Syllabus

1. Terminology: Uncertainty, Approximations and Vaguenes
2. Fuzzy Sets
3. Fuzzy Logic and Fuzzy Systems
4. Fuzzy Control
5. Neuro-Fuzzy Systems

Topics

1. How **imprecision** in concepts can be discussed using the basics of fuzzy sets (concepts are not bounded, they're not set in stone)
2. The basic principles of **organizing** a fuzzy logic system (rather than strict membership of sets, we can have weak membership - a penguin is weakly a bird, can also have elastic membership - a platypus is a fish and a mammal)
3. What is inside the **rule-base** of a fuzzy **control** system
4. About methods of **building** a fuzzy control system

Focus on fuzzy logic and fuzzy control systems, with a brief intro to neural networks. This is a branch of soft computing.

- Inputs and outputs are not provably correctly related, or even complete
- This reflects the impossibility of capturing the world's data exactly

Assessment

- 20% project
  - 4 page report
    1. Fuzzification: take input variable and fuzzifies it
    2. Inference: identifies where the input falls (e.g. is a temperature hot or cold)
    3. Aggreggation
    4. Defuzzification: generate a number from a fuzzy input
  - Group project
- 80% exam
  - 3/5 questions
  - 2 hours

Logic in Fuzzy Systems

Fuzziness is not randomness.
Rather than strict rules such as

if A then B

we have

if $A(\chi_{A})$ then $B(\chi_{B})$
with $\chi_{B} \le \chi_{A}$

Deviant Logics

These test the boundaries of a logic system by determining how far you can deviate from a traditional logic while it's still valid.

- **Jones is tall**: Confidence in the truth of a vague assertion jus because of it's vagueness.
- **Jones is 1.8297m tall**: The laws of physics can acquire this minuteness of detail only by sacrificing some of the fixed absolute certaintly of common sense laws.

There is a balance between precision and certainty.

Fuzzy Sets

A collection of objects that might belong to the set to a degree, varying from 1 (full belongingness) to 0 (full non-belongingness), through all intermediate values. Set membership is elastic.

The concept of a membership function assigning to each element a number from the unit interval to indicate the *intensity of belongingness*

Fuzzy sets are those without a strictly defined membership function. Instead, we define probabilities of membership based on some function based on the item being classified.

Example:
In the context of some urban road, we could define speeds $<$ 10km/h as slow. The probability distribution for a slow speed starts at $P(0)=1$, decreasing linearly to $P(10)=0$. We could then define the probability distribution of fast speeds as 1-slow, or of very slow speeds as slow^2^

Given a fuzzy goal G and a fuzzy constraint C in a space of alternatives X. Then G and C are for a decision D, which is a fuzzy set. Symbolically, $D = G \cap C$.

Fuzzy Boundaries

A 'tree of life' shows interconnectedness between various specifies: the interconnection blurs or *fuzzifies* the boundary between the species. The notion of fuzzification has helped the evolutionay biologists talk about *clades* (share some of the ancestors properties and have their own properties).

Fuzzy Control

Provides a formal methodology for representing, manipulating and implementing a human's heuristic knowledge about how to control a system.
Information based on rules of thub comes from two sources

- Operators running complex control systems
- Design engineering of such systems who have carried out mathematical analysis

Uncertaintly and its Treatment

Fuzzy sets have led to

1. A non-addictive uncertainty theory
2. Tool for both linguistic and numerical modelling: fuzzy rule-based systems

A robot showing human emotions to the speed of a car and it's distance away.

Distance	Stationary	Fast
Very near	Not surprised, no fear	Not surprised, fear
Far	Not surprised, no fear	Surprised, no fear

Applications

- Autonomous helicopter
- Several diseases interacting inside a patient
- Evolution (clades)
- Applying brakes to stop a passenger plane