FUZZY LOGIC & NEURAL NETWORKS

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Workshop Outline:

- Soft-computing: General introduction.
- Fuzzy Logic Systems: Basic concepts
  - Fuzzy relations, Fuzzy sets, Fuzzy rules,
  - Fuzzy inference,
  - Fuzzifier & Defuzzifier.
  - Design of Rule-based Fuzzy Systems.

- Neural Networks:
  - Basic Concepts: Single-layer feedforward network.
  - Multilayer Perceptron.
  - Functional link network.
  - Neuro-Fuzzy networks.
- Fuzzy Logic Control; Basic Concepts.
- Fuzzy Logic Control; Applications.
- Fuzzy Expert Systems.

- Fuzzy Decision Making.
- Different NeuroFuzzy Approaches.
- Tutorial on Using MATLAB and SIMULINK .
- Tutorial on Using Fuzzy Logic Toolbox with Applications.
- Further Applications on Fuzzy Logic & Neural Networks.

INTRODUCTION:

- The term **Soft Computing** was proposed by Lotfi Zadeh in 1994;

" Soft Computing is a collection of methodologies that aim to exploit the tolerance for impressions & uncertainty to achieve tractability, robustness, and low solution cost. Its principle constituents are;

- **Fuzzy logic,**
- **Neurocomputing, and**
- **Probabilistic reasoning.**

The role model for soft computing is the **human mind**. *"*

- FL is concerned with imprecision.
- NN is concerned with learning.
- PR is concerned with uncertainty.

In general, FL, NN, and PR are complementary rather than competitive.

It is clear that in many cases it is advantageous to employ FL, NN, and PR in combination rather than exclusively.

In particular, the combination of FL and NN leads to: **NEROFUZZY SYSTEMS.**

- Today, FL, NN, and GP have been applied to many real world applications.
- Although, these methodologies seem to be different, they have many common features;

- the use of basis functions;

  FL has membership functions, NNs have activation functions, GAs use probability density functions.

- the aim to estimate functions from sample data or heuristics.
- Good results have been achieved by combining different SC methods.

- Soft Computing can also be seen as a foundation for the growing field of COMPUTATIONAL INTELLIGENCE (CI).
- The difference between traditional AI and CI is that AI is based on hard computing while CI is based on soft computing.

BRIEF HISTORY OF FUZZY TECHNOLOGY:

1965 Concept of fuzzy sets theory by Lotfi Zadeh.

1972 First working group on fuzzy systems in Japan

1973 Paper about fuzzy algorithms by Zadeh

1974 Steam engine control by Ebrahim Mamdani in UK

1977 1st fuzzy expert system for loan applicant evaluation in Germany.

1980 Cement kiln control by P. Holland in Denmark.

1984 Water treatment control in Japan.

Subway Sendai Transportation system control in Japan.

1985 1st fuzzy chip developed in Bell Labs (USA)

1986 Fuzzy expert system for diagnosing illness in Omron (Japan).

1987 Soldring robot/ Automated aircraft vehicle landing/ 1st fuzzy company in USA (Togai Infralogic Inc.)

1988 1st dedicated fuzzy controller sold by Omron Inc. (Japan).

1989 Creation of Lab. For Intr. Fuzzy Eng. Research (LIFE) in Japan.

1990 Fuzzy TV set by Sony (Japan).

Fuzzy electronic eye by Fujistu (Japan).

Fuzzy Logic System Institute (FLSI) in Japan

1991 Fuzzy AI promotion center in Japan.

Educational kit by Motorola in USA.

After 1991 fuzzy technology came out of scientific laboratories And became an industrial tool

FUZZY SUCCESSFUL PROJECTS

- Automatic control of hydroelectric power plants in Tokyo.
- Simplified control of robots (Fuji, Toshiba, Omron)
- Camera-aiming for the telecast of sporting events (Omron)
- Efficient and stable control of car engines (Nissan, Subaru).
- Optimized planning of bus timetables (Toshiba).
- Archiving system for documents (Mitsubishi Electric).
- Prediction system for early recognition of earthquakes (Japan).
- Medicine technology: cancer diagnosis (Japan).
- Recognition of motives in pictures with video cameras (Canon).
- Automatic motor control of vacuum cleaners (Matsushita).

FUZZY CONTROLLERS APPLICATIONS

Consumer Products:

- washing machines.
- Microwave ovens.
- Vacuum cleaners.
- Camcoders.
- TVs and VCRs.
- Word translators.

Systems:

- Elevators.
- Trains.
- Cranes.
- Traffic control
- Automotives; engines, transmissions, brakes

Software:

- Medical diagnosis.
- Securities.
- Data compression.

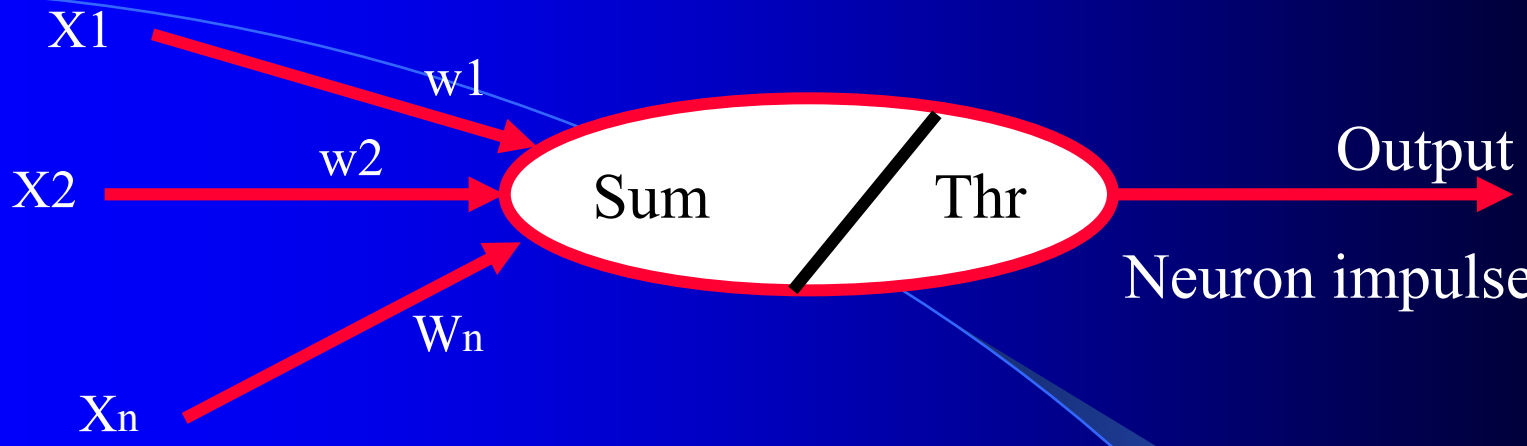
ARTIFICIAL NEURAL NETWORKS

What is a Neural Network?

- A new form of computing, inspired by biological models.
- A mathematical model, composed of a large number of processing elements (PEs) organized into layers.
- A computing system, make up of a number of simple, highly interconnected PEs, which processes information by its dynamic state response to external inputs.

ANN Structure:

- It evaluates the I/p signals, determining the strength of each one.
- It calculates a total for the combined I/p signals & compares the total against some threshold level.
- Depending on the result, it determines what the output should be.



$$Y = w1 * X1 + w2 * X2 + \ldots\ldots + wn * Xn$$

- This is a linear function. You may have another function, not a sum but a product or a logical function.
- To create a nonlinear network, compare the mapping result with the threshold. A special impulse (an excitation signal) is generated if the weighted sum of the inputs is higher than the threshold value (Neuron fired).
- Threshold may be; hard limiter, ramping functions, or sigmoid.

Advantages of Neural Networks:

- They do not need to be programmed, they can learn from examples.
- They can generalize from their training data to other data.
- They are fault tolerant: they can produce correct outputs from noisy and incomplete data, whereas conventional computers usually require correct data.
- They are fast: their interconnected PEs work in parallel.
- They are relatively inexpensive to build and to train.

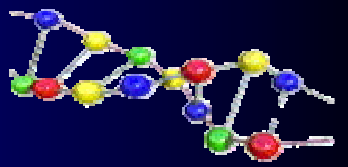
Disadvantages of Neural Networks:

- Neural networks have no model of the universe in which they work.
- Whereas neural networks work well for inputs reasonably similar to their training data, they may give completely unpredictable outputs outside this region.
- Although they require no programming, a considerable effort may go into the pre-processing and post-processing subsystems for a neural network.
- Much of the knowledge about neural networks is empirical.

Genetic Algorithms:

- Genetic algorithms were invented by John Holland and developed by him and his colleagues. Holland's Book "Application in Natural & Artificial Systems" 1975.
- In 1992 John Koza has used GA to evolve programs to perform certain tasks. He called his method "GENETIC PROGRAMMING"
- GA is a model of machine learning which derives its behavior from a metaphor of the processes of evolution in nature. This is done by the creation within a machine of a population of individuals represented by chromosomes. The individuals in the population then go through process of evolution.

For more information:
www.cs.telk.cvut.cz/~xobitko/ga/main.html



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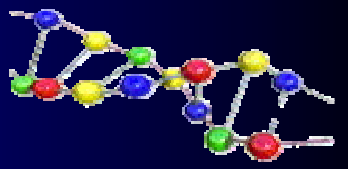
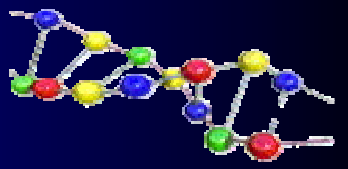


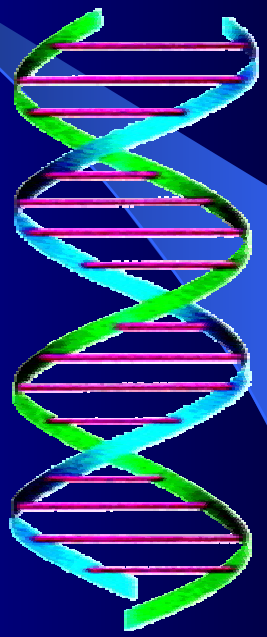
Overview

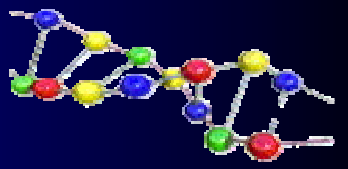
- Introduction
- History
- Details
- Example
- Future

Introduction



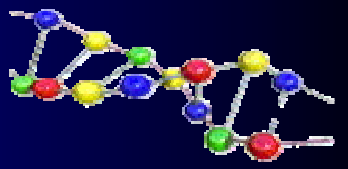
- Optimization has for long been an important goal in the fields of Applied Mathematics and Computer Science.
- Genetic algorithms are a part of evolutionary computing, which is a rapidly growing area of artificial intelligence
- As the name suggests this method is based on Darwin's Theory of evolution.
- Genetic algorithms arose from computer simulations of biological evolution in the late 60s and early 70s.





History

- 1960 – Introduced by I. Rechenberg
- 1975 – Popularized by John Holland
- 1975 - book "Adaptation in Natural and Artificial Systems" published
- 1992 – John Koza's work

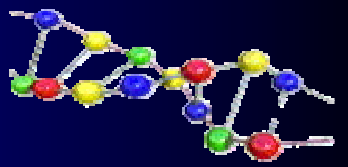


Details

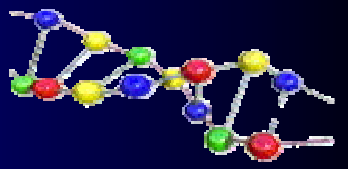
A description of the biological terms used:

- Chromosomes
  - Genes
  - Locus
- Reproduction
  - Crossover
  - Mutation

General Outline



- Start
- Fitness
- New Population
  - Selection
  - Crossover
  - Mutation
  - Accepting
- Replace
- Test
- Loop

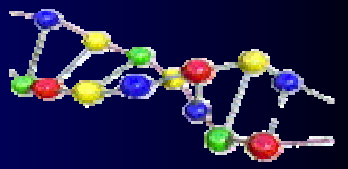


1. Encoding

Chromosome 1	1101100100110110
Chromosome 2	1101111000011110

2. Fitness & Selection

- The fitness function *f(x)*
- Associates fitness of a chromosome to a single number
- This number determines the chance of selection for reproduction

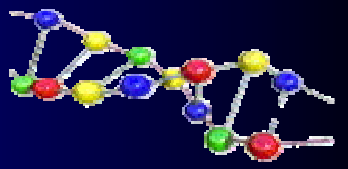


3. Crossover

Chromosome 1	11011 | 00100110110
Chromosome 2	11011 | 11000011110
Offspring 1	11011 | 11000011110
Offspring 2	11011 | 00100110110

4. Mutation

Original offspring 1	11011111000011110
Original offspring 2	11011001001101l0
Mutated offspring 1	11001111000011110
Mutated offspring 2	11011011001101l0

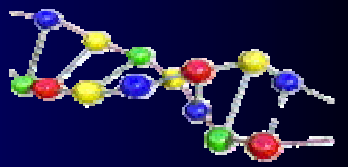


Example

- Character Evolution Algorithm
  - Generate some random individuals
  - Select the n best of them depending on their fitness
  - Take those n best to produce some new individuals, based on the information they hold.

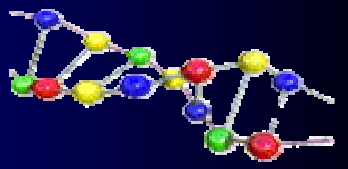
  Repeat from step 2, until you reach what you want.

- Fitness
- Reproduction & Cumulative Selection
- Mutation
- View Applet



Applications

- Decision Making
- Data Mining
- Scheduling
- Computer games
- Stock Market Trading
- Medical
- Information Systems Applications
- Finance Applications



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