Experiment-3.4

Aim of the Experiment:

Study of research paper on Soft Computing.

Theory:

Soft Computing is a branch of computer science that deals with approximate solutions to complex problems. Unlike traditional computing methods that rely on precise mathematical models and algorithms, soft computing approaches aim to handle uncertainty, imprecision, and partial truth to mimic the way humans make decisions. Soft computing techniques are particularly useful for solving real-world problems that involve vagueness, ambiguity, and incomplete information.

CHARACTERISTICS OF SOFT COMPUTING:

1) Soft computing provides an approximate but precise solution for real-life problems.

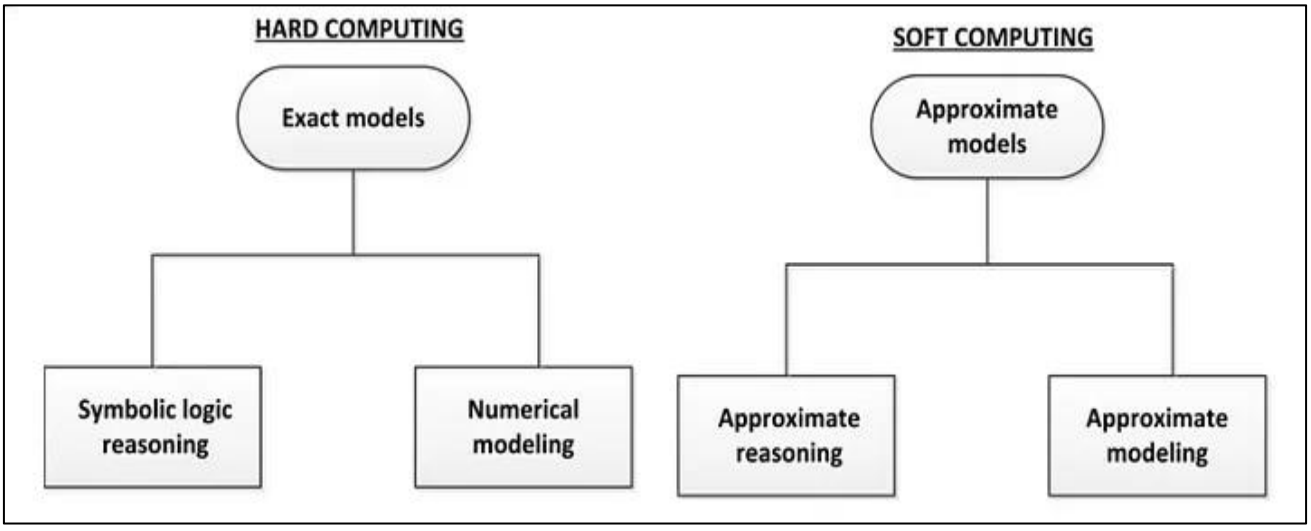
2) The algorithms of soft computing are adaptive in nature.

3) Soft computing does not require any mathematical model to solve the problem.

4) Soft computing provides approximate results that conventional and analytical models cannot solve.

5) It is based on Fuzzy logic, genetic algorithms, machine learning, ANN, and expert systems.

HARD COMPUTING VS SOFT COMPUTING:



Above figure shows the principle differences of the hard and soft computing. The left diagram shows the traditional hard computing requires an exactly state analytic model based on binary logic, numerical analysis. On the other hand, the soft computing deals with partial truth, uncertainty, and approximation. The result is estimated reply on approximate reasoning techniques.

CONSTITUENTS OF SOFT COMPUTING:

A) Fuzzy Logic:

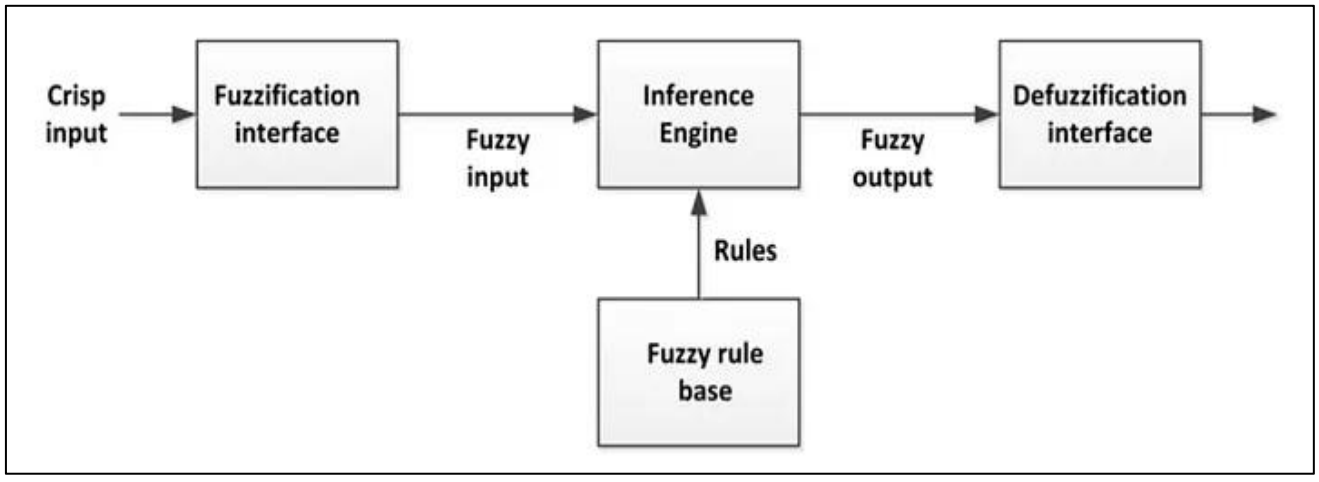
Fuzzy logic is a form of approximate reasoning that deals with uncertainty and imprecision by allowing for degrees of truth. In fuzzy logic, truth values lie on a continuum between 0 and 1, representing degrees of truth or membership. A fuzzy inference system consists of four main components:

1) Fuzzification: This step involves converting crisp inputs into fuzzy sets by assigning membership grades to each input value based on predefined linguistic variables and membership functions.

2) Rule Base: Rule Base consists of different fuzzy rules, which define the relationship between input variables and output variables. Fuzzy rules are applied to determine the degree of membership of each input to each rule. These rules are typically expressed in the form of "if-then" statements.

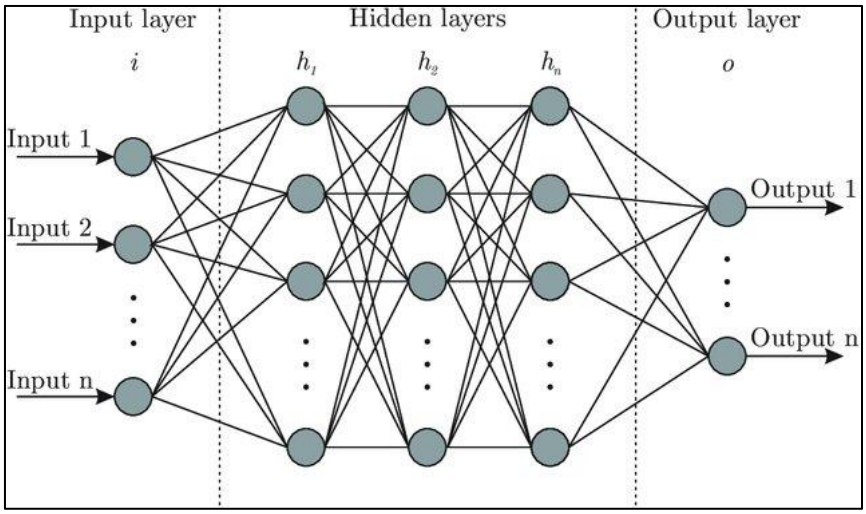
3) Inference Engine: The inference engine computes the degree of membership of the output variables based on the fuzzy rules and the degree of membership of the inputs.

4) Defuzzification: Finally, the fuzzy output is converted back into a crisp value using a defuzzification method, such as centroid or maximum membership.



B) Artificial Neural Network (ANN):

Artificial neural networks (ANNs) are computational models inspired by the structure and function of the human brain. They consist of interconnected nodes (neurons) organized in layers. Each neuron receives input signals, performs a weighted sum of these inputs, applies an activation function, and produces an output signal.



Types of Neural Networks:

1) Feedforward Neural Networks: Neurons are organized in layers, and information flows in one direction from input to output layer. These are used for tasks such as classification and regression.

2) Recurrent Neural Networks (RNNs): Neurons form directed cycles, allowing them to retain state information over time. They are well-suited for sequence data and tasks like language modeling and time series prediction.

3) Convolutional Neural Networks (CNNs): These are specialized for processing grid-like data, such as images. They consist of convolutional layers that extract features hierarchically, followed by fully connected layers for classification.

4) Radial Basis Function Networks (RBFNs): These networks use radial basis functions as activation functions and are often employed for interpolation and function approximation.

Training: ANNs learn from data through a process which involves adjusting the weights of connections between neurons using optimization algorithms such as gradient descent and backpropagation.

C) Genetic Algorithm:

Genetic algorithms (GAs) are optimization algorithms inspired by the principles of natural selection and genetics. They are used to find approximate solutions to optimization and search problems.

Steps of Genetic Algorithm:

1) Initialization: The process of a genetic algorithm starts by generating the set of individuals, which is called population. Here each individual is the solution for the given problem. An individual contains or is characterized by a set of parameters called Genes. Genes are combined into a string and generate chromosomes, which is the solution to the problem.

2) Fitness Assignment: Fitness function is used to determine how fit an individual is? It means the ability of an individual to compete with other individuals. In every iteration, individuals are evaluated based on their fitness function. The fitness function provides a fitness score to each individual. This score further determines the probability of being selected for reproduction. The high the fitness score, the more chances of getting selected for reproduction.

3) Selection: The selection phase involves the selection of individuals for the reproduction of offspring. All the selected individuals are then arranged in a pair of two to increase reproduction. Then these individuals transfer their genes to the next generation. Types of Selection are: Roulette wheel selection, Tournament selection, Rank-based selection.

4) Crossover: A crossover point is selected at random within the genes. Then the crossover operator swaps genetic information of two parents from the current generation to produce a new individual representing the offspring. The genes of parents are exchanged among themselves until the crossover point is met. Types of crossover are: One point crossover,Two-point crossover.

5) Mutation: The mutation operator inserts random genes in the offspring (new child) to maintain the diversity in the population. It can be done by flipping some bits in the chromosomes. Types of mutation are: Flip bit mutation, Swap mutation.

6) Termination: After the reproduction phase, a stopping criterion is applied as a base for termination. The algorithm terminates after the threshold fitness solution is reached. It will identify the final solution as the best solution in the population..

D) Hybrid Systems:

Hybrid systems combine multiple soft computing techniques to leverage their respective strengths and overcome their limitations. For example:

1) Fuzzy-Neural Systems: Combining fuzzy logic and neural networks allows for the integration of human-like reasoning with learning capabilities. Fuzzy systems can provide interpretability and handle linguistic variables, while neural networks can learn complex patterns from data.

2) Neuro-Fuzzy Systems: These systems integrate fuzzy logic with neural networks to create adaptive and intelligent systems. Fuzzy rules can be automatically generated or optimized using neural network learning algorithms.

3) Fuzzy-Genetic Systems: Integrating fuzzy logic with genetic algorithms enables the optimization of fuzzy rule sets for improved performance in complex systems.

4) Neuro-Genetic Systems: These systems combine neural networks with genetic algorithms to optimize neural network architectures and parameters for enhanced learning and generalization.

Learning outcomes :

1. Learnt about the research trends in Soft Computing.
2. Learnt about the constituents of Soft Computing.
3. Learnt about the importance of research in Soft Computing.
4. Learnt about differences between Hard and Soft Computing.
5. Learnt about the Genetic Algorithm and Hybrid Systems.