INTRODUCTION TO SOFT COMPUTING

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WHAT IS HARD COMPUTING?

- Hard computing is a traditional computing.

- It requires a precisely stated analytical model and usually a lot of computation time.

- It strictly follows known steps to solve a task as opposed to soft computing which is heuristic.

- The term, hard computing, was coined by Dr Lotfi Zadeh.
  - Here 'hard' has nothing to do with hardware. The principles of hard computing are precision, certainty and rigor.

- Hard computing is achieved using sequential programs that use binary logic.

- It is deterministic in nature. The input data should be exact and the output will be precise and verifiable.

HARD COMPUTING

- Advantages
  - Accurate solutions can be obtained
  - Faster
- Disadvantages
  - Not suitable for real world problems.
  - Cannot handle imprecision and partial truth.
- Example: Solving numerical problems.

BASICS OF SOFT COMPUTING

- The idea of soft computing was initiated in 1981 when Lotfi A. Zadeh published his first paper on soft data analysis "What is Soft Computing", Soft Computing. Springer-Verlag Germany/USA 1997.]

..BASICS OF SOFT COMPUTING

- Zadeh, defined Soft Computing into one multidisciplinary system as the fusion of the fields of Fuzzy Logic, Neuro-Computing, Evolutionary and Genetic Computing, and Probabilistic Computing.

- Soft Computing is the fusion of methodologies designed to model and enable solutions to real world problems, which are not modeled or too difficult to model mathematically.

- The aim of Soft Computing is to exploit the tolerance for imprecision, uncertainty, approximate reasoning, and partial truth in order to achieve close resemblance with human like decision making.

THE SOFT COMPUTING – DEVELOPMENT HISTORY

SOFT COMPUTING – DEVELOPMENT HISTORY

Soft Computing Zadeh 1981	=	Evolutionary Computing Rechenberg 1960	+	Neural Network McCulloch 1943	+	Fuzzy Logic Zadeh 1965

Evolutionary Computing Rechenberg 1960	= Genetic Programming Koza 1992	+ Evolution Strategies Rechenberg 1965	+ Evolutionary programming Fogel 1962	+ Genetic Algorithms Holland 1970

DEFINITION OF SOFT COMPUTING (SC)

- Lotfi A. Zadeh, 1992: "Soft Computing is an emerging approach to computing which parallel the remarkable ability of the human mind to reason and learn in an environment of uncertainty and imprecision".

- The Soft Computing consists of several computing paradigms mainly:
  - Fuzzy Logic: for knowledge representation via fuzzy If – Then rules.
  - Neural Networks: for learning and adaptation
  - Genetic Algorithms: for evolutionary computation

- Soft Computing is still growing and developing. Hence, a clear definite agreement on what comprises Soft Computing has not yet been reached. More new sciences are still merging into Soft Computing.

GOALS OF SOFT COMPUTING

- Soft Computing is a new multidisciplinary field, to construct new generation of Artificial Intelligence, known as Computational Intelligence.

- The main goal of Soft Computing is to develop intelligent machines to provide solutions to real world problems, which are not modeled, or too difficult to model mathematically.

- Its aim is to exploit the tolerance for Approximation, Uncertainty, Imprecision, and Partial Truth in order to achieve close resemblance with human like decision making.
  - Approximation: here the model features are similar to the real ones, but not the same.
  - Uncertainty: here we are not sure that the features of the model are the same as that of the entity (belief).
  - Imprecision: here the model features (quantities) are not the same as that of the real ones, but close to them.

IMPORTANCE OF SOFT COMPUTING

- Soft computing differs from hard (conventional) computing. Unlike hard computing, the soft computing is tolerant of imprecision, uncertainty, partial truth, and approximation.

- The guiding principle of soft computing is to exploit these tolerance to achieve tractability, robustness and low solution cost. In effect, the role model for soft computing is the human mind.

- The four fields that constitute Soft Computing (SC) are:
  - **Fuzzy Computing (FC)**
  - **Evolutionary Computing (EC)**
  - **Neural computing (NC) and**
  - **Probabilistic Computing (PC), with the latter subsuming belief networks, chaos theory and parts of learning theory.**

.. IMPORTANCE OF SOFT COMPUTING

- Soft computing is not a concoction, mixture, or combination, rather, Soft computing is a FUSION OF METHODOLOGIES THAT WORK SYNERGISTICALLY in one form or another , where each partner contributes a distinct methodology for addressing problems in its domain.

- In principal the constituent methodologies in Soft computing are complementary rather than competitive.

- Soft computing may be viewed as a foundation component for the emerging field of Conceptual Intelligence.

PROPERTIES OF SOFT COMPUTING METHODS

- These methods have in common: They

  - Are non linear.

  - Have ability deal with non linearity.

  - Follow more human like reasoning paths than classical methods.

  - Utilize self learning.

  - Utilize yet-to-be proven theorems.

  - Are robust in the presence of noise or errors.

WHY SOFT COMPUTING APPROACH?

- Mathematical model and analysis can be done for relatively simple systems.

- More complex systems arising in biology, medicine and management systems remain intractable to conventional mathematical and analytical methods.

- Typically human can:
  - Take decisions
  - Derive inference from previous situations experienced.
  - Expertise in an area.
  - Adapt to changing environment.
  - Learn to do better.
  - Social behaviour of collective intelligence.

VARIOUS PROBLEM SOLVING TECHNIQUES
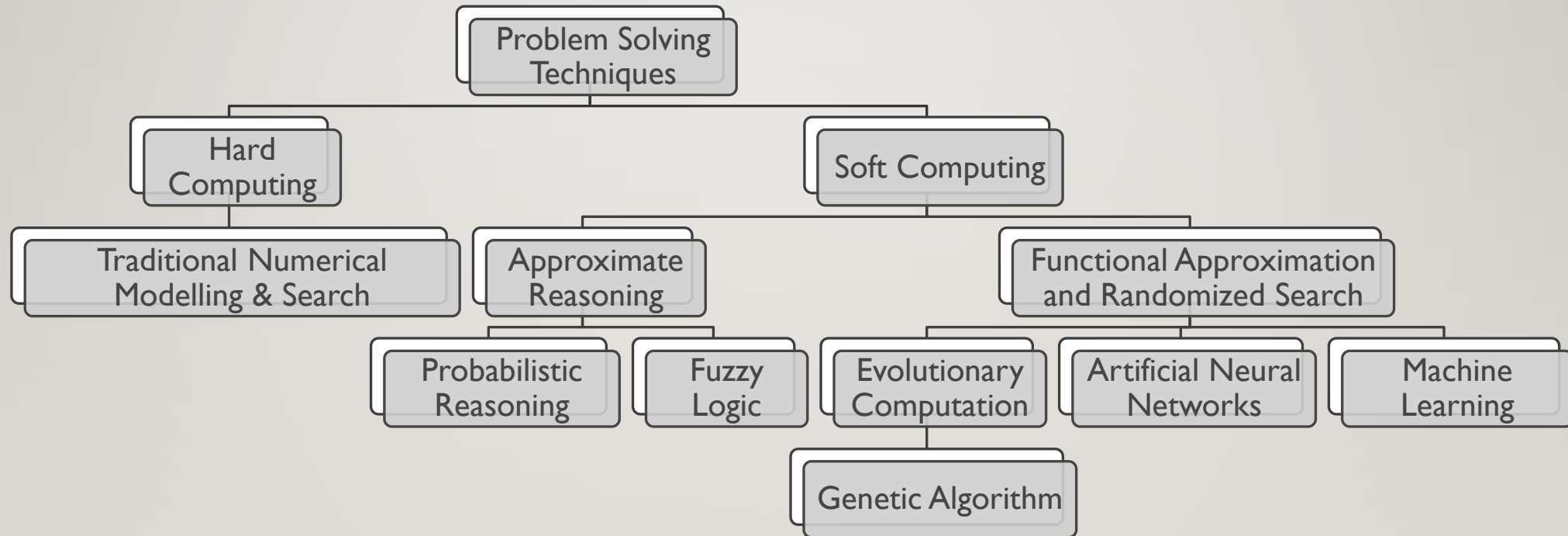
ARTIFICIAL NEURAL NETWORK

- ANN is a parallel distributed information processing structure consisting of a number of nonlinear processing units called neurons.

- The neuron operates as a mathematical processor performing specific mathematical operations on its inputs to generate an output.

- It can be trained to recognize patterns and to identify incomplete patterns by resembling the human-brain processes of recognizing information, burying noise literally and retrieving information correctly.

- ANN are strongly interconnected systems of neurons which have simple behavior, but when connected they can solve complex problems. Changes may be made further to enhance its Performance.

GENETIC ALGORITHMS

- Evolutionary algorithms (EA) were invented to mimic some of the processes observed in natural evolution. Evolution occurs on chromosomes - organic devices for encoding the structure of living beings.

- Processes of natural selection then drive those chromosomes that encode successful structures to reproduce more frequent than those that encode failed structures. In other word, the chromosomes with the best evaluations tend to reproduce more often than those with bad evaluations.

- By using simple encodings and reproduction mechanisms, the algorithms can then display complicated behavior and turn out to solve some extremely difficult problems.

- Based on the principles of natural evolution, GAs are robust and adaptive methods to solve search and optimization problems.

- In addition, by simulating some features of biological evolution, GA can solve problems where traditional search and optimization methods are less effective.

FUZZY LOGIC

- In the real world, information is often ambiguous or imprecise.

- When we state that it is warm today, the context is necessary to approximate the temperature. A warm day in January may be degrees Celsius, but a warm day in August may be 33 degrees. After a long spell of frigid days, we may call a milder but still chilly day relatively warm.

- An organized method for dealing with imprecise data is called fuzzy logic. The data sets engaged in fuzzy logic are considered as fuzzy sets.

- Traditional sets include or do not include an individual element; there is no other case than true or false. Fuzzy sets allow partial membership.

- Fuzzy Logic is basically a multi-valued logic that allows intermediate values to be defined between conventional evaluations like yes/no, true/false, black/white, etc. Notions like rather warm or pretty cold can be formulated mathematically and processed with the computer.

..FUZZY LOGIC

- In this way, an attempt is made to apply a more humanlike way of thinking in the programming of computers.

- Fuzzy logic is an extension of the classical propositional and predicate logic that rests on the principles of the binary truth functionality.

HARD COMPUTING VS SOFT COMPUTING

Hard Computing	Soft Computing
Conventional computing requires a precisely stated analytical model.	Soft computing is tolerant of imprecision.
Often requires a lot of computation time.	Can solve some real world problems in reasonably less time.
Not suited for real world problems for which ideal model is not present.	Suitable for real world problems.
It requires full truth	Can work with partial truth
It is precise and accurate	Imprecise.
High cost for solution	Low cost for solution
Require programs to be written	Can evolve its own programs
Deterministic	Stochastic
Require exact input	Can deal with ambiguous and noisy data
Produce precise answer	Produce approximate answers

EXAMPLES

- Hard Computing
  - Solving numerical problems (for example roots of polynomials, integrations etc).
  - Searching and Sorting Algorithms.
- Soft Computing
  - Soft computing employs ANN, EC, FL etc, in a complementary rather than a competitive way.

APPLICATIONS OF SOFT COMPUTING

- Handwriting recognition

- Automotive systems and manufacturing

- Image processing and data compression

- Architecture

- Decision-support systems

- Data Mining

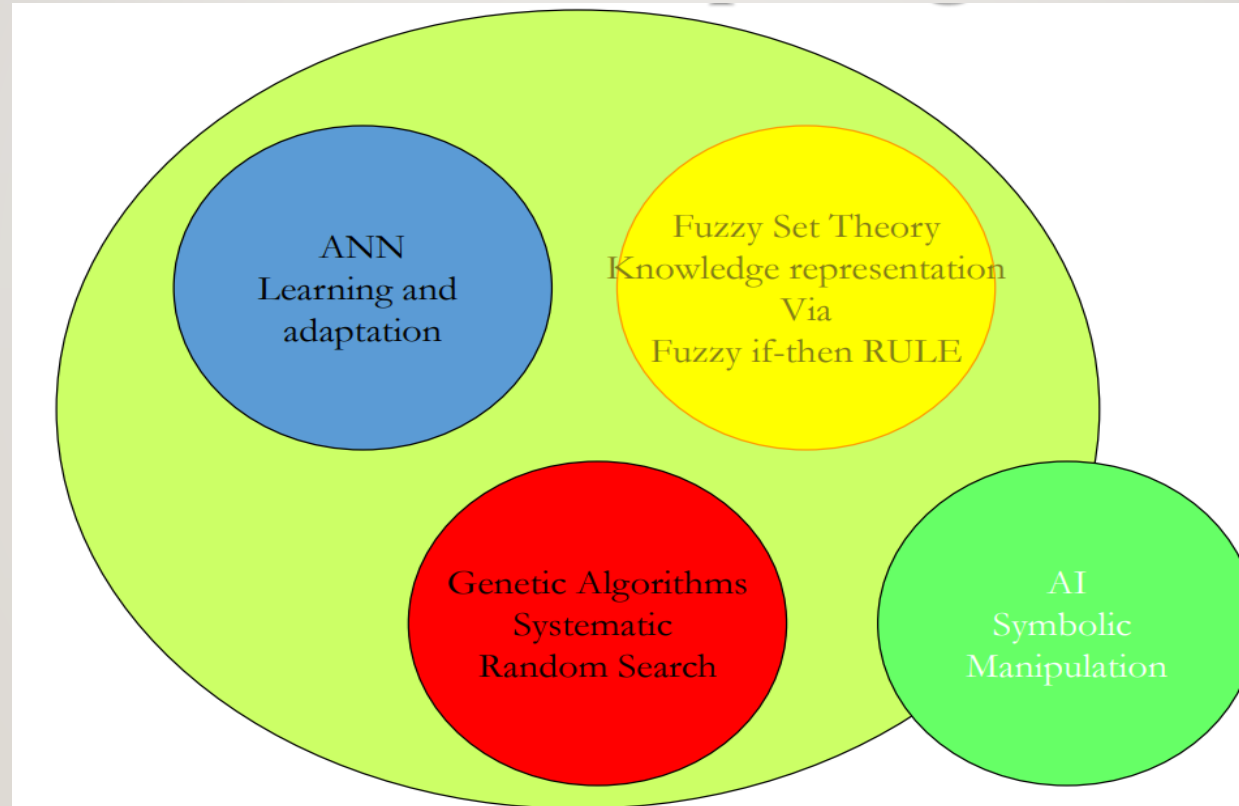- Power systems

- Control Systems

..APPLICATIONS OF SOFT COMPUTING

- Nano technology

- Pattern recognition

- Process control

- Signal processing

- Feature selection

- Fault tolerance etc.

FUTURE OF SOFT COMPUTING (REF.: L.A. ZADEH)

- Soft computing is likely to play an especially important role in science and engineering, but eventually its influence may extend much farther.

- Soft computing represents a significant paradigm shift in the aims of computing
  - A shift which reflects the fact that the human mind, unlike present day computers, possesses a remarkable ability to store and process information which is pervasively imprecise, uncertain and lacking in categoricity.

AI AND SOFT COMPUTING

THANK YOU