Image & data stream analysis, Machine Learning & Classification, Visualisation & Interaction

Jean-Yves Ramel
Tours - Loire valley - France

- 137 046 / 310 000 people
- 204 km southwest of Paris
- Region « Centre - Indre et loire »
- 1h from Paris by high speed train
- Direct train connection to CDG
- Orly airport in 2h00

Loire valley World heritage Unesco
http://loirevalley-worldheritage.org/
Université François-Rabelais PolytechTours

François Rabelais, i.e. a famous French writer of XV° Century

<table>
<thead>
<tr>
<th>Faculties</th>
<th>Art &amp; human sciences, Health, economy, business &amp; management, information and technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students</td>
<td>25 000 (2 500 foreign students)</td>
</tr>
<tr>
<td>Teachers</td>
<td>1 300</td>
</tr>
<tr>
<td>Support staff</td>
<td>1000</td>
</tr>
<tr>
<td>Laboratories</td>
<td>40</td>
</tr>
<tr>
<td>Place</td>
<td>5</td>
</tr>
</tbody>
</table>

- 720 students
- 5 departments (with Labs)

- Urban Planning
  - CITERES
  - Mechanics: LMR
  - Electronics: LMP
- Computer Science
  - Embedded computing: LI
  - CADS Master

Map showing the location of PolytechTours in Tours, France.
Lab. Informatique - Tours (EA6300)

Pattern Recognition and Image Analysis
RFAI; 32; 36%

Scheduling and Control
OC; 28; 31%

Data Bases and Natural Language Processing
BDTLN; 30; 33%

Graphic from 2013: 90 people, 3 research groups
RFAI : Composition and organization

Around 27 members in 2014
- 4 Full Prof – 11 Assistant Prof (2 hdr) – 3 Post-Docs – 9 PhD – 0 ATER
- Permanent staff
  - Stable around 15
  - Dispatched on different sites
- PhD, ATER, PostDoc, Engineers
  - Always around 6 to 10 each year

<table>
<thead>
<tr>
<th>Role</th>
<th>Number</th>
<th>Members</th>
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<tbody>
<tr>
<td>Prof</td>
<td>4</td>
<td>R. Boné H. Cardot J.Y. Ramel G. Venturini</td>
</tr>
<tr>
<td>MCF</td>
<td>11</td>
<td>S. Barrat F. Bouali (HDR) T. Brouard M. Delalandre D. Conte (HDR) P. Makris</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M. Hidane J. Olivier N. Ragot R. Raveau G. Verley</td>
</tr>
<tr>
<td>PostDoc</td>
<td>3</td>
<td>N. Girard The Ahn Pham Alireza Alaei</td>
</tr>
<tr>
<td>PhD Ater</td>
<td>9</td>
<td></td>
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<tr>
<td>Doct. 3-4</td>
<td>9</td>
<td>Z. Abu-Aisheh Tanmoy Besu A. Tarafdar T. Lui A.K. Ngoho O. Razafindramanana</td>
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<tr>
<td>Doct. 1-2</td>
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<td>F Rayar A Nadir</td>
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<tr>
<td>Doct. 0</td>
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<td></td>
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<tr>
<td>IGE/R</td>
<td>0</td>
<td></td>
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</tbody>
</table>

Around 27 members in 2014:
- Total: 27 members
- Full Prof: 4
- Assistant Prof: 11
- Post-Docs: 3
- PhD: 9
- ATER: 0
- Permanent staff: 15
- Dispatched on different sites: 12
- PhD, ATER, PostDoc, Engineers: 6-10 each year
Studied Topics – Scientific skills

Adaptive and interactive Models and Systems for

Image & Video Analysis
- Active contours 2D/3D+T
- Graph based segmentation
- Salient element detection
- Indexation and CBIR
- Quality evaluation

Visual Data-mining
- Knowledge extraction in Virtual Reality
- Graphical interaction
- Visual clustering
- Biomimetic Algorithms

Pattern Recognition
- Incremental learning & classification
- Machine Learning
- Graph-based methods
- Time serie analysis and prediction
Active Contours 2D/3D/3D+T

- **Optimization & prior knowledge integration**
  - Narrow band region-based active contours and surfaces for 2D and 3D segmentation
  - Active Contours Driven by Supervised Binary Classifiers for Texture Segmentation
  - Supervised learning for the optimization of the parameters used in AC

- **Extension to Multimodal and complex images**
  - Extension to 3D+T (ultrasound video)
  - OCT, confocal microscopy
Incremental & interactive Analysis

For 3D image segmentation

- Interactive segmentation of 3D medical images
  - Combining Region Adjacency Graph and Hierarchical Classification Tree during incremental analysis (Dermlab3D)
  - Graph based segmentation (regularization, topology)
- Visual characterization of 3D textured images
  - Proposition of new visual features (easily understandable)
  - Multi-resolution approaches for 3D texture characterization
Incremental & interactive Analysis

• Interactive Indexation and transcription of old documents
  – User-driven methods for layout analysis of old books
  – Pattern redundancy Analysis and exploitation for document indexing
  – Agora, Retro – Google Award: https://sites.google.com/site/paradiitproject/

• Incremental segmentation of degraded characters
  – Combination of multi-agents and blackboard systems with belief theory
  – Segmentation of engraved serial numbers (SNECMA)
Pattern Redundancy in text

- Goal: Analyzing redundancy in images (text and graphics)
  - A text, ancient or not, is made up of sequences of similar patterns
- Methods: Clustering of similar patterns to create groups (classes)
  - Comparison of patterns (matching techniques)
  - Without prior knowledge about the meaning of these patterns
- Constraints are that the techniques should:
  - Produce very homogeneous clusters (without error)
  - Produce a minimal number of clusters
- What could be a pattern?
  - Connected components [Lebourgeois95]
  - Words [Kluzner&Al2009]
  - Others [Roy&Al2011]
  - Redundancy rate > 80%
- Semi-automatic transcription
Word Spotting

• Improvement of elastic word matching techniques
  – Comparison of DTW, MVM and other approaches
  – Adaptation for word spotting purpose (indexing and retrieval)
  – Should work for Multiple scripts (bangla, ...)

• Multi-oriented Word spotting (in Maps)

• Renom & Multi-level word spotting
  – Coarse (CC) to fine (Stroke) approach
  – Using Redundancy analysis → Codebook
  – Word spotting for Named entities localisation in historical documents
  – Renom 2 : Using Language model in word spotting (?)
CBIR and indexing

- Extraction and characterization of salient elements (in documents)
  - Keypoint detection method dedicated to binary images (junctions, ...)
  - New shape descriptors (for junctions or extremities)
  - Indexing scheme based on 2 linked-node m-ary tree structure

- Using semantic for image analysis and indexing
  - Using ontologies to drive segmentation
  - Automatic propagation of textual annotations

<table>
<thead>
<tr>
<th>image</th>
<th>mots-clés initiaux</th>
<th>extension sans RS</th>
<th>extension avec RS</th>
</tr>
</thead>
<tbody>
<tr>
<td>bear</td>
<td>bear</td>
<td>bear</td>
<td>bear</td>
</tr>
<tr>
<td>black</td>
<td>black</td>
<td>black</td>
<td>black</td>
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<tr>
<td>water</td>
<td>water</td>
<td>water</td>
<td>water</td>
</tr>
<tr>
<td>grass</td>
<td>grass</td>
<td>grass</td>
<td>grass</td>
</tr>
<tr>
<td>bear</td>
<td>bear</td>
<td>bear</td>
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<tr>
<td>black</td>
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<td>black</td>
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<tr>
<td>river</td>
<td>river</td>
<td>river</td>
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<tr>
<td>water</td>
<td>water</td>
<td>water</td>
<td>water</td>
</tr>
</tbody>
</table>
Performance Evaluation

• Performance evaluation
  o Benchmarks and image databases
    – Textures 3D
    – Graphics and Symbols
    – Graphs
    – With associated GT
  o Improvement of Evaluation protocols
    – Avoiding Boolean decisions or measures

• Quality measurement
  • OCR prediction (BnF)
  • Impact of compression (smartphone)
Interactive knowledge extraction

• Methods
  – Visual Data mining on complex data by using virtual reality (stereovision)
  – New devices for interactive data mining
  – Graphical interaction and GPU based methods
  – Numeric, symbolic, hierarchical, relational (graph) data processing

• Applications
  – Knowledge extraction from data (groups, isolated cases, relations between data types)
  – Application in dermatology and cosmetology
  – Ongoing contact with the Clinical Investigation Center of Tours (INSERM, CHRU, Univ. Tours)
  – Fibratlas ANR
Biomimetic Algorithms

• Methods
  – Biomimetic algorithms for optimisation and learning (genetic algorithms, artificial ants, swarms, cellular automata)
  – Interactive genetic algorithms
  – Topological graph construction with artificial ants
Adaptive classifiers

- Automatic learning of the structure of Bayesian Networks
  - Structure selection with biomimetic / evolutionary algorithms (GA)

- Supervised Adaptation of HMM structure
  - Modification of HMM parameters to better fit to the data
  - Application on OCR dedicated to old documents (BNF)
Incremental learning & classification

- **One-Class Incremental SVM** for document classification in a non-stationary environment
- Each One class SVM is trained incrementally at each step
- Syed procedure: the classic SVM learning procedure with old support vectors together with new data corresponding to the class the SVM is modeling.
- Use of negative data (when available) during the parameter selection process

<table>
<thead>
<tr>
<th></th>
<th>Handwritten musical scores</th>
<th>Printing I</th>
<th>Printing II</th>
<th>Handwriting I</th>
<th>Handwriting II</th>
<th>Map</th>
<th>ABA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Binary SVM</td>
<td>99.95</td>
<td>99.53</td>
<td>98.88</td>
<td>99.52</td>
<td>100</td>
<td>99.96</td>
<td>99.64</td>
</tr>
<tr>
<td>One-Class SVM</td>
<td>97.94</td>
<td>72.9</td>
<td>93.78</td>
<td>88.73</td>
<td>99.42</td>
<td>82.71</td>
<td>89.25</td>
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<tr>
<td>mOCiSVM</td>
<td>96.33</td>
<td>72.31</td>
<td>93.78</td>
<td>88.51</td>
<td>99.46</td>
<td>83</td>
<td>89.23</td>
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</table>

12 successive learning steps Ti. Each set is mutually exclusive and contains respectively 2%, 2%, 4%, 4%, 6%, 6%, 8%, 8%, 10%, 10%, 20%, and 20% of the training data, drawn randomly. The test set used at each step is remaining part of the data set left apart by cross-validation.
Adaptive classifiers

Document classification and Logo spotting

- Combination of local and global features
- Combination of One-class classifiers (One class kNN, symbolic OCC)
- Extraction (painting) and characterization of Patches for logo detection
- Document compression techniques
Adaptive Classifiers

- Personalization of biometric classifiers
  - Study of the temporal variability of handwritten signatures along time
  - Automatic creation of new classes of users – Reject management
  - Automatic adaptation of the parameters & hyper-parameters of the classifiers

<table>
<thead>
<tr>
<th>Variation</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed</td>
<td>variation</td>
</tr>
<tr>
<td>Length</td>
<td>variation</td>
</tr>
<tr>
<td>Duration</td>
<td>stable</td>
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</table>

Total duration per signer/session

Total length per signer/session
Graph based methods for PR

- Graph based representation of image content
  - Combination of statistical and structural descriptors
  - Combination of graphs and levelsets
  - ROI detection using graph representation
  - Interactive Segmentation using graph manipulation and transformation

- New Graph matching and indexing techniques
  - “Soft” graph matching algorithms - Similarity measure between graphs
  - Topological Graph embedding - Fuzzy Graph embedding
  - Distributed GED for graph indexing – PhD RFAI/OC
  - GraphLib : An open source library for graph matching
Structural methods for Video Analysis

• Object Tracking by Particle Filters
  – States and observations are represented using graphs
  – One state ➔ all the scene where objects are moving
  – The weights of particle graphs are computed by means of Graph kernel

• Structural De-noising of Foreground Mask
  – Representation of the 3D (2D+T) Structure for an Image Sequence by 3D Combinatorial Maps
  – Noise removal according Topological properties of the Combinatorial Map
  – Noise regions ➔ Many tunnels/voids
    ➔ High Value of Betti Numbers
Time series Analysis and exploitation

- Predicting tool improvement (adaptive methods)
  - Introduction of a priori knowledge
  - Selection/extraction of pertinent and exogen features
  - Prediction at multiple time-steps (Boosting of RNN)
  - Local Approach

- Exploitation
  - In IA: object position prediction in 2D+T or 3D+T image sequences
  - In PR: Variability detection in data streams, classical time series prediction
  - Collaboration with LIFO
Conclusion

• **Adaptive and interactive Models** in order to solve some of the actual limitations, like:
  – Systems dedicated to very specific databases (lack of genericity)
  – In IA & PR, recognition of pre-segmented shapes only
  – Lack of explicit representation of the (prior) knowledge used by the methods
  – Lack of exploitation of contextual information during the analysis/recognition (lack of incrementality)

• Propose more interactive systems better suited to user needs (pluridisciplinarity considerations)

• Combination of methods (operators, classifiers, visualisation)

• Propose more robust and generic systems able to support scalability
  ➔ Mass of data (Big and open data projects)

• **2013** ➔ Union between RFAI and FOVEA
Projects & partners

Regional projects

Industrial Partners

So famous!

Atos Origin is a leading international IT services provider for business solutions

international high-technology group in aerospace, defense and security

Bibliothèque Nationale de France - portail Gallica

Gestion Electronique de documents
capturing, automatically processing, and managing all company’s incoming documents

Digitalisation company

National projects

<table>
<thead>
<tr>
<th>Project</th>
<th>Years</th>
<th>People</th>
<th>Institutes</th>
<th>Length</th>
<th>Funding</th>
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</thead>
<tbody>
<tr>
<td>ACI Madonne</td>
<td>2003-2006</td>
<td>55</td>
<td>8</td>
<td>2 years</td>
<td>110 k€</td>
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<tr>
<td>ANR Navidomass</td>
<td>2006-2009</td>
<td>40</td>
<td>7</td>
<td>3 years</td>
<td>443 k€</td>
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<tr>
<td>Technovision ÉPEIRES</td>
<td>2004-2007</td>
<td>30</td>
<td>7</td>
<td>3 years</td>
<td>100 k€</td>
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<tr>
<td>ANR Digidoc</td>
<td>2011-2014</td>
<td>18</td>
<td>7</td>
<td>3 years</td>
<td>866 k€</td>
</tr>
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</table>
Projects & partners

Institut de Recherche en Informatique de Paris 5 (Paris)

LIPADE : Centre de Recherche en Informatique de Paris 5 (Paris)

Laboratoire Lorrain de Recherche en Informatique et ses Applications (Nancy)

Laboratoire d'InfoRmatique en Image et Systèmes d'information (Lyon)

Laboratoire d'informatique image et interaction (La Rochelle)

Laboratoire Informatique (Tours)

Centre d’Etude Supérieures de la Renaissance (Tours)

Laboratoire Bordelais de Recherche en Informatique (Bordeaux)

Bibliothèque Nationale de France (Paris)
Projects & partners

Computer Vision Center
Document Analysis Group
Barcelona - Spain
“J. Llados, E. Valveny”

Dept. of Computer Science and IS
Osaka Prefecture University
Osaka - Japan
“K. Kise”

Indian Statistical Institute
Kolkata - India
“U. Pal”

Université de Salerne Italy -
Groupe Mivia –
“M. Vento”

Computational Intelligence
Laboratory – IIT
Athens, Greece.
“B. Gatos”

Research Group Parallel and
Distributed Systems
University of Heidelberg
“A. Andrzejak”
Some pictures...