Applications of fuzzy systems

Michael J. Watts

http://mike.watts.net.nz

Lecture Outline

- Advantages of fuzzy systems
- Pattern recognition / Classification
- Fuzzy control
- Decision making

Advantages of Fuzzy Systems

- Comprehensibility
- Parsimony
- Modularity
- Explainability
- Uncertainty
- Parallelism
- Robust

Pattern Recognition

- Task is to classify a pattern based on certain measurements of that pattern
- Inexact
- Ambiguous
- Corrupted data
- High variability

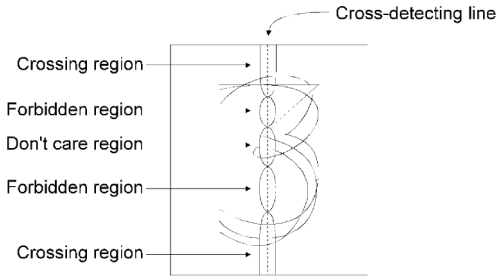
Pattern Recognition

- Examples
  - handwriting recognition
  - iris classification

Handwriting Recognition

- Identifying handwritten characters
- Much variation between writers
- Much variation from the same writer
- Track where character “crosses” specific zones

Handwriting Recognition



Iris Classification

- Classic classification problem
- Problem is to identify the species of an iris flower
- Input variables are four measurements of the flower
- Output variable is the species of the iris

Iris Classification

- Why is this a difficult problem?
- Uncertainty
  - wide variety in the species
  - living things have a wide variation
  - uncertainty about species

Iris Classification

- Accurate classification can be performed with the appropriately defined MF and rules
  - about 12 rules will do
  - optimal MF are harder to define
  - Lab 6

Control Systems

- Use mathematical systems to transform the current state of a system and the desired state of a system into a future state of a system
- Current State + Desired State = Influences
- Behaviour of the system must be modelable by a mathematical function

Control Systems

- Don’t scale well
- Don’t handle non-monotonic functions well

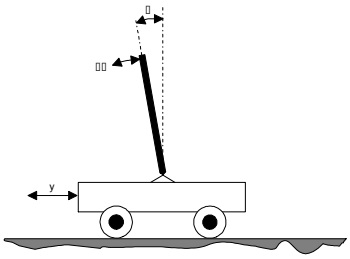
Fuzzy Control

- Replaces mathematical approximations with a fuzzy system
- Rules define actions for specific conditions
- Biggest application area of fuzzy logic
- Examples
  - Inverted pendulum
  - Sendai subway system
  - Washing machines

Inverted Pendulum

- Classic fuzzy control application
- Task is to keep an inverted pendulum balanced on a mobile platform
- Platform can move left and right
  - moved by an electric motor
- Motor can operate at different speeds
  - controlled by current

Inverted Pendulum

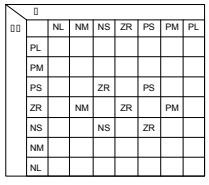


Inverted Pendulum

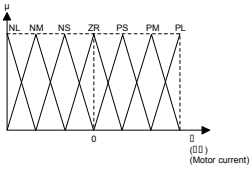
- Two inputs
  - angle of pendulum
    - positive or negative
  - angular speed of pendulum
    - positive or negative
- One output
  - current to motor
    - positive or negative

Inverted Pendulum

- MF range from “Negative Small” (NL) to “Positive Large” (PL)



	NL	NM	NS	ZR	PS	PM	PL
PL							
PM							
PS			ZR		PS		
ZR		NM		ZR		PM	
NS			NS		ZR		
NM							
NL							



Inverted Pendulum

- This has been used as a demo for fuzzy control chips
  - Videos

Sendai Subway

- Underground train in Sendai, Japan
- Fuzzy system controls
  - train accelerator
  - brakes
- Fuzzy controller must
  - accelerate to target speed
  - maintain speed
  - stop accurately

Sendai Subway

- Rules obtained from experienced train drivers
- Very efficient system
- Not portable

Washing Machines

"Bosch - Washing Machine - WOL2200 - Free Standing

Premium Fuzzy Logic, Top loader washing machine with 1100 rpm spin and 15 Clothes Care wash programmes. "

- http://www.itlocal.co.uk/rdo/acatalog/Online_Catalogue_FREESTANDING_273.html

Washing Machines

- Inputs
  - amount of dirt
  - type of dirt
- Outputs
  - wash time
  - can also include amount of detergent

Washing Machines

- Commercial success
- Possibly the most widely known application of fuzzy logic / fuzzy systems
- How much is due to marketing techno babble?

Decision Making

- Given measurements of a specific situation, decide what to do
- Many such measurements are not clear-cut
  - boundaries
- Examples
  - loan approval
  - insurance evaluation

Summary

- Advantages of fuzzy systems make them applicable to many different applications
- Biggest application area is fuzzy control
- Fuzzy control applies fuzzy systems to control systems
- Largest commercial use of fuzzy logic

Summary

- Other applications include
  - pattern recognition
  - decision making
  - fuzzy databases / information retrieval
- Specialised applications