Soft Computing

What is soft computing

- The idea behind soft computing is to model cognitive behavior of human mind.
- Soft computing is foundation of conceptual intelligence in machines.
- Unlike hard computing, soft computing is tolerant of imprecision, uncertainty, partial truth, and approximation.

- Soft computing is a collection of techniques that help us to construct computationally intelligent system
- Soft computing is a new approach to computing that parallels the remarkable ability of the human mind to reason and learn in an environment of uncertainty and imprecision
- Prof. Lofti Zadeh is the Father of Soft Computing

Goals of Soft Computing

- To develop intelligent machines to provide solutions to real world problems, which are not modeled, or too difficult to model mathematically
- To exploit the tolerance for Approximation, Uncertainty, Imprecision, and Partial Truth in order to achieve close resemblance with human like decision making

Constituents of Soft Computing

- **Neural network**
  - Neural networks mimic certain processing capabilities of the human brain
  - A neural network is a processing device, either an algorithm or an actual hardware
  - A computing world has a lot to gain from neural networks
  - Neural networks have the ability to learn by example, which makes them very flexible and powerful
  - For a neural network, there is no need to devise an algorithm to perform a specific task, that is , there is no need to understand the internal mechanisms of that task
  - These networks are well suited for real- time systems because of their fast response and computational times.
- **Fuzzy Logic**
  - FL is a multi valued logic for treatment of imprecision and vagueness
  - The concept of FL was conceived by Lotfi Zadeh
  - Fl is a superset of Boolean logic and contains similarities and differences with Boolean logic
  - It is based on degrees of truth
  - For example, traditional sets include or do not include an individual element; there is no other case than true or false
  - Fuzzy sets allow partial membership
  - FL's approach to control problems mimics how a person would make decisions, only much faster.
- **Evolutionary algorithm(Genetic Algorithm)**
  - GAs are used to mimic some of the processes observed in natural evolution

- GAs are adaptive computational procedures modeled on the mechanics of natural genetic systems
- GAs are executed iteratively on a set of coded solutions, called population, with three basic operators: selection/reproduction, crossover and mutation
- They use only the objective function information and probabilistic transition rules for moving to the next iteration
- GA s are used to solve complex optimization problems

From Conventional AI to Computational Intelligence

- **Conventional AI** mostly involves methods now classified as machine learning, characterized by formalism and statistical analysis
- **Conventional AI** also known as **symbolic AI, logical AI or neat AI**
- **It's methods include:**
  - **Expert systems**
    - Applies reasoning capabilities to reach a conclusion
    - An expert system can process large amounts of known information and provide conclusions based on them
  - Case-based reasoning
    - It is the process of solving new problems based on the solutions of similar past problems
  - Bayesian networks
    - It represents a set of variables together with a joint probability distribution with explicit independence assumptions
  - Behavior-based AI
    - A modular method of building AI systems by hand
- **Computational Intelligence** involves iterative development or learning
- Learning is based on empirical data
- It is also known as non-symbolic AI, scruffy AI, and soft computing
- Methods mainly include:
  - Neural networks
    - Systems with very strong pattern recognition capabilities
  - Fuzzy systems
    - Techniques for reasoning under uncertainty, have been widely used in modern industrial and consumer product control systems
  - Evolutionary computation
    - Applies biologically inspired concepts such as populations, mutation and survival of fittest to generate increasingly better solutions to the problem
    - These methods most notably divide into evolutionary algorithms and swarm intelligence
  - Hybrid intelligent systems
    - Attempt to combine these two groups
    - It is thought that the human brain uses multiple techniques to both formulate and cross- check results

- Thus, system integration is seen as promising and perhaps necessary for true AI

Machine Learning

- To build computer systems that can adapt and learn from their experience
- Provides computers with the ability to learn without being explicitly programmed
- Focuses on the development of computer programs that can teach themselves to grow and change when exposed to new data
- Machine learning programs detect patterns in data and adjust program actions accordingly
- The process of machine learning is similar to that of data mining
- Instead of extracting data for human comprehension machine learning uses the data to improve the program's own understanding

Types of Machine Learning

- Supervised Learning
  - It consist of a target / outcome variable (or dependent variable) which is to be predicted from a given set of predictors (independent variables)
  - Using these set of variables, we generate a function that map inputs to desired outputs
- Unsupervised Learning
  - In this learning, we do not have any target or outcome variable to predict / estimate
  - It is used for clustering population in different groups
- Reinforcement Learning
  - In this learning, the machine is trained to make specific decisions
  - It works this way: the machine is exposed to an environment where it trains itself continually using trial and error
  - This machine learns from past experience and tries to capture the best possible knowledge to make accurate decisions

Characteristics of SC

- Human expertise
- Biologically inspired
- New optimization techniques
- New application areas
- Simple computation
- Model free
- Fault tolerant
- Goal driven
- Suitable for real world problem

Hard computing vs. Soft Computing

Hard Computing	Soft Computing

Conventional computing requires a precisely stated analytic model and often a lot of computation time	Soft computing is tolerant of imprecision, uncertainty, partial truth, and approximation. In effect, the role model for soft computing is the human mind
Based on binary logic, crisp systems, numerical analysis and crisp software	Based on fuzzy logic, neural nets and probabilistic reasoning
Requires exact input data to solve a particular problem	Can deal with ambiguous and noisy data
Allows strictly sequential computation	Allows parallel computations
Produces precise answers	Can yield approximate answers
Requires programs to be written	They are model free i.e. they can evolve their own models and programs
It is deterministic and uses two valued logic	It is stochastic and uses multivalued logic
Has the characteristics of precision and categoricity	Has characteristics of approximation and dispositionality
Hard computing techniques are not fault tolerant	Soft computing techniques are fault tolerant
Not suited for real world problems for which ideal model is not present.	Suitable for real world problems.
High cost for solution	Low cost for solution

Applications

- Handwriting recognition
- Automotive systems and manufacturing
- Image processing and data compression
- Architecture
- Decision-support systems
- Data Mining
- Power systems
- Control Systems

SOFT COMPUTING APPLICATIONS: CONTROL

- Heavy industry (Matsushita, Siemens, Stora-Enso).
- Home appliances (Canon, Sony, Goldstar, Siemens).
- Automobiles (Nissan, Mitsubishi, Daimler-Chrysler, BMW, Volkswagen).
- Spacecrafts (NASA).

SOFT COMPUTING APPLICATIONS: BUSINESS

- supplier evaluation for sample testing,
- customer targeting,
- sequencing,
- scheduling,
- optimizing R&D,
- projects,
- knowledge-based prognosis,
- fuzzy data analysis
- hospital stay prediction,
- TV commercial slot evaluation,
- address matching,
- fuzzy cluster analysis,
- sales prognosis for mail order house,
- multi-criteria optimization, etc.

SOFT COMPUTING APPLICATIONS: FINANCE

- fuzzy scoring for mortgage applicants,
- creditworthiness assessment,
- fuzzy-enhanced score card for lease risk assessment,
- risk profile analysis,
- insurance fraud detection,
- cash supply optimization,
- foreign exchange trading,
- insider trading,
- trading surveillance,
- investor classification, etc.

A Fusion Approach of Multispectral Images with SAR (Synthetic Aperture Radar) Image for Flood Area Analysis.

Optimization of Traveling Salesman Problem using Genetic Algorithm Approach.

Genetic Algorithm based Internet Search Technique.

Soft Computing Based Hybrid Fuzzy Controllers.

Soft Computing Based Rocket Engine Control.