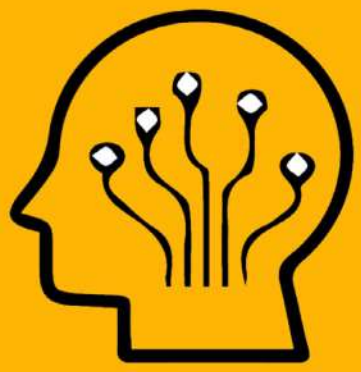

SOFT COMPUTING

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MODULE 1: INTRODUCTION TO SOFT COMPUTING

Computing: ***is the systematic study of algorithmic processes that describe and transform information: their theory, analysis, design, efficiency, implementation, and application.***

It can be broadly classified into Soft Computing and Hard Computing.

Hard Computing:

- Hard Computing refers to traditional computing techniques based on principles of precision, uncertainty and rigor.
- The problems based on analytical model can be easily solved using such techniques.
- However, Real world problems, which deal with changing of information and imprecise behaviour, cannot be handled by hard computing techniques.

That's where soft computing comes in.

Soft Computing:

- Soft Computing is a new multidisciplinary field, to construct new generation of Artificial Intelligence, known as Computational Intelligence.
- Lotfi A. Zadeh, defines Soft Computing as – "*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.*"
- Soft Computing is the fusion of methodologies designed to model and enable solutions to real world problems, which are not modelled 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.

Difference between Hard and Soft Computing:

HARD COMPUTING	SOFT COMPUTING
Does not tolerate imprecision, uncertainty, partial truth, and approximation.	Tolerant of imprecision, uncertainty, partial truth, and approximation.
Based on Binary Logic, Crisp Systems, Numerical Analysis, and Crisp Software.	Based on Fuzzy Logic, Neural Nets, and Probabilistic Reasoning.
In hard computing, imprecision and uncertainty are undesirable properties.	In soft computing, tolerance for imprecision and uncertainty is exploited to achieve tractability, lower cost, high Machine Intelligence Quotient (MIQ) and robustness.
Hard computing requires programs to be written.	Soft computing can evolve its own programs
Hard computing uses two-valued (binary) logic.	Soft computing uses multi-valued or fuzzy logic.
Hard computing is deterministic.	Soft computing incorporates stochasticity.
Hard computing requires exact input data.	Soft computing can deal with ambiguous and noisy data.
Hard computing is strictly sequential.	Soft computing allows parallel computations.
Hard computing produces precise answers	Soft computing can yield approximate answers.

Goals of Soft Computing:

- Soft Computing aims is to exploit the tolerance for Approximation, Uncertainty, Imprecision, and Partial Truth in order to achieve close resemblance with human like decision making.
- **Approximation:** Features closely similar are modelled, but not the exact same.
- **Uncertainty:** Not sure whether the features of the model are the same as that of the entity (belief).
- **Imprecision:** The model features (quantities) are not the same as that of the real ones, but close to them.

Constituents of Soft Computing:

- Soft Computing consists of several computing paradigms, including neural networks, fuzzy set theory and Genetic Algorithm.
- The integration of methodologies form the core of soft computing.

- **Neural Network:**

  - Neural networks are simplified models of biological nervous system which is massively parallel distributed processing system made up of highly interconnected neural computing elements.
  - They have the ability to learn and acquire knowledge and make it available for use.

- **Fuzzy Logic:**

  - Fuzzy logic is a mathematical tool for dealing with uncertainty.
  - It provides a technique to deal with imprecision and information granularity.
  - Fuzzy logic provides an inference structure that enables appropriate human reasoning capabilities.

- **Genetic Algorithm:**

  - Genetic algorithms are adaptive heuristic algorithms based on the idea of natural selection and genetics.
  - T0his exploit historical information to speculate on new improved solution with better performance.
  - It represents an intelligent exploitation of a random search used to solve optimization problems.
  - GA are more robust than conventional algorithms.
  - These systems do not break even if inputs are changed or in presence of reasonable noise.

Characteristics of Neuro-Computing and Soft Computing:

- **Human Expertise:** Soft Computing utilizes human expertise in form of Fuzz If-then rules to solve practical problems.

- **Biologically Inspired Computing Model:** Inspired from biological neural network, artificial neural networks are employed for perception, pattern recognition and non-linear regression and classification problems.

- **New optimization Techniques:** Soft computing applies innovative optimization method that arise from genetic algorithms, simulated annealing, random search method and downhill simplex method.

- **Numerical Computation:** Soft computing relies on numerical computation, unlike the symbolic AI.

- **New Application Domains:** Soft computing has number of computation intensive applications include adaptive signal processing, adaptive control, non-linear system identification, non-linear regression and pattern recognition.

- **Model Free Learning:** Neural networks and adaptive fuzzy inference systems have the ability to construct models using only target system sample data. Detailed insight of the target is not needed.

- **Intensive Computation:** Without much background knowledge of program solving, neuro computing rely on high speed number crunching computation to find rules and regularities in data set.

- **Fault Tolerance:** Deletion of a neuron in the neural network or change in a fuzzy rule does not destroys the system. The system continues to perform because of its parallel and redundant architecture.

- **Goal driven Characteristics:** Neuro computing and soft computing are goal driven.

- **Real World applications:** Most of the real-world problems are having high level of uncertainties. Soft computing approach utilizes specific techniques to construct satisfactory solutions to these problems.

Application of Soft Computing:

- Handwriting recognition
- Automotive systems and manufacturing
- Application of soft computing to image processing and data compression
- Architecture designing
- Decision-support systems
- Power systems
- Nero-fuzzy systems
- Fuzzy logic control
- Areas of image processing (Image retrieval and Image analysis)
- Remote sensing
- Data mining (Swarm intelligence, Diffusion process, Agent's technology)

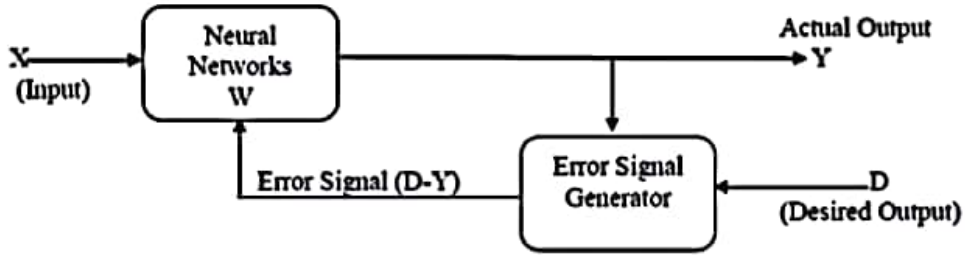
Learning and Adaptation:

- Learning is the process by which a neural network adapts or changes itself to an external stimulus (input) by making proper adjustments in the parameters, resulting in the production of desired output.
- There are mainly two types of learning.
    - **Parameter learning:** It updates the connecting weights in a neural network.
    - **Structure learning:** The structure of the network is changed i.e. the number of processing elements and connection types.
- Learning in Artificial neural network can be classified into the following categories –
    1. **Supervised Learning**
    2. **Unsupervised Learning**
    3. **Reinforcement Learning**

1. Supervised Learning:

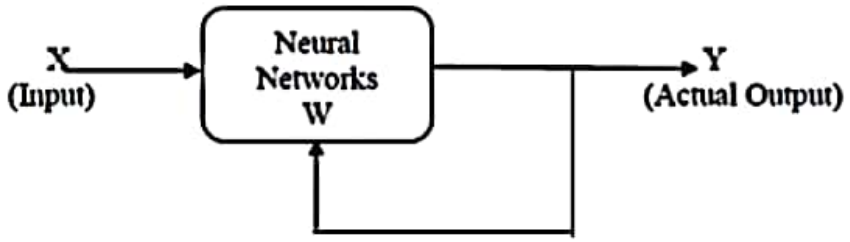
- Learning process with the help of a teacher is called Supervised Learning.
- Each input vector requires a corresponding target vector that represents the desired output.
- The input vector along with the target vector is called the training pair.

- During training process the input vector is presented to the network which produce the actual output vector.
- Each output vector is compared with the desired (target) output vector.
- The difference between the actual output and desired output is called the error signal which is used for the adjustment of weights until the actual output matches with the desired output.
- Diagram –



2. Unsupervised Learning:

- Learning Process without the help of a Teacher is called as Unsupervised Learning.
- In unsupervised learning, input vectors of similar type are grouped without the use of training data to specify how a member of each group looks or to which group a number belongs.
- During training, network receives the input pattern and organizes these patterns to form clusters.
- When a new input pattern is applied, the neural network gives an output response indicating the class to which the input pattern belongs.
- That is the network undergoes changes in parameters.
- This process is called self-organizing in which exact clusters will be formed by discovering similarities and dissimilarities among objects.
- Diagram –



3. Reinforcement Learning:

- Similar to Supervised Learning.
- In this learning process only critic information is available not the exact information.
- The learning process is done based on the critic information and a feedback signal called reinforcement signal is sent back from output to the input.
- The feedback given is only evaluative and not instructive.
- Reinforcement learning is a learning process with critic rather than with a teacher.
- Diagram –