10].
- E. Anquetil is Program Chair of the 17th Conference of the International Graphonomics Society (IGS 2015) [11].
- E. Anquetil is Guest editor of the Special Issue on "Drawing and Handwriting Processing for User-Centered Systems" IEEE Transactions on Human-Machine Systems.
- E. Anquetil, B. Coüasnon and A. Lemaitre are members of the program committee of the International Conference on Document Analysis and Recognition (ICDAR 2015).
- A. Lemaitre is member of the program committee of the International Workshop on Historical Document Imaging and Processing (HIP 2015).
- B. Coüasnon is member of the program committee of the International Workshop on Graphics Recognition (GREC 2015).
- E. Anquetil is members of the program committee of the International Conference on Frontiers in Handwriting Recognition (ICFHR 2016).
- E. Anquetil and A. Lemaitre are members of the program committee of the "Colloque International Francophone sur l'Écrit et le Document" (CIFED 2016).
- B. Coüasnon is General Chair of the "Colloque International Francophone sur l'Écrit et le Document" (CIFED 2016).

9.1.2 Reviewing

- E. Anquetil is a reviewer in 2015 of:
  - IEEE Transactions on Human-Machine Systems ;
  - IJDAR (International Journal on Document Analysis and Recognition);
  - PR (Pattern Recognition).
- B. Coüasnon is a reviewer in 2015 of:
  - IJDAR (International Journal on Document Analysis and Recognition);
  - PR (Pattern Recognition).
- A. Lemaitre is a reviewer in 2015 of:
  - PR (Pattern Recognition);
  - IJDAR (International Journal on Document Analysis and Recognition).

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.
- E. Anquetil is an elected member of the 27e section of the CNU council of INSA.
- B. Coüasnon is an elected member of the laboratory council of the INSA component of IRISA.

9.1.4 Participation to PhD and HDR defenses

- E. Anquetil was a reviewer for the PhD of Anh Khoi NGO HO, Méthodes de classifications dynamiques et incrémentales, Application à la numérisation cognitive d'images de documents, Université de Tours, Mars 2015.
- B. Coüasnon was a member of the PhD committee of the PhD of Luc Mioulet, Reconnaissance de l'écriture manuscrite avec des réseaux récurrents, Université de Rouen, Juillet 2015.
- B. Coüasnon was a member of the PhD committee of the PhD of Bingqing Qu, Inférence de la grammaire structurelle d'une émission TV récurrente à partir du contenu, Université de Rennes 1, Déc. 2015.

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 and 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 two courses at Master-Research "New technologies applied to History" of the Ecole nationale des Chartes on : "Digital Documents: Textual Documents" and "Automatic Access to Old Documents", Paris, France.

9.3 Patent and Deposit of digital creations (APP)

9.3.1 Patents

- E.Anquetil, A. Almaksour and G. Richard deposited a Europeen and US Patents on "Evolve Touch" technology - N° 2995704 / 14/429,649 : "Méthode de sélection de mode d'interactivité" (see section 5.2)

9.3.2 Deposit of Digital creations (APP)

- E.Anquetil, A. Almaksour and G. Richard deposited sevral digital creations (APP) on "Evolve Touch" technology (see section 5.2)
  - EvolveTouch.Net : api IHM, windows .net version IDDN.FR.001.540005.000.S.P.2015.000.10000
  - EvolveTouch.winRT : api IHM, windows Store version IDDN.FR.001.540004.000.S.P.2015.000.10000
  - EvolveTouch.JNI : api IHM, android version IDDN.FR.001.540006.000.S.P.2015.000.10000
  - EvolveTouch.ios : api IHM, ios version IDDN.FR.001.540008.000.S.P.2015.000.10000
  - ShowCase Evolve : Windows EvolveTouch ShowCase IDDN.FR.001.530013.000.S.P.2015.000.10000
  - Varchitect - Windows Store: (https://www.microsoft.com/fr-fr/store/apps/varchitect/9wzdncrdh6w0) IDDN.FR.001.530015.000.S.P.2015.000.10000
  - Vscript - Google Play (https://play.google.com/store/apps/details?id=fr.irisa.intuidoc.vscripthl=fr) IDDN.FR.001.530014.000.S.P.2015.000.10000

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.

Books and Monographs

[10] B. Coüasnon, B. Barrett, V. Frinken, H. Amiri, V. Märgner (editors), *HIP '15: Proceedings of the 3rd International Workshop on Historical Document Imaging and Processing*, New York, NY, USA, ACM, 2015. To appear.

[11] C. Rémi, L. Prévost, E. Anquetil (editors), *Drawing, Handwriting Processing Analysis: New Advances and Challenges*, Pointe-à-Pitre, Guadeloupe, 2015.

Articles in referred journals and book chapters

[12] S. Fleury, E.Jamet, A. Ghorbel, A. Lemaitre, E. Anquetil, "Application of the Resources Model to the Supervision of an Automated Process.", *Human-Computer Interaction 30:2*, 2015, p. 103–121, `https://hal.inria.fr/hal-01089413`.

[13] A. Ghorbel, A. Lemaitre, E. Anquetil, S. Fleury, E. Jamet, "Interactive interpretation of structured documents: Application to the recognition of handwritten architectural plans", *Pattern Recognition 48*, 8, 2015, p. 2446 – 2458, `http://www.sciencedirect.com/science/article/pii/S0031320315000473`.

Publications in Conferences and Workshops

[14] M. Bouillon, E. Anquetil, "Handwriting Analysis with Online Fuzzy Models", *in : Proceedings of the 17th Conference of the International Graphonomics Society (IGS'15)*, p. 71–74, 2015.

[15] C. Carton, A. Lemaitre, B. Coüasnon, "Automatic and interactive rule inference without ground truth", *in : 13th International Conference on Document Analysis and Recognition*, 2015.

[16] Z. Chen, E. Anquetil, H. Mouchère, C. Viard-Gaudin, "Recognize multi-touch gestures by graph modeling and matching", *in : Proceedings of the 17th Conference of the International Graphonomics Society (IGS'15)*, 2015.

[17] C. Rémi, L. Prévost, E. Anquetil, "Drawing, Handwriting Processing Analysis: New Advances and Challenges", *in : 17th Biennial Conference of the International Graphonomics Society*, 2015.