

# *Applications of fuzzy systems*

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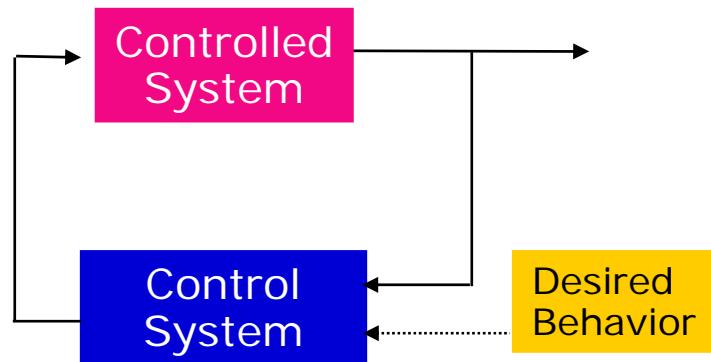
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## Applications of fuzzy models

- Fuzzy control
- Interfaces
  - user modeling
  - information retrieval
  - database queries
- “AI” Systems
  - Expert Systems
  - Scheduling
  - Decision Support Systems (DSS)

## What is a control system?

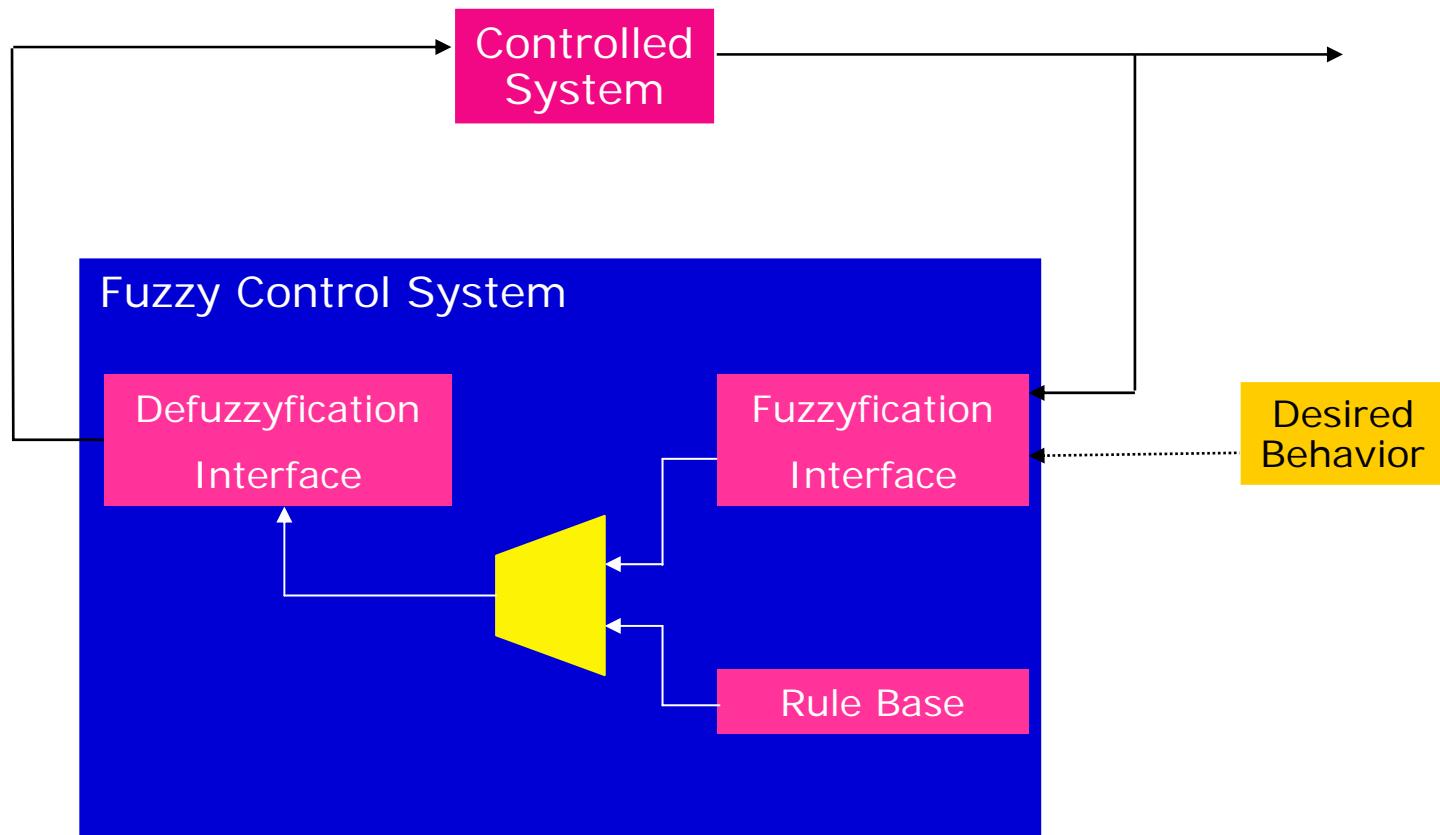
A system able to control the behavior of another system  
(a device, a biological body, a plant, a community, the society, ...)



In most cases it is a PID controller, where the output  $u$  depends on the difference  $e$  between the desired, and the observed behavior, its derivative (how fast  $e$  changes) and its integral (how large  $e$  has been in the past):

$$u = K_P e + K_D \frac{de}{dt} + K_I \frac{1}{T} \int_0^t e dt$$

## What is a fuzzy control system?



## Why fuzzy control is so successful?

Features:

- robustness
- wide range of applicability
- heuristic definition
- smoothness
- non linearity

## Example FLC - 1: Wide range of variable values

1985: Sendai (Japan) metro

**Goal:** Control train stop

**Why fuzzy?**

Different load conditions in the different stations

**Results**

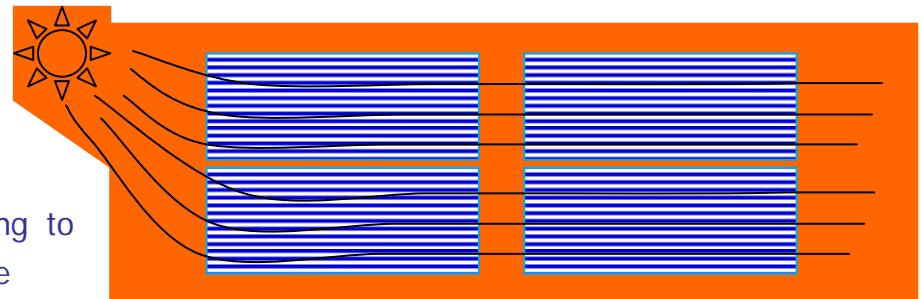
- Energy saving
- Precision
- Higher comfort



## Example FLC - 2: wide range of variable values

1996: oven for aluminum bars aging

**Goal:** reach the aging temperature according to technological constraints, in the shortest time

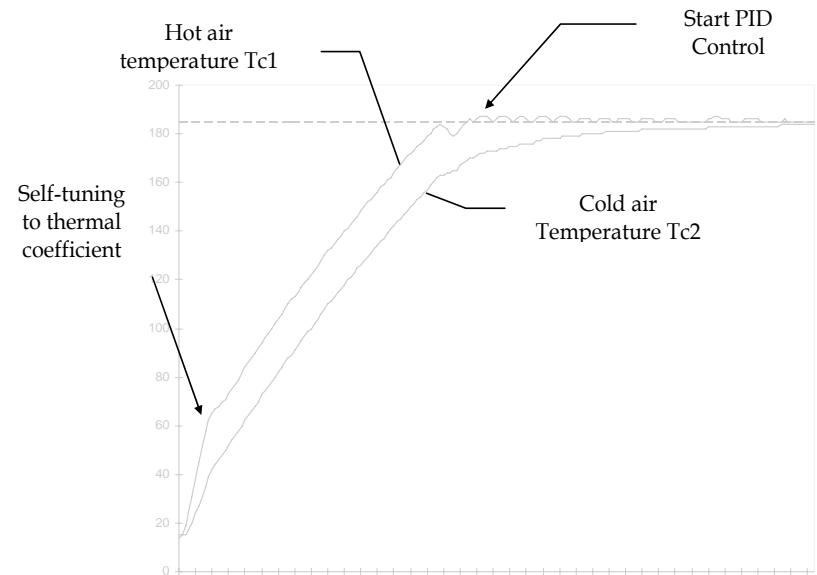


### Why fuzzy?

- Different load conditions (10,000 different profiles)
- Low quality of sensor data (air temperature at the ends of the bars)

### Results

- Energy saving
- Higher speed
- No need to tune continuously the control system



## Example FLC - 3: noisy systems

1990: mini-helicopter in windy days (Tokio)

Goal: Control the stability and movement of the helicopter

Why fuzzy?

No forecast about the situation

Results

It flies...



## Example FLC - 4: Low cost control

1990: fuzzy video cameras, fuzzy vacuum cleaners, fuzzy washing machines, fuzzy refrigerators, fuzzy rice cookers, fuzzy taps...

### Why fuzzy?

- Simplify the interaction with the user
- Nice performances at low cost (low cost sensors, low cost processors, ...)

### Results

Reliable and simple mass products at a low cost

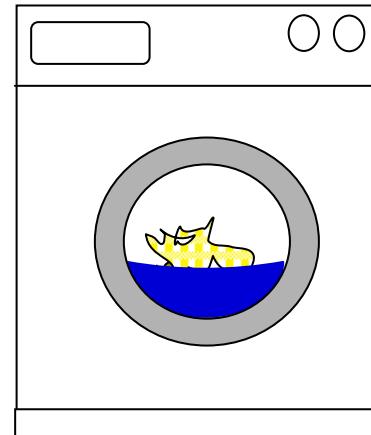
## FLC-4 – An example: fuzzy washing machine

### Goal:

1. recognize the kind of fabric and adapt the washing
2. rinse till needed
3. adapt to the water hardness

### How:

1. Measure the charging time of a condenser and the number of pressostate activations
2. measure the dielectric coefficient of the water at the beginning and rinse till it become the same at the end.



## Example FLC - 5: control of complex systems

1986: cement kiln, chemical plants

Goal: control the plant

Why fuzzy?

- hard to define and parametrize a mathematical model
- experts available (operators)

Results

- effective and robust control



## Example FLC - 6: hybrid control

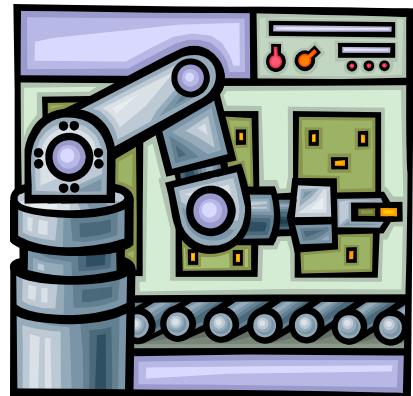
1990: temperature sensor, robot arm, ...

Why fuzzy + PID?

Augment the range of applicability of a PID

Results

Fast control without overshooting



## Example FLC - 7: high-level control

1998: autonomous robot

Why fuzzy?

Clear representation of control rules

High level tasks

Results

Good control developed in a short time



## Fuzzy databases and information retrieval

Flexible queries with human-like sensibility

E.g.:

"Give me the names of all the people that have **recently** invested **a lot**"

**SELECT Name , MatchingRate**

**FROM Investments**

**WHERE ((InvestmentDate is Recent) 0,8) AND ((InvestedAmount is Large) 0,5)**

Name	InvestmentDate	InvestedAmount
PAOLO BIANCHI	28	310
MARTA ROSSI	10	170
.....		

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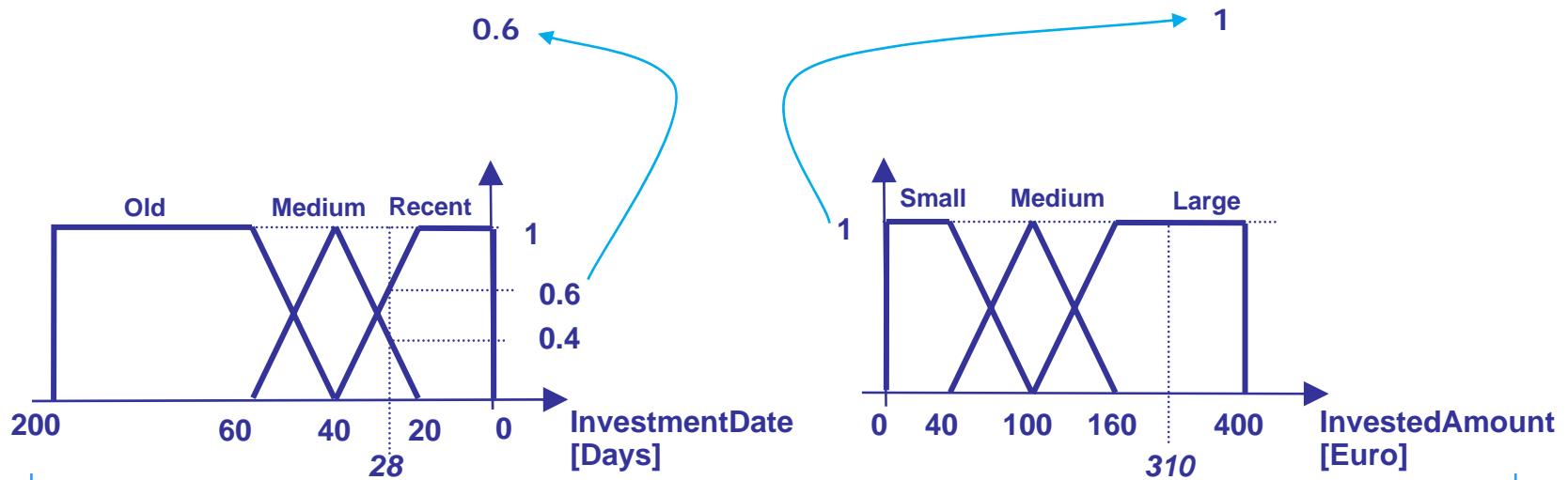
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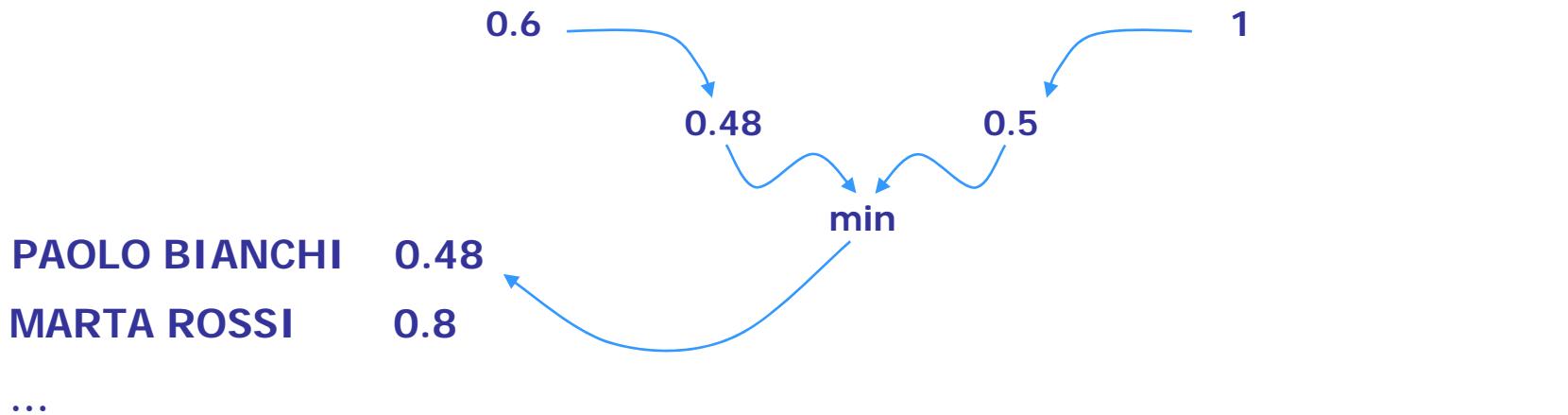
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## Example AIFS - 1: Quality control

### Goal:

Control the quality of a product (car, beer,...) in a qualitative way, and relate the results to the part of the production process responsible for eventual problems



### Why fuzzy?

Qualitative data from operators

### Results

Quality control at low cost: the operator provides data, he/she should not interpret them

## Example AIFS - 2: diagnosis

### **Goal:**

Diagnosis of industrial plants in the commissioning phase

### **Why fuzzy?**

- approximate, uncertain data
- approximate diagnostic knowledge, low reliability

### **Results**

- fast diagnosis at low cost
- it's easy to understand the diagnostic process



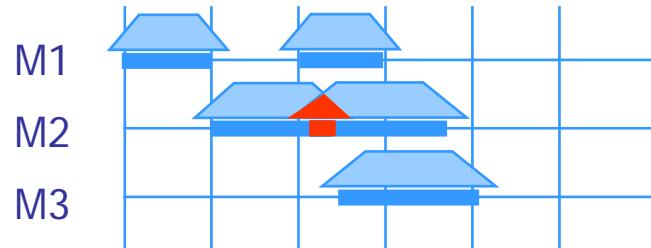
## Example AIFS - 3: scheduling

### Goal:

production scheduling in a job-shop production plant

### Why fuzzy?

fuzzy definition of constraints



### Results:

fast and effective scheduling systems

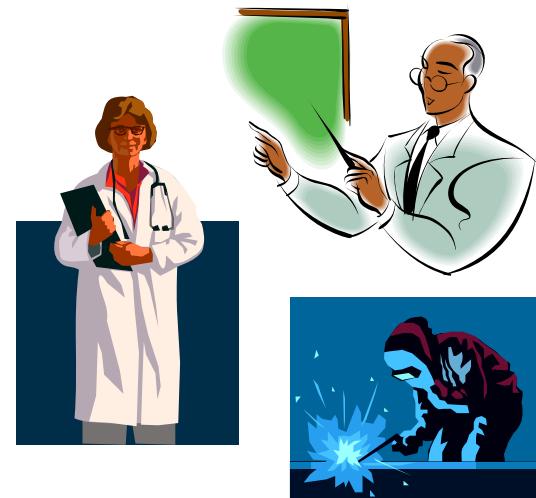
## Example AIFS - 4: advice-giving

### Goal:

decision support (e.g.: when to buy bonds, who is the right person for a job,...)

### Why fuzzy?

- uncertain and approximate data
- approximate decision process
- shared formal model



### Results

suggestions about decisions to be taken, weighted by criteria that can be easily defined by the management

## Example AIFS - 5: User-modeling

### Goal:

model how a driver changes gears in different road situations to implement a robotic gear shift (CRF)

### Why fuzzy?

- uncertain and approximate data
- approximate decision process
- high level features synthesized from objective data



### Results

adaptive robotic gear shift