From Artificial Neural Networks to Artificial Intelligent Systems

Prof. Kurosh Madani

Laboratoire Images Signaux & Systèmes Intelligents (LISSI Lab.)

University PARIS-ESTE / PARIS X12 University

madani@univ-paris12.fr

L M D Principle & Dr. Hab.

"D" level: Doctoral
3 years + ε

"M" level: Masters
2 years

MR or MP

"L" level: Bachelor
3 years

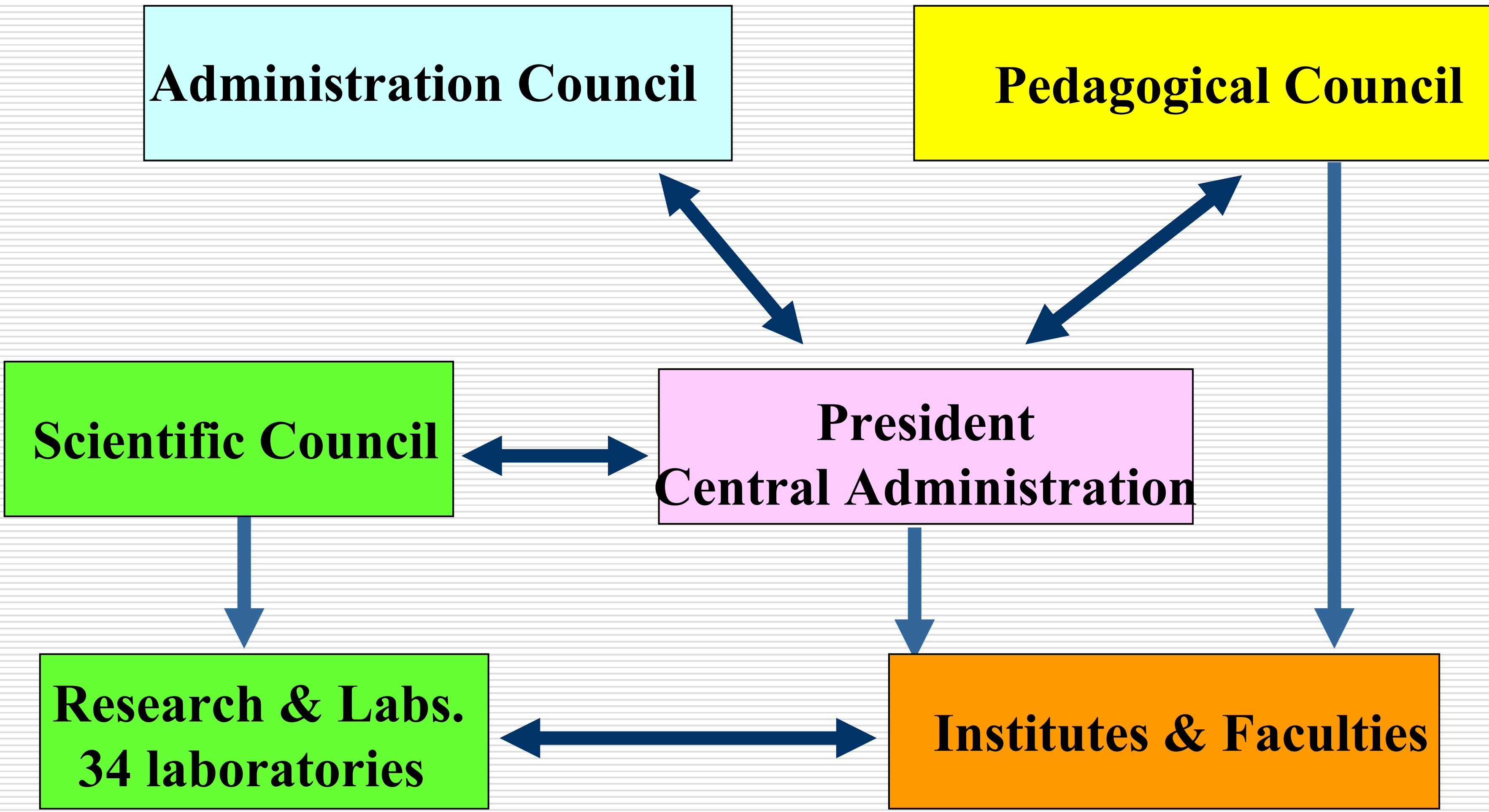
LG or LP

DUT: Tech. Dipl.

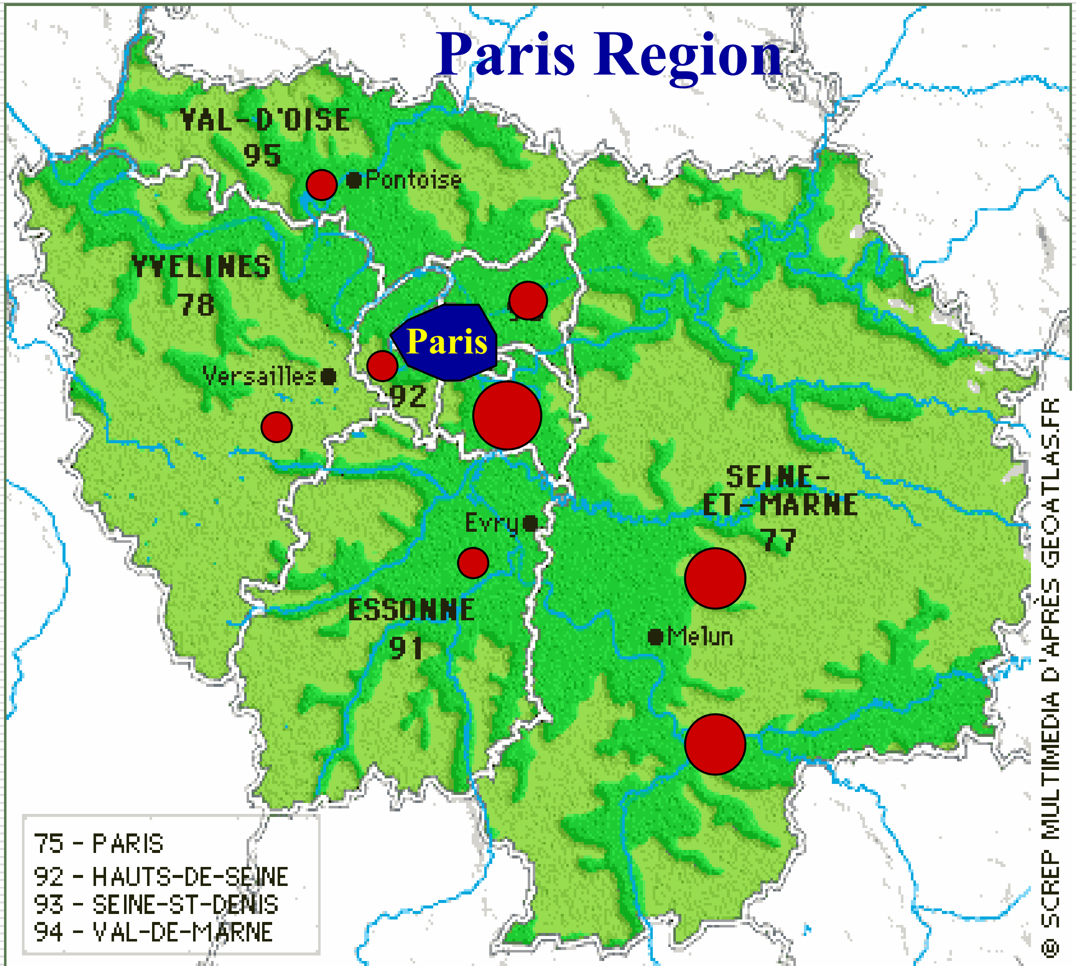
"DHDR" level:
Doctor-Hab.

5 ≤ years ≤ 20

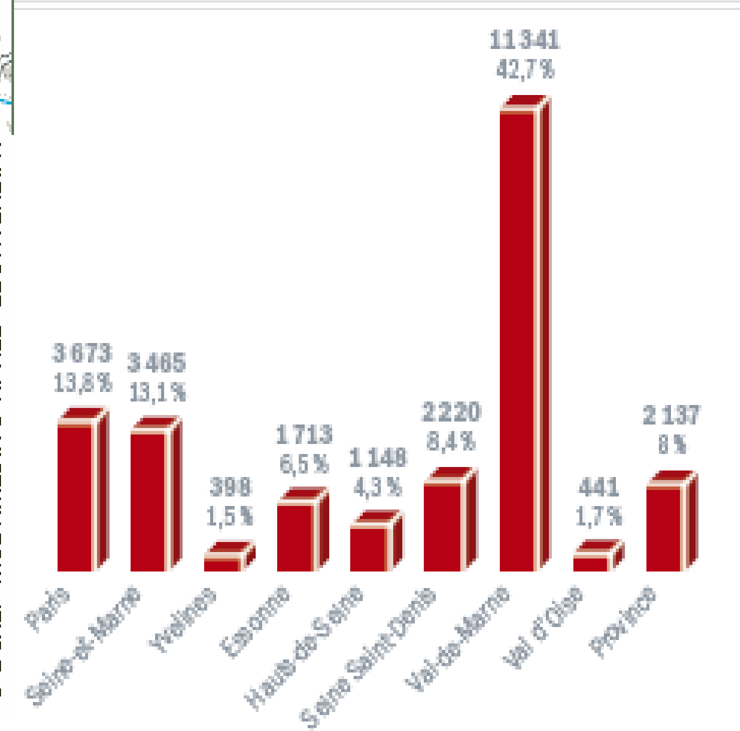
Univ. Paris XII - General Structure



Students and location (distribution)



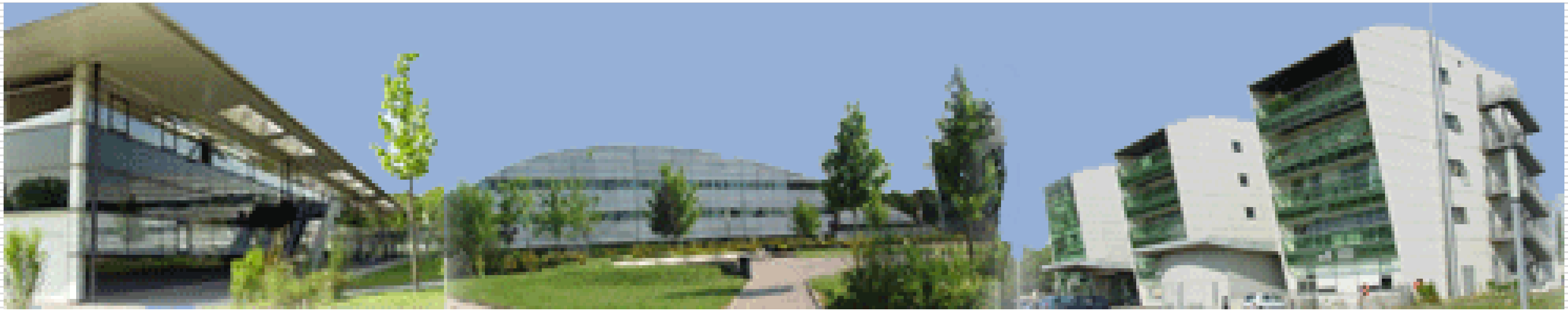
Less than: 35000 Students

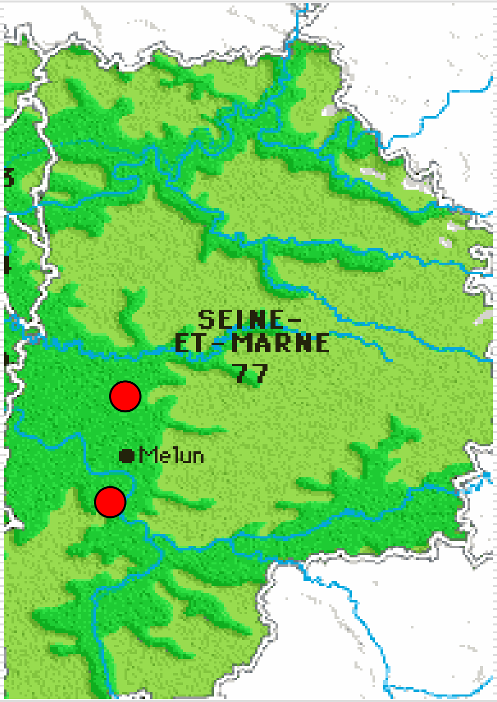


University PARIS XII

University PARIS XII

University PARIS XII / Senart Institute of Tech.





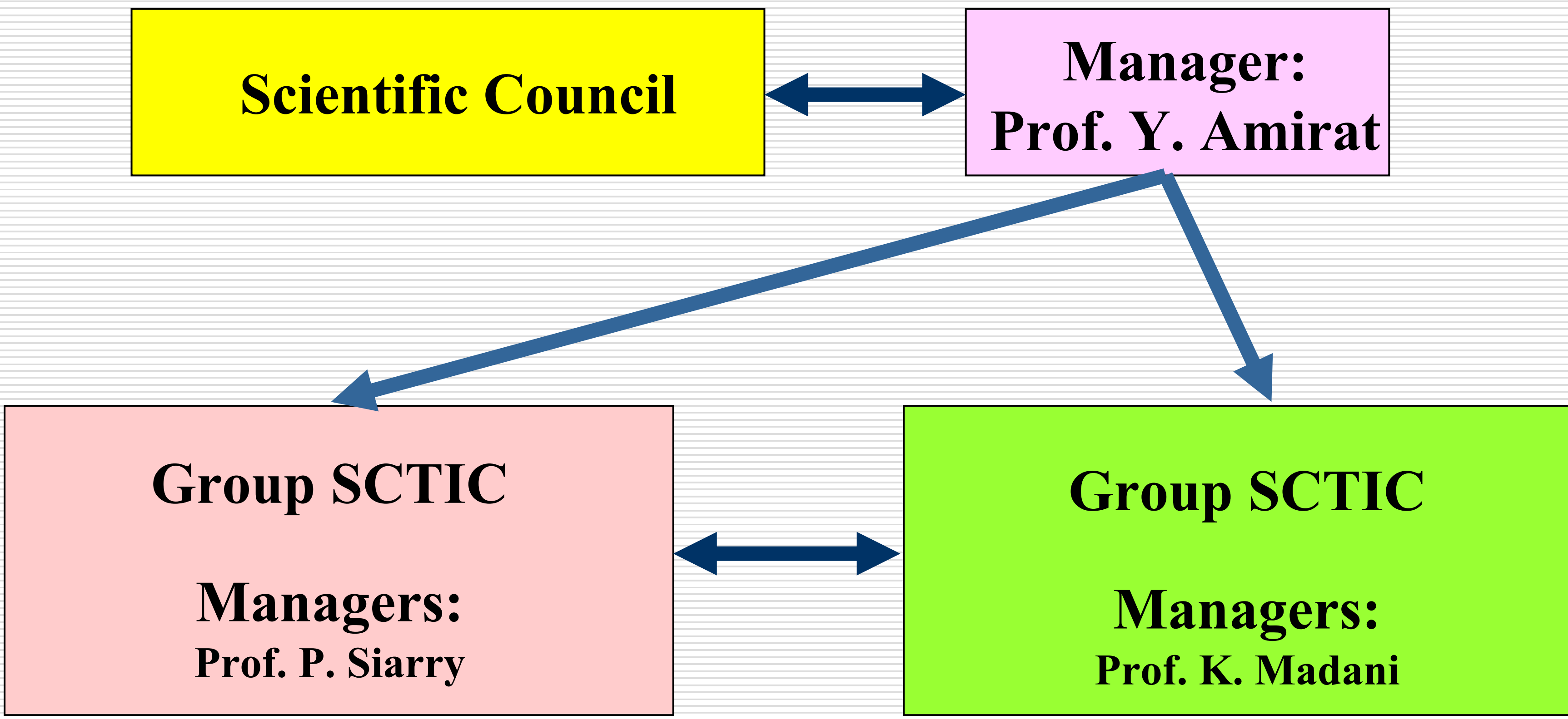
UNIVERSITÉ PARIS XII VAL de MARNE
CONNAISSANCE ACTION

LISSI

About LISSI Laboratory

- 60 to 65 researchers
  - about 30 staffs :
    - 7 Professors, (Prof. des Universités)
    - 3 Dr. Hab. Assistant-Profs., (MCF – HDR)
    - 22 Dr. Assistant-Profs (MCF)
  - 30 to 35 Post-Doctoral or Ph.D. students
- Image, Signals & Intelligent Systems:
  - Multi-modeling
  - Complex information processing (Image, Signal, etc…)
  - Intelligent Identification, Control & decision
  - Real-world & industrial applications

LISSI's Funct. & Admin. Structure



LISSI – Senart

Dr. V. Amarger
Dr. A. Chebira
Dr. A. Chohra
Prof. K. Madani
Dr C. Sabourin

W. Yu (Cotutelle - China)
Ting Wang (China)
I. Budnyk (Eiffel Program)
A. Bahrammizaee (P12 Scholarship)
D. Kanzari (Tunisian Scholarship)
L. Voysekhovich (Belrus / Brest)
D. Ramik (MRES Scholarship)

Dr. L. Thiaw (Senegal)
Dr. M. Sene (Senegal)

Research activities & objectives

☞ Senart team of LISSI's SCTIC group works on exploitation of bio-inspired mechanisms in order to realize and implement « intelligent artificial systems »: application to Real-World problems.

☞ Privileged areas & applications are:

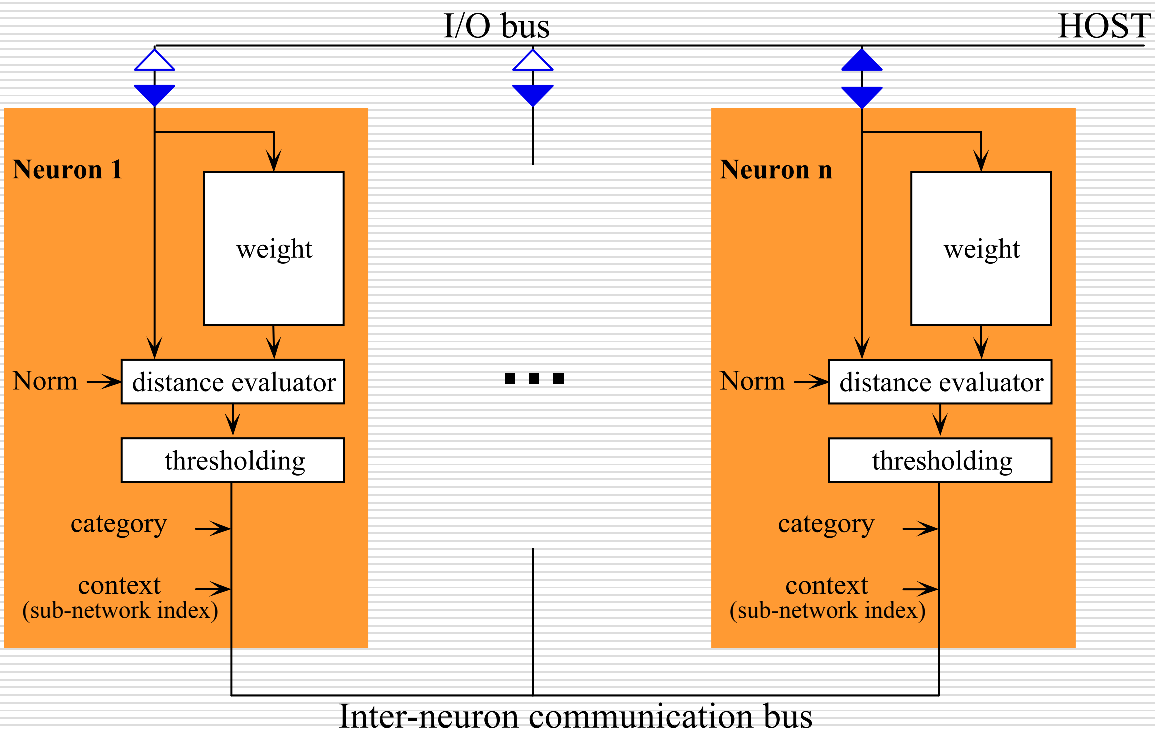
❶ complex information processing

❷ "industrial" & "Real-World" problems

❸ modeling & implantation of complex systems (Humanoid robots, Collective & Socials Systems, Self-Organizing Systems, etc…).

ZISC-036 Neuro-processor

(Thesis: G. De Tremiolles)



ZISC-036 Neuro-processor

(Thesis: G. De Tremiolles)

- 36 Neurons (processors) per Chip
- Chips Cascadability
- 250000 Recognition per second
- 2000 MIPS equivalent computing power
- 64 components Input Vector / each component encoded on 8 bits
- Output (Category and Distance) coded on 14 bits

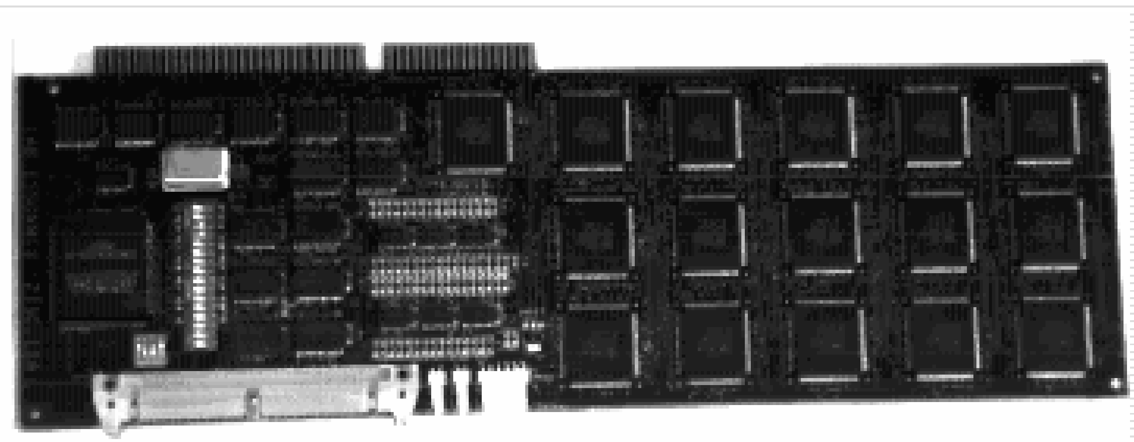
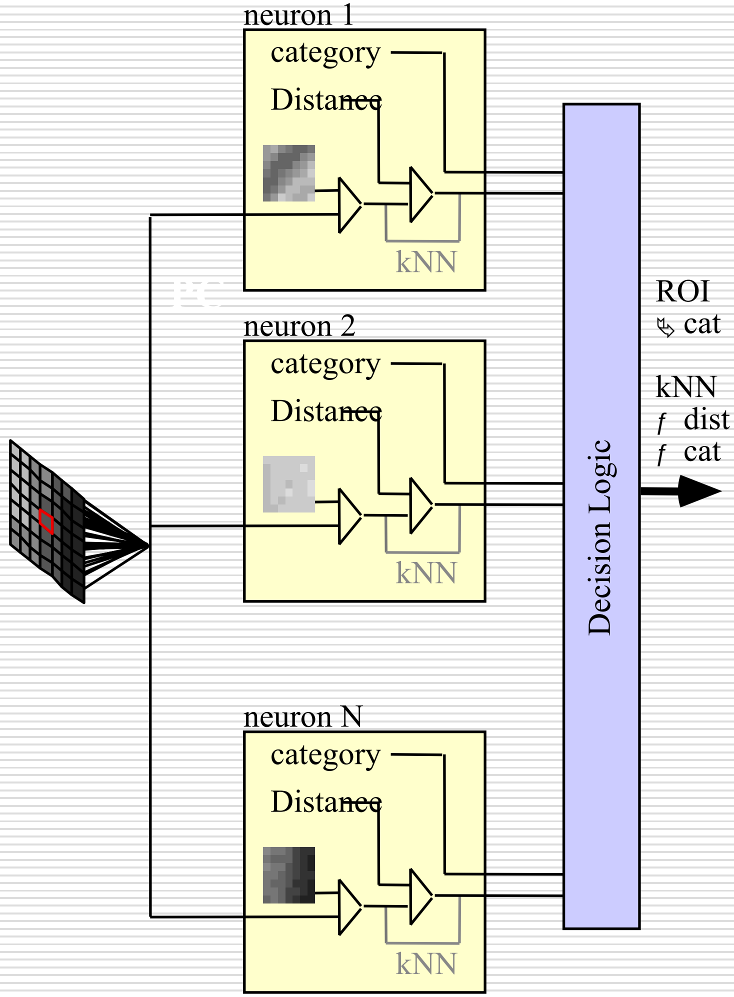
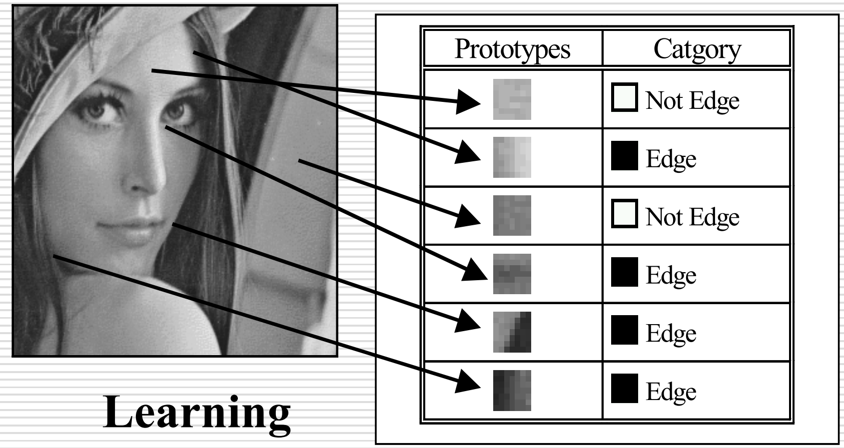


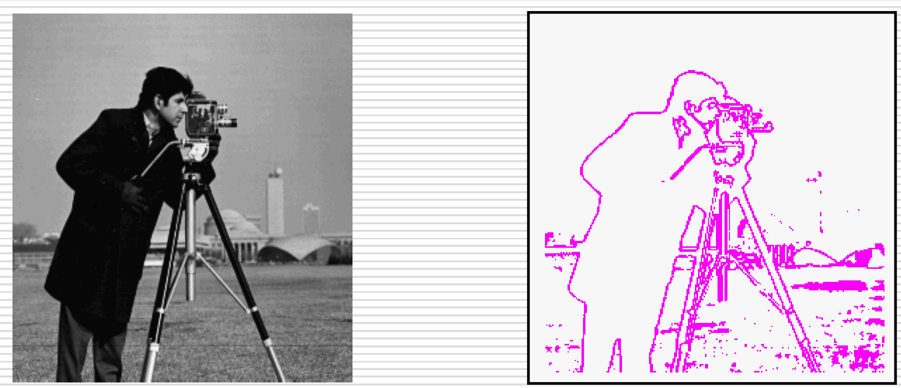
Image processing & reconstruction

(Thesis: G. De Tremiolles)



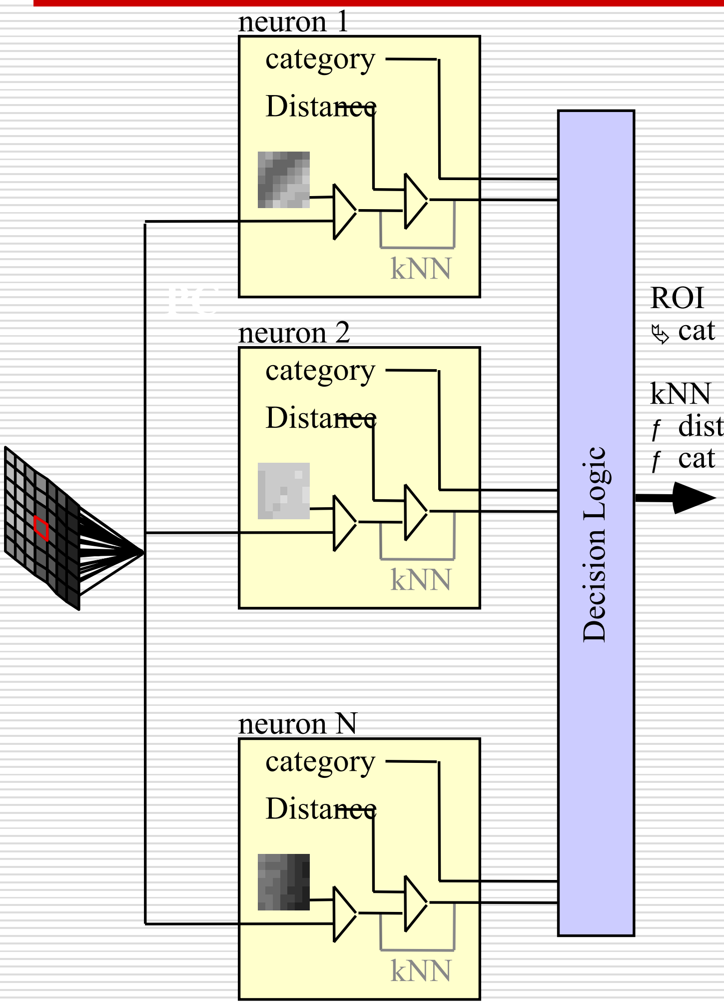


Learning



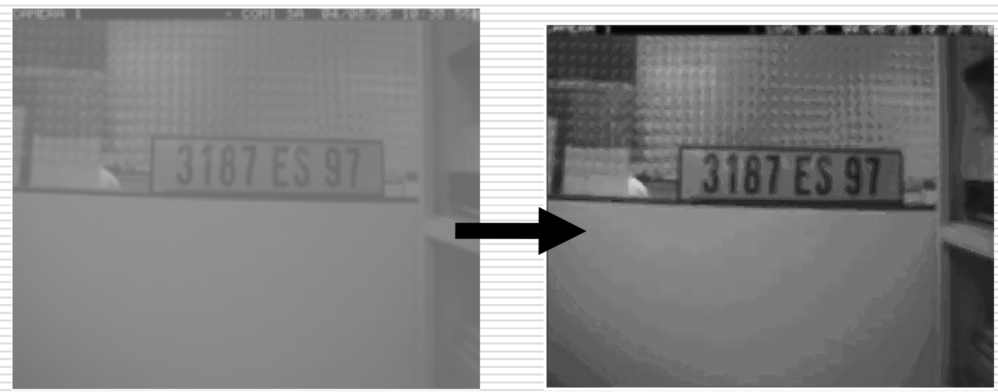
Generalization

Image processing & reconstruction



(L) (R)

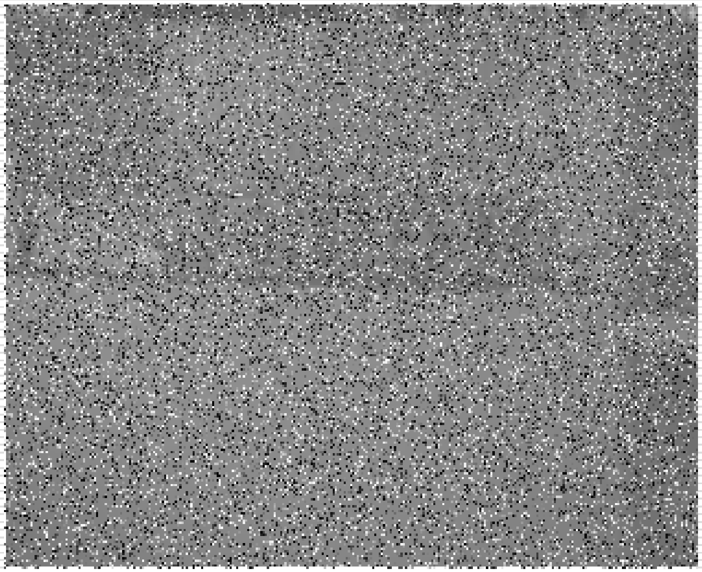
Learning : the degraded image (L) and the reference image (R).



(L) (R)

Generalization : Input image (L) and output image (R).

Image processing & reconstruction



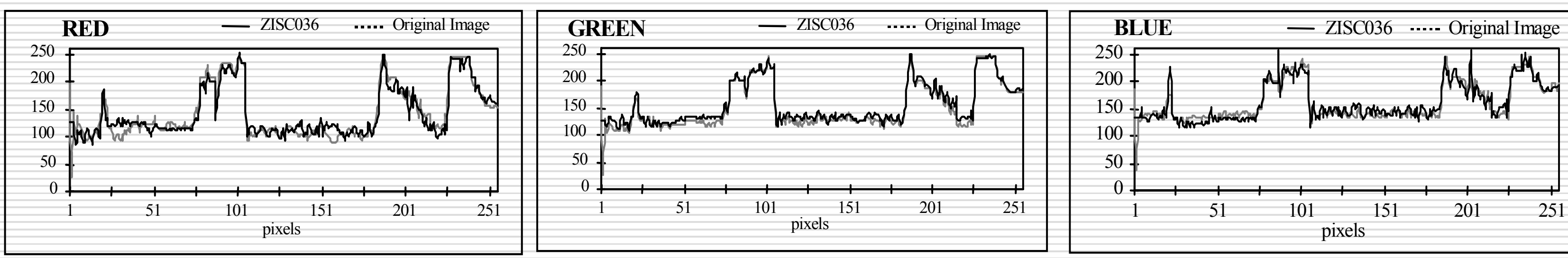
(L)

Generalization : Input image (L) and output image (R).

(R)

Image processing & reconstruction

Experimental results relative to color images reconstruction. (L) image used for the learning. (R) image used for generalization test.

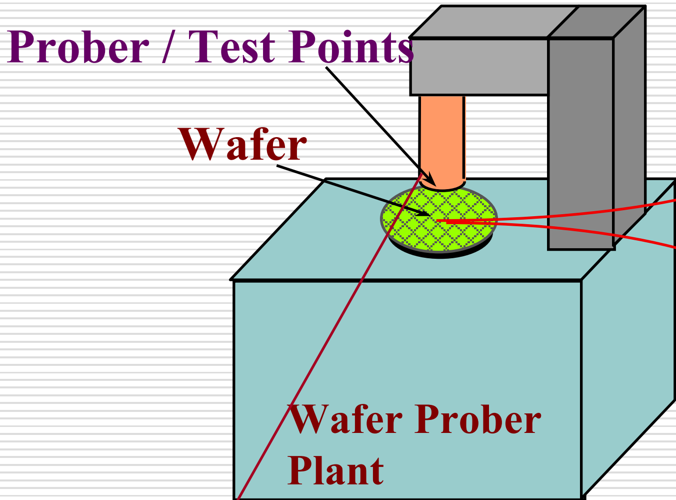


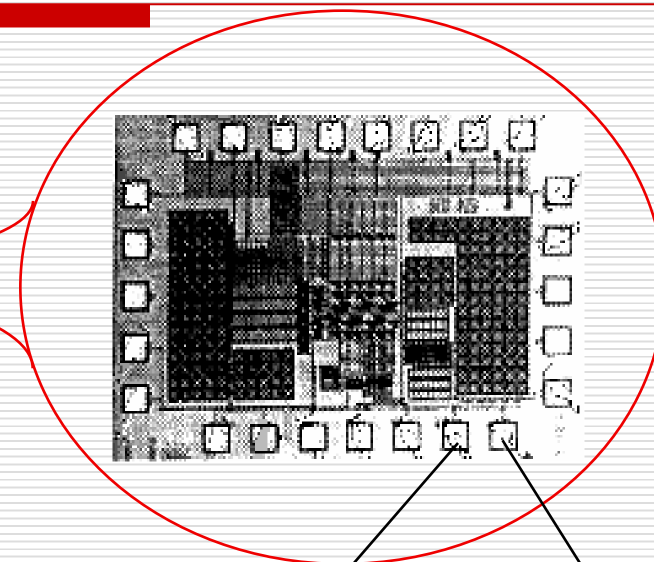
Red   Green   Blue

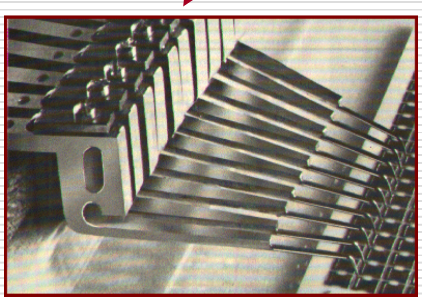
Comparison of the colored (reconstructed) image with the original image in generalization phase. Red (a), Green (b) and blue (c).

Fault detection and diagnosis

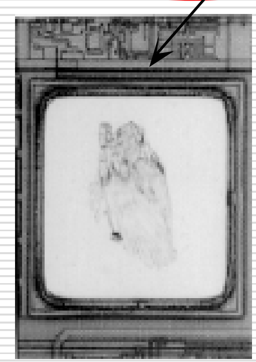
(Thesis: G. De Tremiolles)

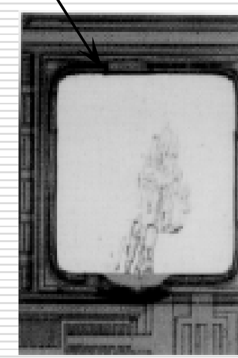






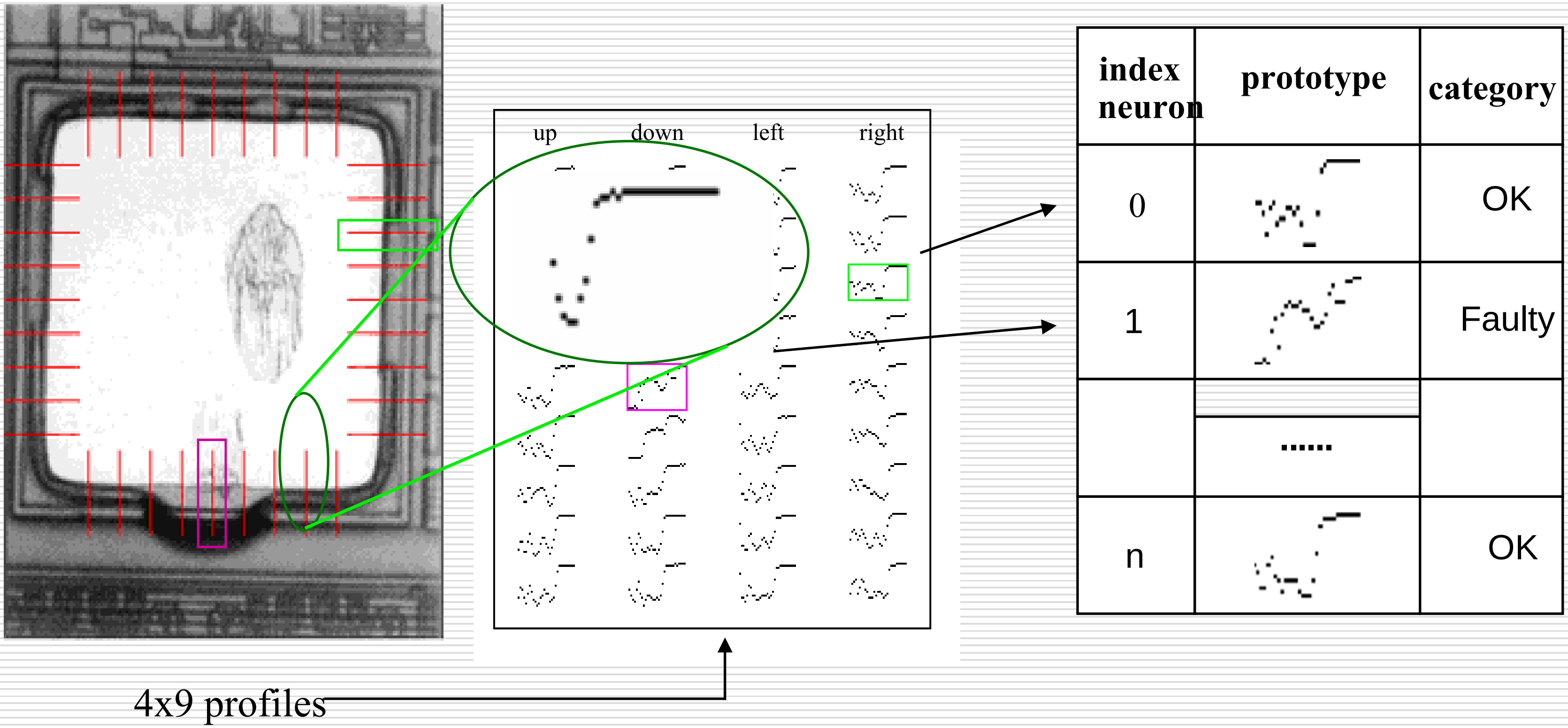
Probe-head device





Correct or Faulty
circuit

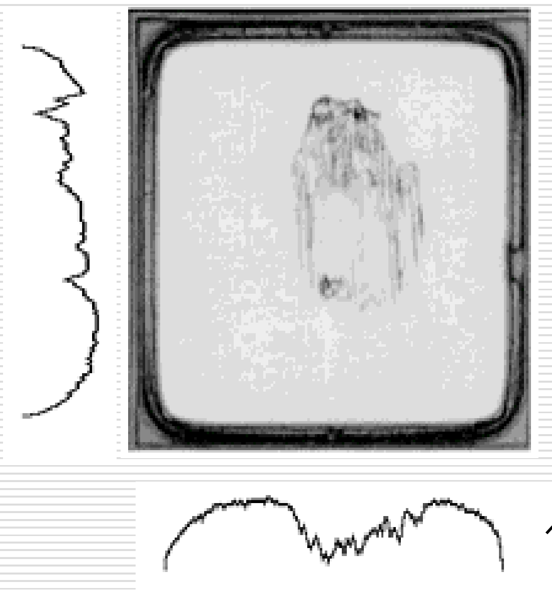
Fault detection and diagnosis



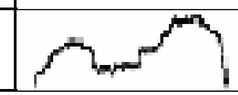
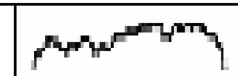
Number of neurons: 20
Learning delay: 7ms
Processing delay: 4 μs per circuit
(250000 recognitions per second)

Fault detection and diagnosis

Probes impact related faults Analysis

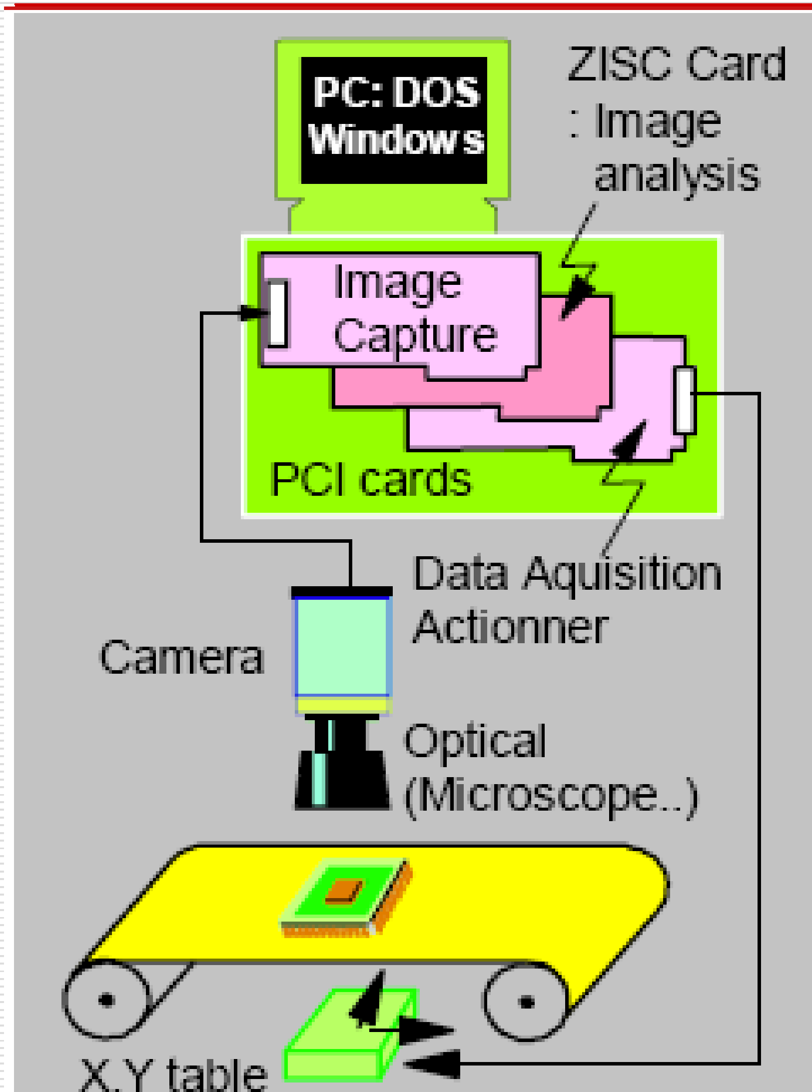


X-Y Projection

index neuron	prototype	category
0		0,25
1		0,3
n		0,1

Number of neurons: 100
Learning delay : 10ms
Processing delay: 4 µs per circuit
(250000 recognitions per second)

Fault detection and diagnosis

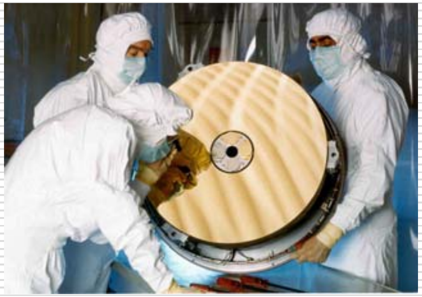


ESSONNES C.D. LAB.

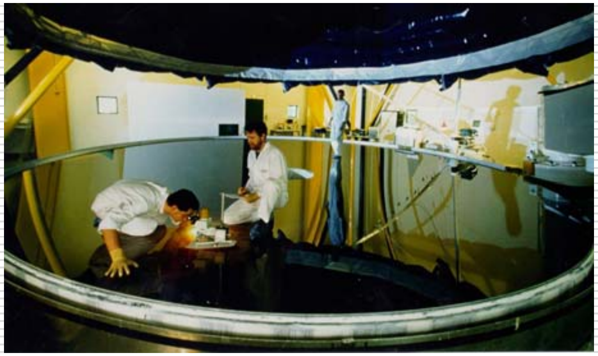
Fault detection and diagnosis
(Thesis: M. Voiry)

► **Detection & identification of esthetic defects**

Space Optics & Devices
Telescopes, objectives, filters



Astronomy Optics & Devices Huge mirrors & segmented mirrors

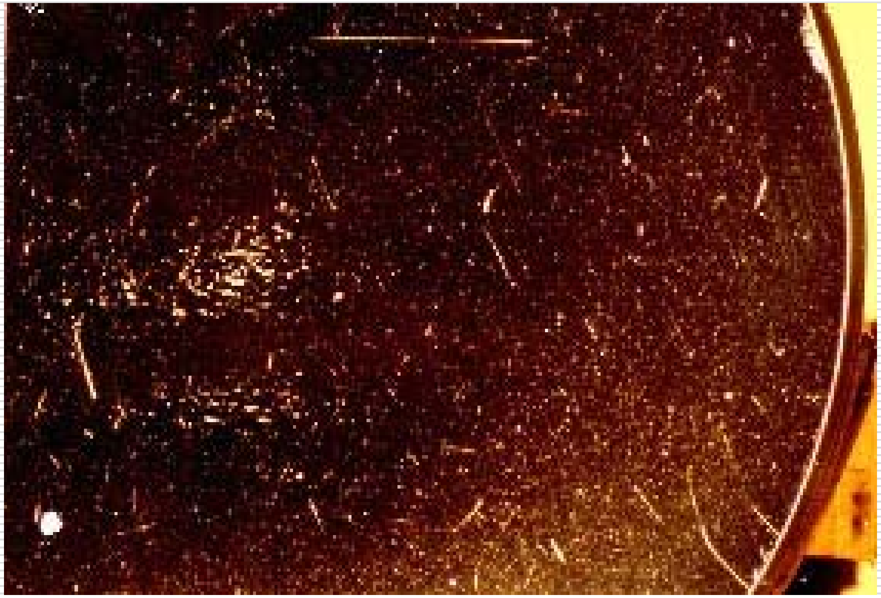


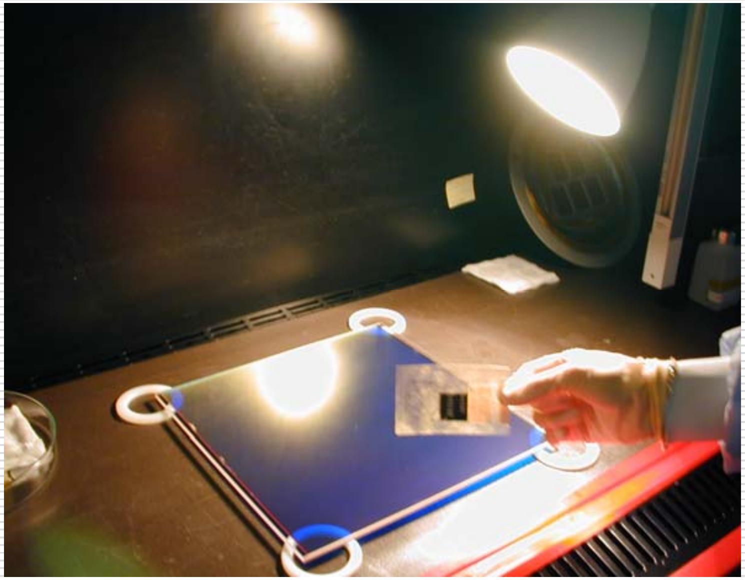
Industrial Optics UV, lithography

Optics for High Energy Laser, UV, X Ray, ...

Fault detection and diagnosis
(Thesis: M. Voiry)

► **Detection & identification of esthetic defects**





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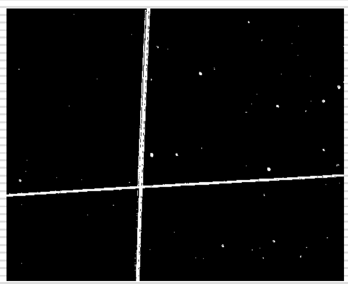
LiSSi

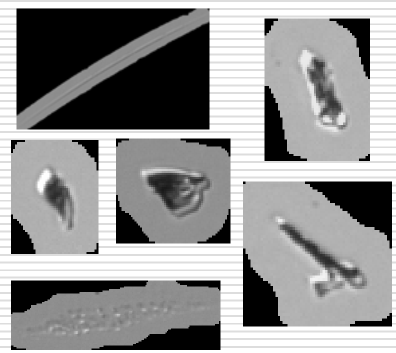
Sagem Défense Sécurité
SAFRAN Group

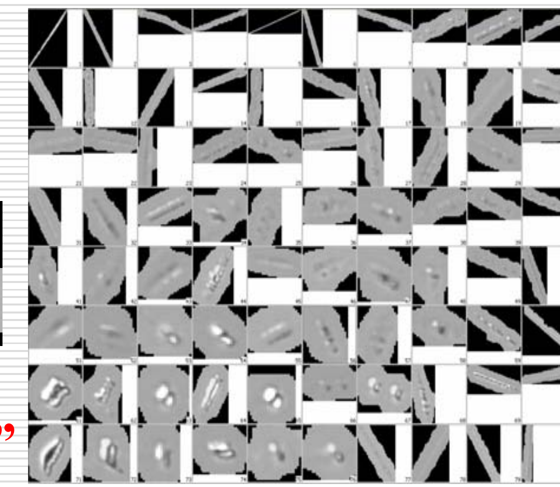
Fault detection and diagnosis

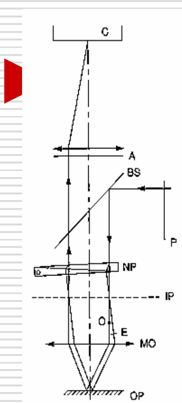
▶ Detection & identification of esthetic defects

Nomarski's microscopy Images → DETECTION → Defect's Image → DATA EXTRACTION → Defect's Features → CLASSIFICATION → Defect's Nature









▶ osed solution:

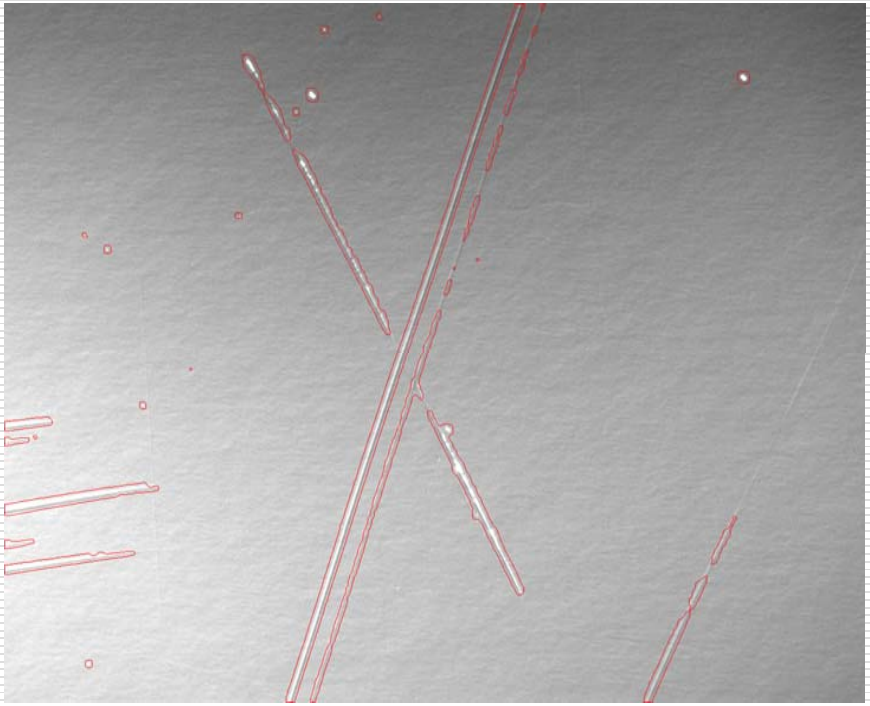
Adaptive Image Processing & Matching

“13 Components” InvariantVector Representation

Fault detection and diagnosis

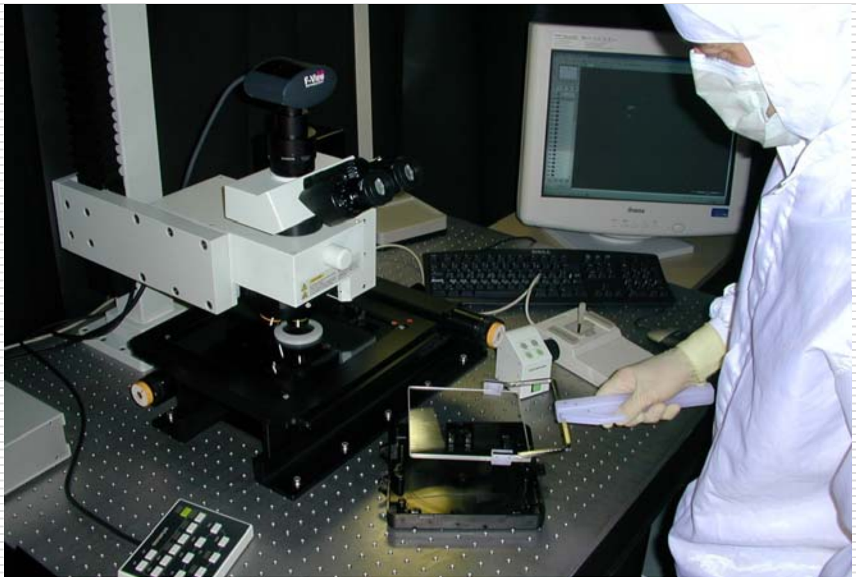
Defects Detection

Nomarski image



Items detection

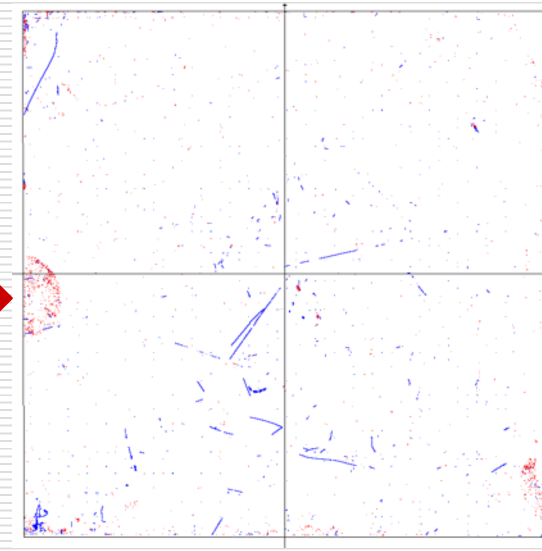
Fault detection and diagnosis

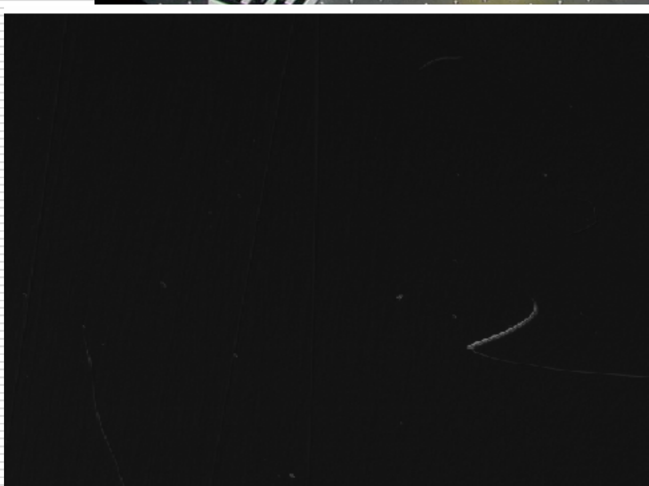


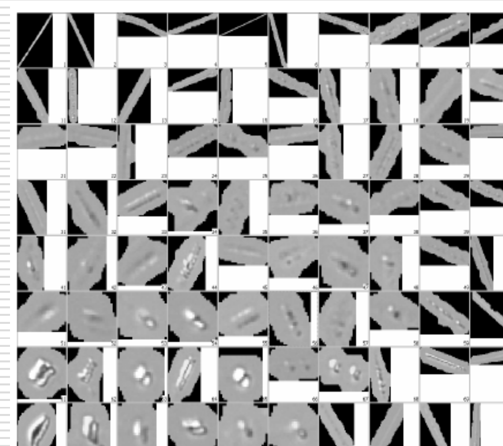
3700 fields

9000 mm²

33 Mbytes







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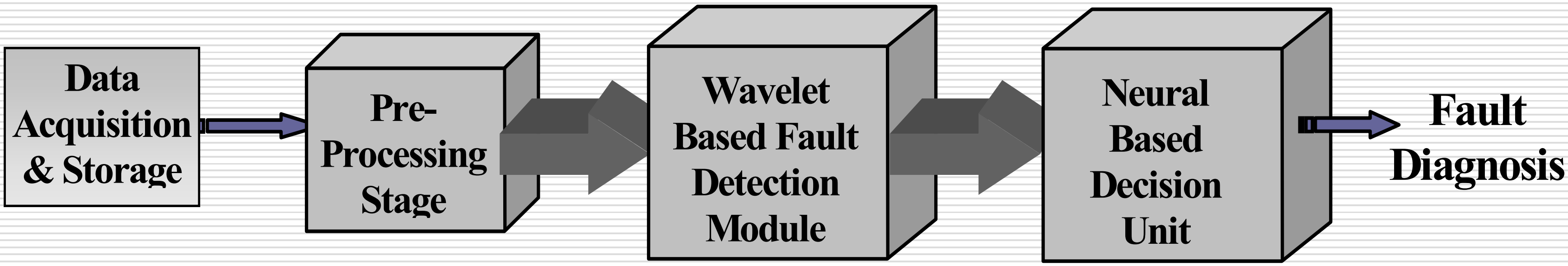
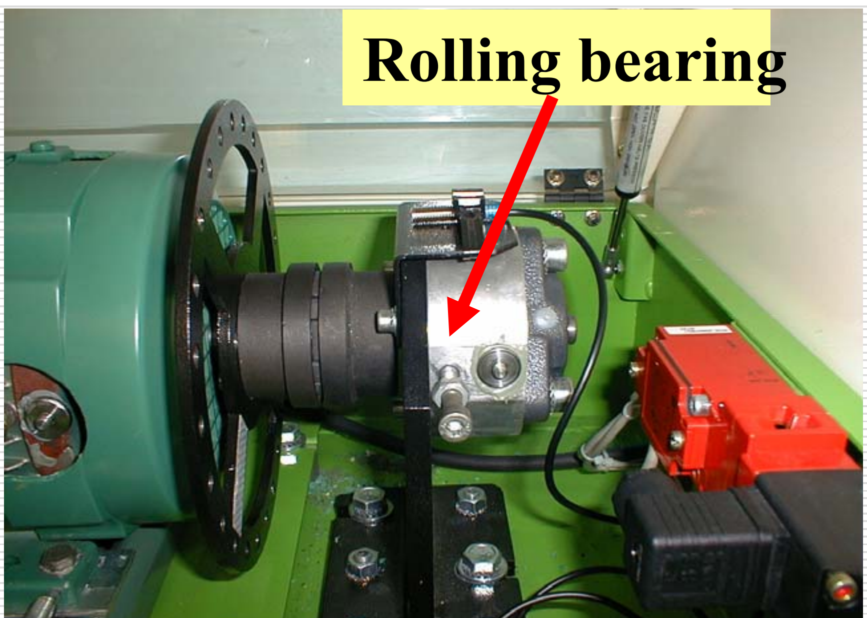
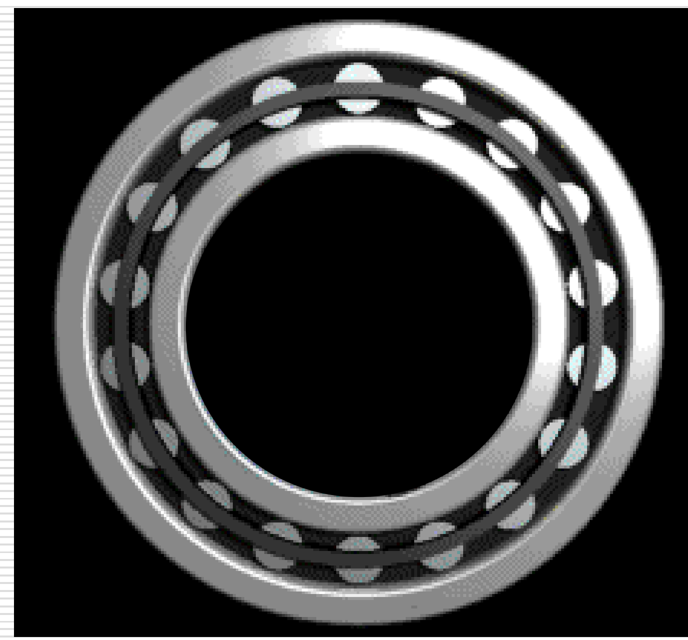
Fault detection and diagnosis: mechanical devices

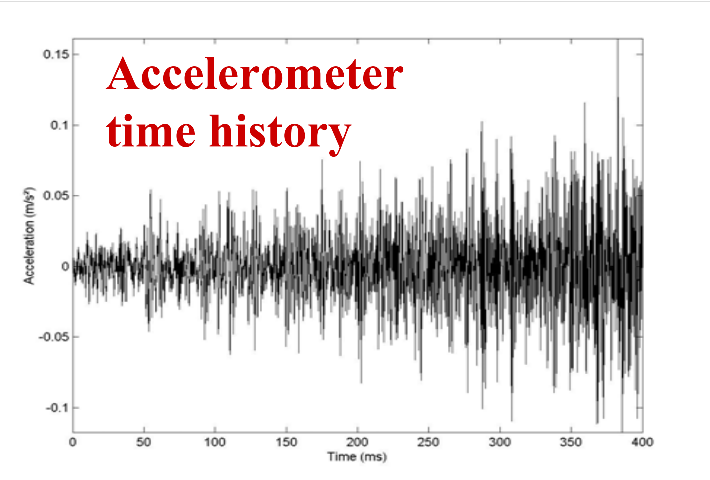
(Thesis: S. Diouf & M. Sene)

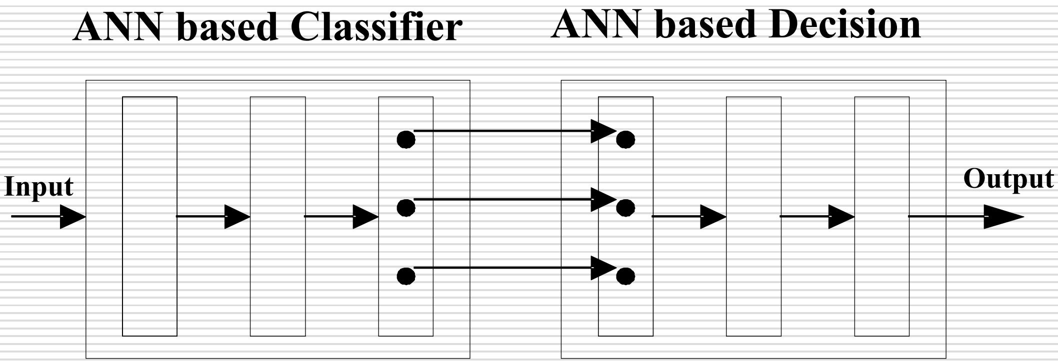






Fault detection and diagnosis: mechanical devices





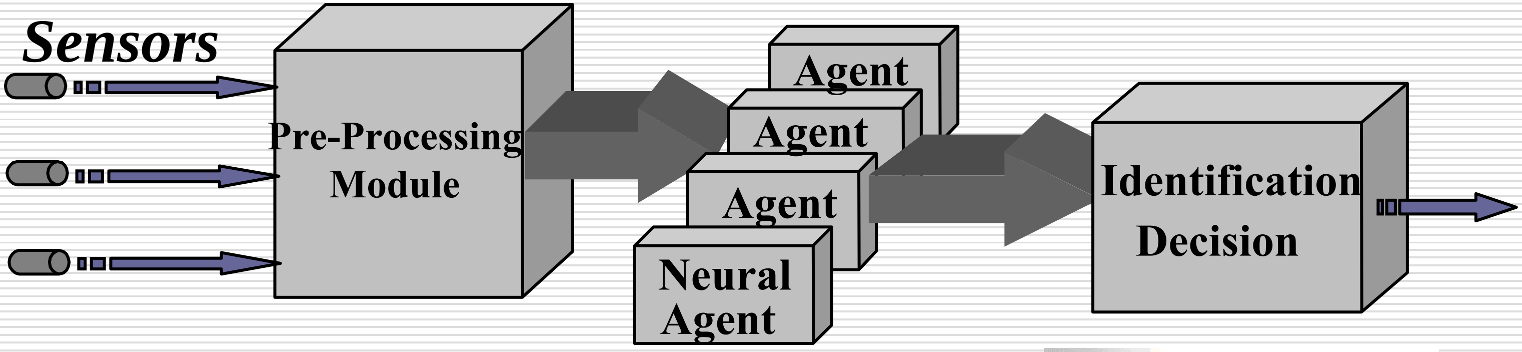
	RBF/LVQ MNN	RBF/BP MNN	RBF ANN
"Normal" Class	84%	98,8%	84,6%
"Imbalance" Class	82,7%	97,2%	78,9%
"Rolling Bearing Defect" Class	95%	99,7%	95,3%

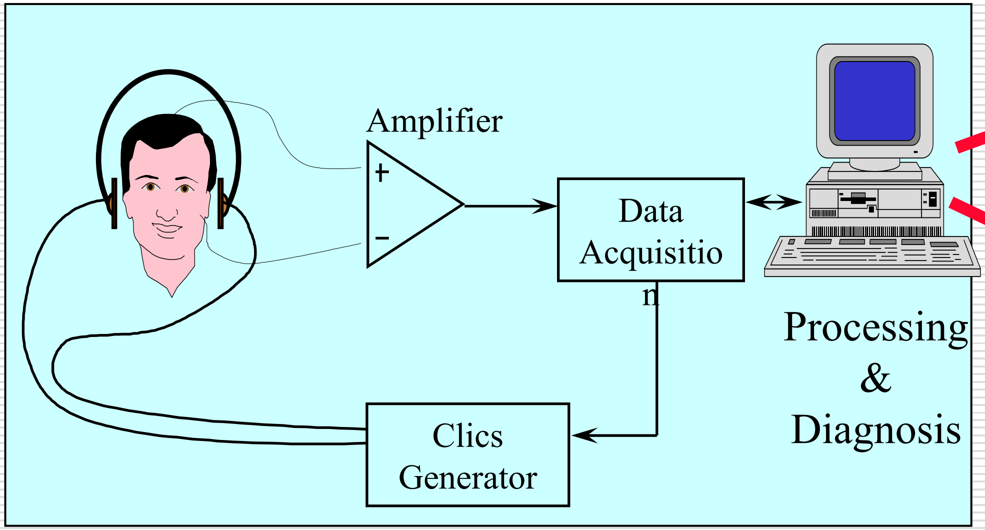
☞ **Learning Database: 66 "signatures"**

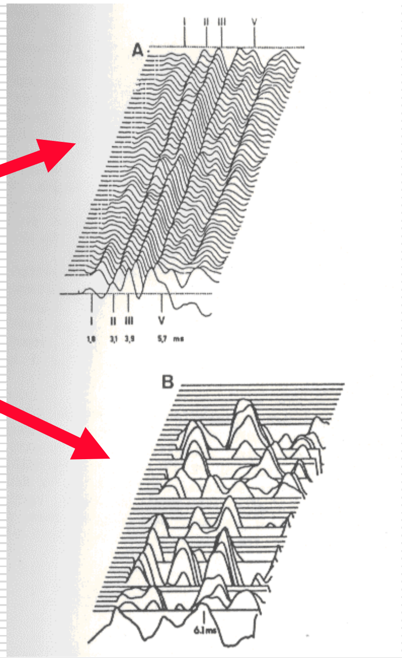
☞ **Testing Database: 992 "signatures"**

Biomedical Computer Aided Diagnosis

(Thesis: A. Dujardin, N. Kanaoui)







Modular Structures
Self-Organizing Structures

- Much is still unknown about how the animal's brain processes the information.

- However, recent progresses in neurobiology seem state a number of its operations skills.

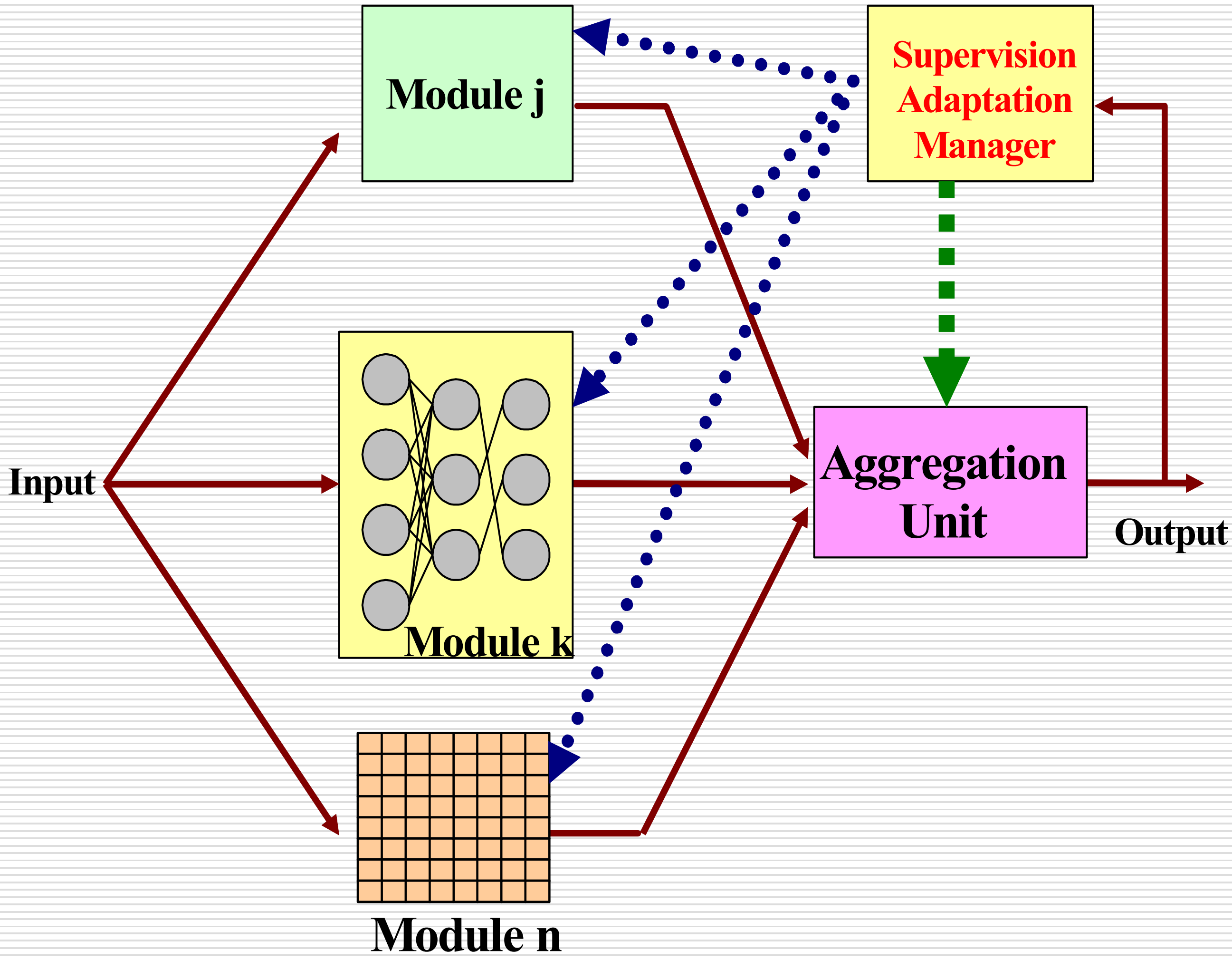
- Among them one can mention:

  ❶ The brain's "modular" stucture (multi-functions)

  ❷ The brain's "Self-organization" capability

  ❸ The brain's "complexity reduction" ability.

Modular Structures
Self-Organizing Structures



Modular Structures
Self-Organizing Structures

Idea:

Experts' mixture & aggregation

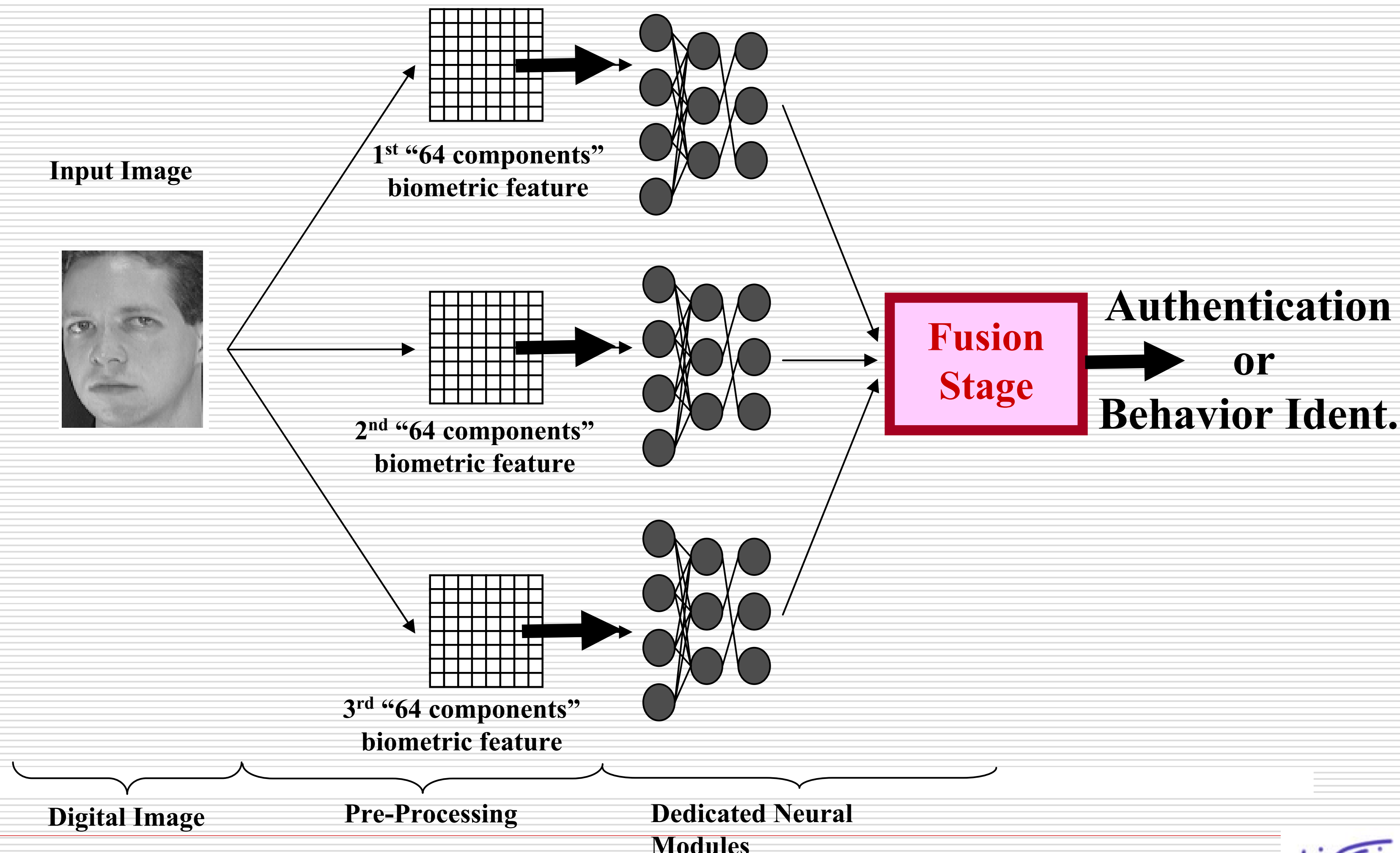
Processing Self-Organization

Techniques' Hybridization

Mass Biometry

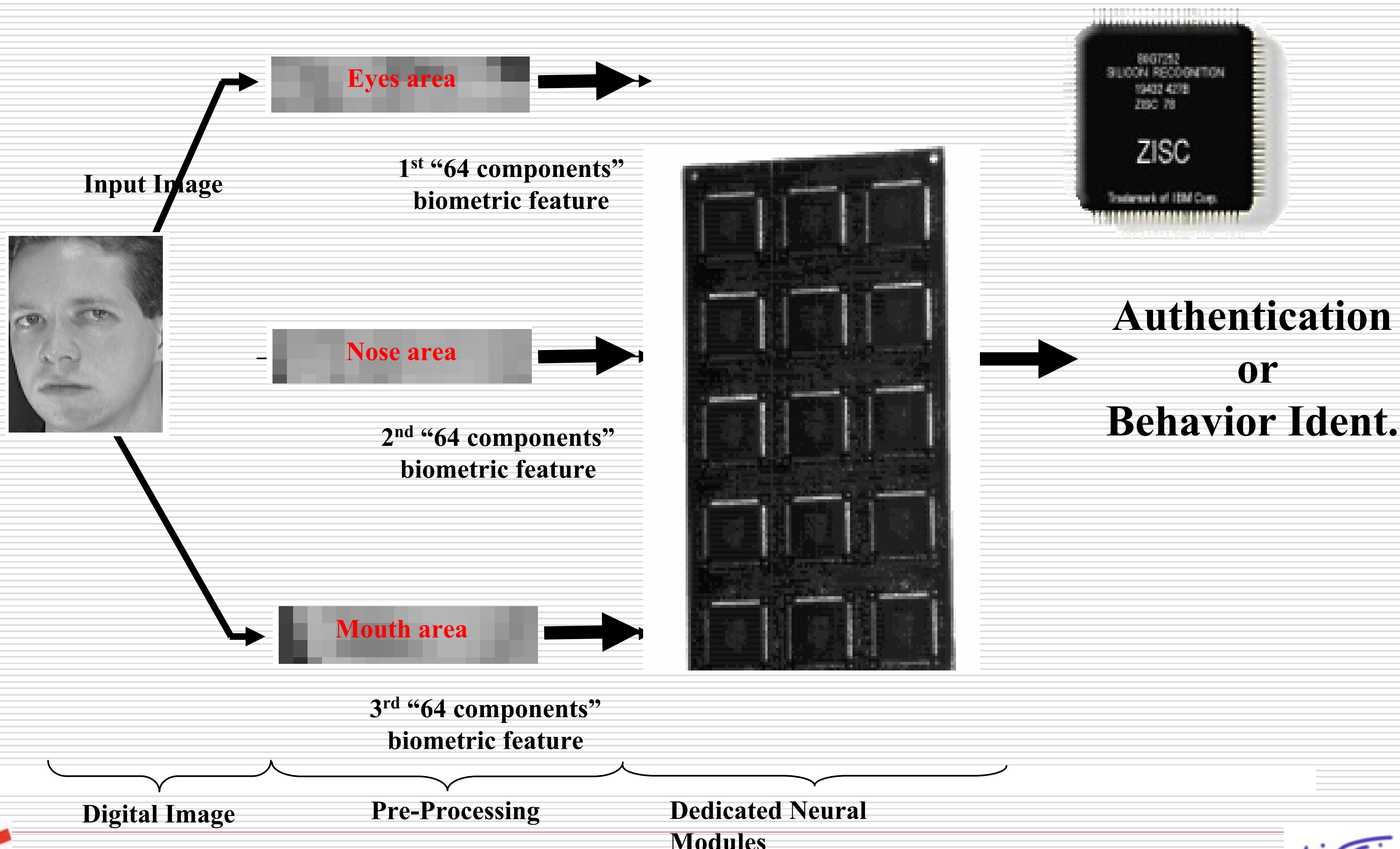
- **Contrary to "individual biometry", the main goal in "Mass Biometry" is to authenticate and/or identify a suspect individual or unusual behavior within a flow of mass customary persons or behaviors.**
- **"Real-time" requirement is a chief constraint**
- **Moreover: poorness of available information**

Mass Biometry

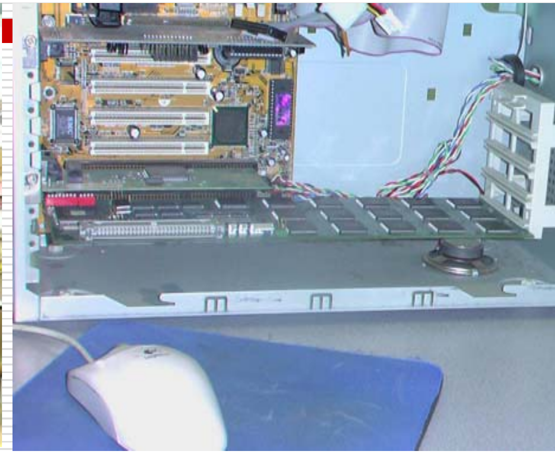


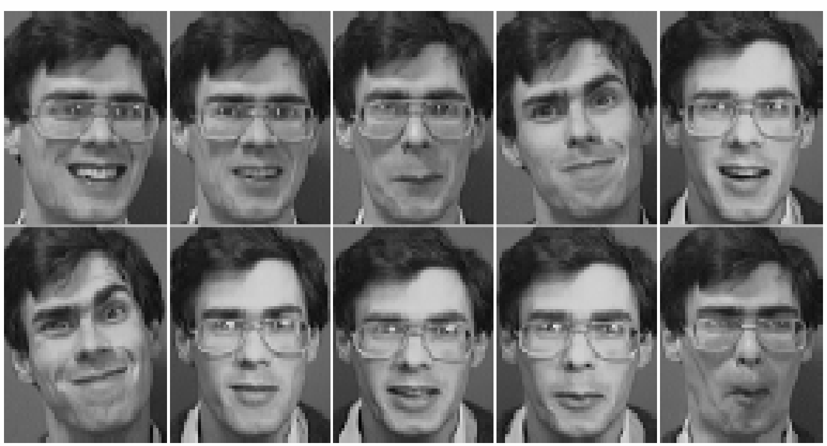
Mass Biometry

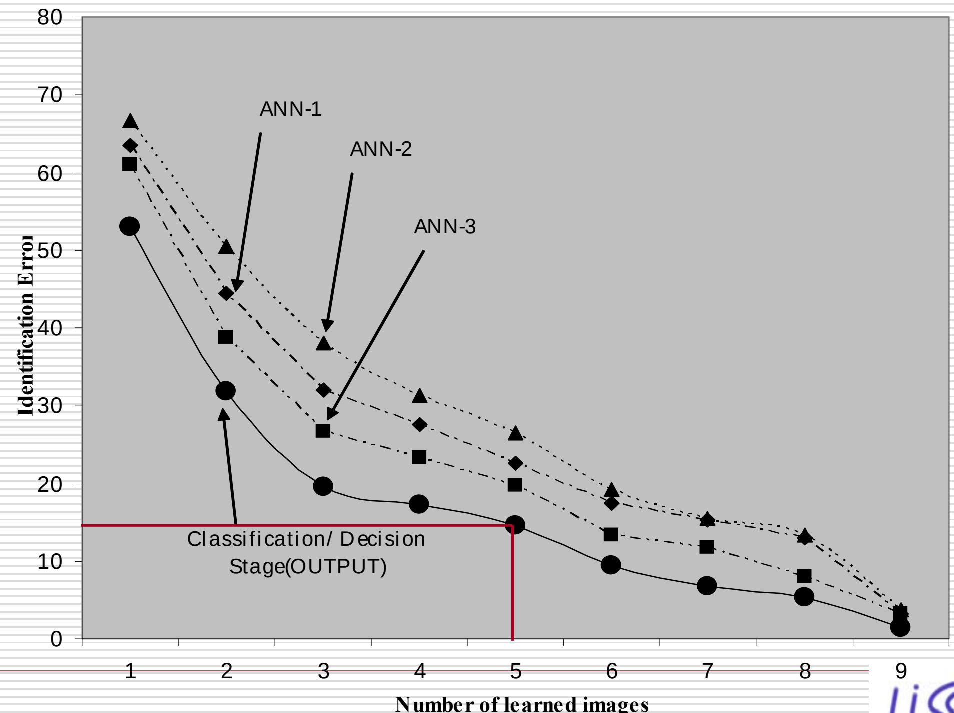
ZISC (Zero Instruction Set Computer)



Prototype & Validation



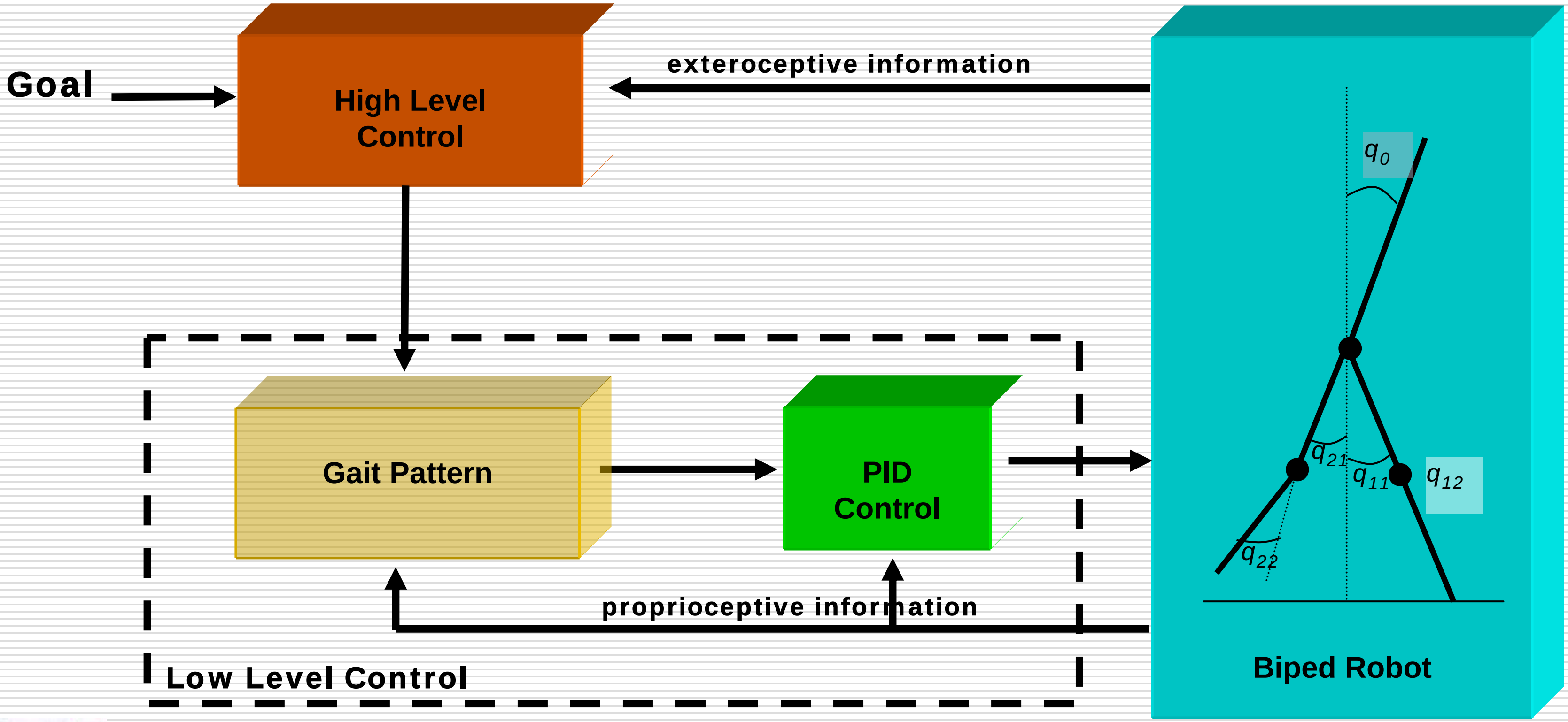




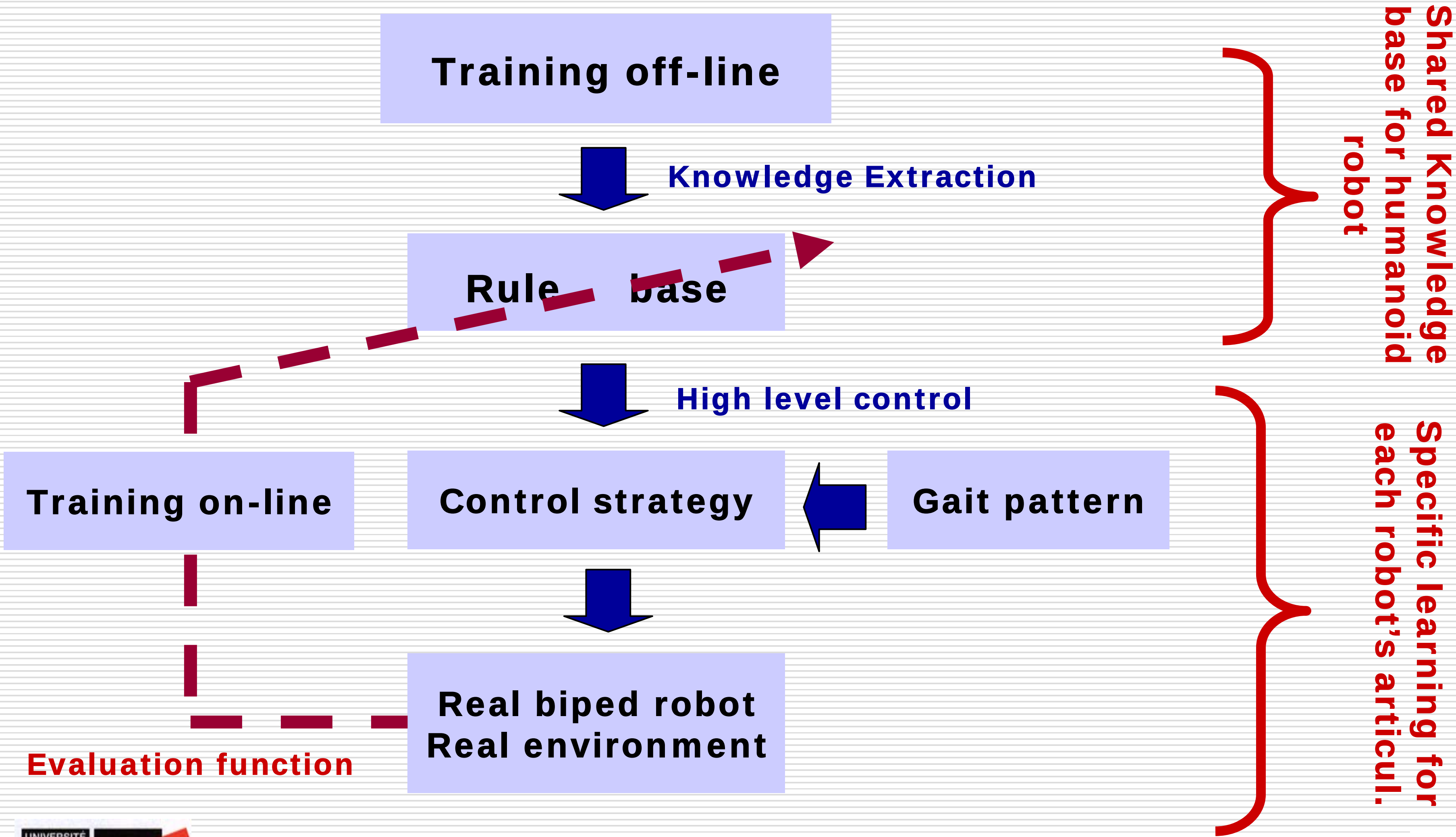
Humanoid Robotics

High level control ⇨ **Path planning = f (Goal, exteroceptive information)**

Low level control ⇨ **Joint trajectories = f (high level control, proprioceptive info.)**



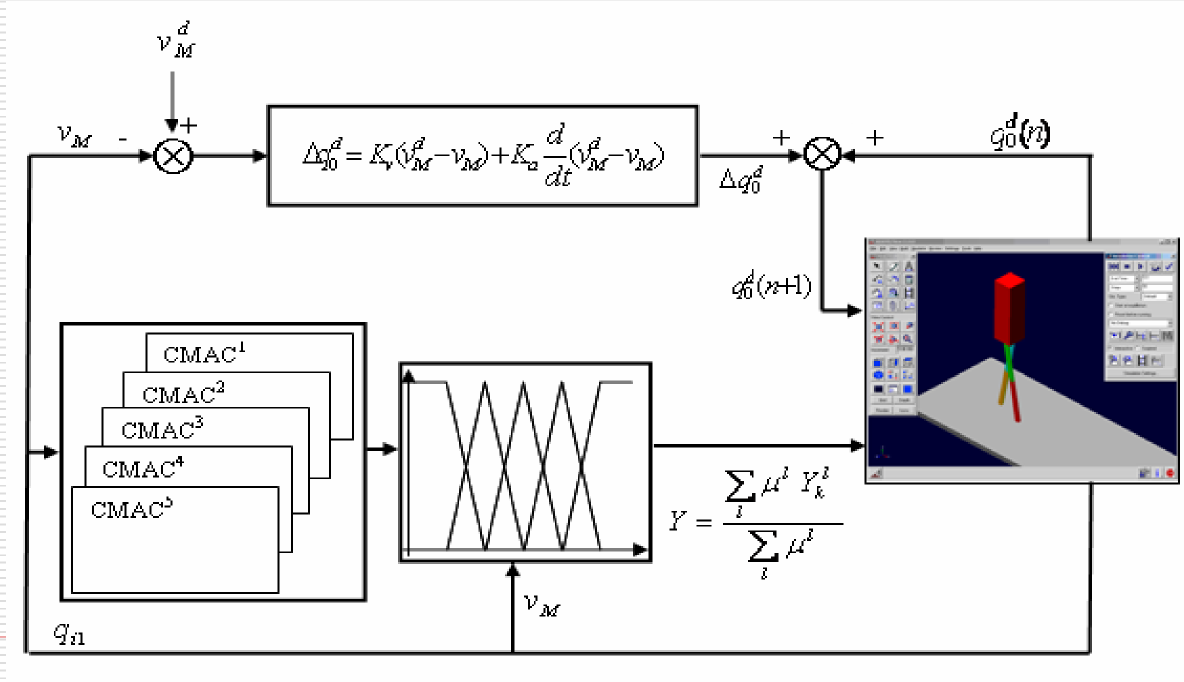
Humanoid Robotics



Humanoid Robotics

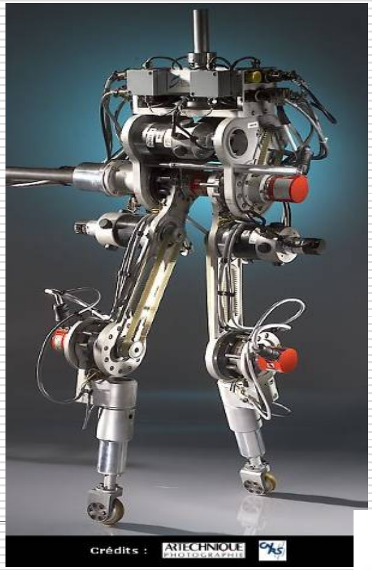
(Thesis: W. Yu and D. Ramik)

- **Swing legs' trajectory computing using several CMAC neural networks and a Fuzzy Inference System.**
- **Regulation of the average velocity from a modification of the desired pitch angle at each new step.**

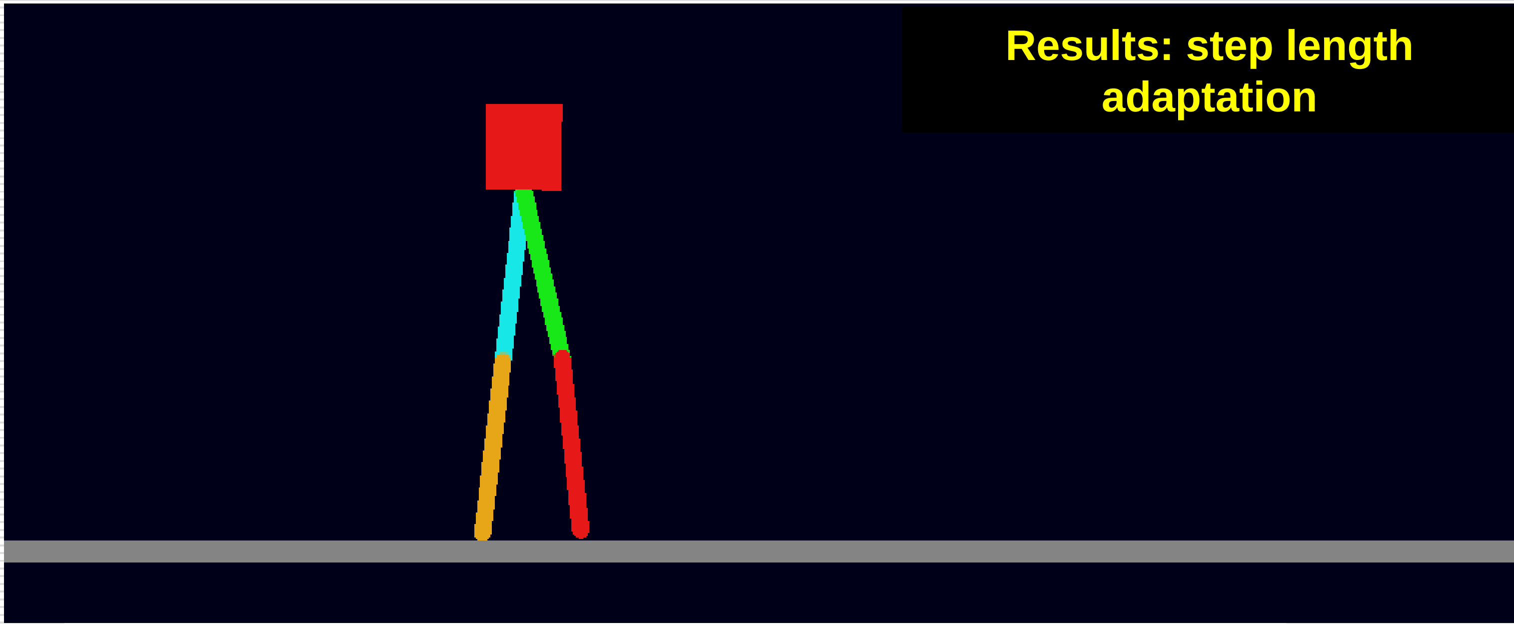


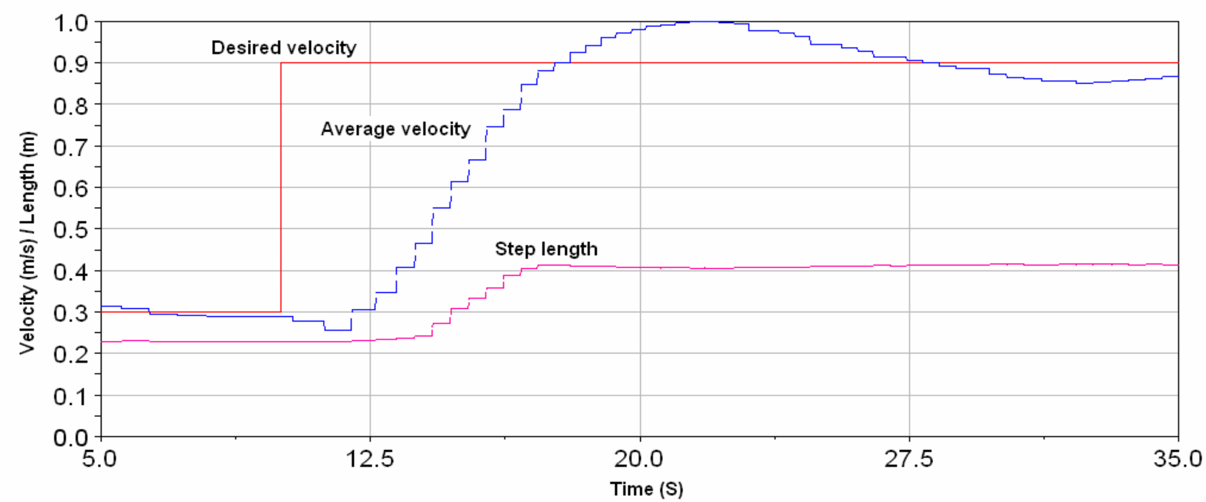
Robot RABBIT

GIPSA - CNRS

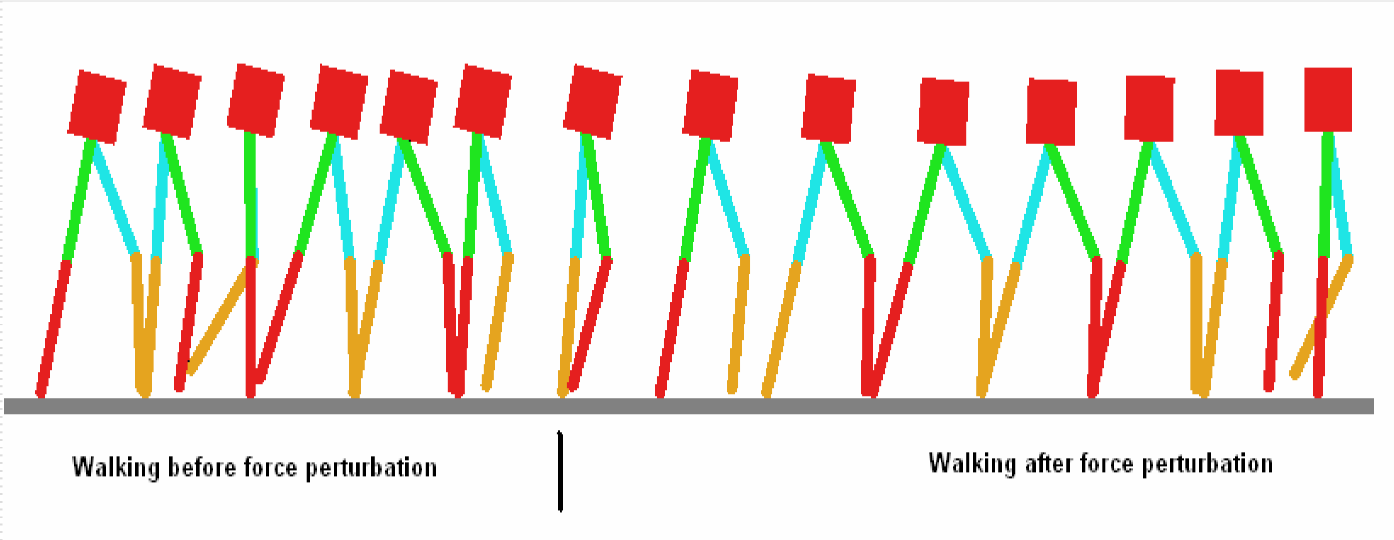


Humanoid Robotics



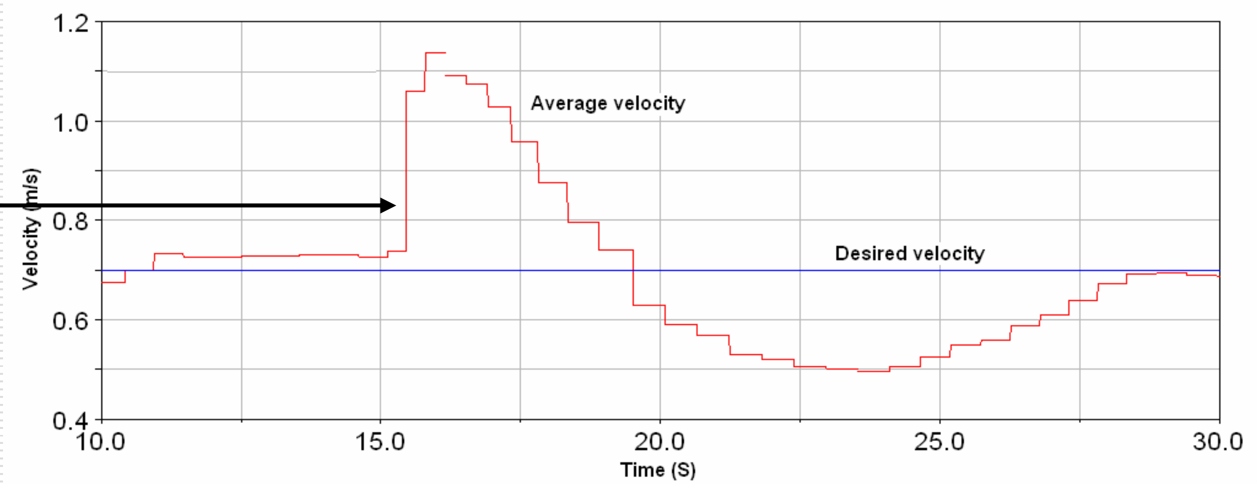


Humanoid Robotics



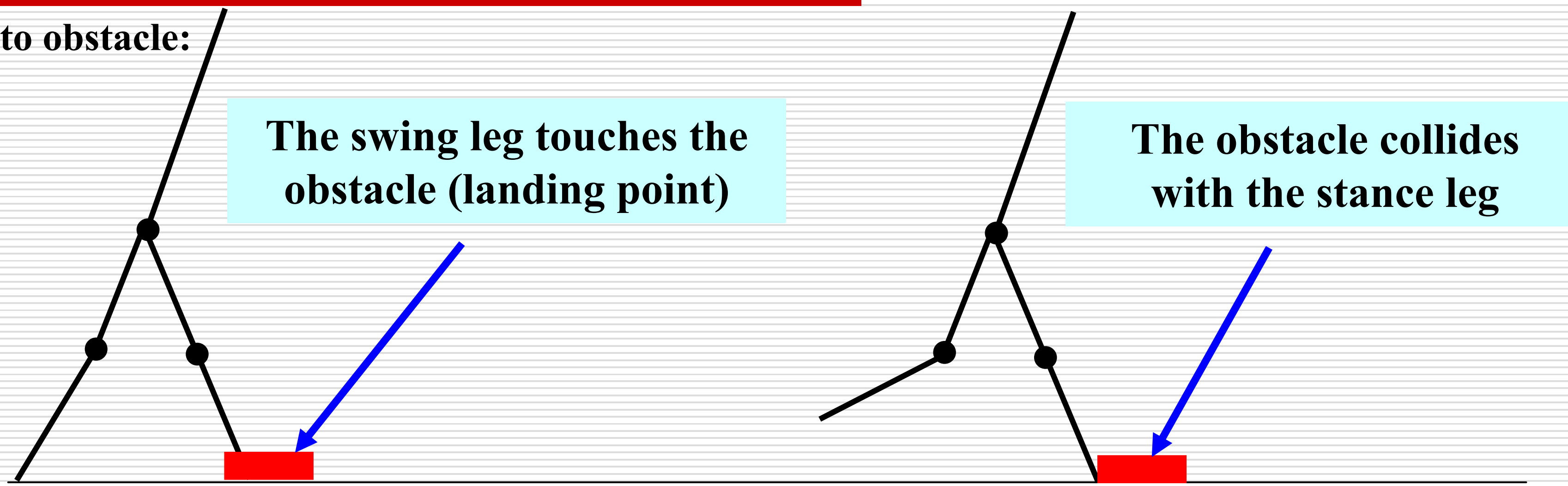
Foward force perturbation

(50N during 0,2s)



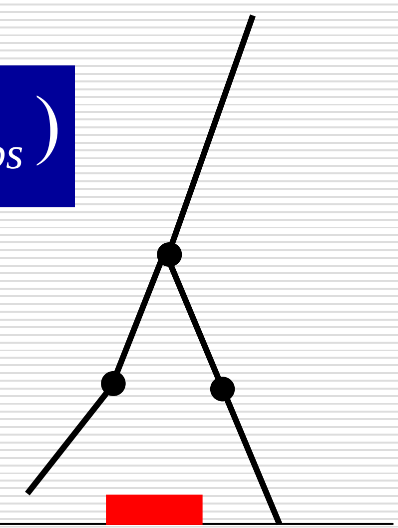
Humanoid Robotics

Crash into obstacle:



The goal is to find: $[L^{i}_{step}, t^{i}_{step}] = f(d^{i}_{obs}, v^{i}_{obs})$

Biped robots stepping over dynamic obstacle using gait adaptation (i.e. L_{step}, t_{step})



Humanoid Robotics

Fuzzy Q-learning:

- **Reinforcement learning**
- **Combination both fuzzy logic and Q-learning**
- **Continuous state-space**

The FQL algorithm uses a set of fuzzy rules such as:

$$\text{If } x \text{ is } S_i \text{ then } \begin{cases} a[i,1] \text{ with } q = q[i,1] \\ \text{or } a[i,2] \text{ with } q = q[i,2] \\ \text{or } a[i,J] \text{ with } q = q[i,J] \end{cases}$$

FQL algorithm

1. **Observe the state x**
2. **For each rule: choose the actual consequence using EEP**
3. **Compute the global consequence a(x) and its corresponding Q-value**
4. **Apply the action a(x)**
5. **Receive the reinforcement r**
6. **Update Q-value**

The learning agent has to find the best conclusion *a(i)* for each rule *i*

Inferred action *a(x)* for input *x* is:

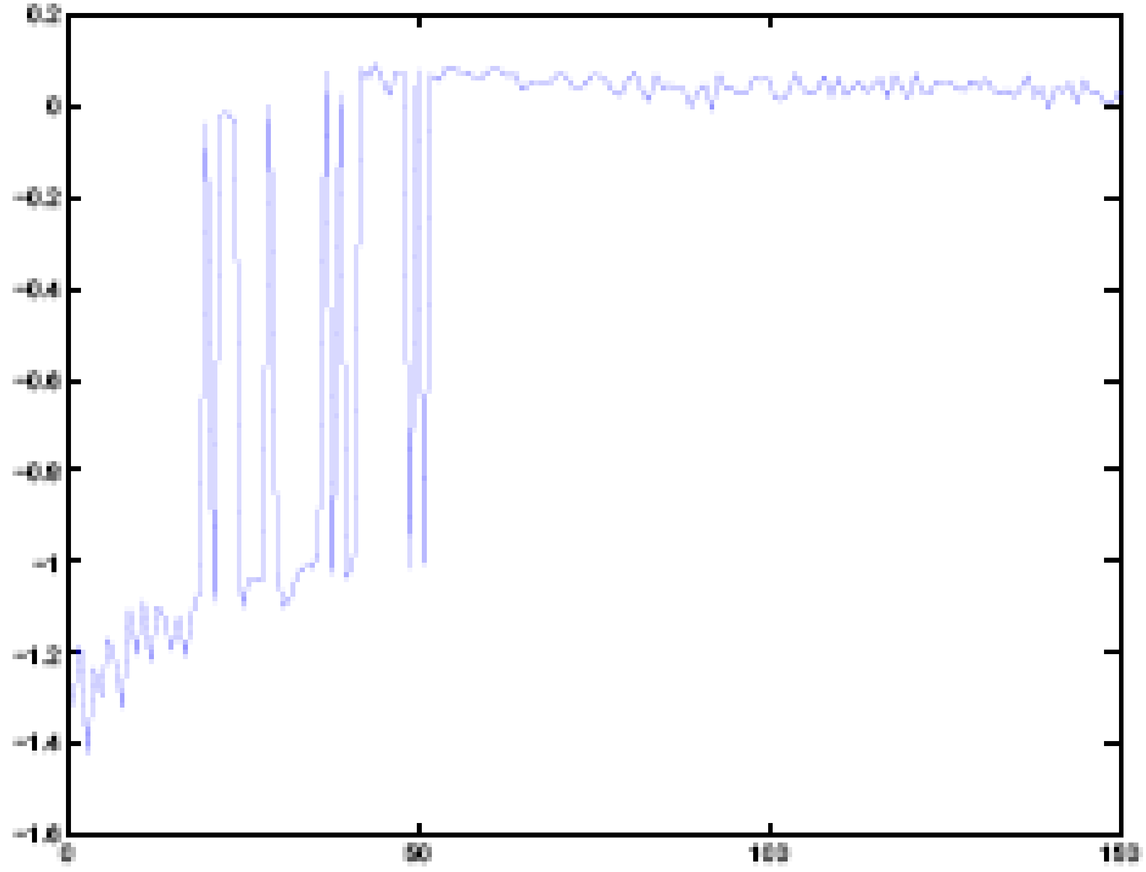
$$a(x) = \frac{\sum_{i=1}^{N} \alpha_i(x)\, a_i}{\sum_{i=1}^{N} \alpha_i(x)}$$

Q-value is given by:

$$Q(x,a) = \frac{\sum_{i=1}^{N} \alpha_i(x)\, q_i(S_i, a_i)}{\sum_{i=1}^{N} \alpha_i(x)}$$

Footstep planning based on FQL:

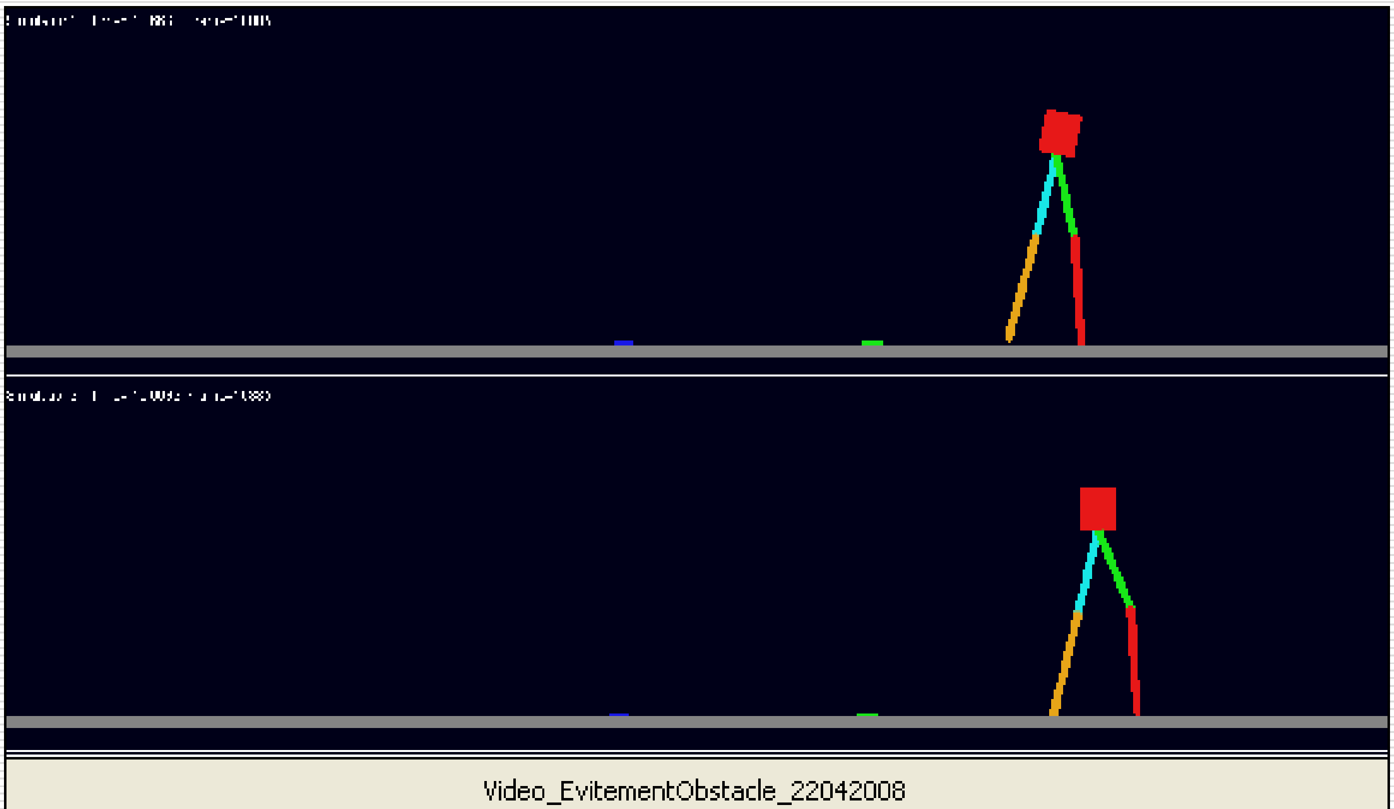
Humanoid Robotics



Humanoid Robotics

Blue : static obstacle

Green : dynamic obstacle (V_{obs}=0.3m/s)



Simulation N°1

Without adaptation

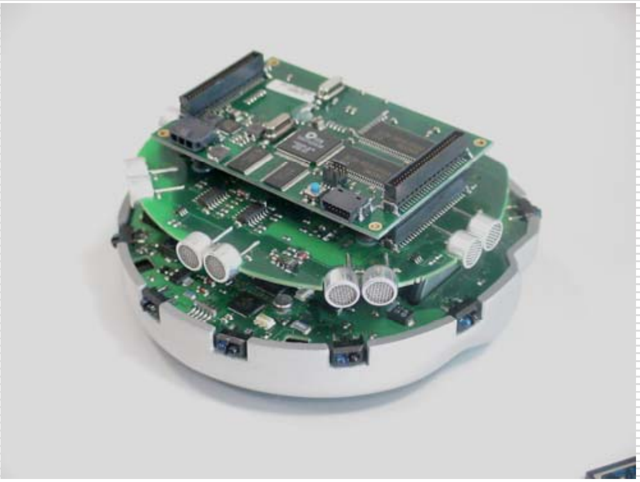
Simulation N°2

With adaptation

Humanoid Robotics

Collective Robotics: group & social behavior

(Thesis projects: T. Wang and D. Ramik)

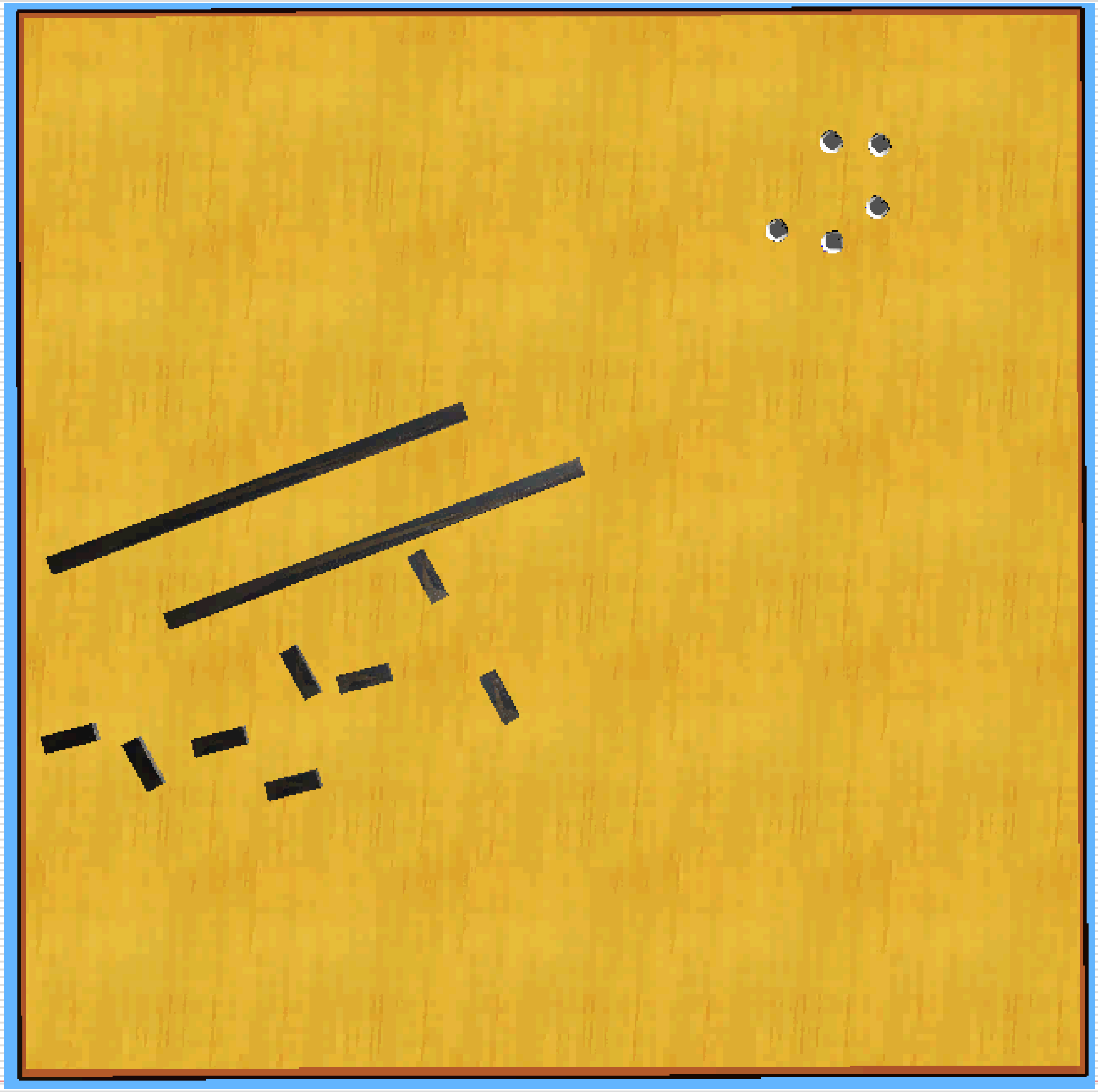


Collective Robotics: group & social behavior

(Thesis project: T. Wang)

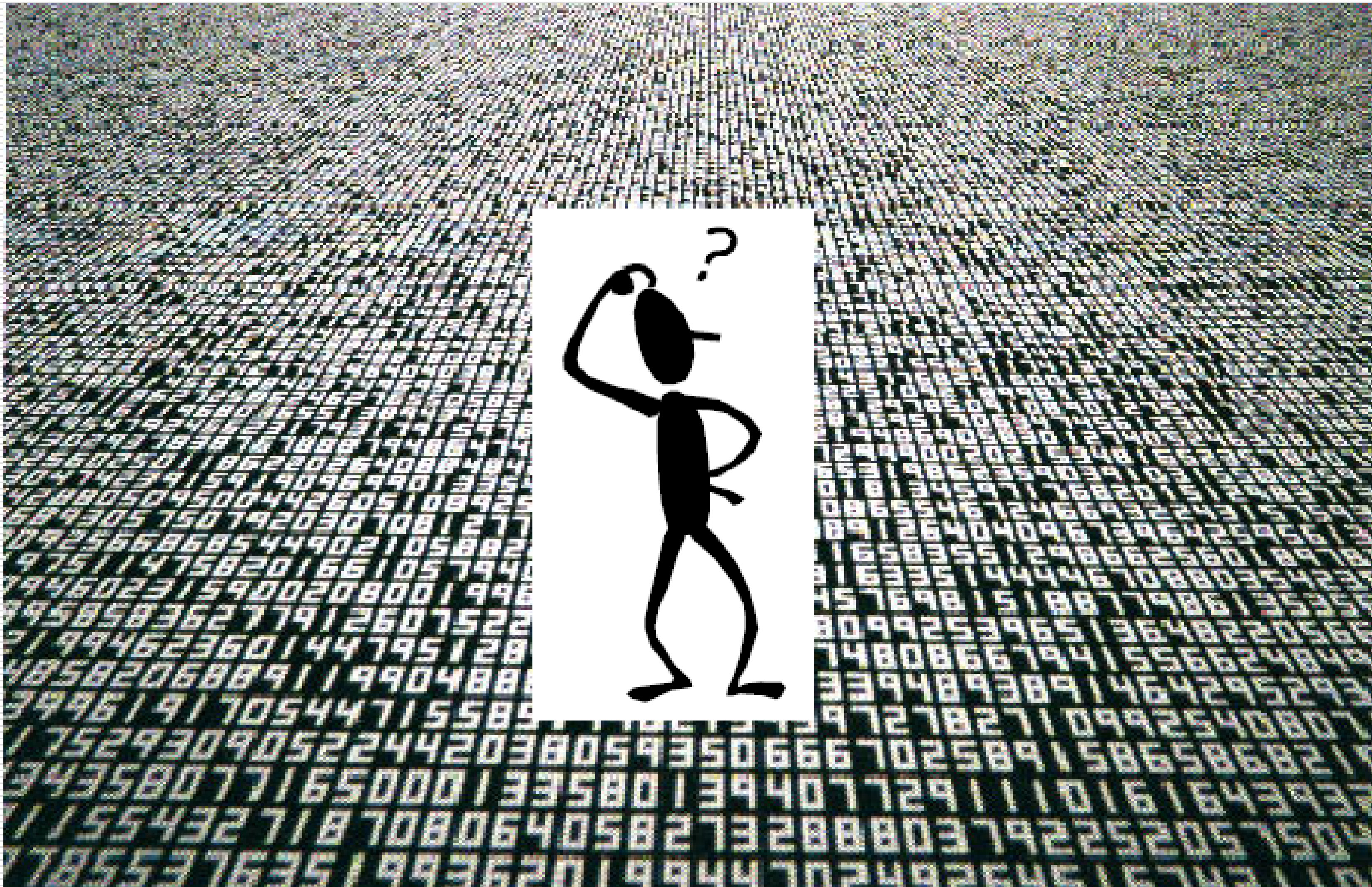
Distributed Intelligence: Multi-Agents control

Collective Robotics: group & social behavior



Modular Self-Organizing Structures

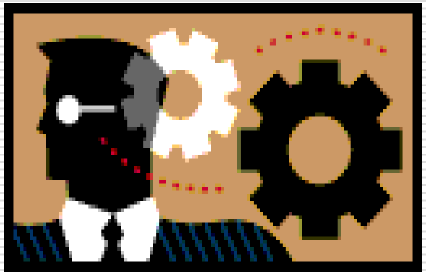
(Thesis: M. Rybnik, E. Bouyoucef, I. Budnyk)



Modular Self-Organizing Structures

(Thesis: M. Rybnik, E. Bouyoucef, I. Budnyk)

- **Main operations:**
  - **Pre-processing task**
  - **Clustering task**
  - **Classification task**

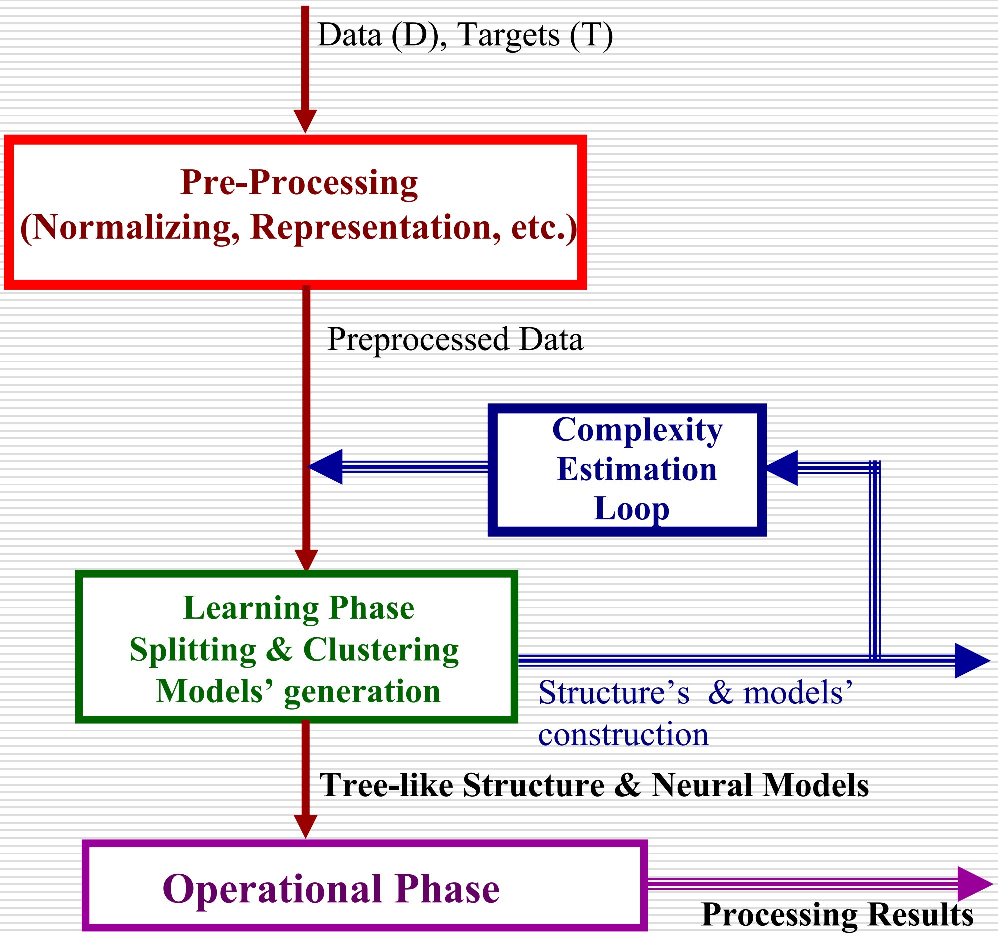


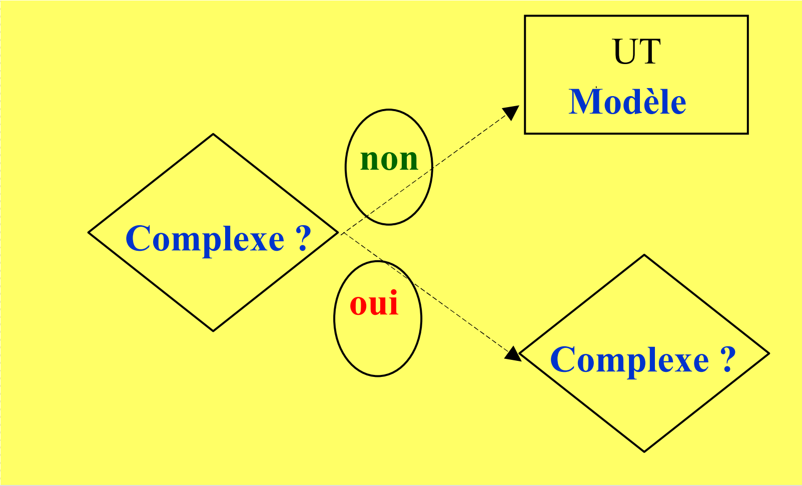
- **How:**
  - **to chose “features”?**
  - **to chose the appropriate classifier?**
  - **to organize the system?**

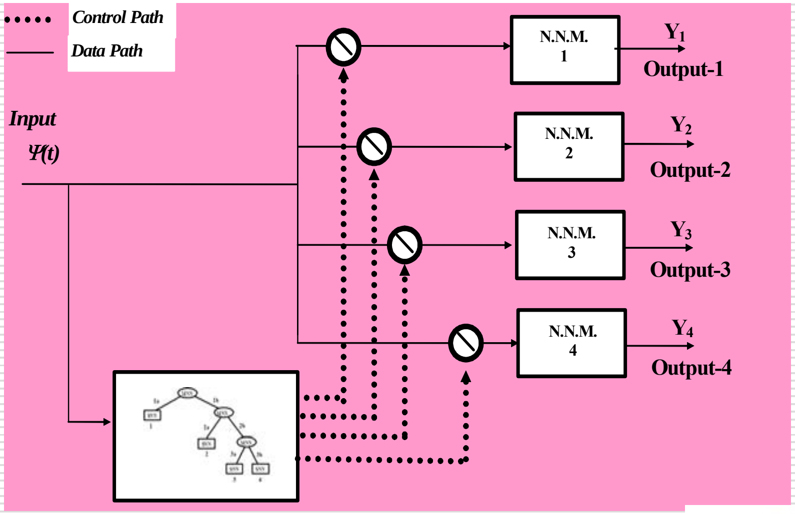
Modular Self-Organizing Structures

(Thesis: M. Rybnik, E. Bouyoucef, I. Budnyk)

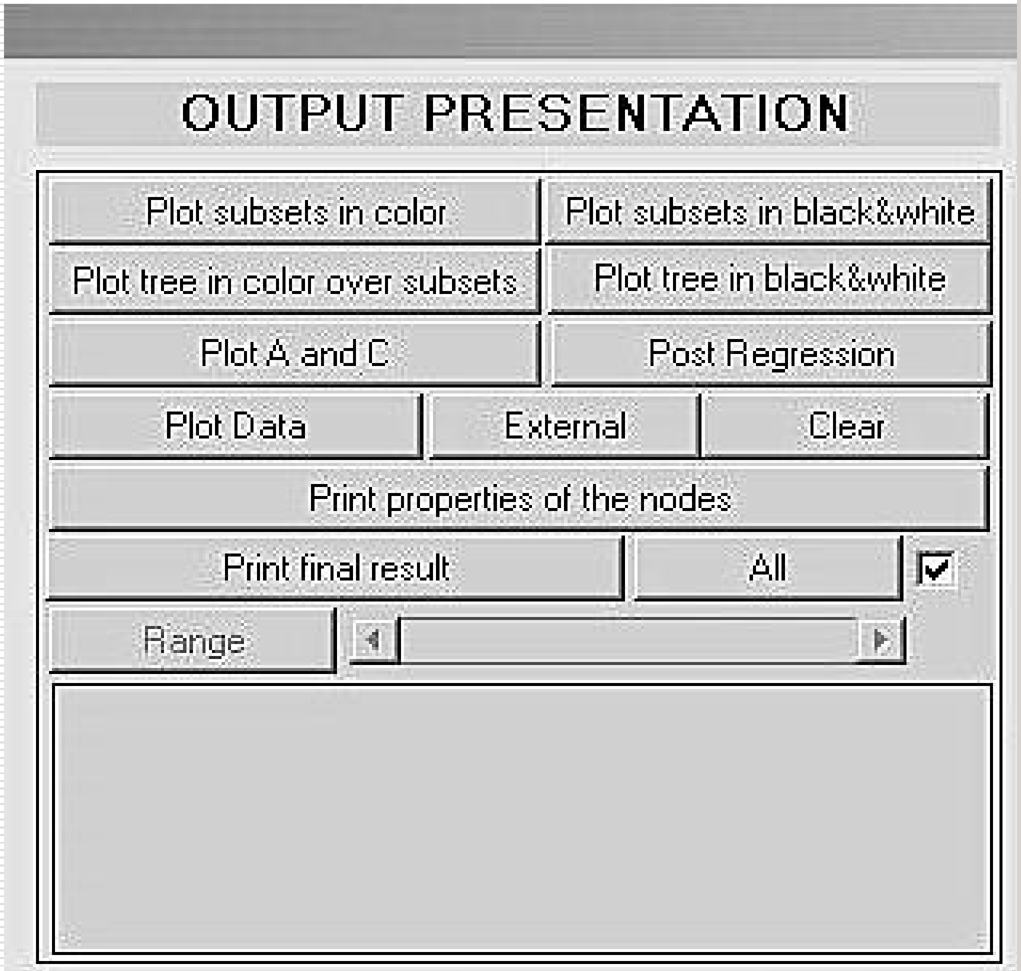
T-DTS concept: Divide To Simplify

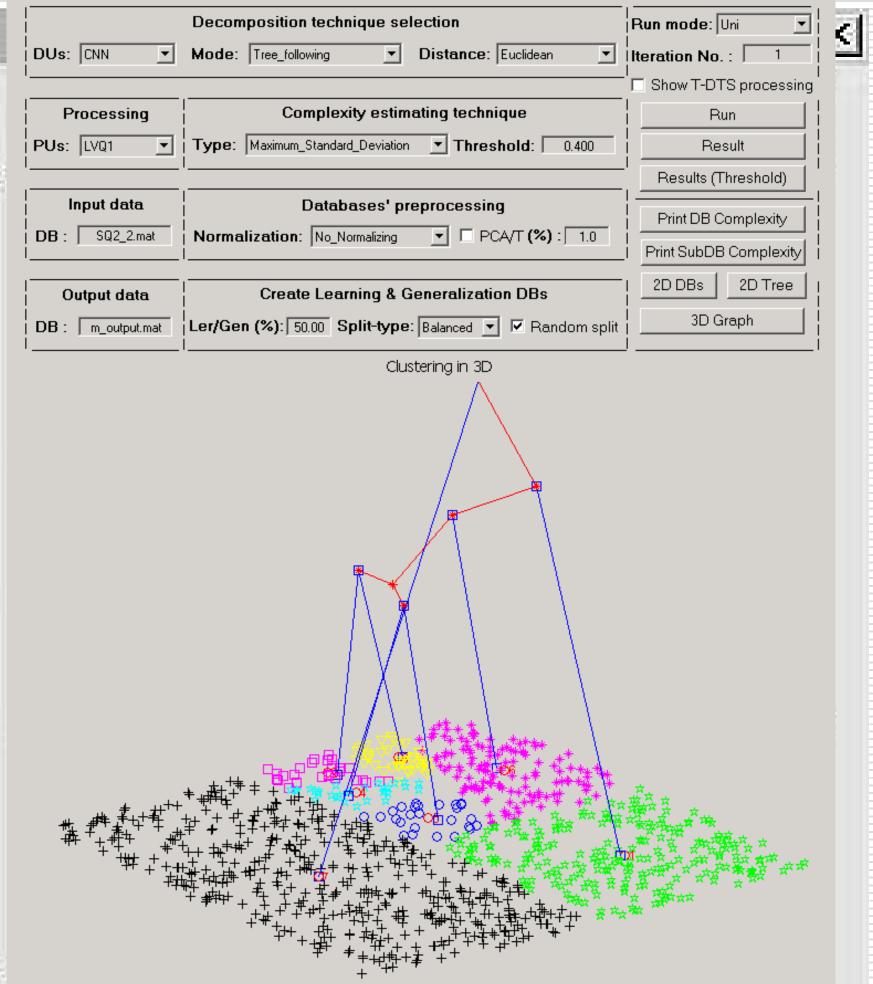






Modular Self-Organizing Structures

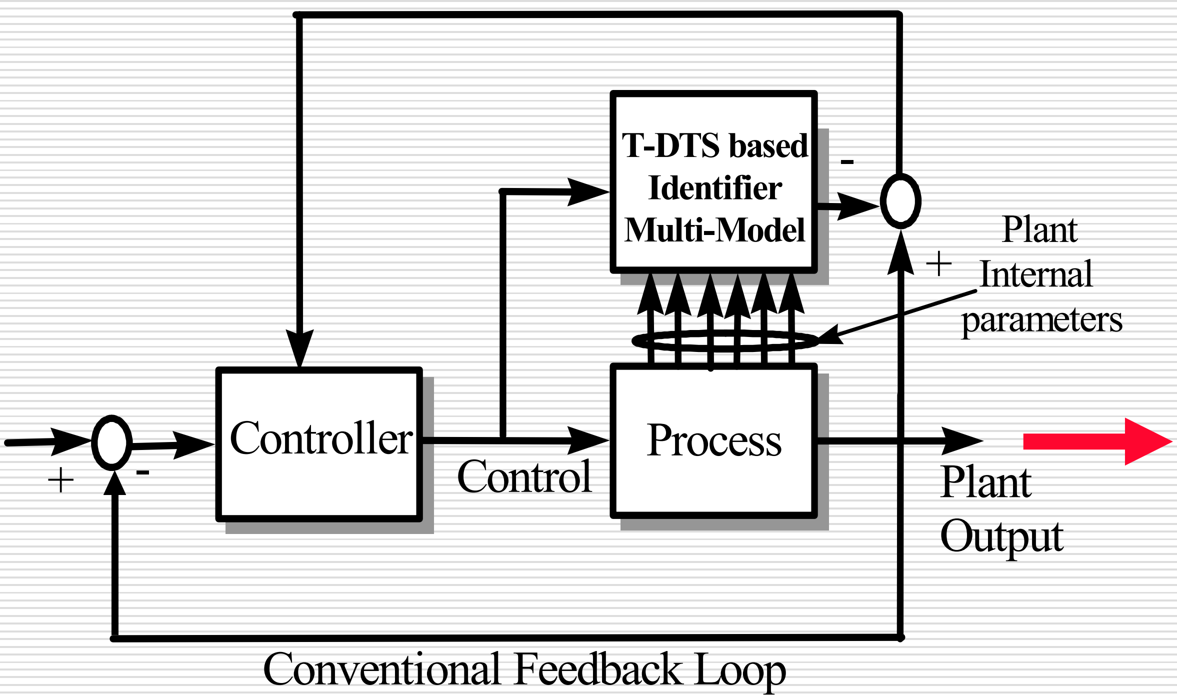


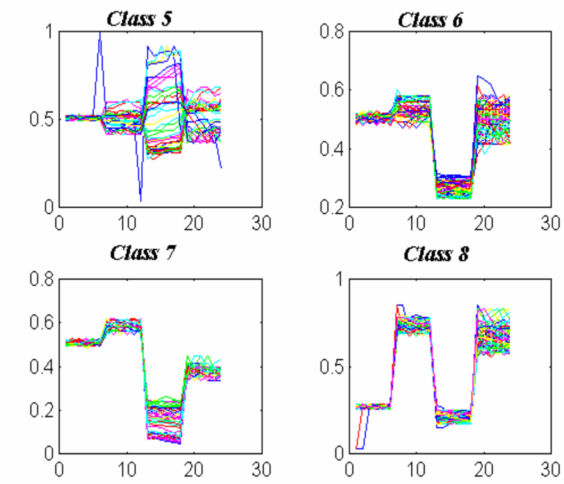


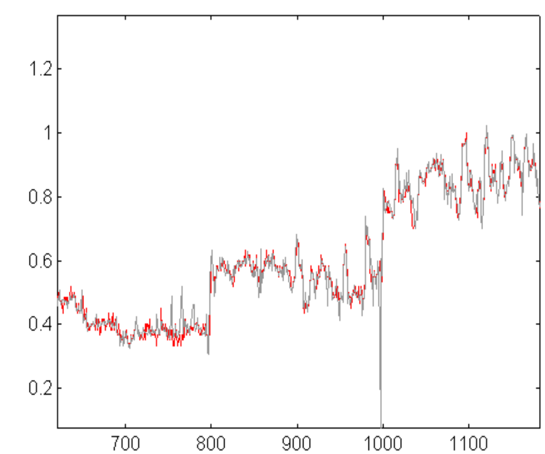
Modular Self-Organizing Structures

Application: Complex systems & processes identification

Industrial plants' identification & adaptive control (Group TOTAL)



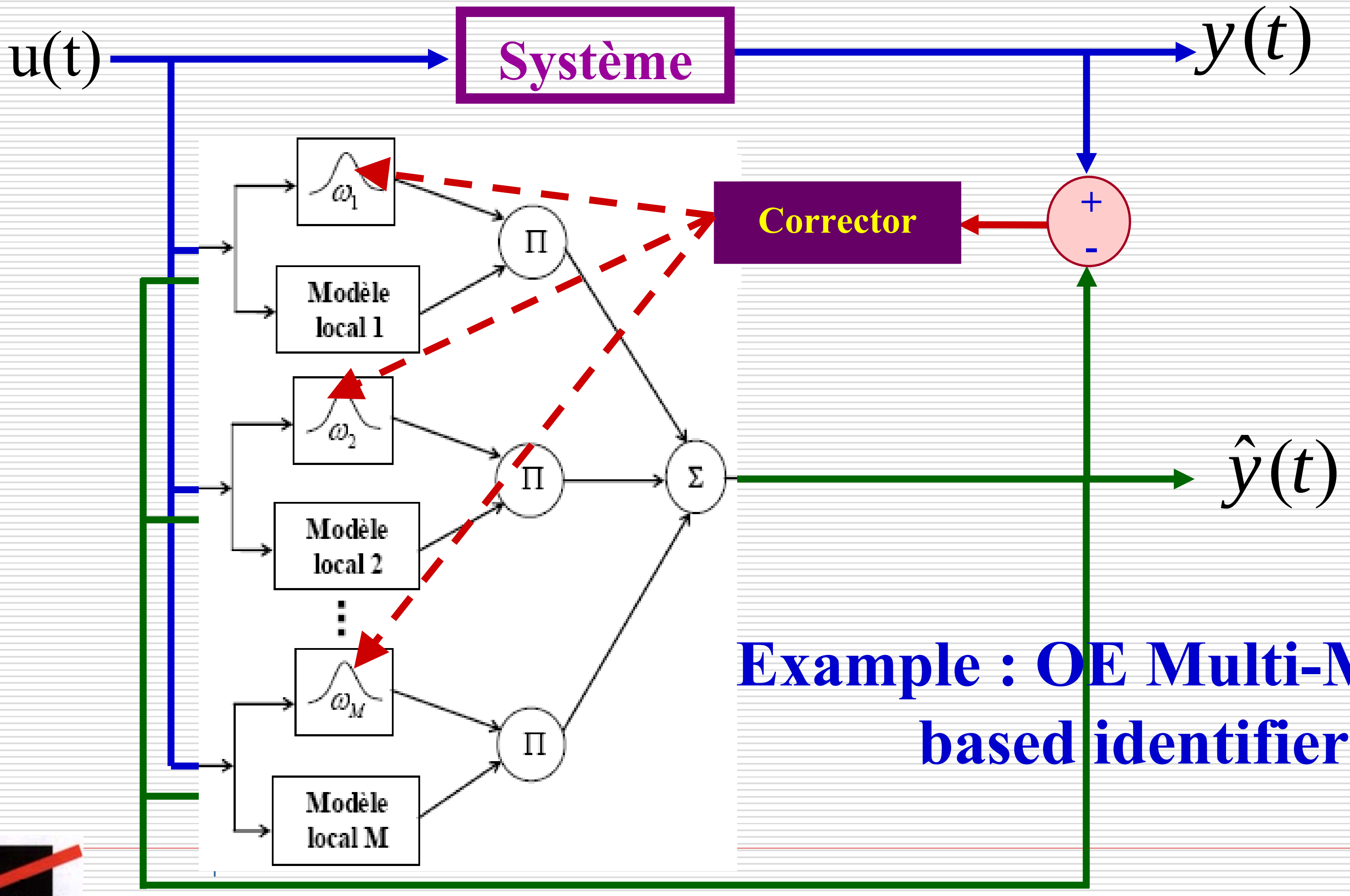




Groupe TOTAL

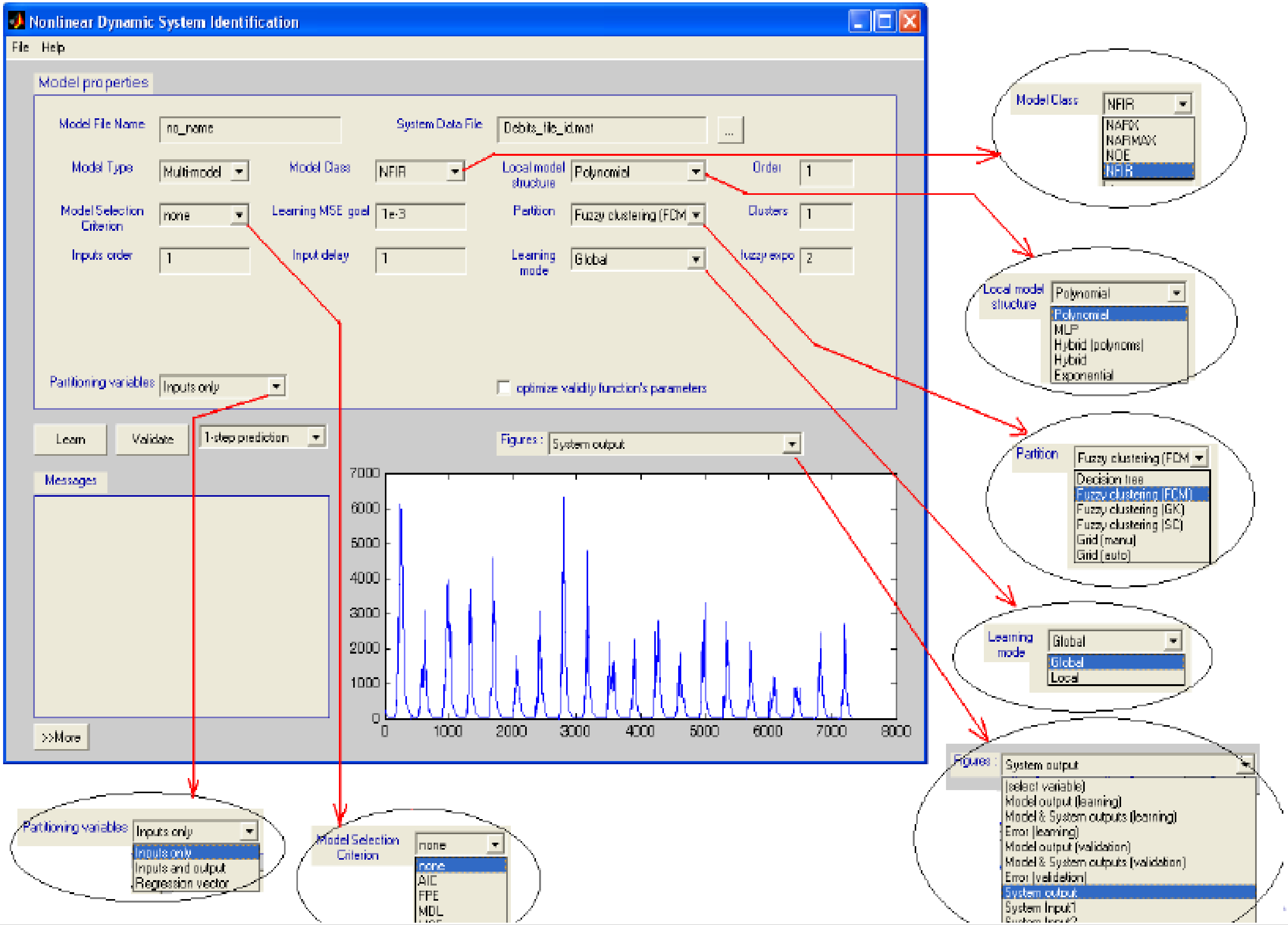
Multi-model Self-Organizing Systems: application to nonlinear complex systems' identification

(Thesis: L. Thiaw + Collaboration with Senegal)



Example : OE Multi-Model based identifier

Multi-model Self-Organizing System: software implementation

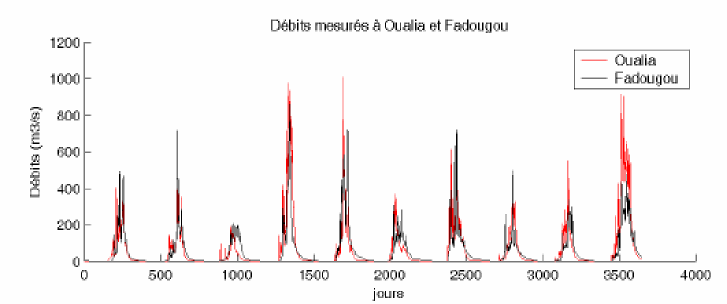


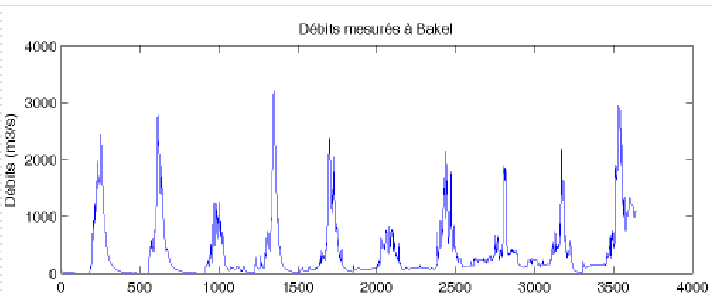
Multi-model Self-Organizing Systems

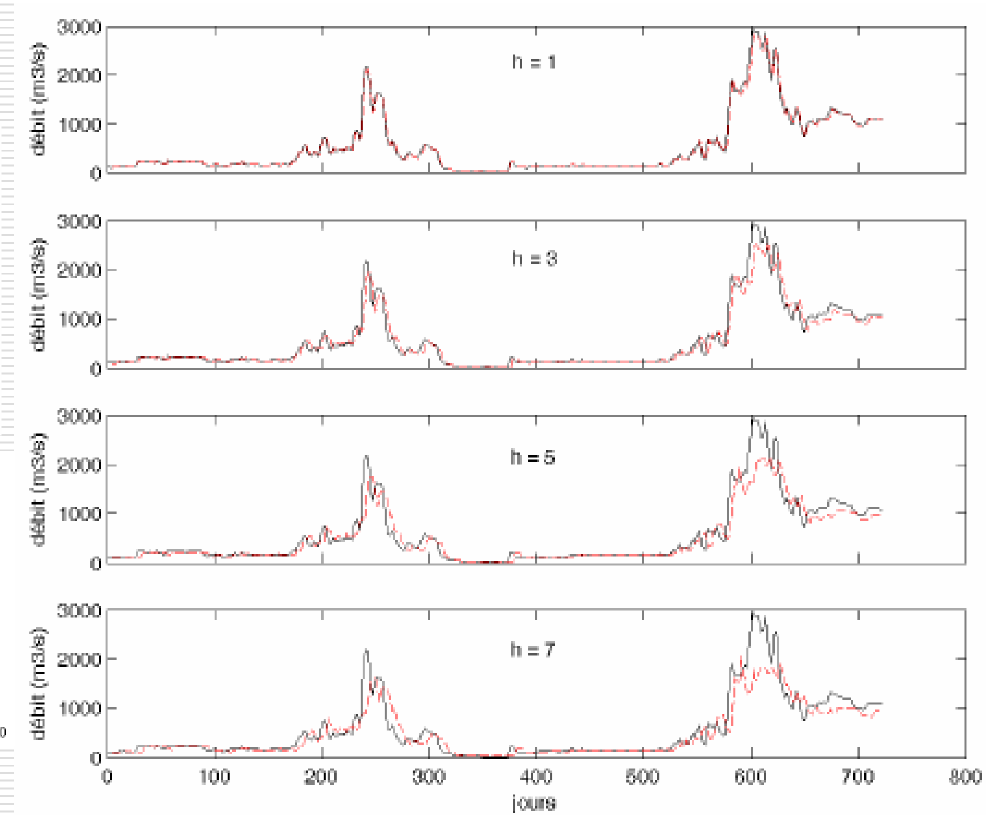
Application: Natural catastrophes forecasting

Multi-model Self-Organizing Systems

Application: Natural catastrophes forecasting







Complex behaviors’ simulation

(Thesis: A. Bahrammirzaee, D. Kanzari)

« Serious Games »

Simulation & Training of the « Negotiation» process

SISINE

Sistema Integrato di SImulazione di NEgoziatione

SISINE PROJECT / Leonardo Da Vinci Program

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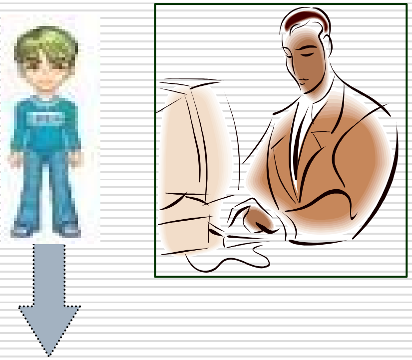
ENTERTAINMENT ROBOTICS

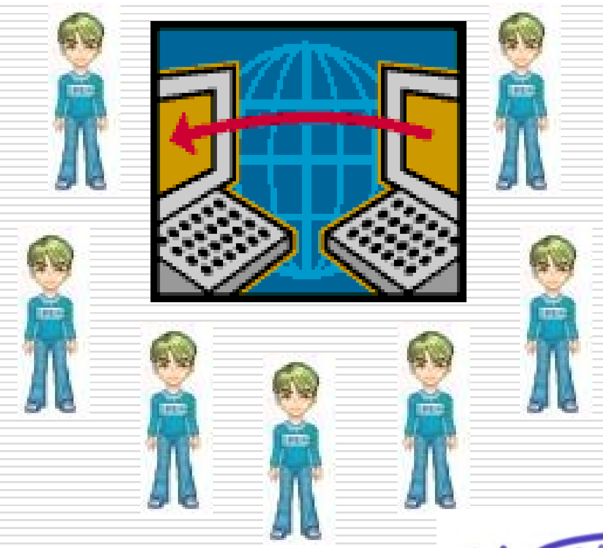
The complex process: Negotiation

- Negotiation process modeling & simulation:
  - Negotiation strategies' design
  - Negotiation strategy validation
  - Negotiation process learning

To look at the "Negotiation Process" as an interactive "Game" in virtual environment



- Modeling the Negotiation sequence as a "Role-Playing Game":
  - "Face-To-Face" negotiation
  - Group Negotiation
  - Scenario based negotiation



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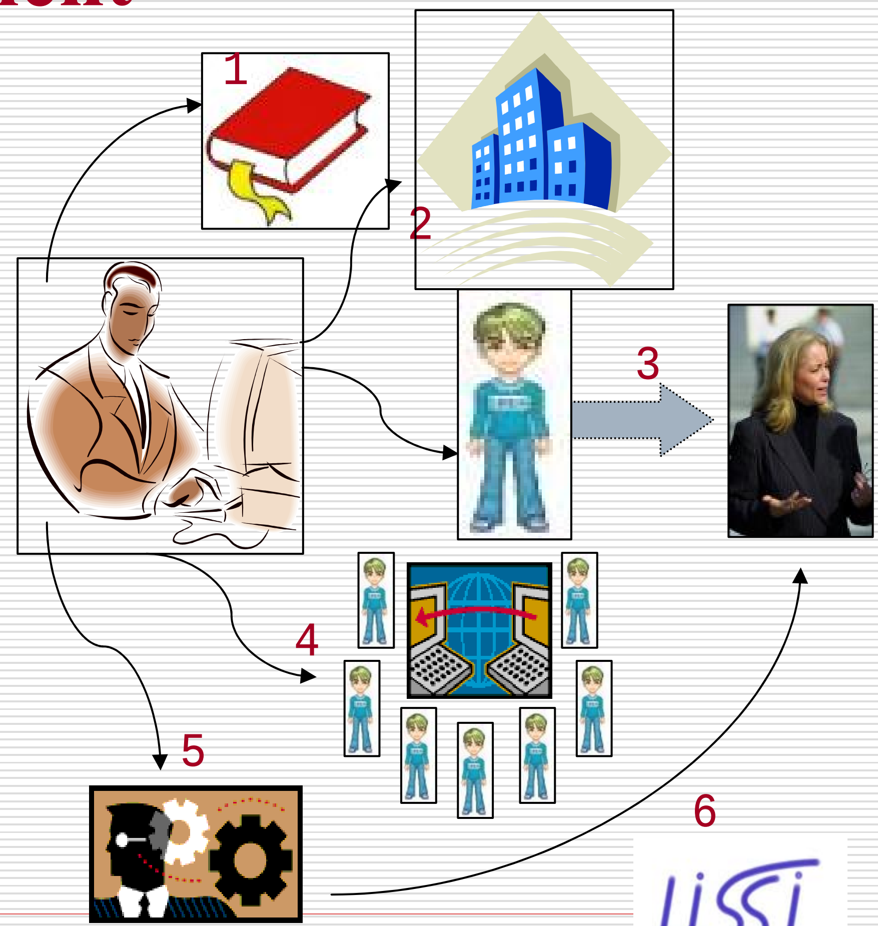
Interactive " Role-Playing " game in " Virtual " environment

Computer controlled :

- **"Avatars" controlled by human player**
- **"Avatars" controlled by computer**
- **Pedagogical facilities**



SISINE PROJECT / Leonardo Da Vinci Program

SISINE PROJECT / Leonardo Da Vinci Program

Final Word

We are progressing…

Other Labs as well…

But a lot remains to do…

Final Word

However, today, the most important is of course:

Your Opinion

UNIVERSITÉ PARIS XII VAL de MARNE

CONNAISSANCE ACTION

Thank you for your attention

LISSI

Laboratory

IUT Sénart / Fontainebleau