

## Part 4 –Applications

- Nondestructive inspection of structures
- Visual inspection of transmission lines
- Liquid Level Process
- Water treatment plant
- Automatic Car Guiding
- Consumer Electronics
- Path Planning
- Building Automation – (Ambient Intelligence)



# Applications:

## Nondestructive inspection of structures

### DAMAGE DETECTION USING AN HIBRID FORMULATION BETWEEN CHANGES IN CURVATURE MODE SHAPES AND NEURAL NETWORK.

Miguel Genovese, Adolfo Bauchspiess, José L.V. de Brito, Graciela N. Doz

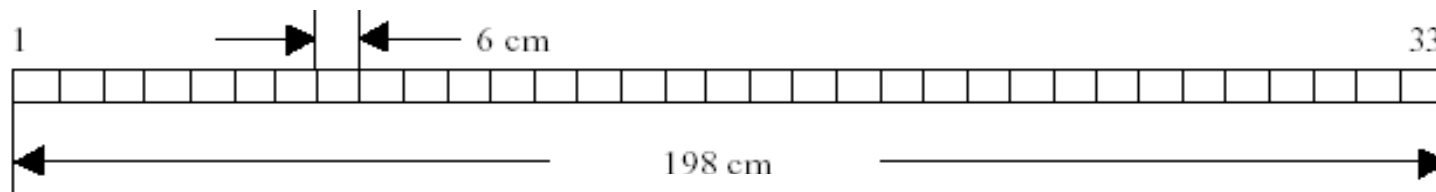
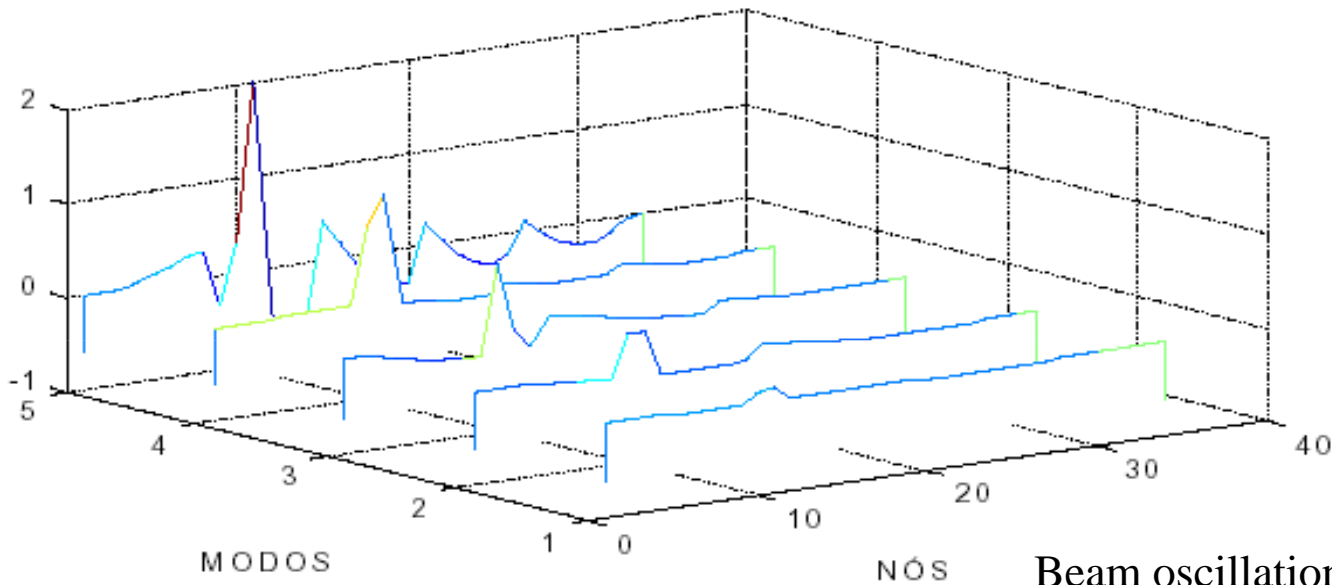


Figura 2: Discretization of the test beam

- strain gauges
- Hammer hit
- Signal acquisition

# Applications:

## Nondestructive inspection of structures

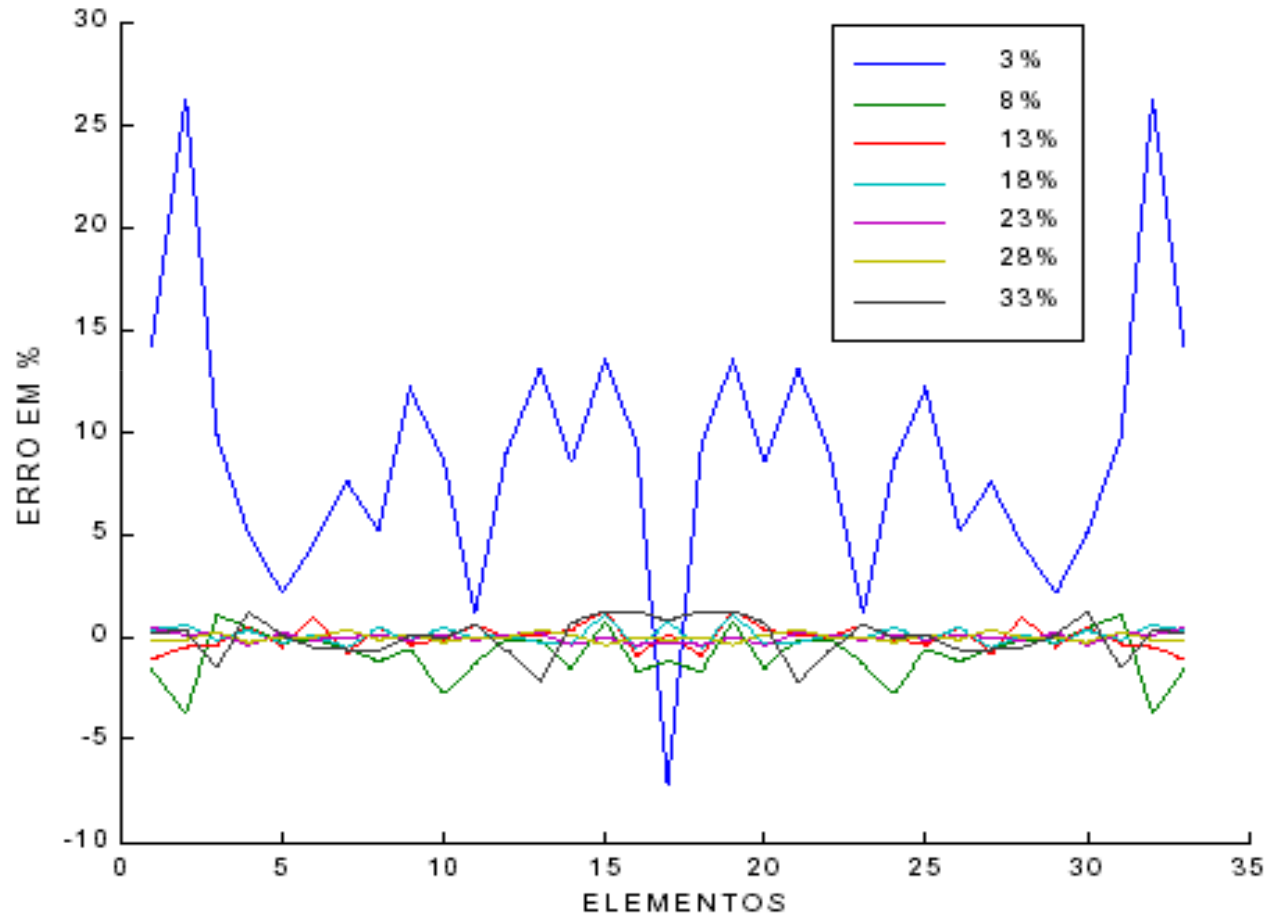


Beam oscillation frequencies (Hz): with and without damage

Harmonics	Beam without damage	Beam with 20% moment of inertia reduction at element 10
First	67.76	67.48
Second	184.22	182.72
Third	354.01	352.62
Fourth	570.26	569.59
Fifth	825.83	821.93

# Applications:

## Nondestructive inspection of structures



ANN error at the training data

# Inspection of Transmission Lines



# Inspection of Transmission Lines

- Autonomous computational system for the visual inspection of electricity transmission lines
- Detection of flaws in the gripper of the line spacers



# Inspection of Transmission Lines



- Traditional inspection of transmission lines:
  - Aerial survey using a helicopter
  - Staff onshore
- Costly and expensive

# Inspection of Transmission Lines



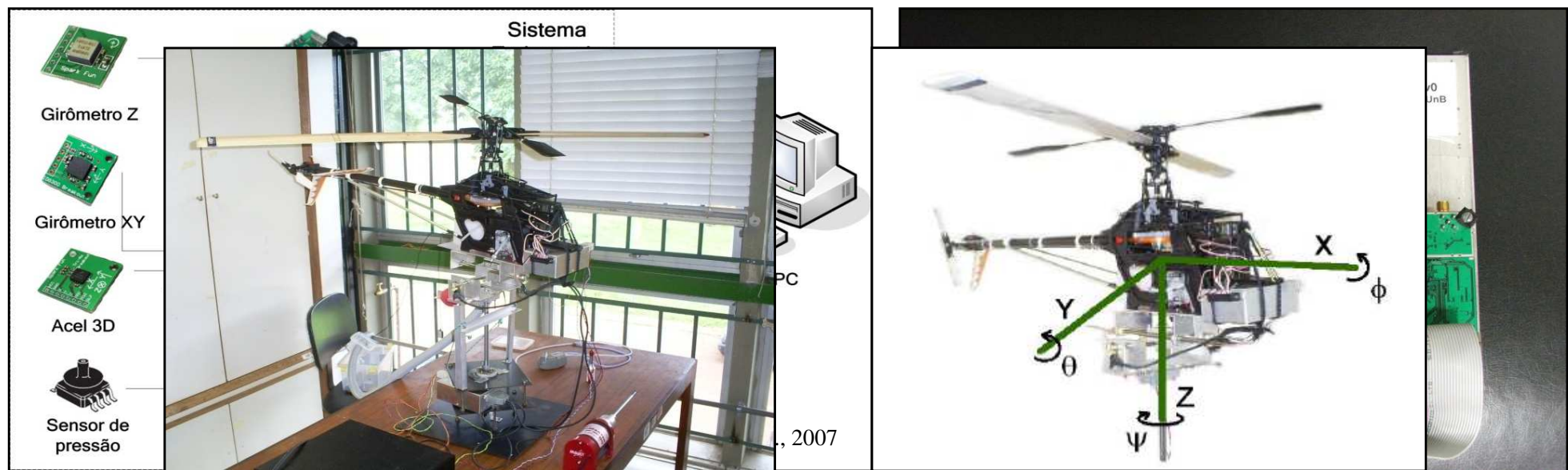


# UAV – LARA/UnB



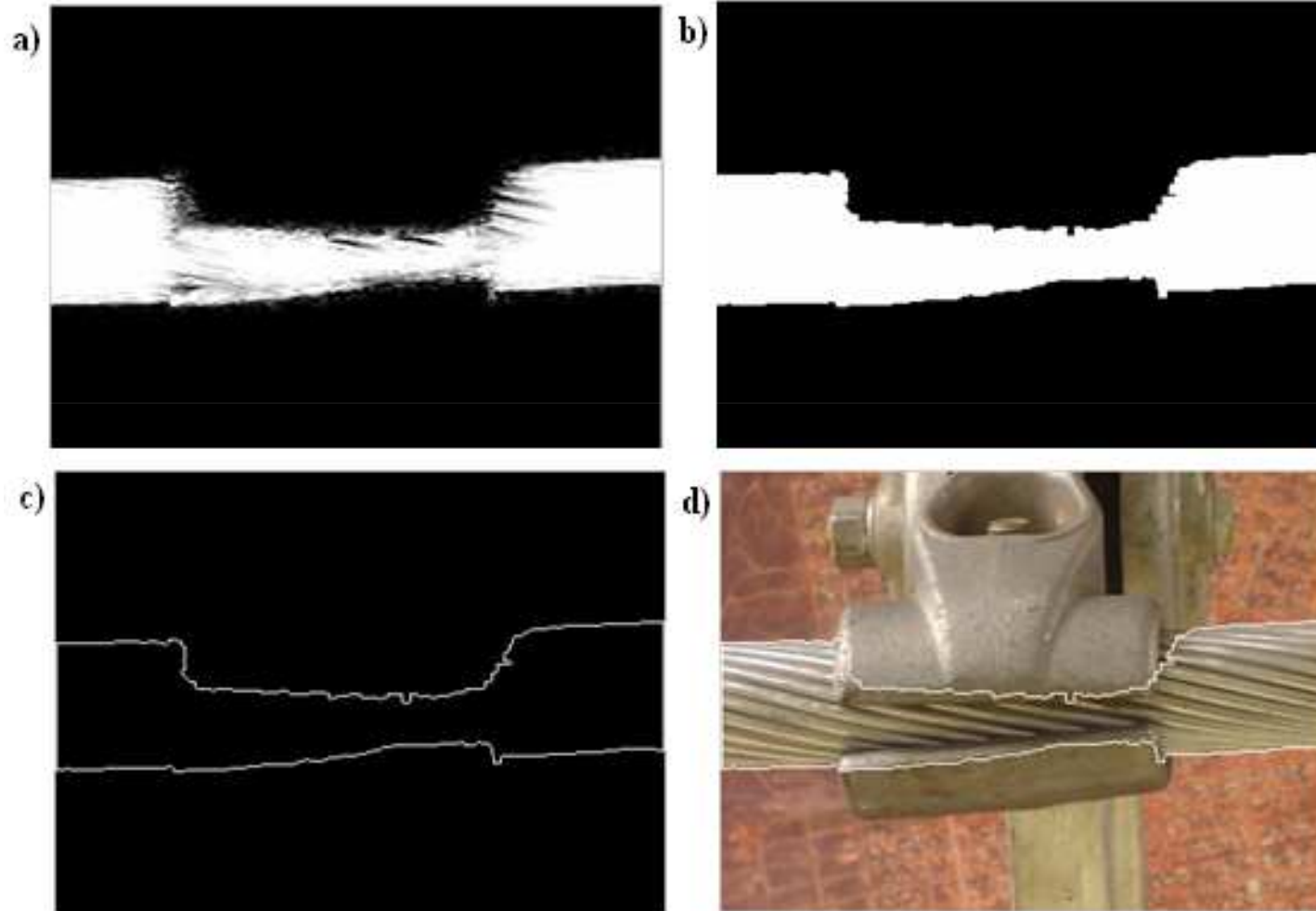
# Inspection of Transmission Lines

- Adaptation of Unmanned Aerial Vehicles (UAVs)
- Research project UNB / ANEEL - Expansion
  - Development of an UAV to aid inspecting transmission lines

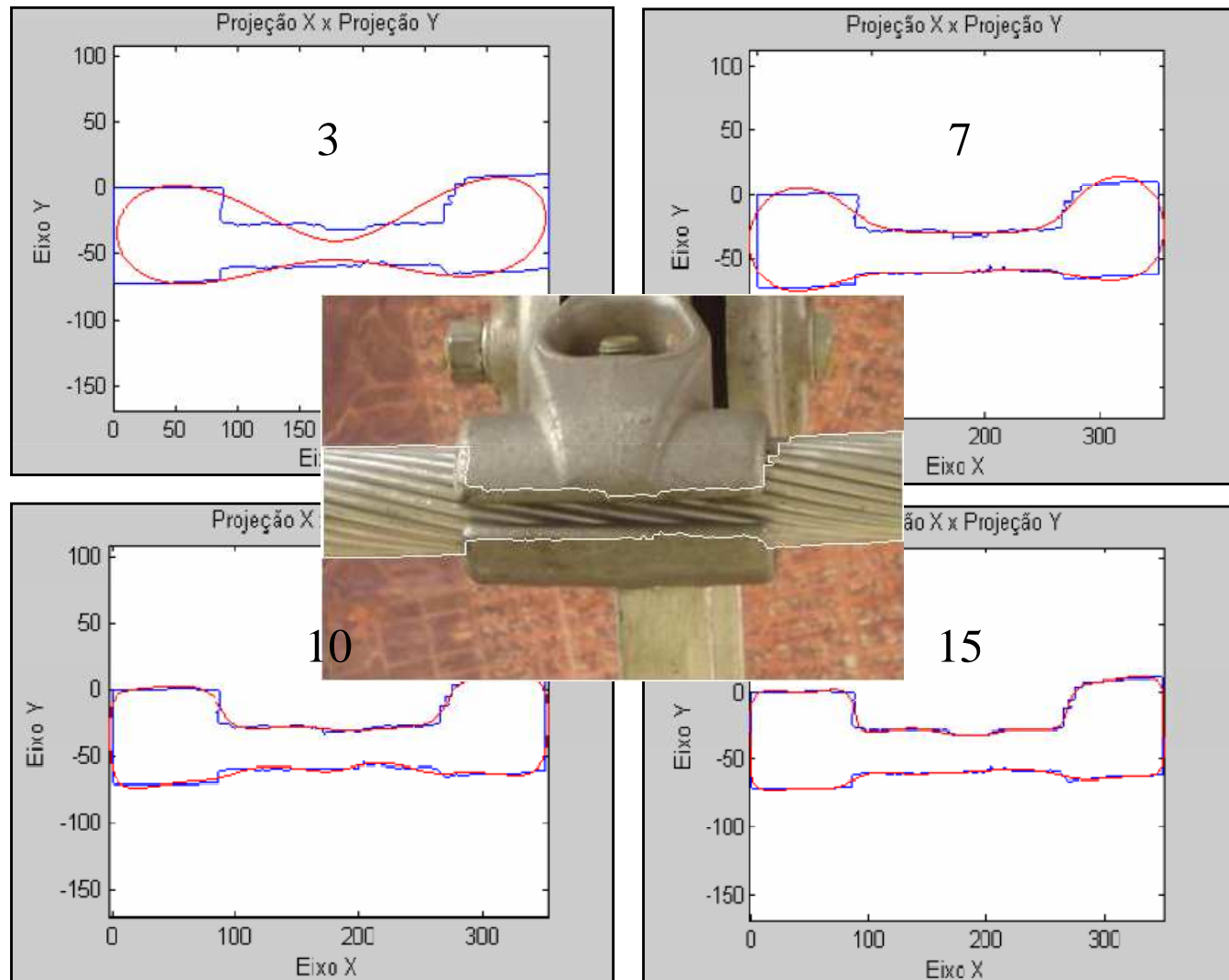


# Image Processing

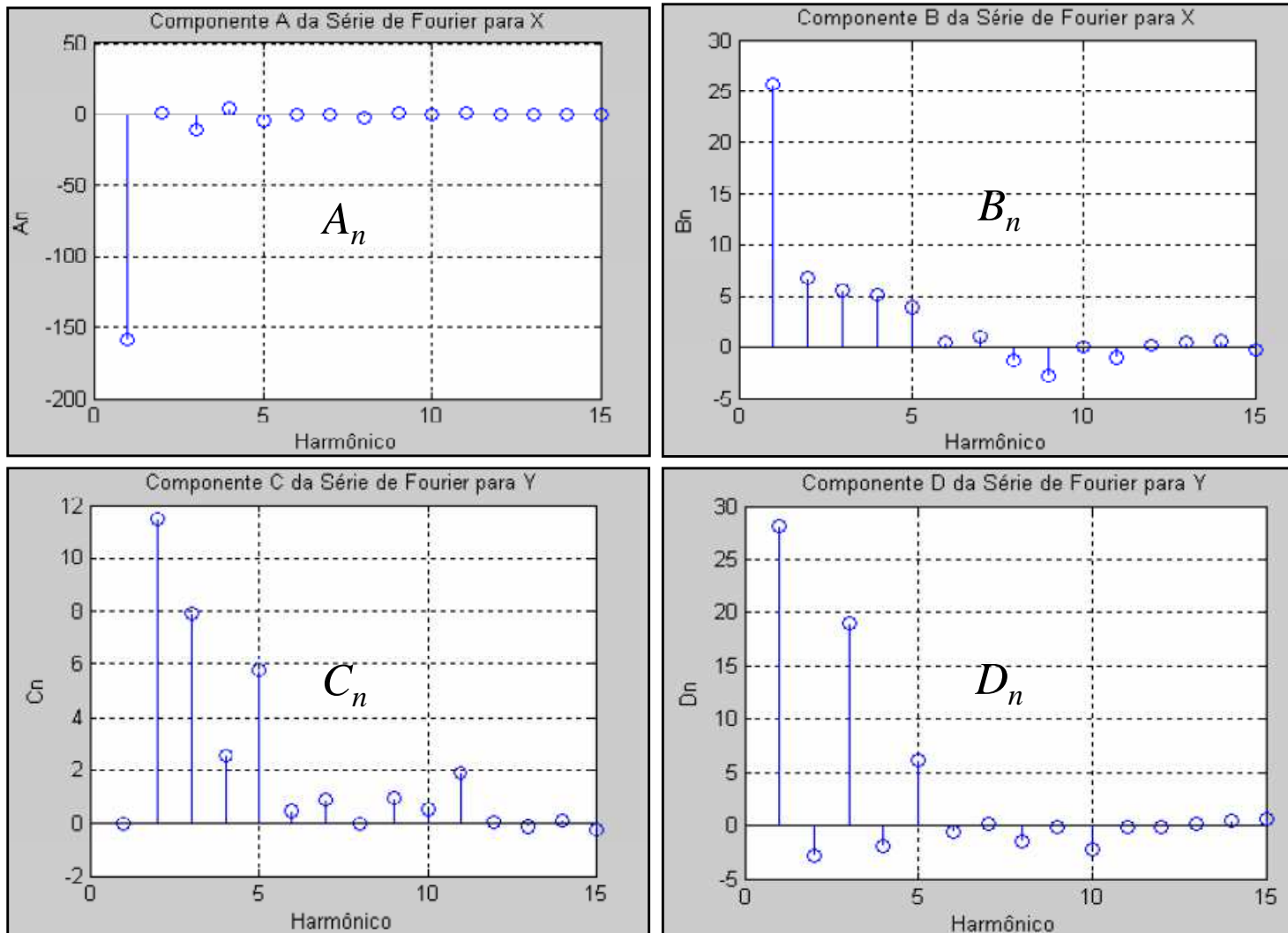
## → Failures Recognition



# Results – Representation of the contour

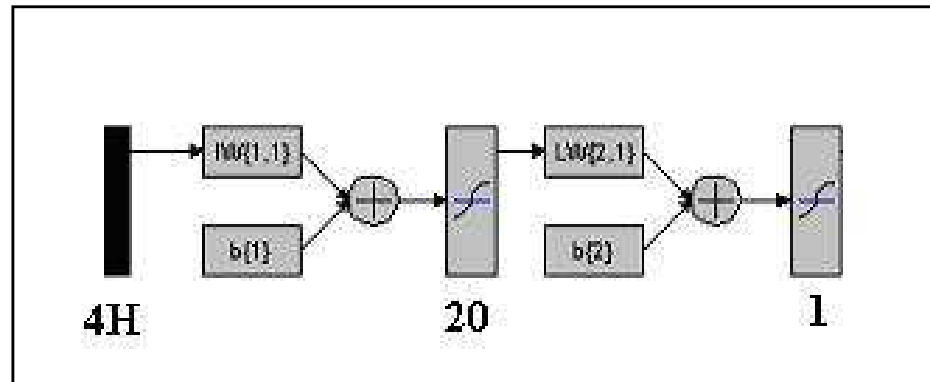


# Results – Representation of the contour

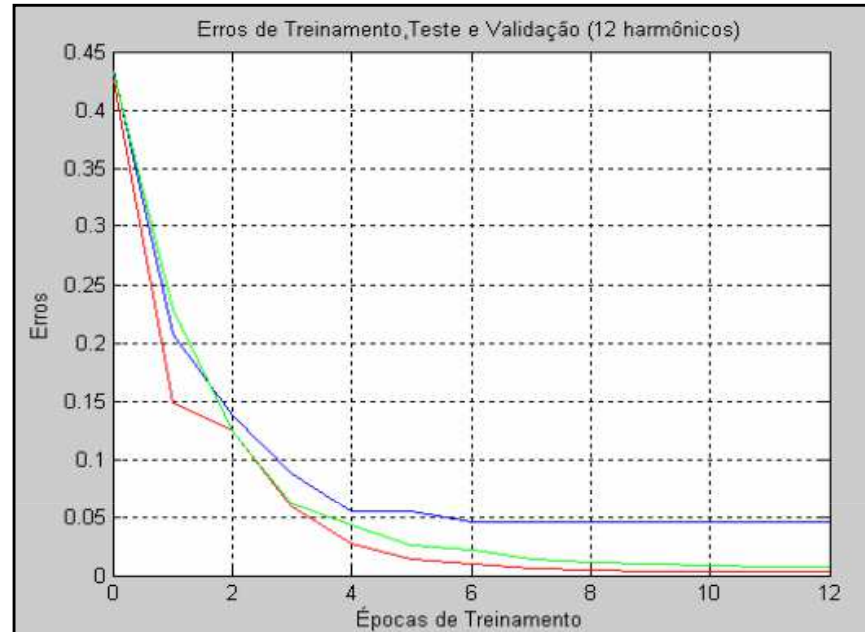


# Results – Neural Network training

- Training set: 70 images
- Test set: 25 images
- Validation set: 25 images
- Output Target
  - -0.5 for defect-free images
  - 0.5 for defective images
- Architecture used:



# Results – Neural Network training



- Simulation of the validation set for the network trained with 10 harmonics
  - Misclassification of 2 images
- Simulation of the validation set for the network trained with 12 harmonics
  - Misclassification of 1 image

# Liquid Level Process

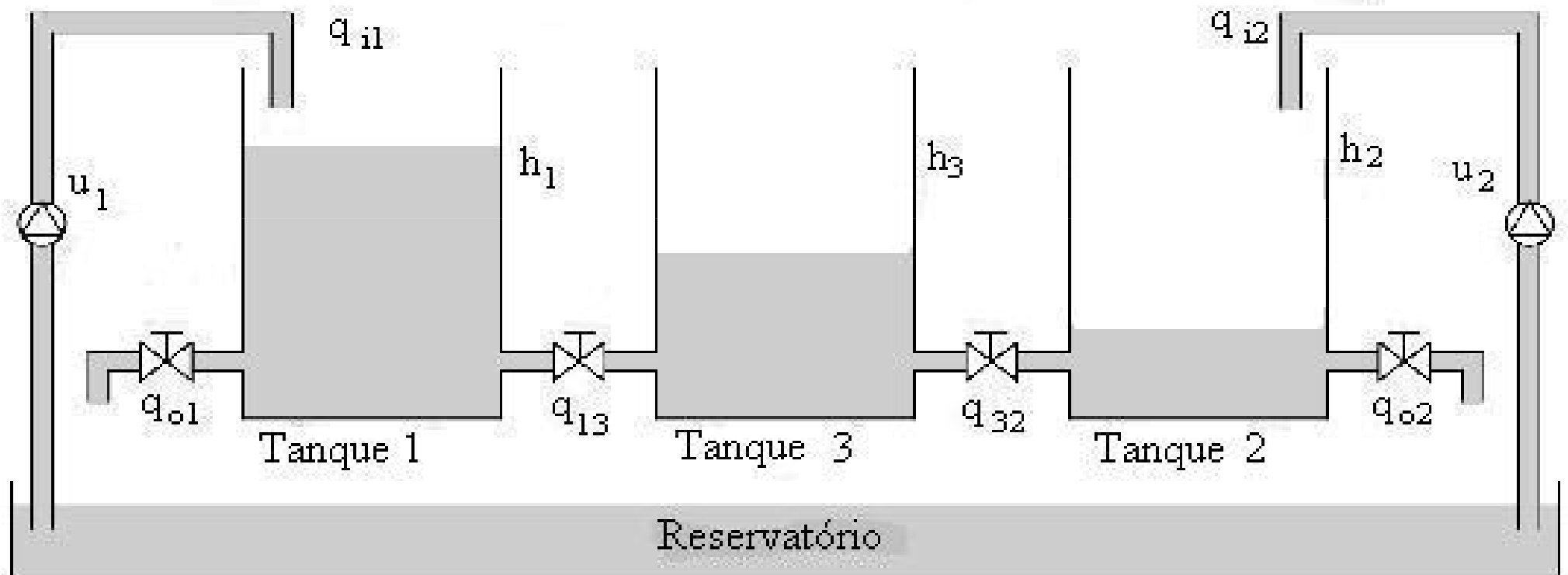


## Components

- 3 Reservoirs (5x25x35 cm)
- 1 Supply Tank
- 3 Level Sensors
- 2 Pumps (0 to 10 V)
- 2 Power Circuits
- A/D & D/A Interface
  
- Time Constant = 5 min
- Sampling Rate = 2Hz



# Schematic Diagram



# Dynamics

Bernoulli:

$$A \frac{dh_1}{dt} = q_{i1} + \text{signal}(h_3 - h_1)k\sqrt{|h_3 - h_1|} - k\sqrt{h_1},$$

$$A \frac{dh_2}{dt} = q_{i2} + \text{signal}(h_3 - h_2)k\sqrt{|h_3 - h_2|} - k\sqrt{h_2},$$

$$A \frac{dh_3}{dt} = -\text{signal}(h_3 - h_1)k\sqrt{|h_3 - h_1|} \\ - \text{signal}(h_3 - h_2)k\sqrt{|h_3 - h_2|}$$

**Non-Linear, Coupled e Multivariable**

# Remotely operated process - www



Client

Process

Controller-PC

Server

# Experimental Results

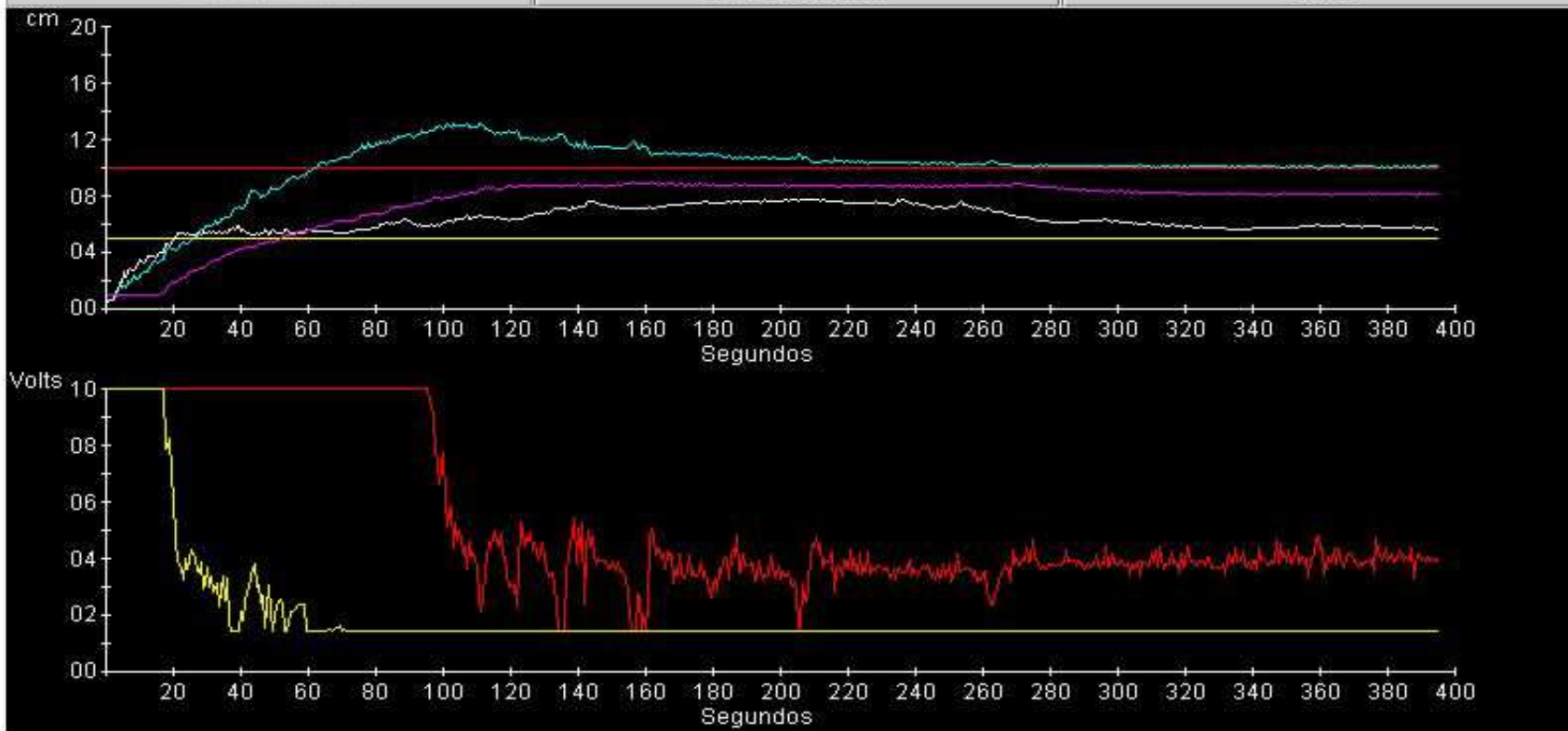
Prop. Deri.     PID Control    Kp    Ki    Kd    Send Controller 2

Define reference

Step     Square        Send reference 1

Triangular     Senoidal    Frequency    Amplitude    Offset    Send reference 2



## Step Response

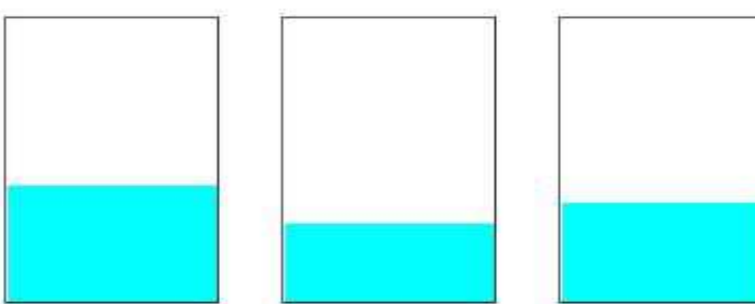
- 10 cm (tank 1)
- 05 cm (tank 2)

Edit reference

Show Plots:

Reservoir-1  
 Reservoir-2  
 Reservoir-3

Actuator-1     Actuator-2



Instructions

# Experimental Results

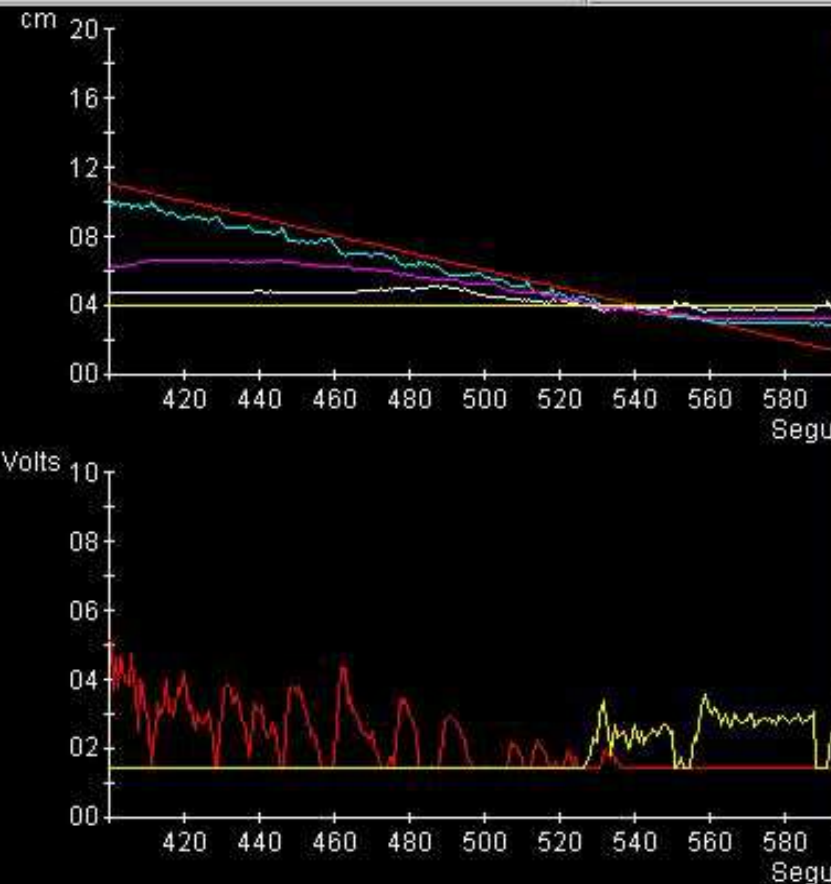
Prop. Deri.     PID Control    Kp    Ki    Kd    Send Controller 2

Define reference

Step     Square        Send reference 1

Triangular     Senoidal    Frequency    Amplitude    Offset    Send reference 2

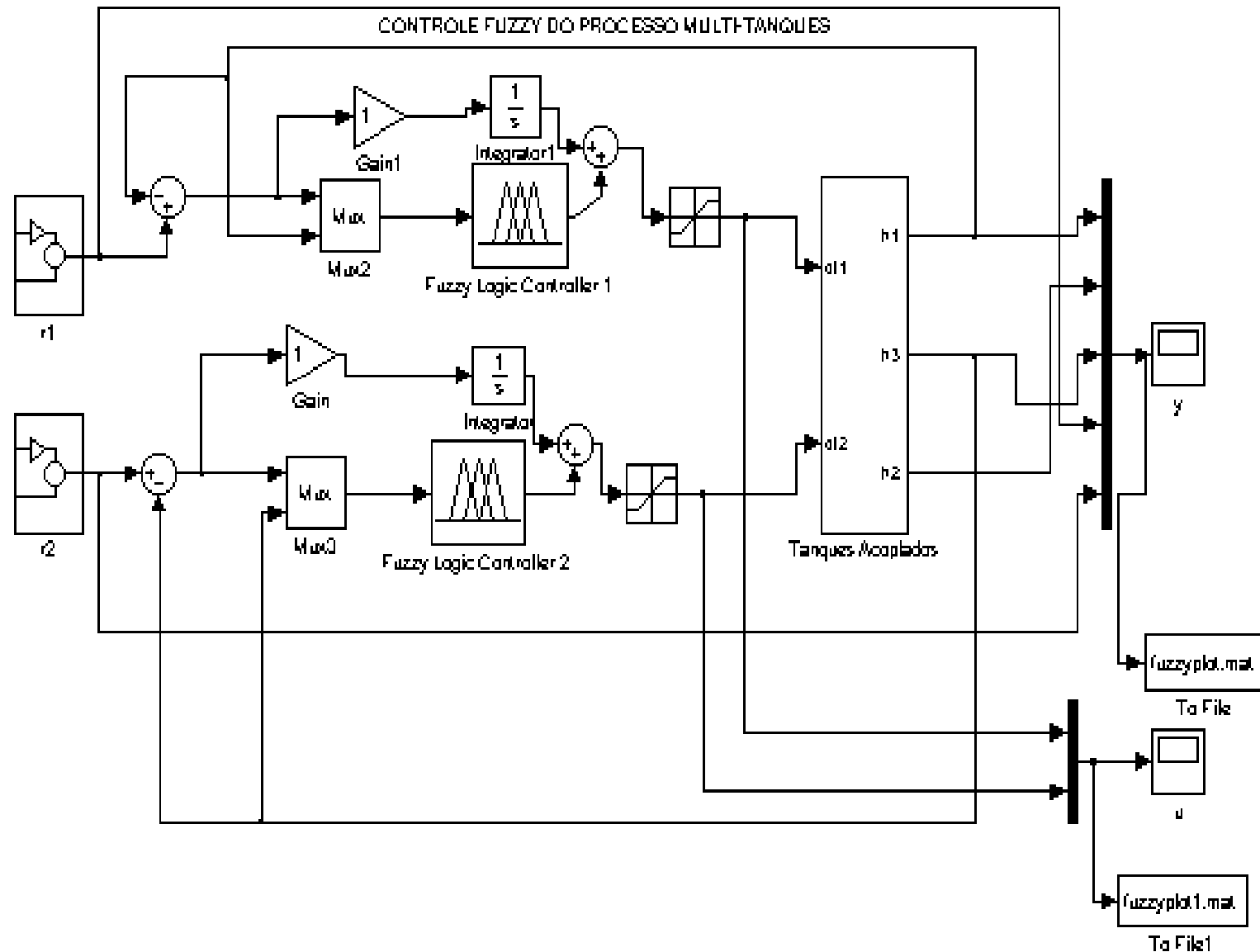
Start Experiment    Stop Experiment    Finish



Reference  
Step and  
Triangular

Live Video  
Streaming

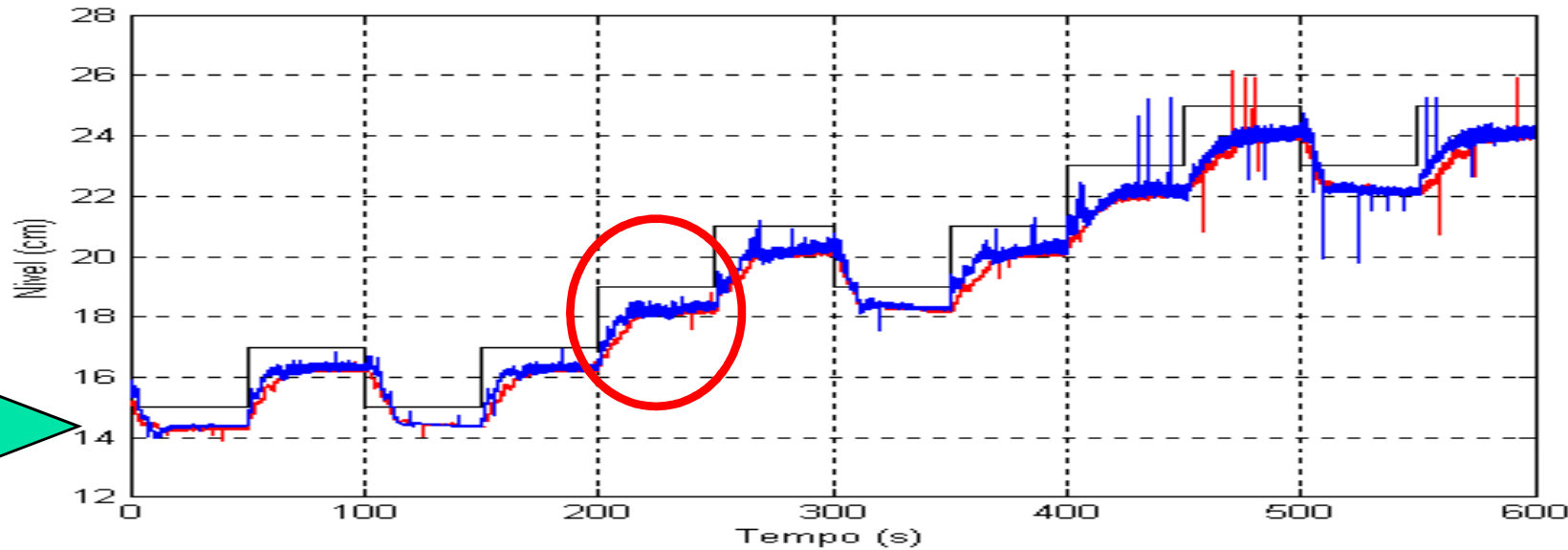
# Fuzzy Control in Simulink



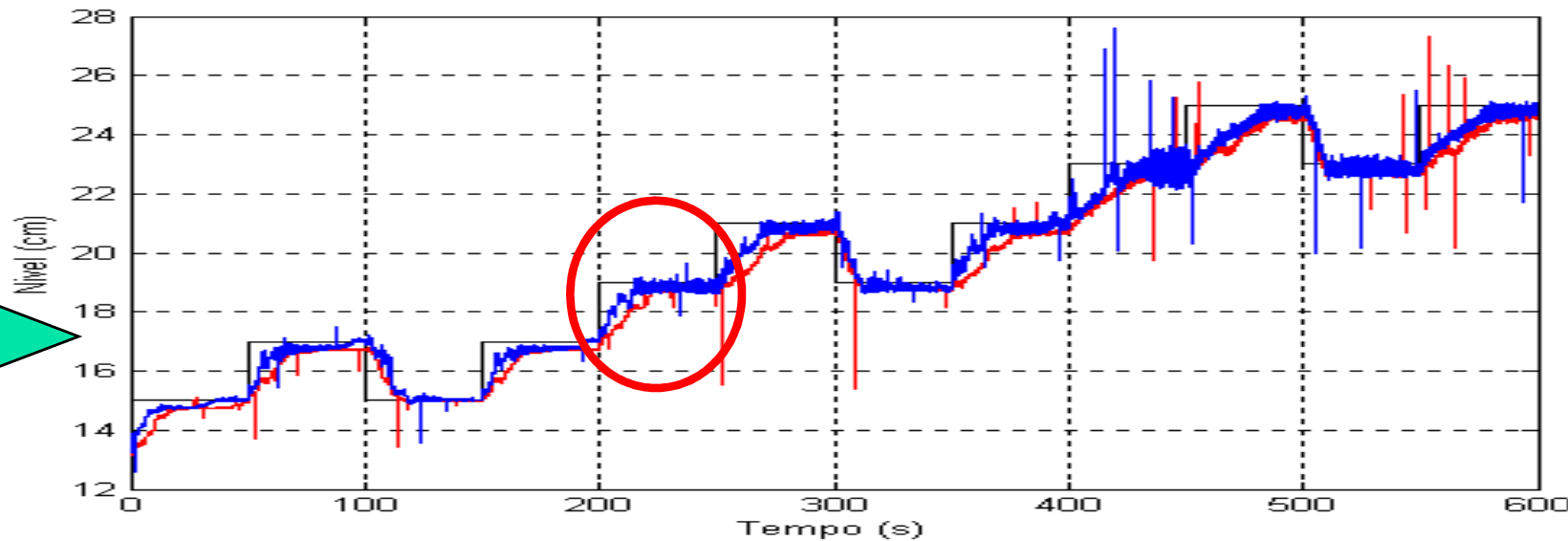
# Fuzzy Control

Step Response to  
different levels:

Controle PI



Fuzzy Control



## Remotely operated Automation Laboratory (Laboratório de Ensino de Automação Remoto)

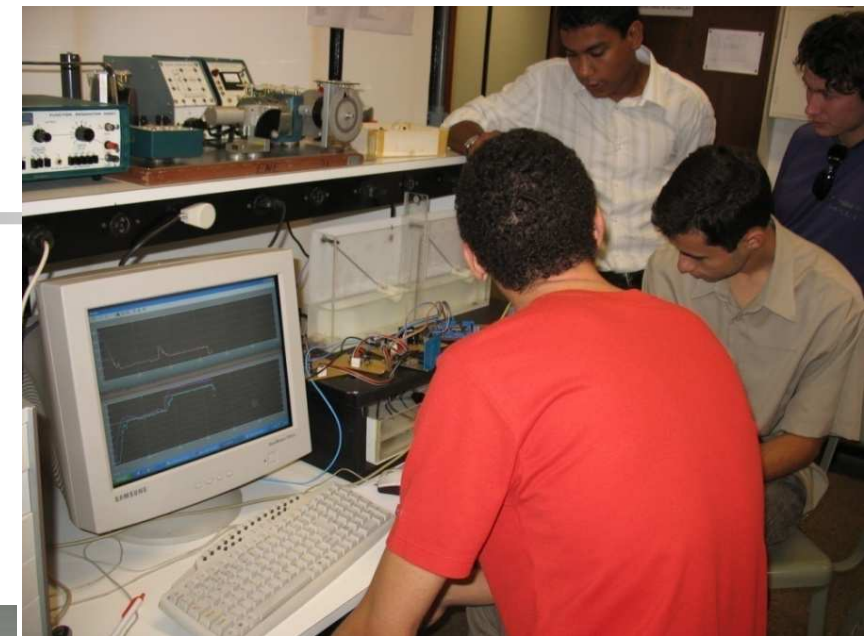
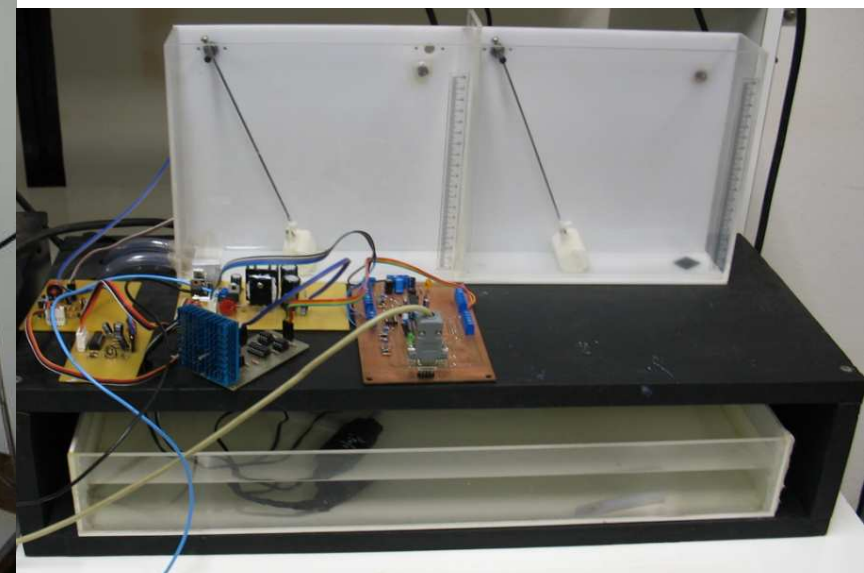
3<sup>rd</sup> order



4<sup>th</sup> order



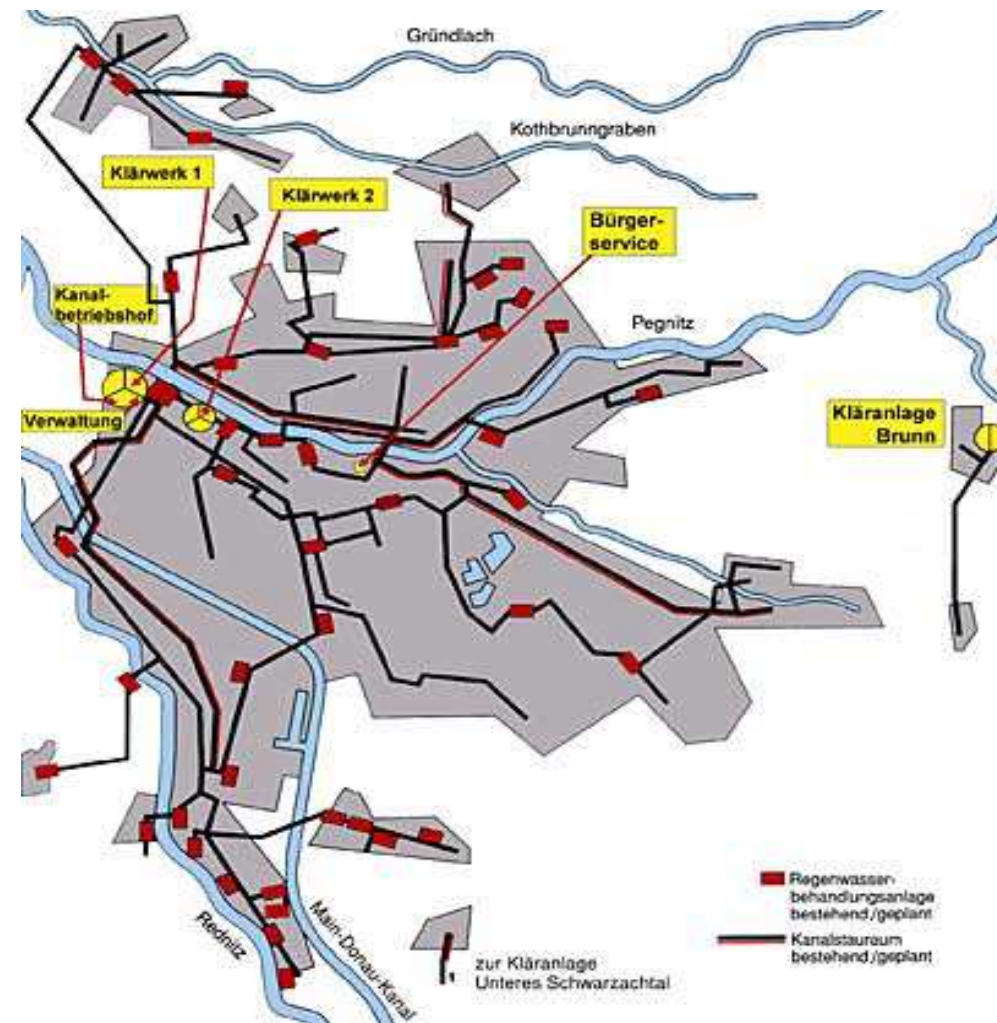
2<sup>nd</sup> order





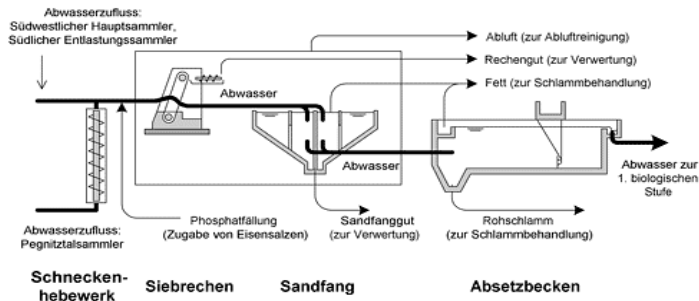
# Water Treatment Station –

[www.abwasser.nuernberg.de](http://www.abwasser.nuernberg.de)



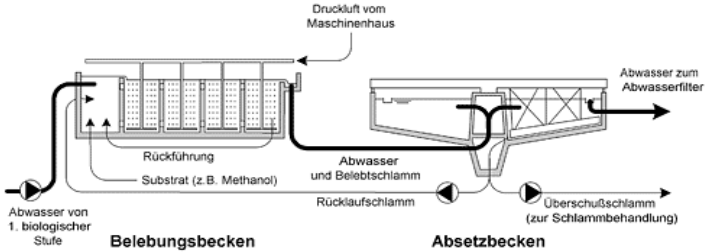
## Klärwerk 1

### Mechanik (Rechen, Sandfang, Vorklärung)

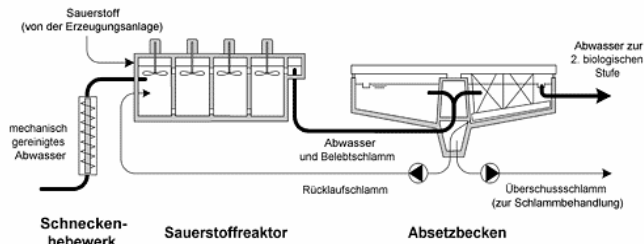


## Klärwerk 1

### 2. biologische Stufe (Schwachlastbelebungsanlage)

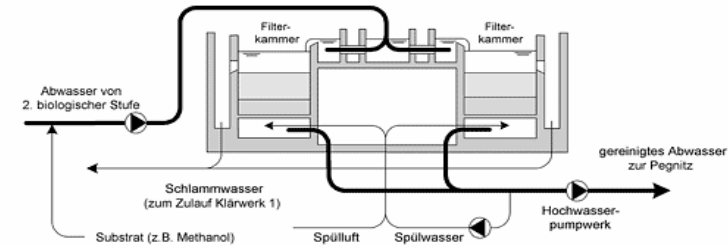


### 1. biologische Stufe (Hochlastbelebungsanlage)



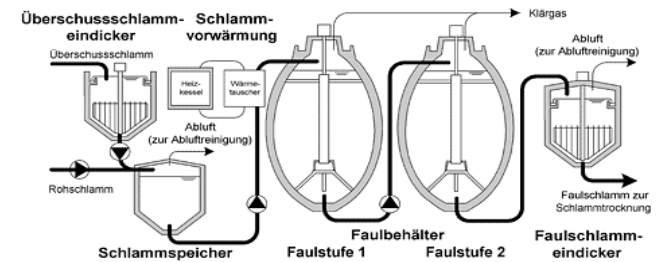
## Klärwerk 1

### Abwasserfilter



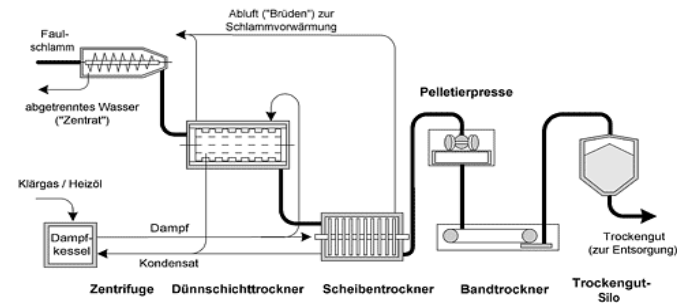
## Klärwerk 1

### Schlammfaulung



## Klärwerk 1

### Schlamm-trocknung



# Automatic guiding - BMW



BMW 645 ci - [www.bmw.de](http://www.bmw.de)

Cruise Control

automatic transmission

User Profile

sporting

economic

cautious

Proximity Sensor

front

back

side

# Fuzzy Air Conditioner



A High Definition Of Design And Performance.

ENERGY SAVING, BETTER STARTING CURRENT, PLASMA FILTER, DESIGNER PANEL

LP-K2465QC

- 4 WAY SWING
- DEHUMIDIFICATION
- FUZZY LOGIC
- JET COOL

WHERE TO BUY

Rs.49826  
MRP

ADD TO COMPARE

# Camera

Olympus IS-5  
Auto Focus SLR Camera - 28-140mm 5x zoom lens,  
Date imprinting capability, Panorama Mode - w/Case  
& Batteries



## Features

...

Programmed Auto Exposure lets you choose between Full Auto, Stop Action, Portrait, Night Scene and Landscape modes

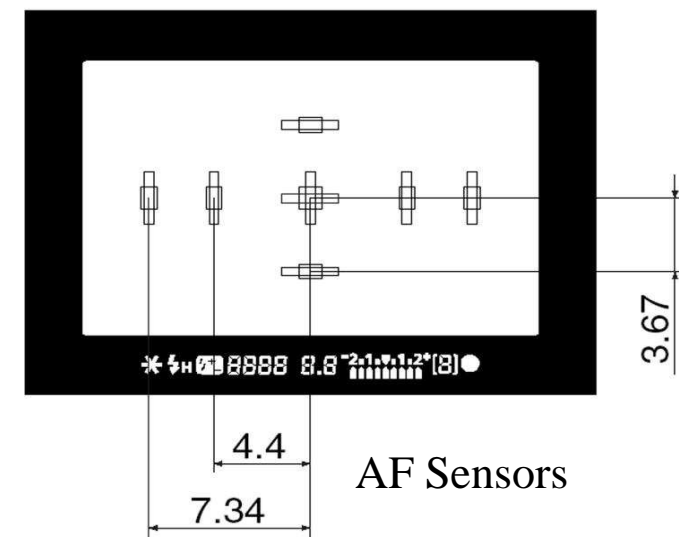
TTL metering system: *Fuzzy logic* ESP, center-weighted average, Spot

## Specifications

...

**Focus Type**TTL phase-difference detection system with autofocus focus lock. Auto focus beep available. Auxiliary flash activation in low light.

**Focus Range**0.6 m to infinity in macro shooting; 0.6m to infinity at wide angle and 0.9m to infinity at telephoto in standard shooting. Predictive autofocus (in Stop Action mode only)



# Washing machine

---

- Modern washing machines automatically determine the optimum settings to get your clothes clean with the use of *fuzzy logic*. That's the 'skill' that gets machines to make 'best case' decisions based on incomplete information.
- Previously, washing machines were manually set. You had to make trial-and-error decisions on the amount of washing detergent, the size of the load, and the length of washing time. A fuzzy logic controller, comprising sensors, microchips and software algorithms, mathematically works out the amount of dirt and type of dirt on the clothes with the help of an optical sensor, which measures the transparency of the water.
- When the clothes are loaded into the washing machine and water added, the sensor checks to see how dirty the water is - dirtier clothes mean dirtier water, naturally. It also checks the type of dirt on the clothes by how fast the water gets saturated by the dirt. With this input, the fuzzy logic controller determines how soiled the load is, decides how much detergent is needed and how long it must wash the clothes.



# Vacuum cleaner

Power Consumption : 2000W  
Suction Power : 450W  
Digital Auto Power Control (*Fuzzy Logic*)  
Variable Power Control  
5-Stage HEPA-Filter System  
Exbug : Mite Killing Function  
LED Display Panel  
2 Step Smart Brush  
Aluminium Telescopic Tube  
Smart Protector  
3 Built-in Accessories  
2-Way Parking System  
With Twister System

Samsung VC-8930EN



# Digital Wrist Pressure Monitor



## Model WS 501

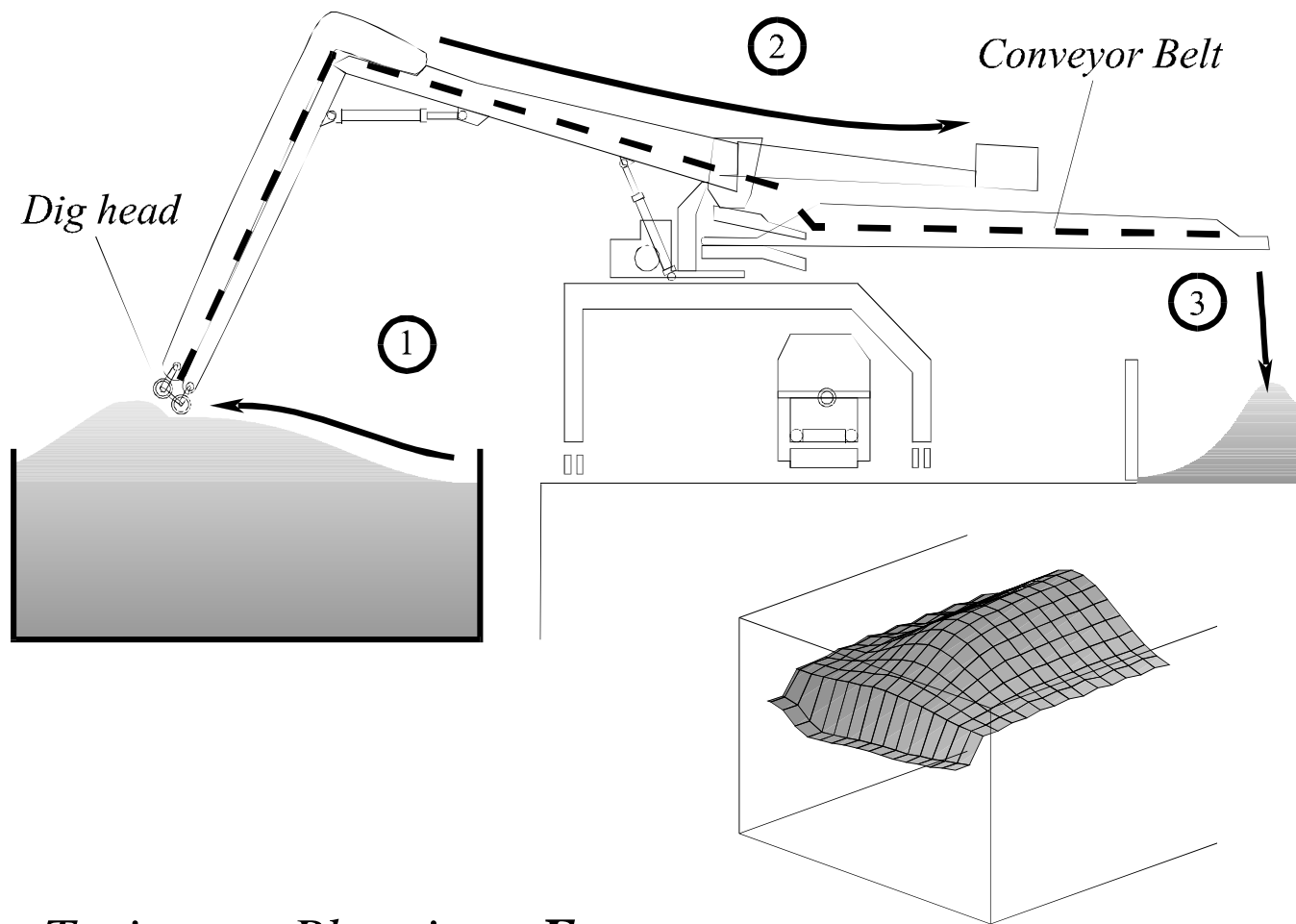
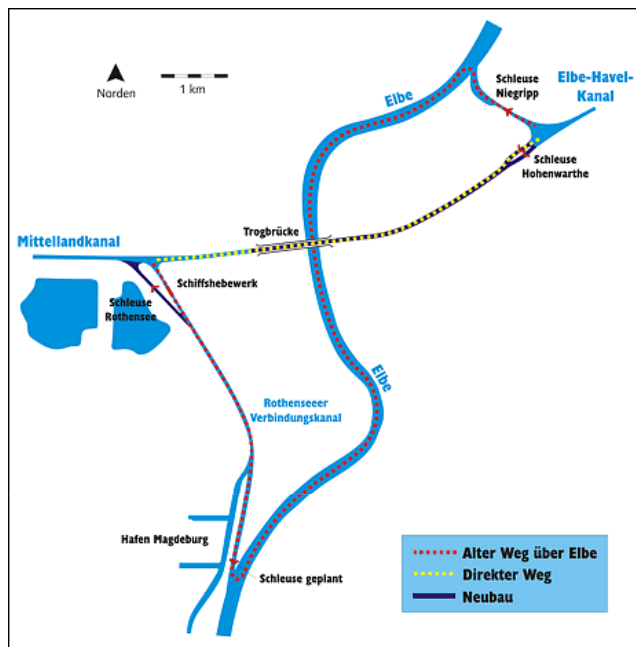
It has 60 memories with date and time (digital clock) that facilitates distance monitoring between doctor and patient. Battery charge indicator.

Japanese FUZZY LOGIC technology of the latest generation. R\$220,00

[www.etrronics.com.br/detalhes.asp?codpro=495](http://www.etrronics.com.br/detalhes.asp?codpro=495)



# Coal Unloading – Erlangen/Germany



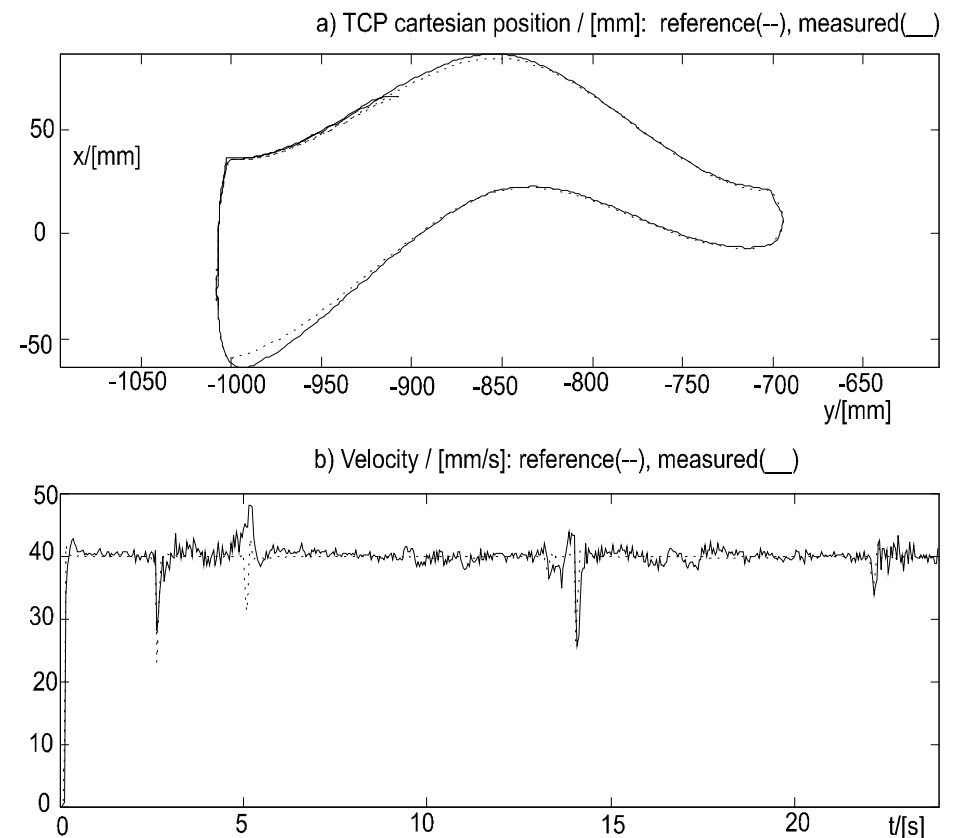
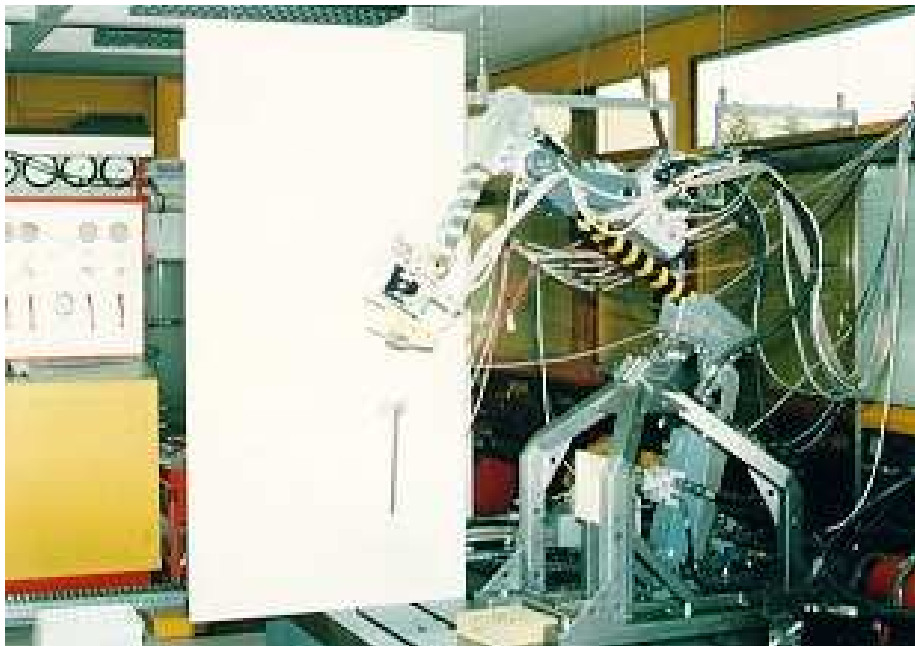
River Crossing – Minden, Elbe, Germany

*Trajectory Planning - Fuzzy*

*“Redundant Sensor Guided Unloading Crane” – MAN*

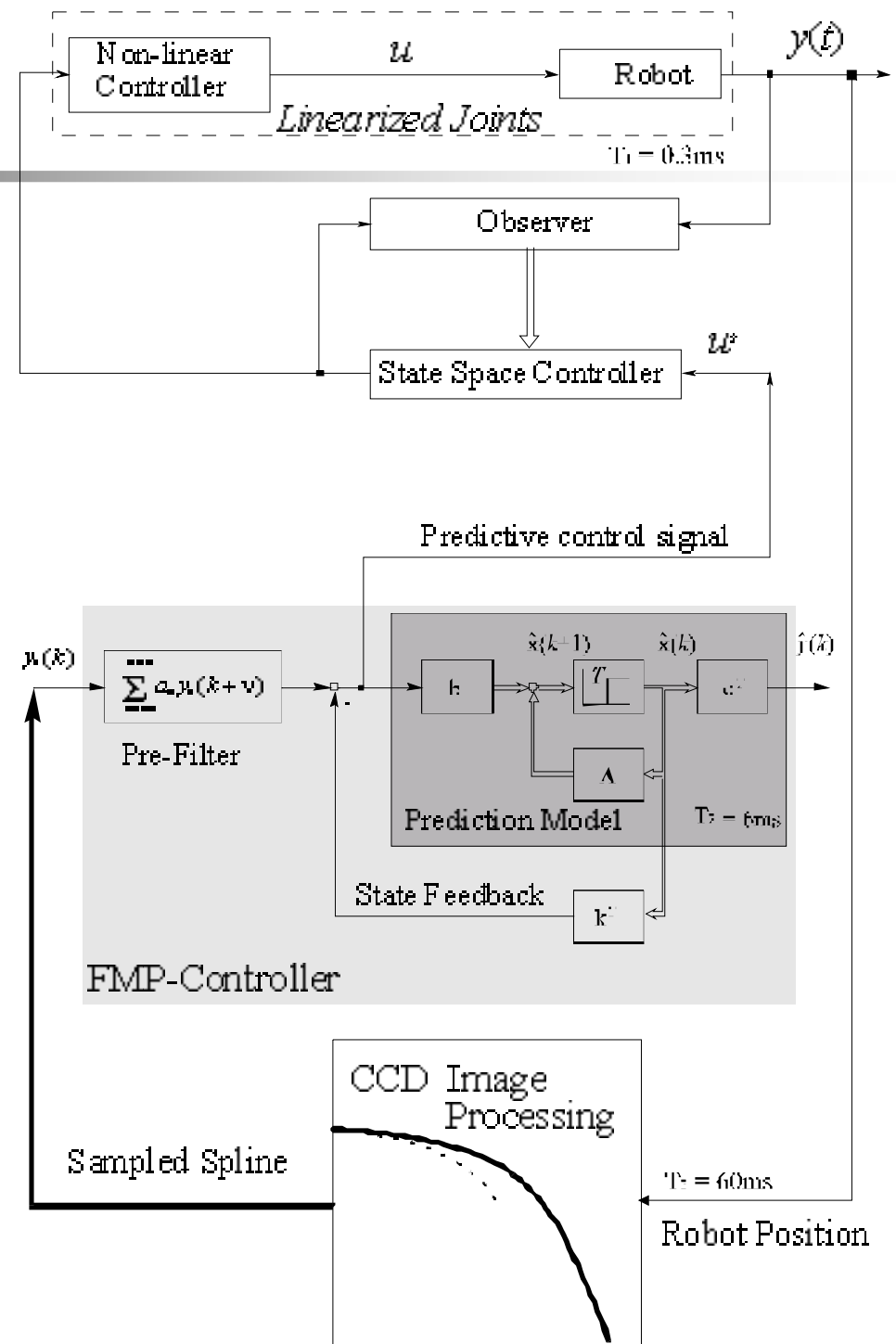
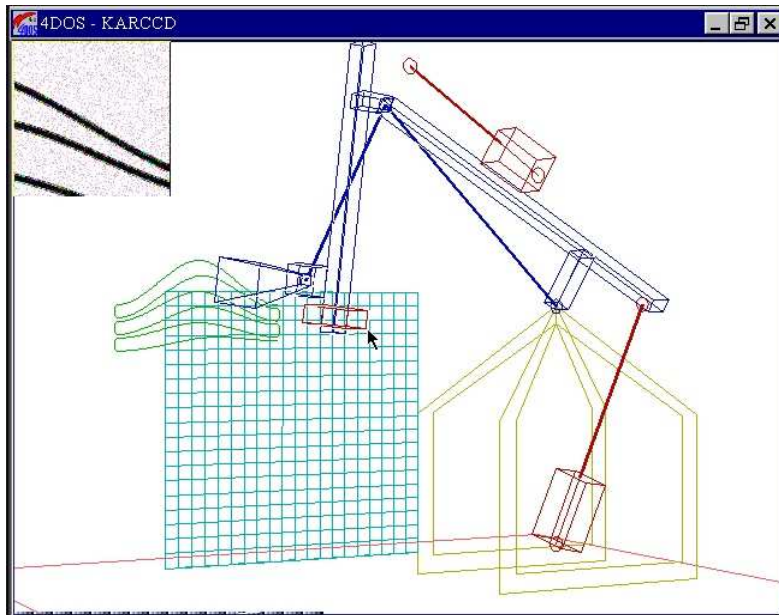
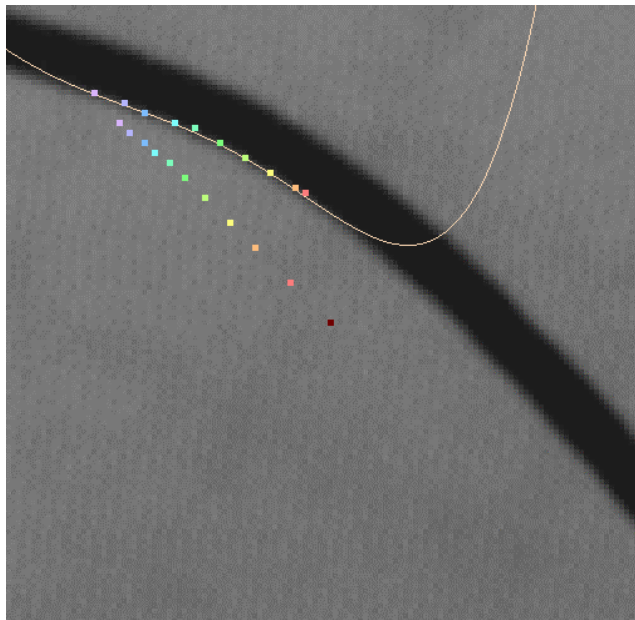
*Bauchspiess, 1995*

## *Sensor guided Hydraulic Robot*



*Bauchspiess, 1995*

# Path tracking



# Ambient Intelligence

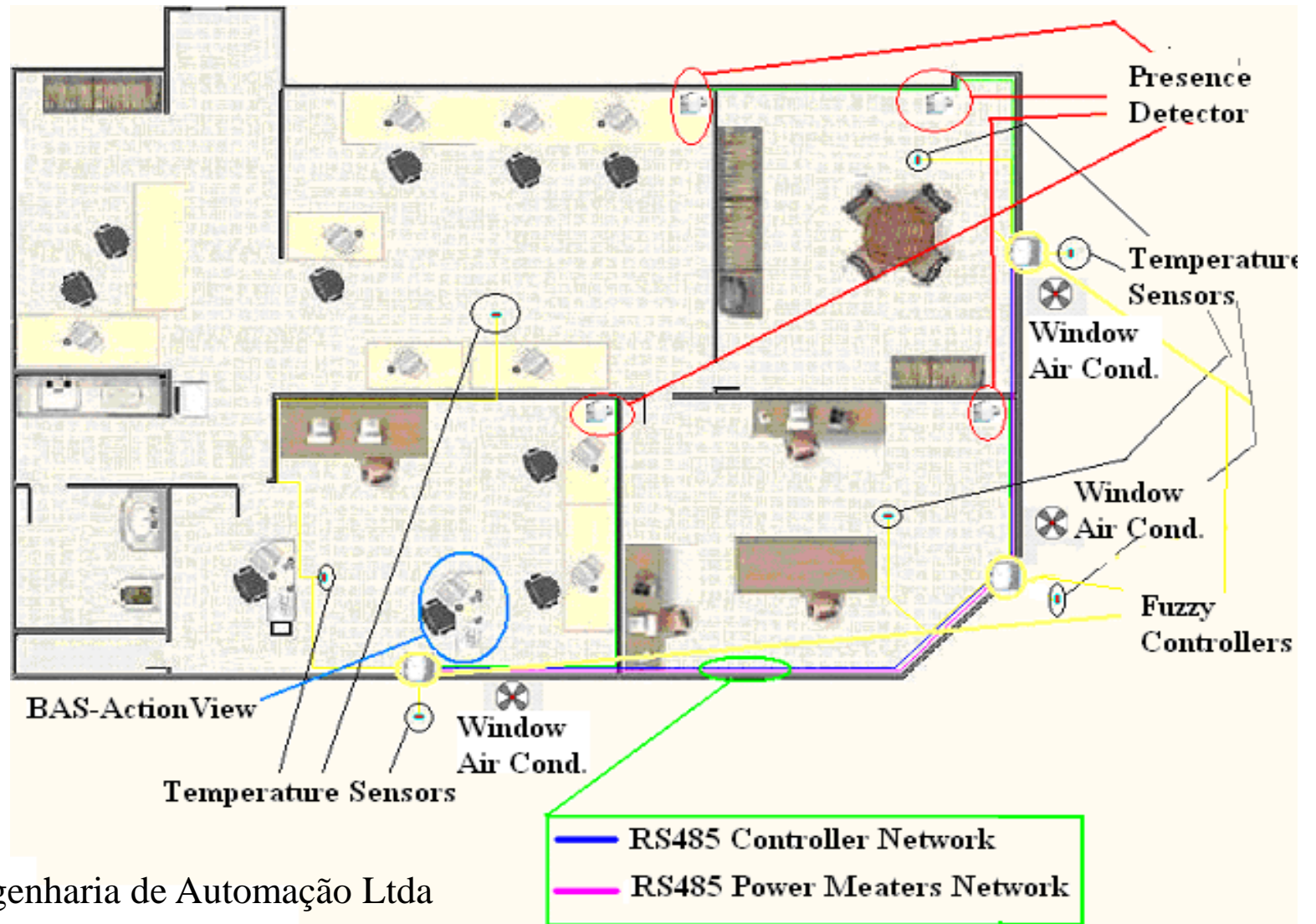
- Comfort and energy rationalization

- Factors

- temperature,
    - humidity,
    - outside temperature,
    - solar radiation,
    - neighboring rooms,
    - presence of persons,
    - furniture int the rooms,
    - heat sources (e.g., computers),
    - windows,
    - heaters,
    - air conditioners
    - etc.



# Thermal Comfort x Energy Rationalization



Spin Engenharia de Automação Ltda



SUPER



HORA KMC

16 9

SETPOINT  
24,50 °C



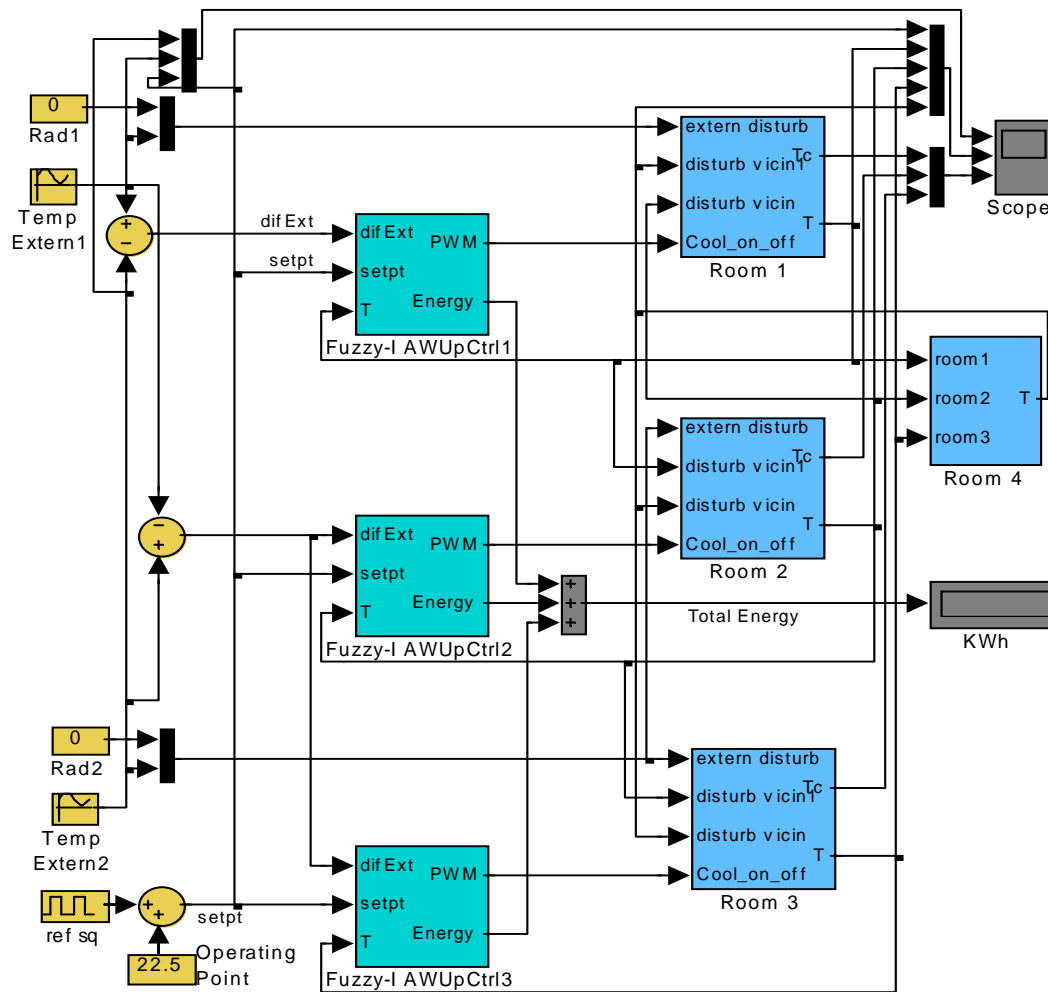
TEMPERATURA EXTERNA  
26,55 °C

TEMPERATURA EXTERNA  
26,55 °C

TEMPERATURA EXTERNA  
32,46 °C



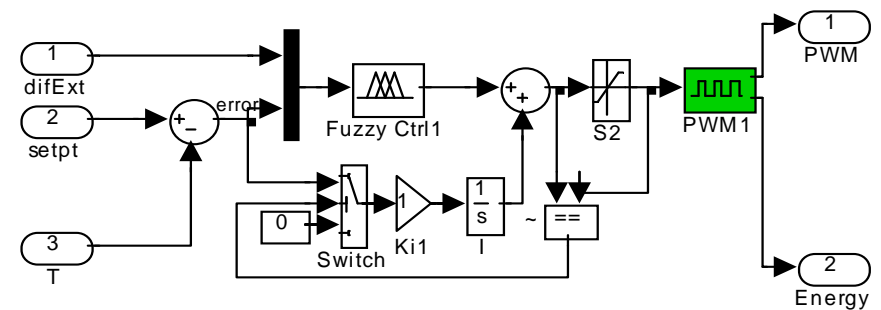
# Simulation of the Energy Rationalization – Thermal Comfort



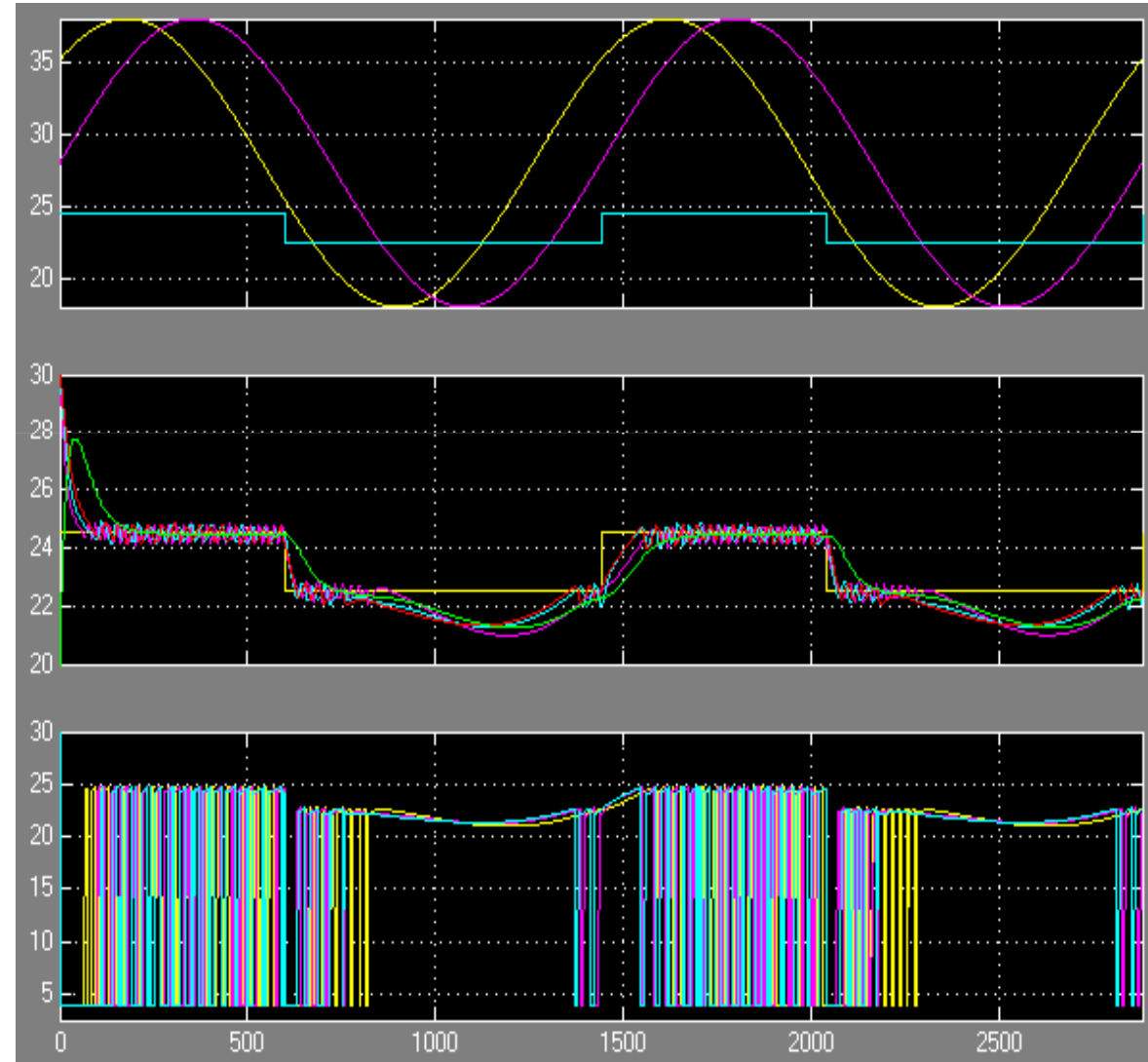
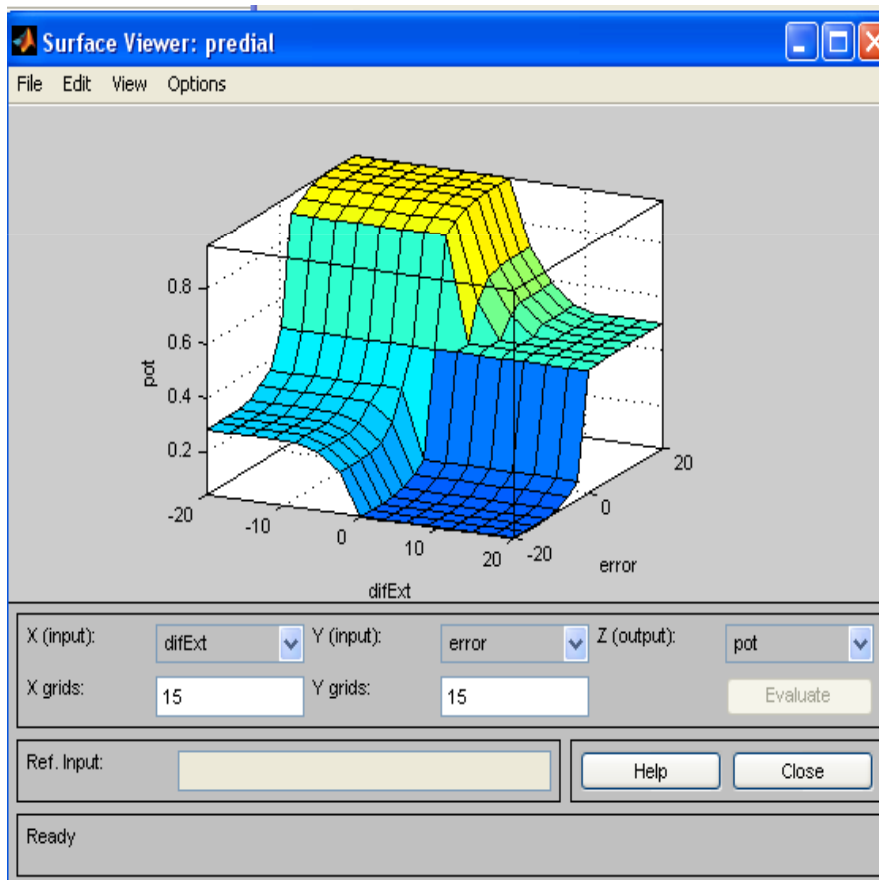
Projects:

FAP-DF

Finep – LabInov



# Simulation of Fuzzy Thermal Comfort





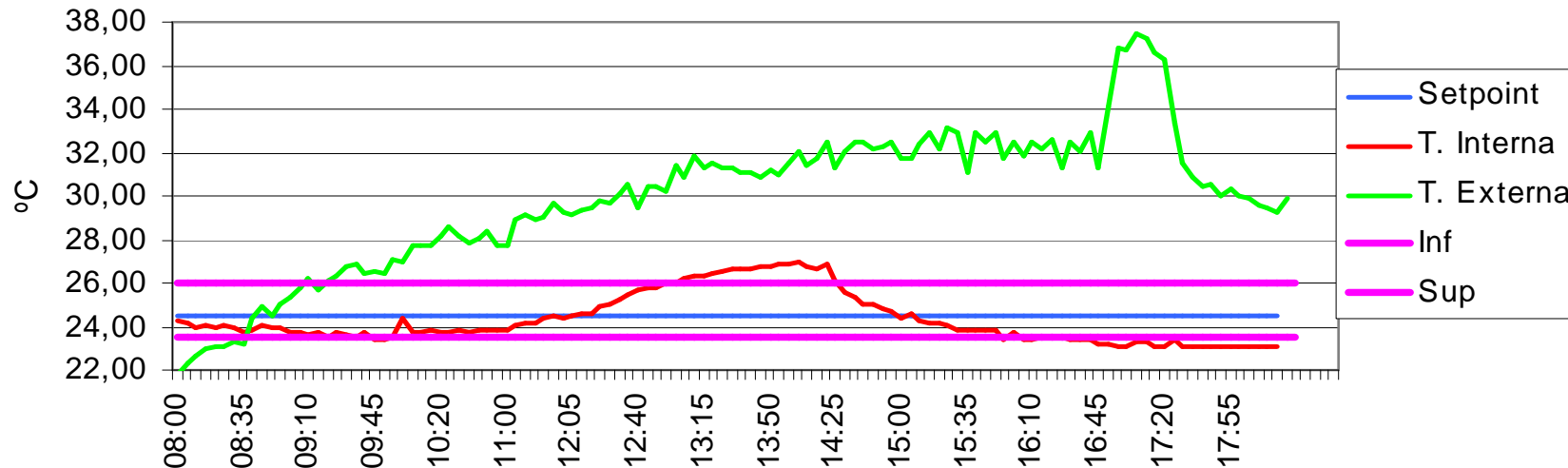
# Measured Energy Consumption (kWh)

Experiment\ Room	Develop.	Directors	Meeting	Total
On-Off Dawn	19,39	11,87	12,04	43,30
Fuzzy Dawn	03,78	01,07	02,05	06,90
On-Off 8-12 14-18	35,25	17,42	19,07	71,71
Fuzzy 8-12 14-18	21,97	13,50	18,14	53,61
On-Off 8-18	35,34	17,96	19,95	73,48
Fuzzy 8-18	16,41	15,80	13,10	45,32

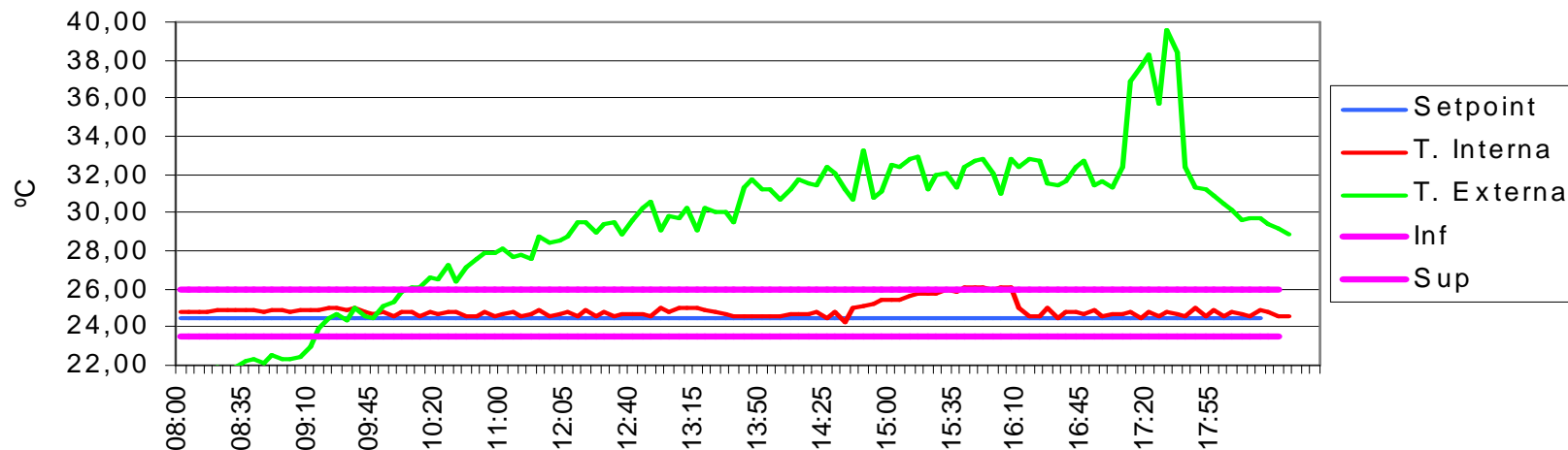
Spin Engenharia de Automação Ltda, 2006

# Development Room

## On-Off 16-09-2006



## Fuzzy Control 14-09-2006

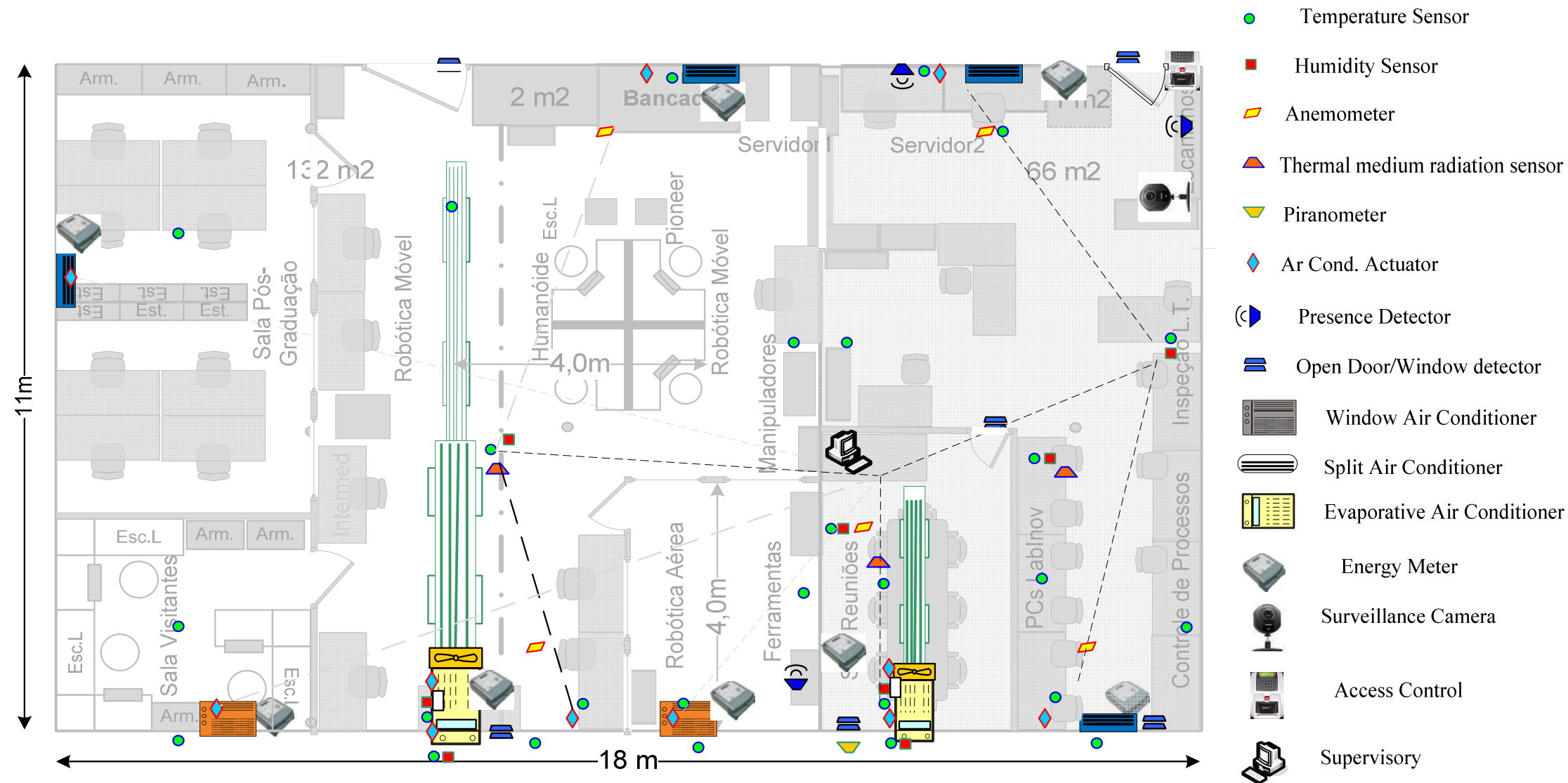


~30% saving!



# Finep/LabInov

## Ambient Intelligence Innovation Laboratory



Energy-Saving Approach:

# Model-Based HVAC Control

$$J = \underbrace{\sum_{i=1}^{h_p} (y(k+i) - y_R)^2}_{\text{comfort related}} + \sum_{i=0}^{h_c-1} \Delta \mathbf{u}^T(k+i) \mathbf{Q}_{\Delta u} \Delta \mathbf{u}(k+i) + \underbrace{\mathbf{u}^T(k+i) \mathbf{Q}_u \mathbf{u}(k+i)}_{\text{energy related}}$$

Where :

$h_p$  – prediction horizon

$h_c$  – control horizon

$y$  – controlled variable

$y_R$  – reference

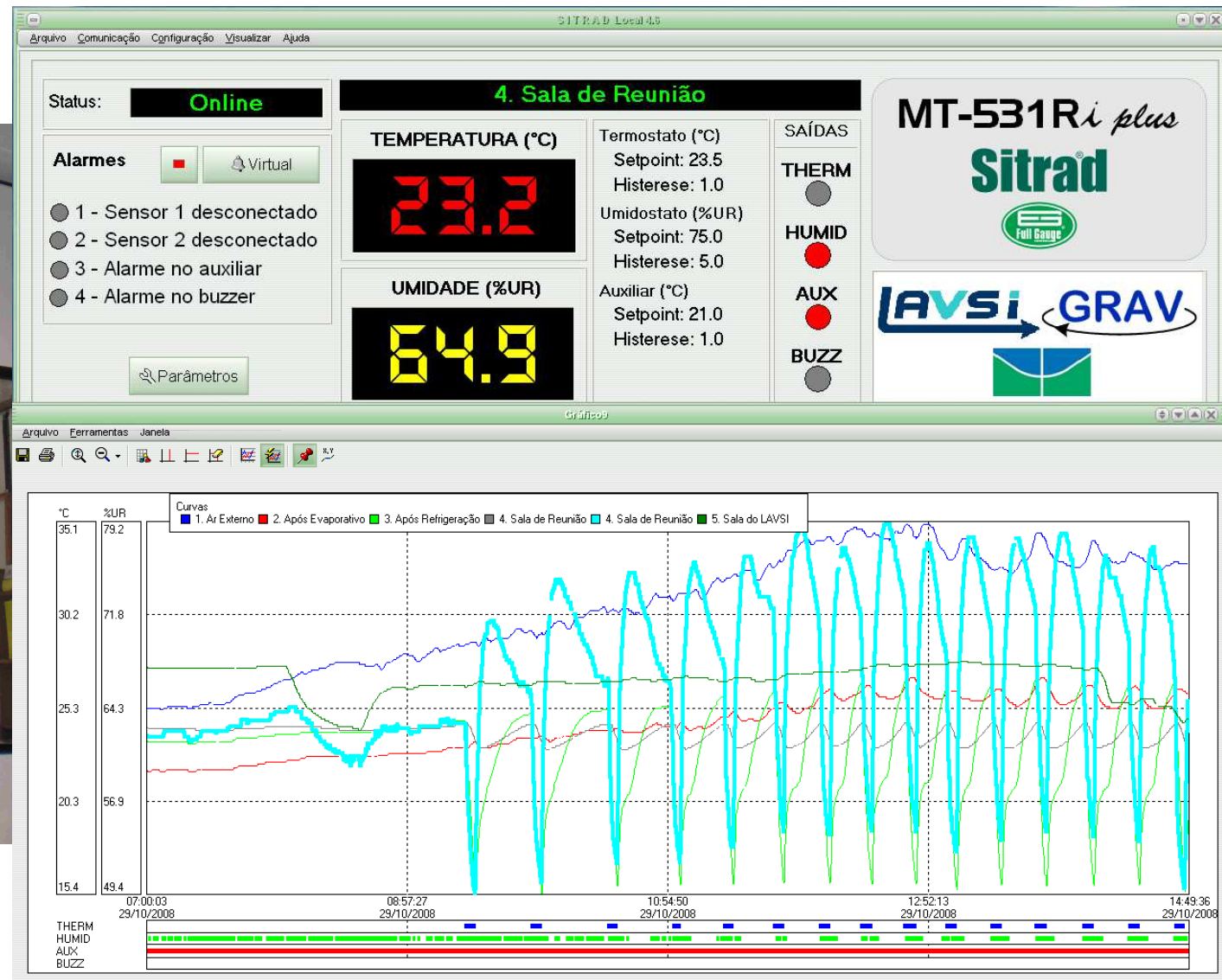
$u$  – manipulate d variable

$\mathbf{Q}_{\Delta u}, \mathbf{Q}_u$  – weighting matrices

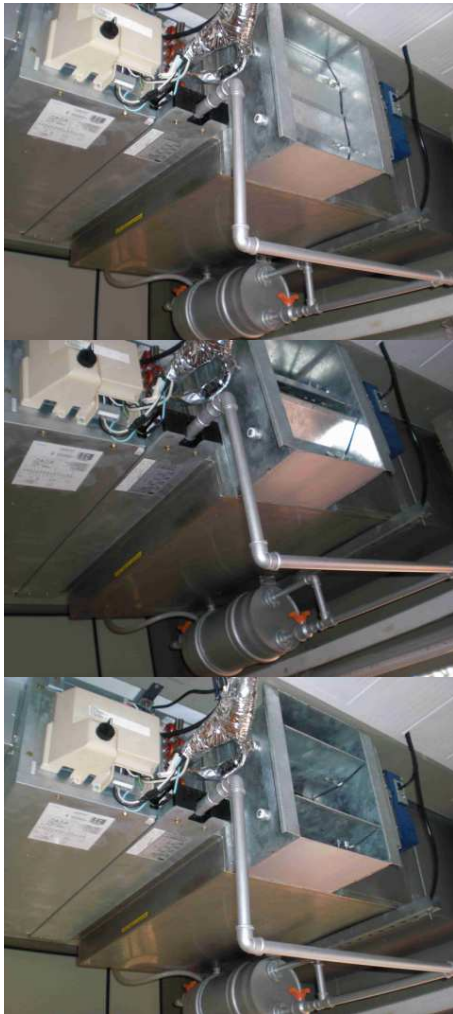
Predictive Cost Function:

Considers comfort and energy saving. Needs model!

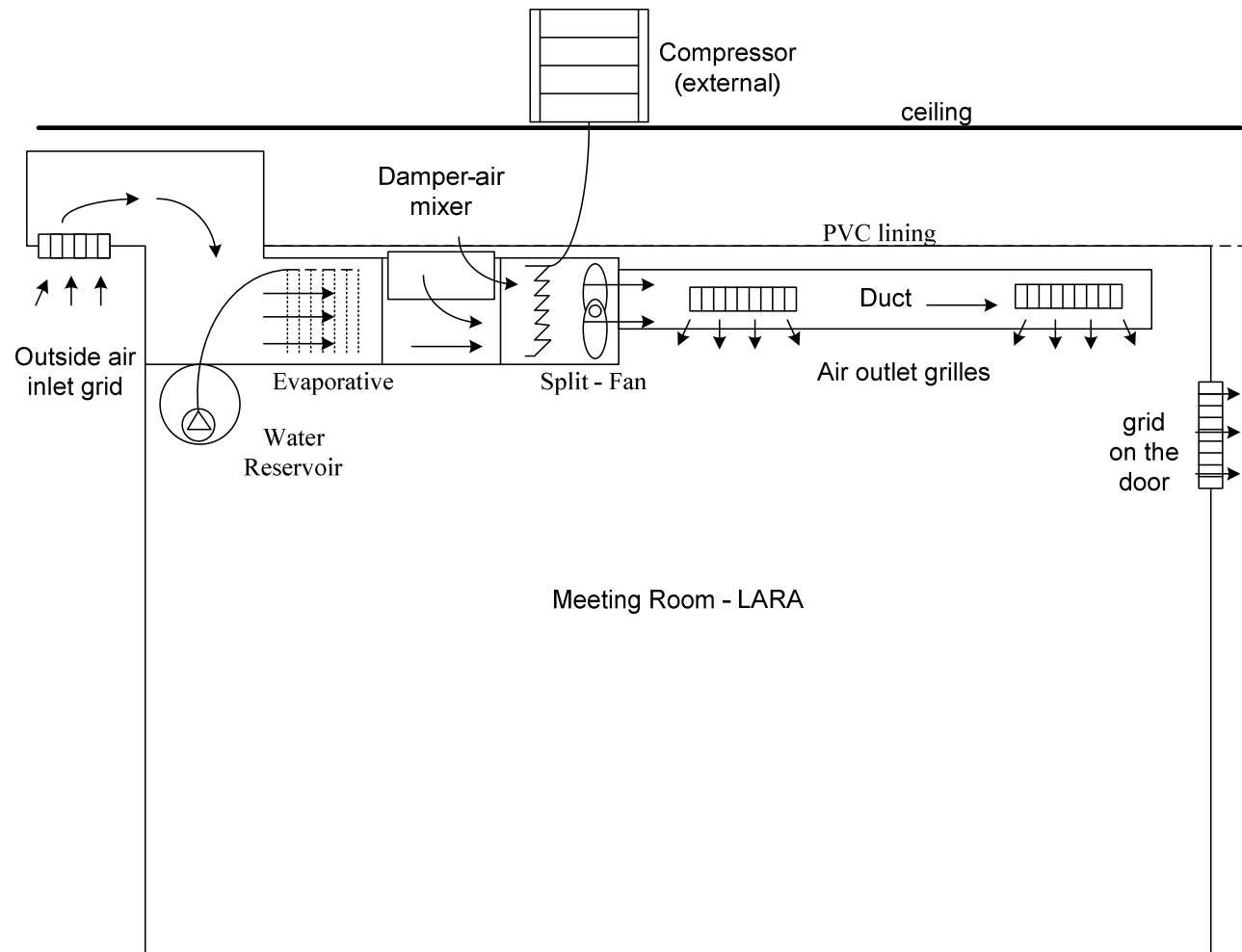
# Hybrid Air Conditioning: Evaporative-Conventional



# Hybrid Air Conditioning: Evaporative-Conventional

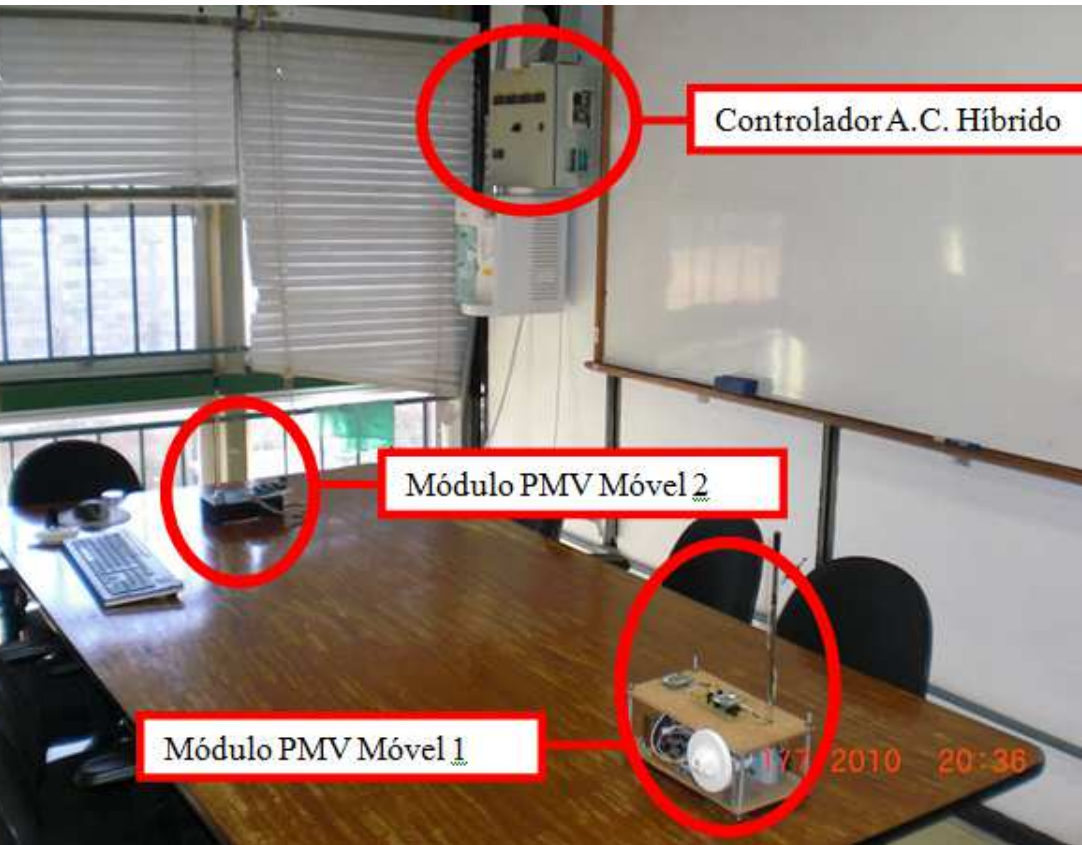


Damper  
(air mixer)



Schematic Diagram

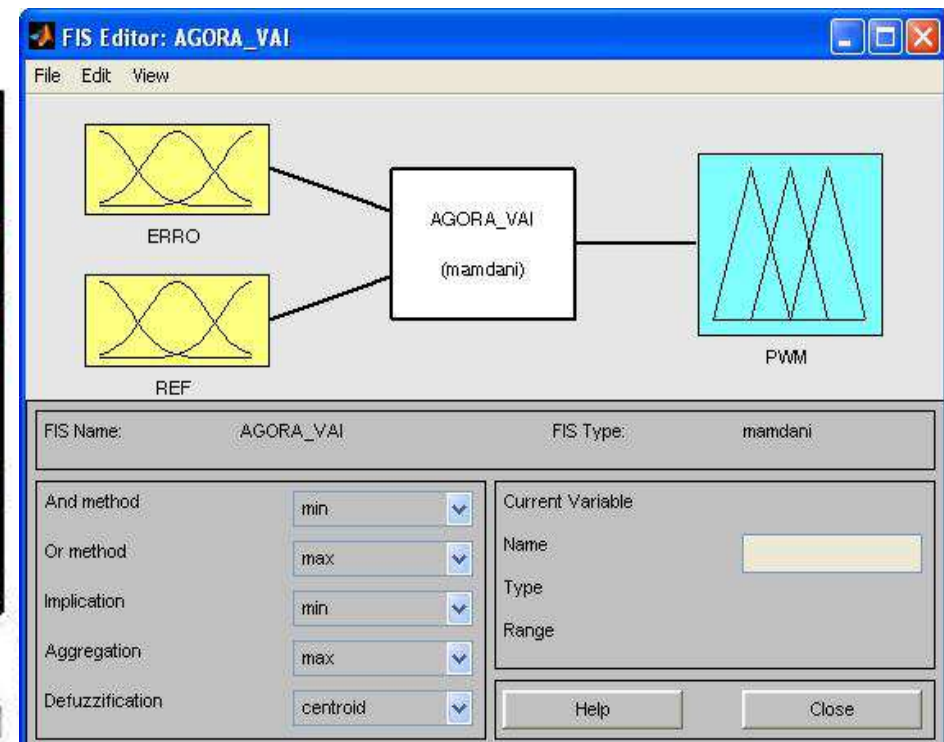
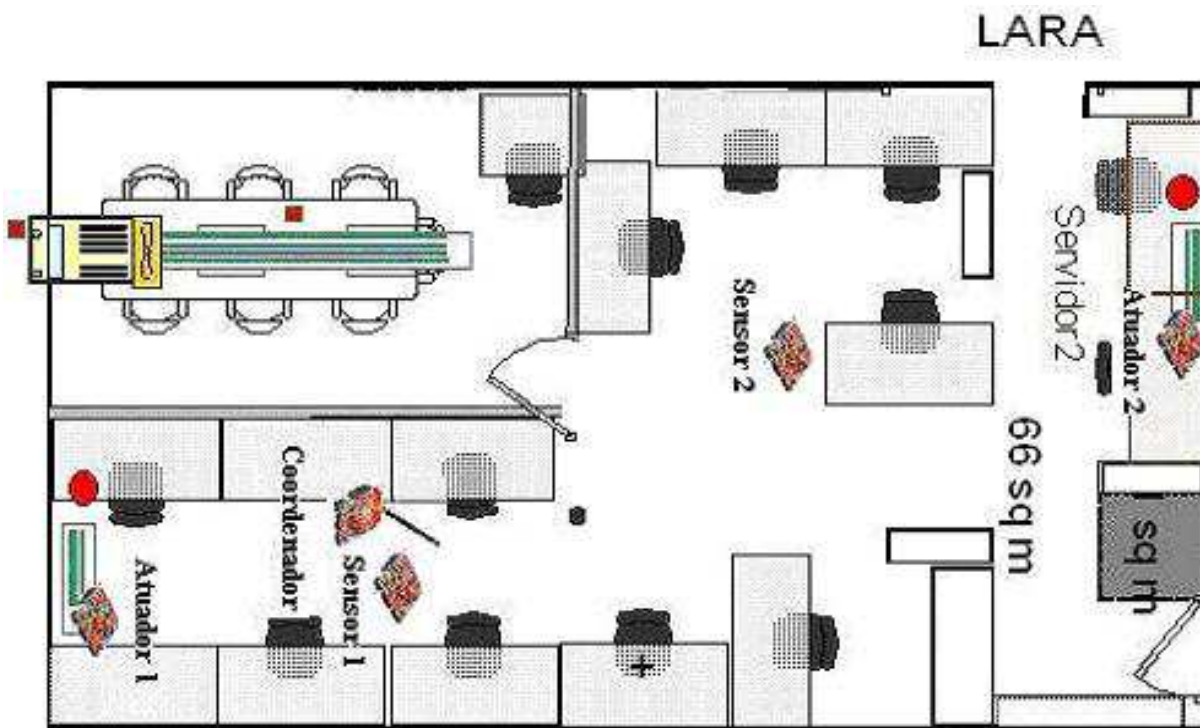
# Hybrid Air Conditioner Controller



Meeting Room LARA.  
Mobile modules 1 e 2. Actuator of the hybrid  
air conditioner híbrido

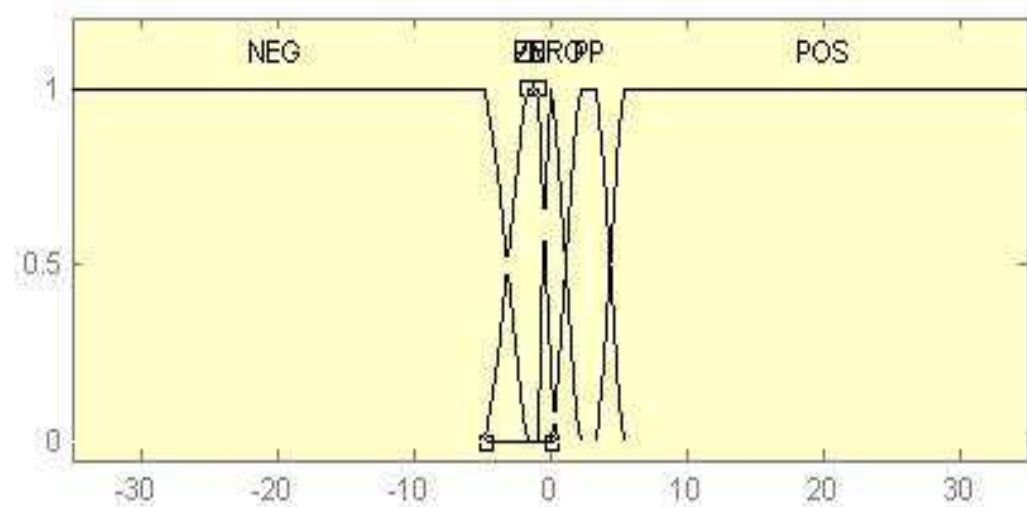
Sensors attached to the wall - Temperature,  
Humidity and Thermal Radiation

# Fuzzy Control in Wireless Network





# Fuzzy Control in Wireless Network



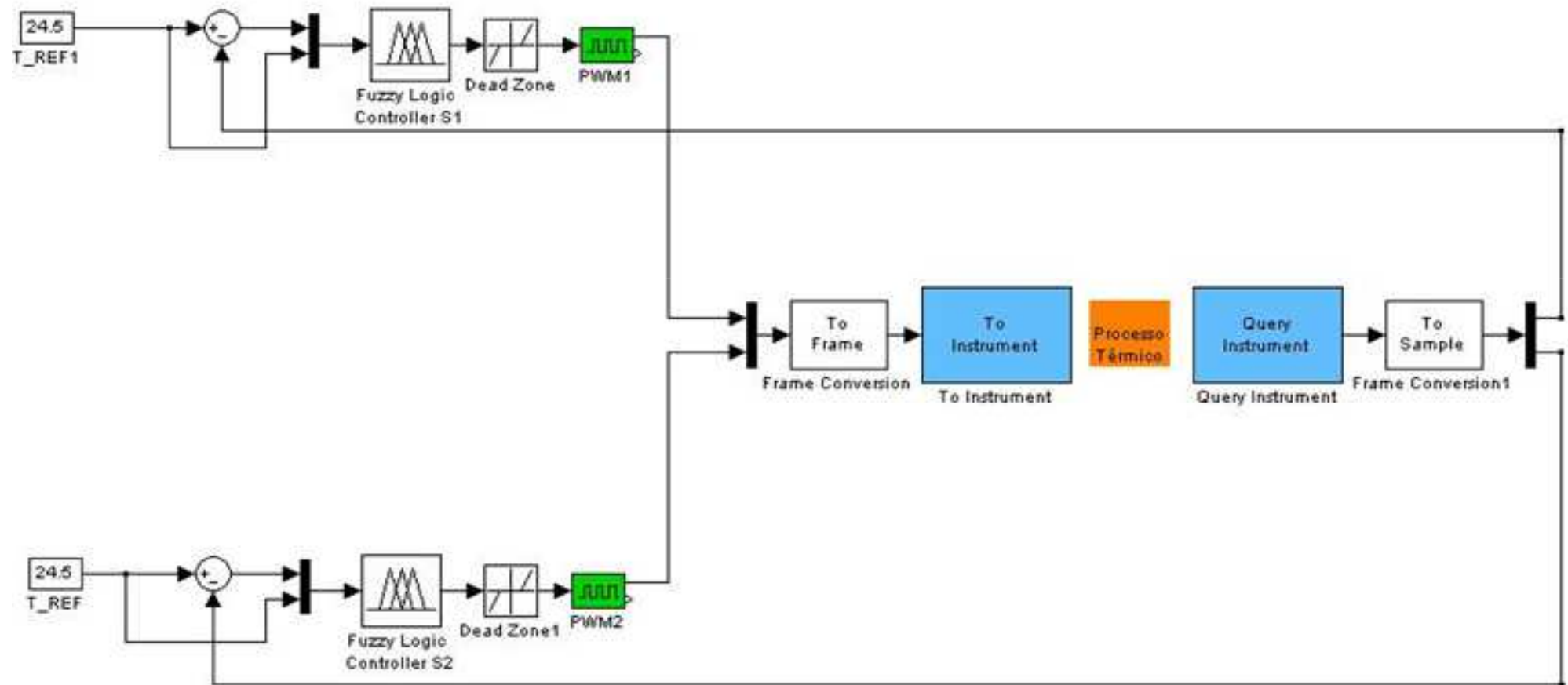
Membership functions of the input variable error



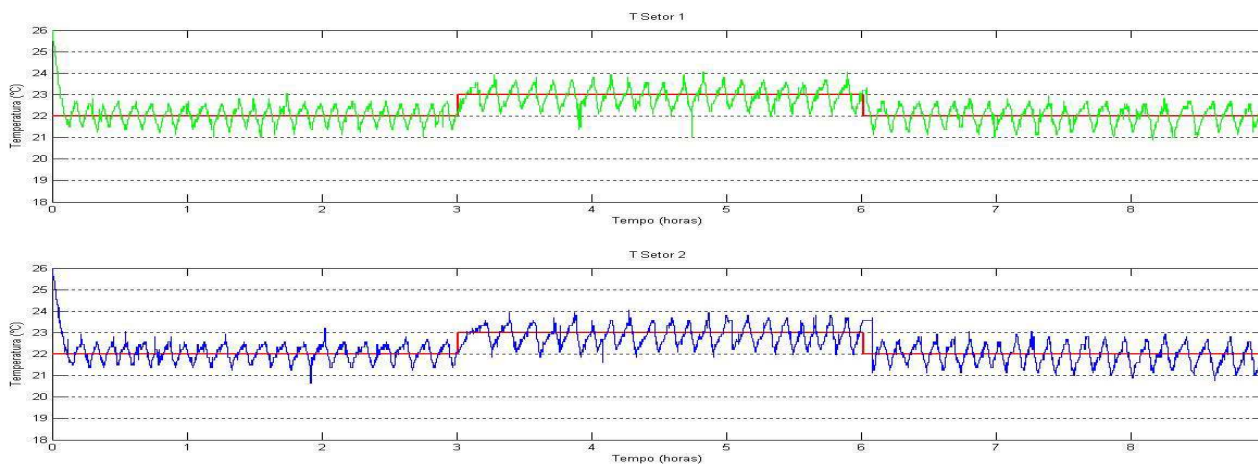
Truth Table of Fuzzy inference-LAVSI/ENE/UnB

Erro x T <sub>ref</sub>	MB	B	M	A	MA
NEG	A	A	A	A	A
PN	M	M	M	M	M
ZERO	M	M	M	M	M
PP	MB	MB	MB	MB	MB
POS	MB	MB	MB	MB	MB

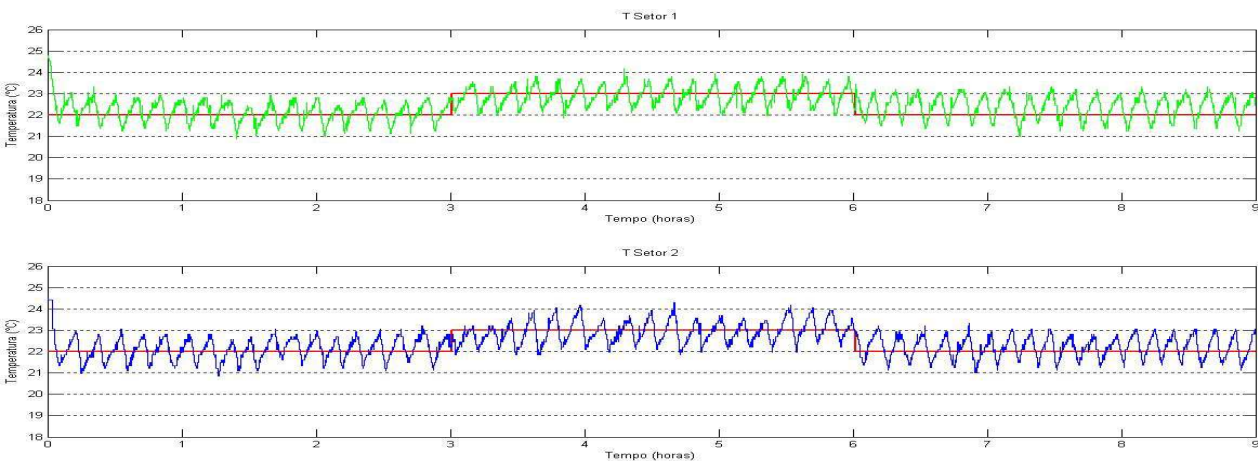
# Fuzzy Control in Wireless Network



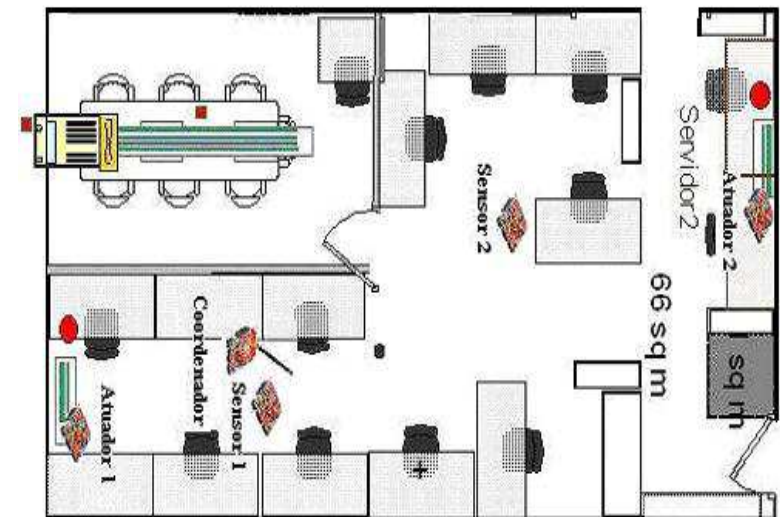
# Fuzzy Control in Wireless Network



Temperaturas no setor 1 e setor 2 – Controle On-Off



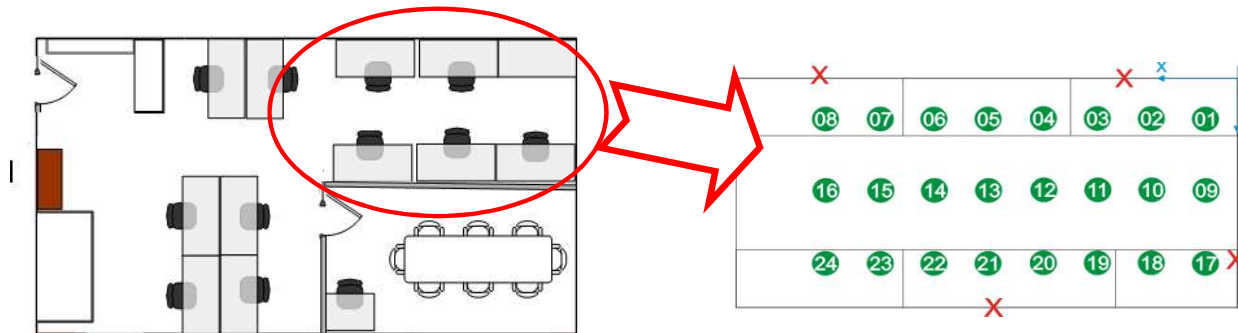
Temperaturas no setor 1 e setor 2 – Controle *Fuzzy*



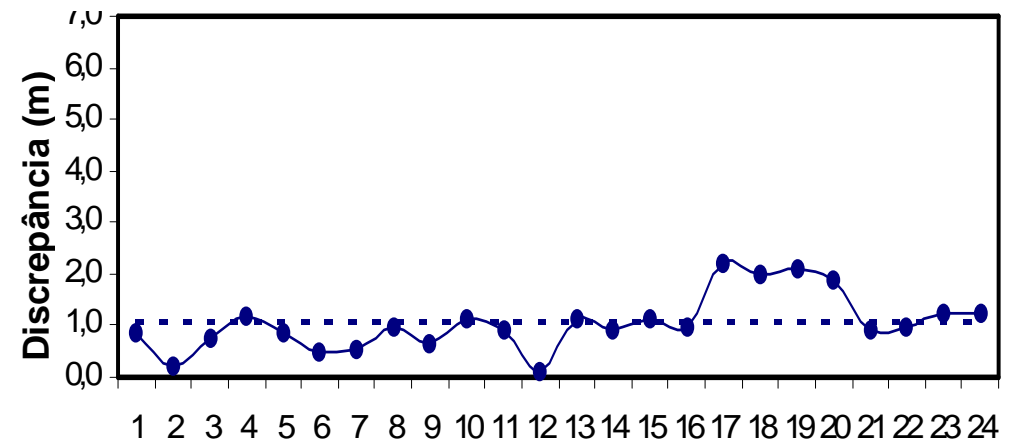
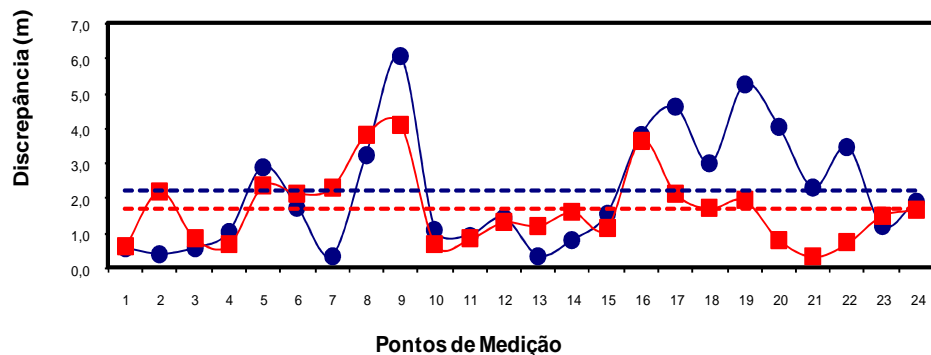
Energy saving: On-Off x Fuzzy Wireless,  
Ferreira Júnior, 2009.

Controller	Energy (kWh)	Energy saving
On-off	15,69	17,00 %
Fuzzy	13,41	

# Mobile Measurement of Thermal Comfort



Discrepancia entre Posições Calculadas e Posição Real

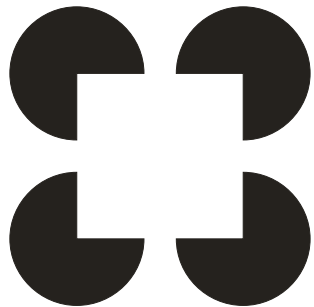


Pontos de Medição

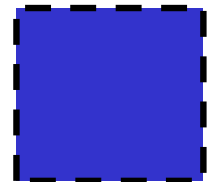
RNA

Hyperbolic triangulation

## Part 5 – Conclusions



- RNA - A technique that involves learning
- Fuzzy – Demands a Human Expert
- Neuro-Fuzzy - ANFIS
- Commercial products available

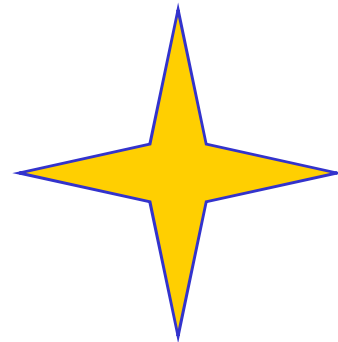


# Philosophical origins



René Descartes  
“analytic geometry”  
1637

**Reason**

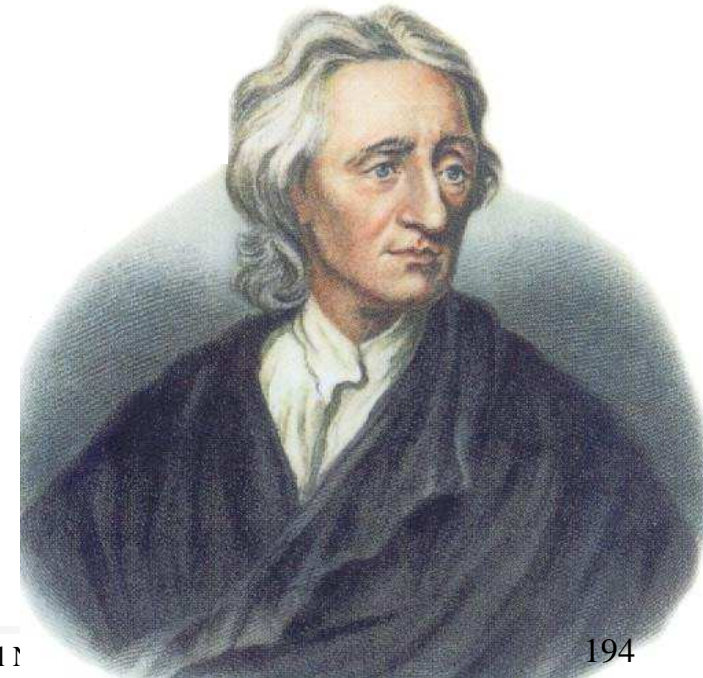


Immanuel Kant  
“Critique of Pure  
Reason”  
1781



**Senses**

John Locke  
“Essay on  
Human Understanding”  
1689



# Philosophical origins

René Descartes

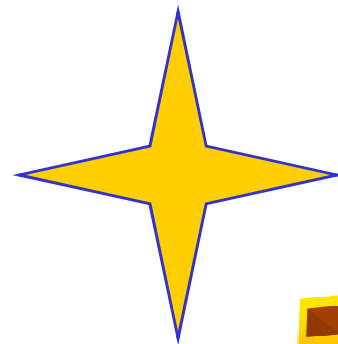
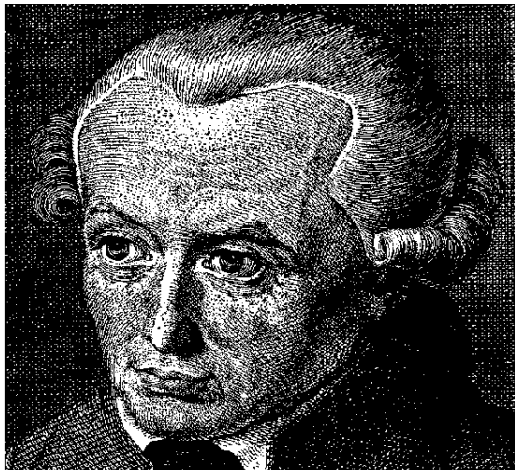
“I think, therefore I am”

**Rationalism**



Immanuel Kant

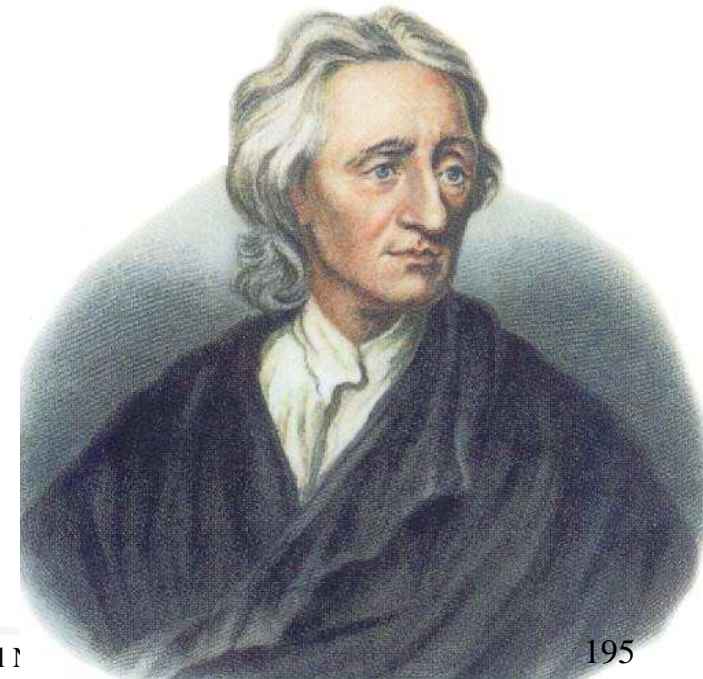
“We can only know what  
we perceive”



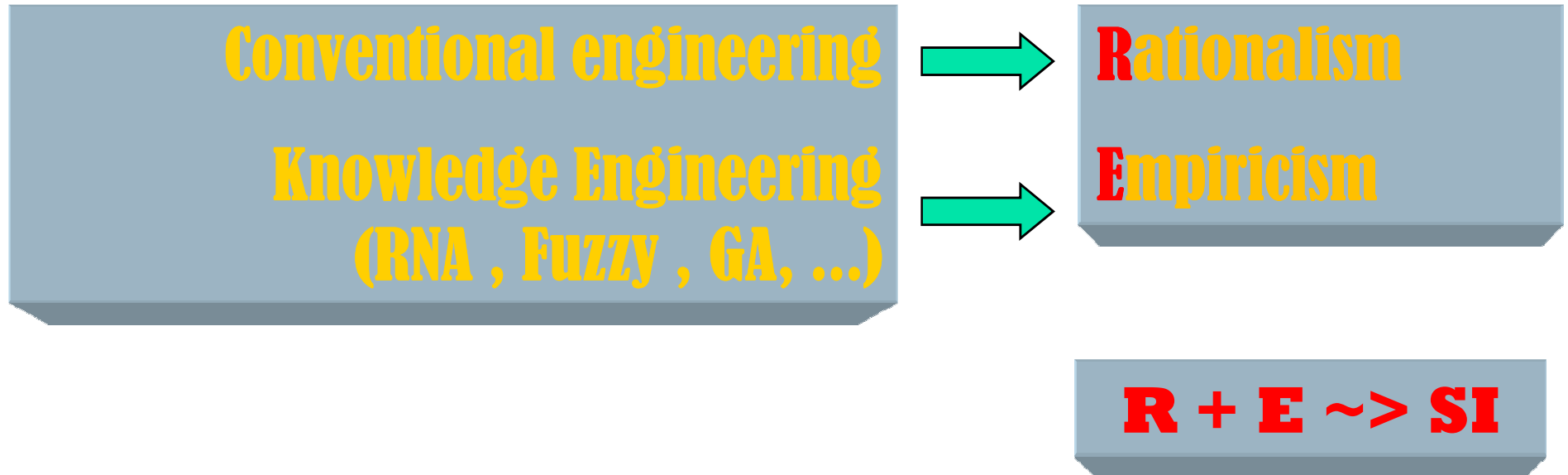
**Empiricism**

John Locke

“The knowing of no man  
can go beyond his experience”



# Conclusion



*To be able to design intelligent systems that are really useful you must have a good theoretical background.*

*Normally, only what is already known to exist, will be found.*





*Thank You!*

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