Applications of fuzzy systems

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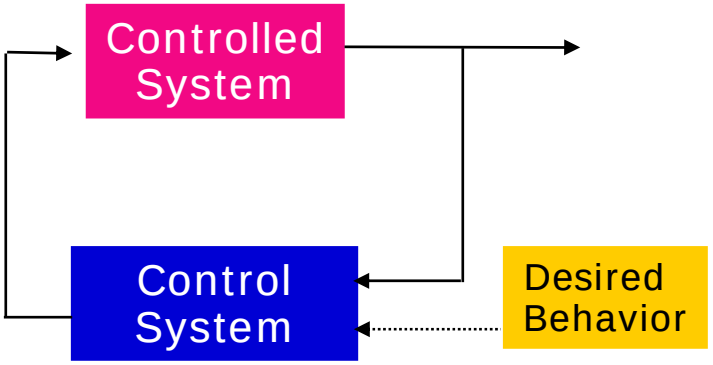
Applications of fuzzy models

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

What is a control system?

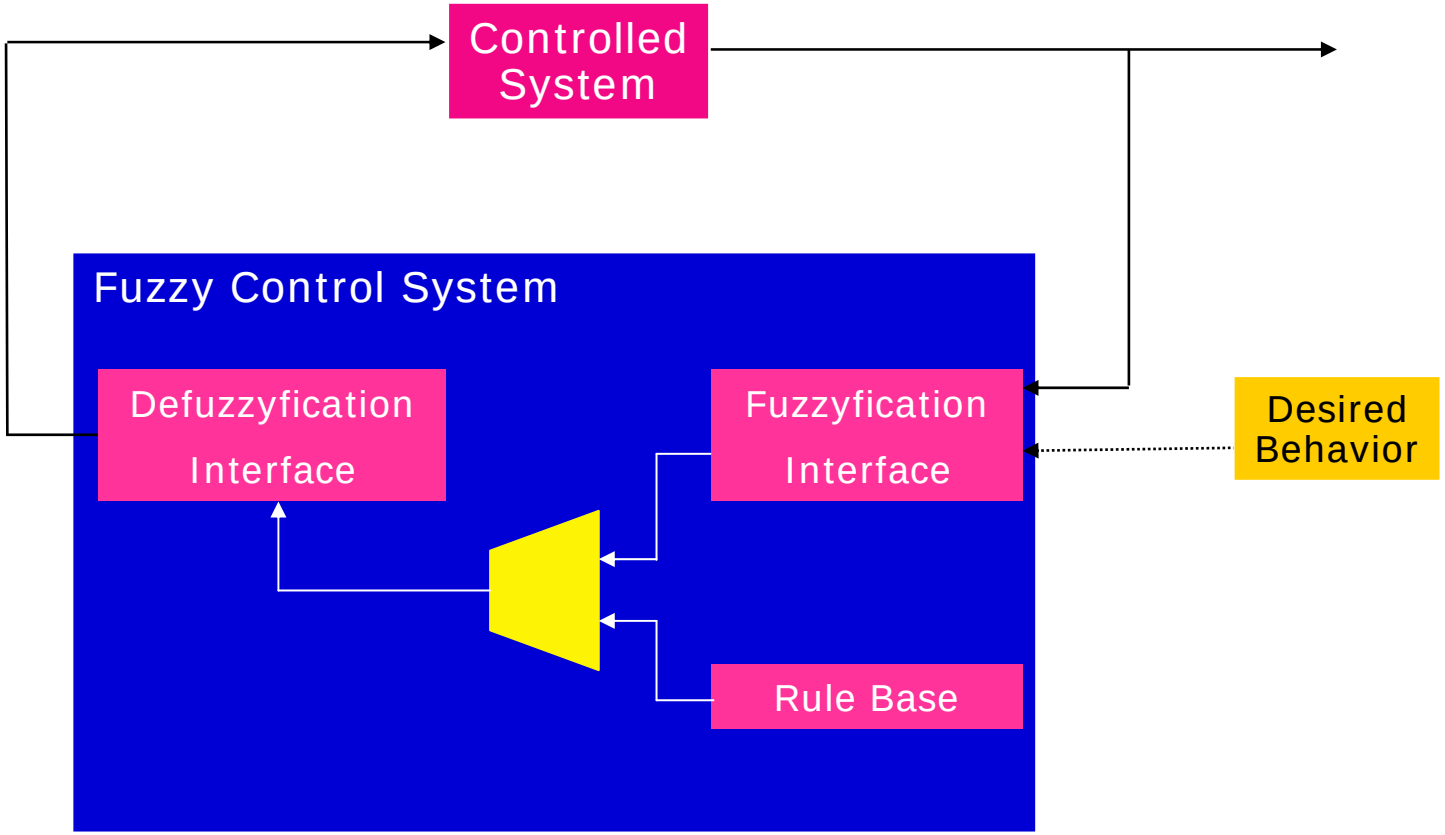
A system able to control the behavior of another system
(a device, a biological body, a plant, a community, the society, ...)



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

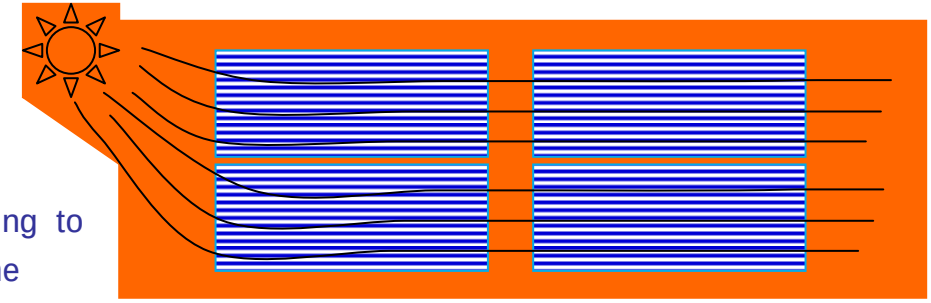
Why fuzzy?

Different load conditions in the different stations

Results

- Energy saving
- Precision
- Higher comfort

Example FLC - 2: wide range of variable values



1996: oven for alluminum bars aging

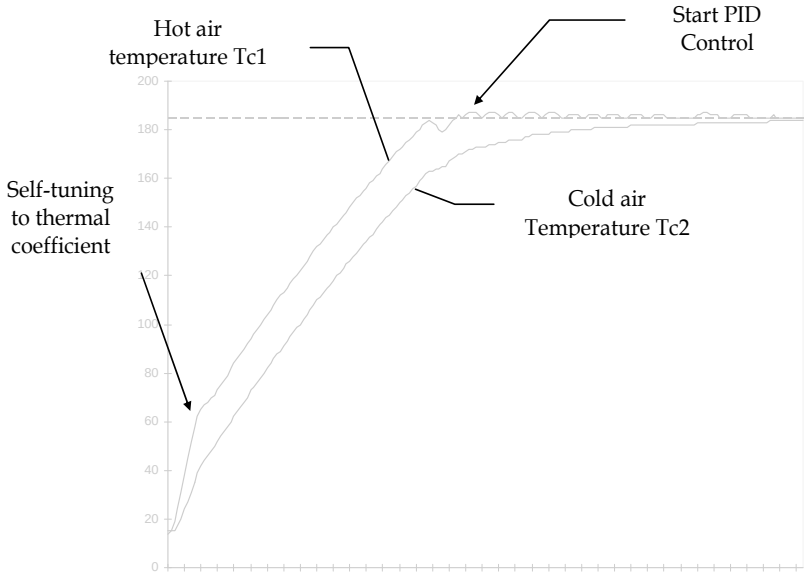
Goal: reach the aging temperature according to technological constraints, in the shortest time

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

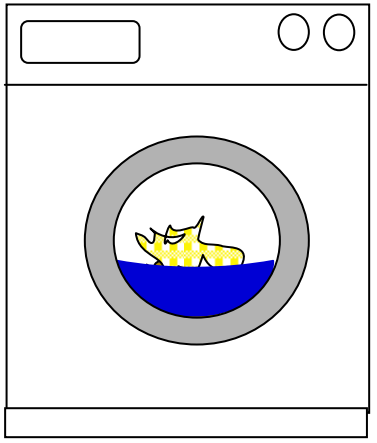
FLC-4 – An example: fuzzy washing machine

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

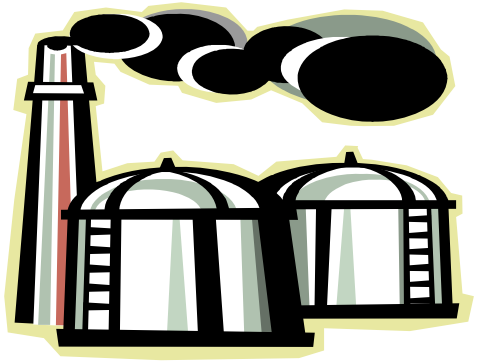
Goal: control the plant

Why fuzzy?

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

Results

- effective and robust control



Example FLC - 6: hybrid control

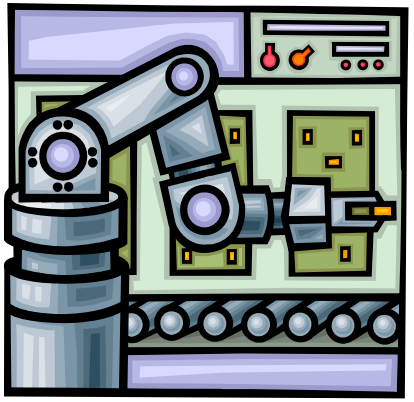
1990: temperature sensor, robot arm, ...

Why fuzzy + PID?

Augment the range of applicability of a PID

Results

Fast control without overshooting



Example FLC - 7: high-level control

Since 1998: autonomous robot

Why fuzzy?

- Clear representation of control rules
- High level tasks

Results

- Good control developed in a short time

No Movie

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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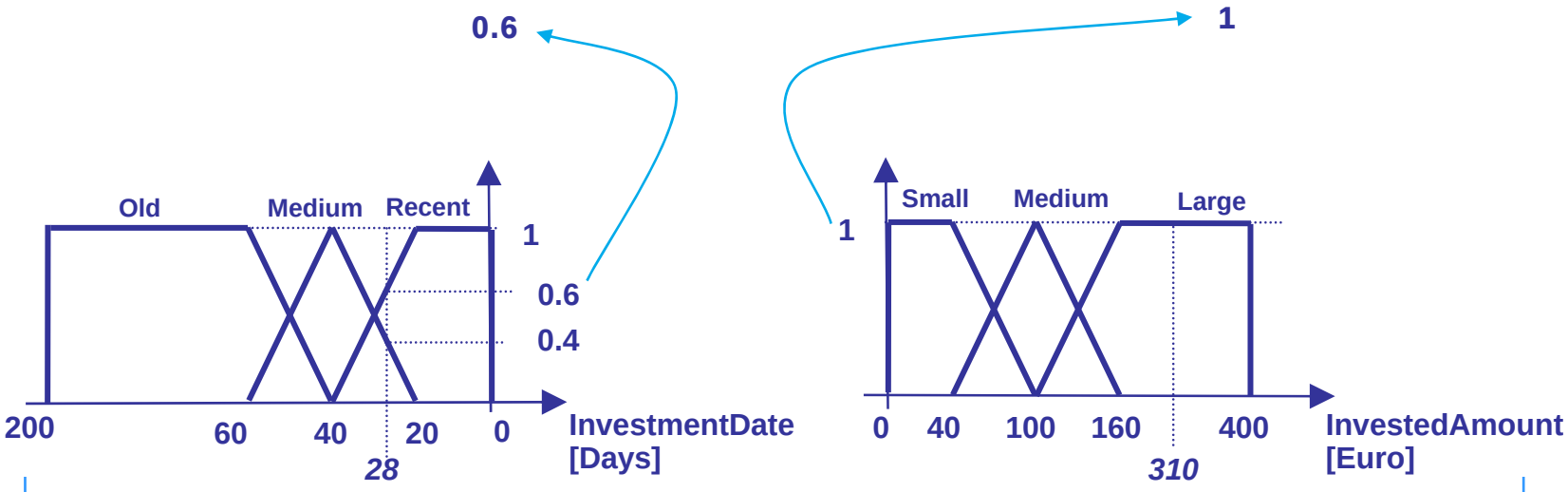

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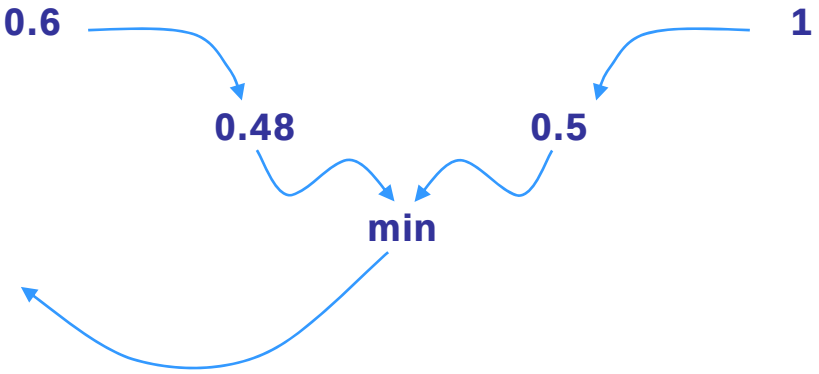


PAOLO BIANCHI 0.48

MARTA ROSSI 0.8

...

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

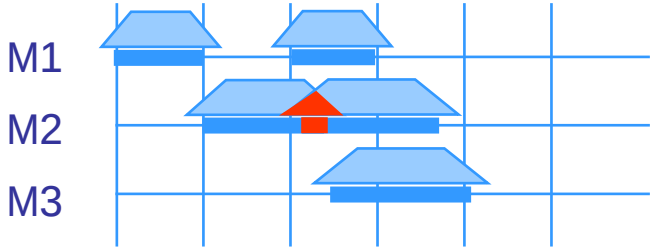
Example AIFS - 3: scheduling

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
- hign level features synthesized from objective data

Results

adaptive robotic gear shift