What is covered in this class?

We will teach techniques useful in creating intelligent software systems that can deal with the uncertainty and imprecision of real world problems.

Some components of Intelligent systems are:

- **human-like** - they possess human-like expertise within a specific domain,
- **adaptable** - they adapt themselves and learn to do better in a changing environment, and
- **explanations** - they explain how they make decisions or take actions
How will we teach the techniques?

We will present
- multiple techniques from Soft Computing +,
- when each technique is applicable
- examples of industrial applications

“If the only tool you have is a hammer, then every problem looks like a nail”
- anonymous

Soft Computing

“Soft computing is an emerging approach to computing which parallels the remarkable ability of the human mind to reason and learn in an environment of uncertainty and imprecision”
- Lotfi Zadeh
The information revolution going on is allowing us to automate information processing tasks which require intelligence much like the industrial revolution automated manufacturing tasks. “Soft Computing” techniques have already been applied successfully.

Soft Computing is a field that currently includes

- Fuzzy Logic
- Neural Networks
- Probabilistic Reasoning (Genetic Algorithms, BBN), and

Other related methodologies
  - Case-Based Reasoning

Soft Computing combines knowledge, techniques, and methodologies from the sources above to create intelligent systems.
Fuzzy Logic - Kai

Sets with fuzzy boundaries

\[ A = \text{Set of tall people} \]

- **Crisp set A**
  - \[ \text{Heights (cm)} \]
  - \[ \text{Membership function} \]
  - \[ \text{Heights (cm)} \]

- **Fuzzy set A**
  - \[ \text{Heights (cm)} \]
  - \[ \text{Membership function} \]
  - \[ \text{Heights (cm)} \]

Fuzzy Set Theory - Kai

Fuzzy set theory provides a systematic calculus to deal with imprecise or incomplete information.

Fuzzy if-then rules are used in fuzzy inference systems.

If \(<1>\) is tall and \(<1>\) is athletic then \(<1>\) is good basketball player.

\[ \text{T-norm} \]

\[ \text{X} \]

\[ \text{Y} \]

\[ \text{Z} \]
Neural Networks - Kai

Pattern matching technique where inputs are matched with a specific output pattern.

Network architecture
Modeled after the neurons in the brain.

Weights on the links
Learns by modifying the weights

Genetic Algorithms - Bill

Use Idea of Evolution to Guide Search

Human Evolution

Find Max of a Function
Genetic Algorithms - Bill

An optimization technique

Current generation

Next generation

Selection  Crossover  Mutation

Elitism

Case-Based Reasoning - Bill

CBR Cycle
(Aamodt & Plaza, 1994, AI Communications)

A methodology of solving new problems by adapting the solutions of previous similar problems
Models the way experts reason using their experience
What Is CBR? - Quiz

What is $12 \times 12$?
144

What is $12 \times 13$?
$12 \times 12 + 12$
156

Other Techniques – Bill & Kai

Bayesian belief networks
- represent and reason with probabilistic knowledge

Decision Trees
- classification using tree structure

Least-squares estimator
- statistical regression

Hybrid approaches
- use multiple techniques
Soft Computing is a Hybrid Method

How does SC Relate to Other Fields

What is AI?

“AI is the study of agents that exist in an environment and perceive and act.” (S. Russell and P. Norvig)

“AI is the art of making computers do smart things.” (Waldrop)

“AI is a programming style, where programs operate on data according to rules in order to accomplish goals.” (W. A. Taylor)

“AI is the activity of providing such machines as computers with the ability to display behavior that would be regarded as intelligent if it were observed in humans.” (R. McLeod)
How does SC Relate to Other Fields

What is AI? (Jang)

Broad Definition
The long term goal of AI research is the creation and understanding of machine intelligence.

Narrow Definition
Conventional AI research focuses on an attempt to mimic human intelligent behavior by expressing it in symbolic rules.

What is an Expert System (ES)?

User

Questions

Responses

Inference Engine

KB
Rules – if a then b
Facts – a is true

Knowledge Acquisition

Knowledge Engineer
Types of Programming

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Stages of Reasoning

- Complex Math
- Logic
- Evolution Experience Uncertainty

Humans

- Functional Programming
- Symbolic Programming (AI)
- Soft Computing

Computers
Soft Computing Characteristics

- Human Expertise (if-then rules, cases, conventional knowledge representations)
- Biologically inspired computing models (NN)
- New optimization techniques (GA, simulated annealing)
- Model-free learning (NN, CBR)
- Fault tolerance (deletion of neuron, rule, or case)
- Real-world applications (large scale with uncertainties)

Soft Computing Entertainment

Star Trek

- Kirk and Spock are the classic fuzzy and crisp reasoners

Errand of Mercy episode
- Klingon army attacks a neutral planet
- Kirk and Spock beam down
- Enterprise is chased away
- Inhabitants are not concerned
- Should they try and help?

- Spock – odds of succeeding are 7,249.5 to 1
- Kirk – we should do it anyway
Soft Computing in History

“If a man will begin with certainties, he will end with doubts, but if he will be content to begin with doubts, he shall end in certainties.”

- Francis Bacon 1605
THE ADVANCEMENT OF LEARNING