Q. Soft Computing v/s Hard Computing.

Hard computing-

- Hard computing refers to traditional, classical computing techniques
- These techniques are highly accurate, but they can be inflexible and may not be able to handle uncertainty or incomplete data.
- It requires mathematical model to solve problems.
- It deals withs the precise models.
- It consumes a lot of time to deal with real life problem.
- It is based on binary logic and crisp systems.
- It can work with exact input data.
- It produces precise outcome.
- It performs sequential computation.

Soft computing-

- Soft computing combines different techniques and concepts.
- Soft computing is designed to model and enable solutions to real world problems, which cannot be modelled mathematically
- Human mind is the role model for soft computing.
- Soft computing deals with approximate models.
- Soft computing techniques are more flexible and less precise than hard computing techniques, used to deal with uncertainty, imprecision, and incomplete data more robustly.
- These techniques are often used in machine learning and artificial intelligence applications.
- It is based on fuzzy logic and probabilistic reasoning.
- It handles imprecise and uncertain information of the real world.
- Complex systems can be designed with soft computing to deal with the incomplete information.
- It can work with ambiguous and noisy data.
- It produces approximate outcome.

Q. Applications of Soft Computing -

→ Cannot be modelled mathematically can be solved.
→ Non-linear problems can be solved.
→ Introduce human knowledge such as cognition, understanding, recognition, learning.
→ Used in Handwritten Script Recognition.
→ Used in Image Processing and Data Compression.
→ computational complexity and efficiency can easily be solved.
→ Genetic algorithms, genetic programming, classifier systems, evolutionary strategies, etc are the techniques of soft computing that can be used, give the fastest solutions to pattern recognition & distinct low-cost solutions.
→ It helps in analysing the medical images obtained from microscopes as well as examine the X-rays.
→ Automobile industry has also adapted soft computing to solve some of the major problems.
→ Fuzzy logic techniques are used in engine control, automatic transmissions, antiskid steering.

→ fuzzy logic is used to create behaviour-based architecture to deal with the unpredictable nature of the environment (In intelligent buildings).

→ Pattern recognition technique is used to analyse the pattern or behaviour of the data.

Q. Soft computing paradigm / Soft computing techniques-

(1) Fuzzy logic

(2) Neural networks

(3) Genetic algorithms

(4) Adaptive Resonance Theory (ART)

(5) Classification

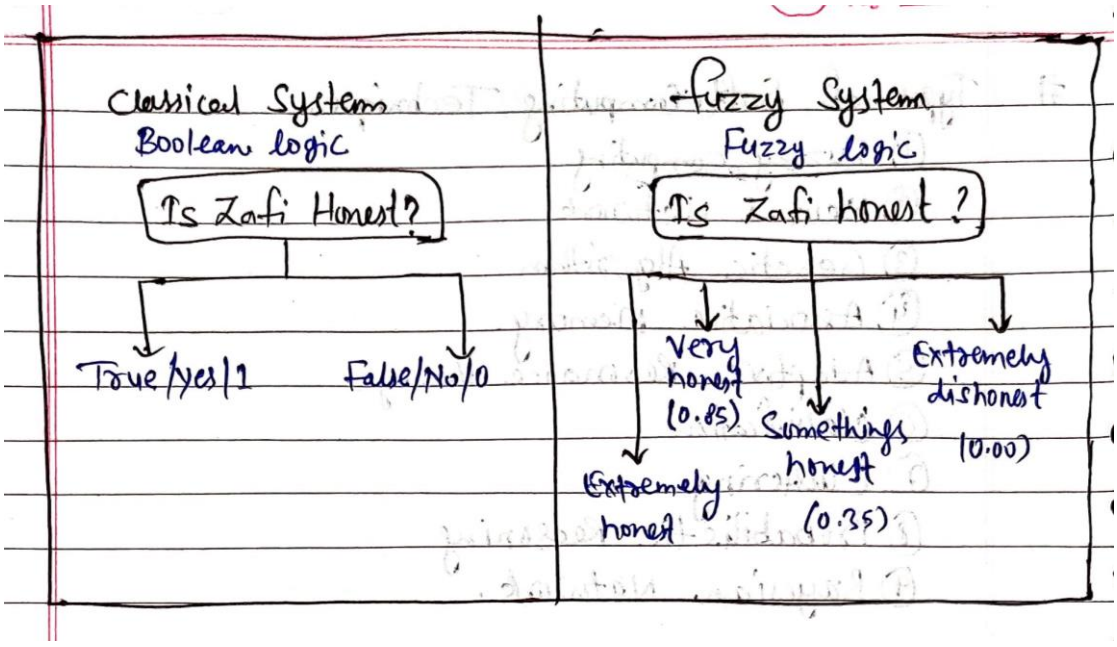
(6) Clustering

(7) Probabilistic reasoning

1. Fuzzy computing/logic (Or Its Advantages) :

① Fuzzy Computing / Fuzzy Logic :
- A knowledge that exist in real-world in the form of imprecise, uncertain or probabilistic (ग़लत) (ग़ैरयक़ीनी)
- Human thinking & reasoning involves in fuzzy knowledge.
- Classical computing system was not capable to handle subjective data.
  & Sometimes may not be able to answer some questions as human does.

- In 1965, Lofti Zahed introduced fuzzy set theory.
- In fuzzy system, there is no logic for absolute truth & absolute false value.
- There is intermediate value → partially true & partially false.
- But in classical system, 1 represent → true & 0 represent → false (absolute true or false).



- Fuzzy computing, also known as fuzzy logic.
- It used in a variety of fields, including computer science, engineering, and artificial intelligence.
- Fuzzy logic is a form of logic that allows for imprecision and uncertainty.
- It is used in control systems and decision-making processes.
- fuzzy logic is used to create behaviour-based architecture to deal with the unpredictable nature of the environment (In intelligent buildings).
- Fuzzy logic techniques are used in engine control, automatic transmissions, antiskid steering.
- This allows for more flexibility in problem-solving and decision-making

 # It is used in -->

→ It is used for commercial and practical purposes.
→ It helps to deal with uncertainty in data mining.
→ No precise inputs are required.
→ It provides a most effective solution to complex issues.

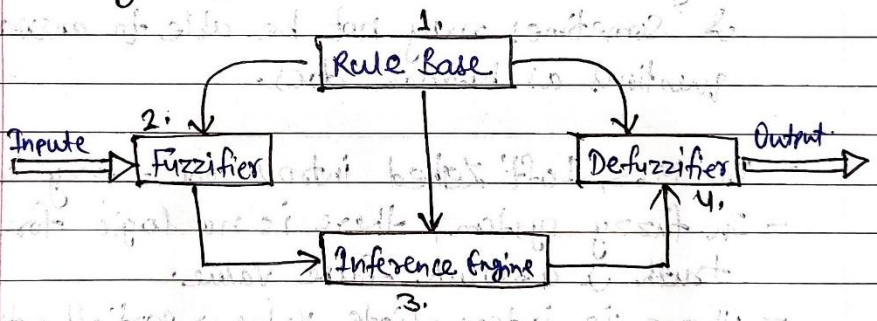
- Refrigerators
- Vacuum cleaners
- Washing Machines
- Four-Wheel Steering
- Automatic Gearboxes
- video cameras
- Air conditioners

Characteristics of Fuzzy Logic-

⇨ Characteristics of fuzzy logic -

① Easy & flexible to implement.
② Implement/Represent human logic.
③ Highly suitable method for Uncertain & approximate learning.
④ It helps to control machines & in data mining.
⑤ No precise (~~crisp~~) inputs are required.

⇨ Fuzzy logic Architecture:



① Rule Base -
- It contains set of rule.
- If-then conditions provided by expert decision system.
- Process of applying set of fuzzy rules to fuzzified

② Fuzzifier -
- It convert the crisp input data into fuzzy sets.
- And passed into control system for processing.

③ Interference Engine -
- It combining the output of multiple rules to produce a final result.

or,

- It applied the rule from 'rule base' to the fuzzified input to produce a fiddl output.

④ Defuzzifier -
- It converts the fuzzy output (obtained from Interference engine) into crisp value that can be used by the system.

2. Neural Computing /Artificial neural networks (ANNs) -

- Artificial Neural Network (ANN) also known as neural network.
- ANN are inspired by the structure and function of the human brain and the way the neurons in the human brain works.
- It contains large number of interconnected processing elements called as neuron.
- Every neuron is connected with other neurons by a connection link.
- Each connection is associated with weights which contain information about the input signal.

 # It is used in -->

→ They are used to recognize patterns and make decisions based on input data.
→ It is used in machine learning and artificial intelligence applications, such as image and speech recognition, language translation, and decision making.
→ The structure of an ANN is designed to learn and adapt to new data, without being explicitly programmed so it can perform a particular task.

- Image recognition
- Pattern recognition
- Medical diagnosis
- Email spam filtering
- In self-driven car for trajectory predication

Components of Neural Networks (ANNs):

① Neuron model:
- It is the Information process unit in ANNs.
- It consists of -
  - ⓐ Input
  - ② Weight
  - ③ Activation Functions.

② Architecture:
- Arrangement of Neurons.
- And Links, through which neurons connected.
- Following are ANN Architecture :-
  - ⓐ Single layer Feed Forward Net.
  - ⓑ Multi-layer feed forward Net.
  - ⓒ Single Node with its own feedback

③ A learning Algorithm:
- Traing ANN by modifying weights.
- Following are types of learning Algorithm:
  - ⓐ Supervised Learning
  - ⓑ Unsupervised learning
  - ⓒ Reinforcement Learning

Applications of Neural Networks (ANNs):
→ Image recognition
→ Pattern recognition
→ Medical diagnosic
→ Email spam filtering
→ In self-driven car for trajectory prediction.

3. Genetics Algorithms -

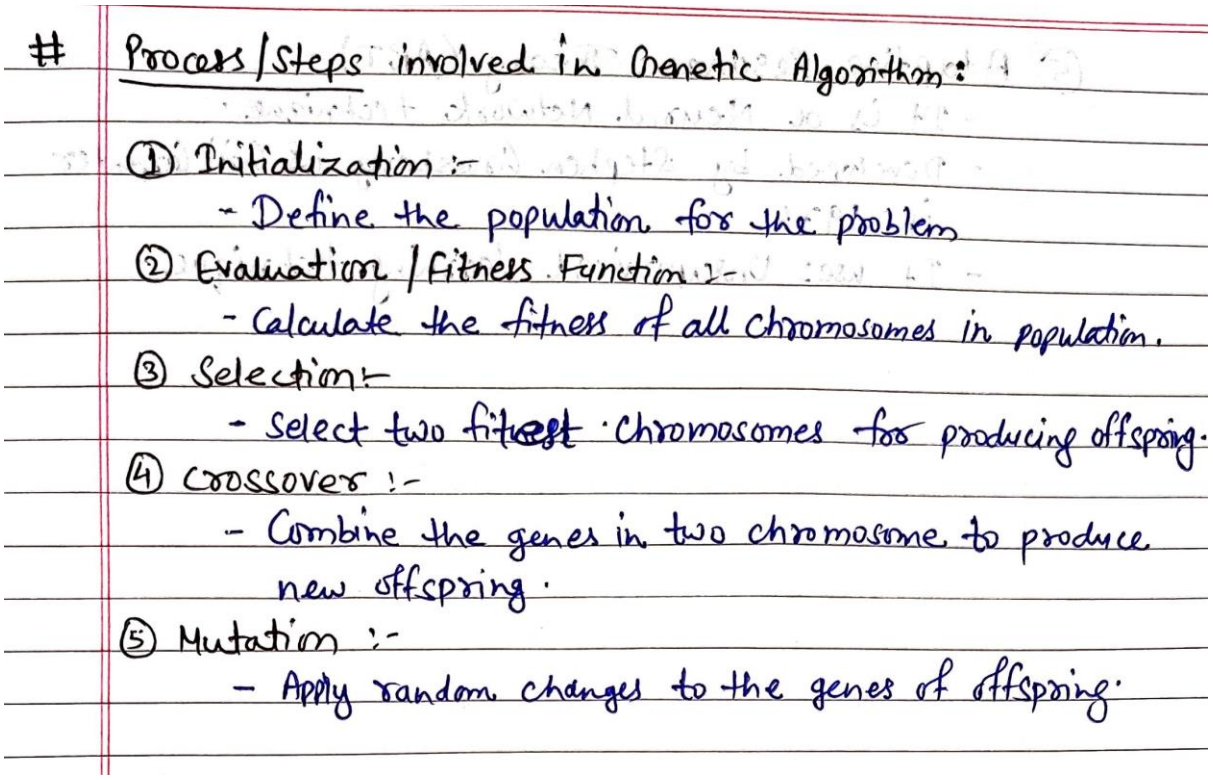
- It is the optimization algorithm that are inspired by the process of natural evolution.
- Genetics Algorithms are used to find solutions to problems that are too complex to solve by traditional methods.
- Solve the problems with a very large search space or problems with complex, nonlinear relationships.
- Genetic algorithms can be used to solve a wide variety of problems including --- **optimization of financial portfolios**, **scheduling**, **image recognition, Artificial Intelligence** and M**achine learning problems.**

Benefits Of Genetic Algorithm -

→ It can find good solutions to problems that are too complex to solve using traditional methods.
→ simple to implement and can be used to solve a wide range of problems.
→ It can handle problems with a large number of variables and constraints.
→ It finds multiple solutions to a problem.
→ It is useful for finding alternative solutions or for comparing the quality of different solutions.

Application of Genetic Algorithm:

→ Genetic algorithms are used to solve complex problems in artificial intelligence.
→ It used in engineering to optimize the design of products, such as aircraft or automobiles.
→ It used to optimize treatment plans for patients.
→ Determining the most effective combination of drugs for a particular illness.
→ developing intelligent agents in AI, that can learn and adapt to their environment.



4. Adaptive Resonance Theory -

- "Adaptive Resonance Theory" invented by **Stephen Grossberg** in 1976.
- ART system is an unsupervised learning model.
- It is used to classify patterns or categories of information such as in **image recognition** or **natural language processing**.
- The basic idea behind ART is that the brain is able to recognize patterns by comparing with stored patterns in memory.
- If the new pattern is too different from the stored patterns, the brain creates a new pattern in memory to represent it.

There are two main components in ART network:

(1) F1 layer :- The F1 layer is responsible for processing the incoming stimuli

(2) F2 layer:- F2 layer stores the patterns in memory.

==> When a new pattern is presented to the network, the F1 layer compares it to the patterns stored in the F2 layer and activates the one that is most similar.

==> If the new pattern is too different from the stored patterns, the F1 layer creates a new pattern in the F2 layer to represent it.

5. Classification -

- Classification is supervised learning.
- Classification algorithms is used to predict the categorical values.
- Trained to identify the category of new observations.
- It trained through dataset or observations and then classifies new observation into a classes or groups.

 # Application of Classification:

→ Email Spam Detection
→ Speech Recognition
→ Identification of Cancer tumour cells
→ Biometric Identifications

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6. Clustering -

- Clustering is type of unsupervised learning.
- Clustering is used to grouping the unlabelled data.
- it is used as a process to find **meaningful structure**, **explanatory underlying processes**, **generative features**.
- Its task is to divide the population or data points into several groups.
- Similar data points are taken in the same group, and dissimilar data points in other groups.

 # Applications of Clustering in different fields :

- Marketing
- Biology
- Insurance
- City Planning

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7. Probabilistic reasoning -

- In probabilistic reasoning, we apply the concept of probability to indicate the uncertainty in knowledge
- It is a key component of artificial intelligence and machine learning.
- It is used to make predictions or decisions based on data that is uncertain or incomplete.
- This can be useful in a wide range of applications, including decision-making, risk assessment, machine learning, and artificial intelligence.

Types of Learning in Artificial Intelligence?

1. Supervised
2. Unsupervised
3. Reinforcement

1. Supervised learning :-

- As the name indicates, Supervised learning act as the presence of a supervisor or a teacher.
- In which we teach & train the machine using data.
- Some data already tagged with correct answer.
- In this learning, we put new input to check the desire output is correct or not.
- To maintain this learning, we need a supervisor or teacher to train machine on the basis of data.
- Machine learns things from training data & apply knowledge to test data.

e.g → We train the machine with different fruits.
- If shape of object is rounded, depression on top and having color red → It will be Apple.
- If shape of object is long curving cylinder, having color yellow → It will labelled as Banana.
- After training the data, we showing new Banana.
- Machine already about banana, that recognized and gives the output Banana. (shape, size, color)

- Supervised learning allows collecting data & produced data output from previous experience.

② Unsupervised learning -

- In Unsupervised learning, learning is performed without the help of a teacher or a trainer.
- Input vectors of similar type are grouped together to form clusters.
- Data is in unlabelled form.
- The system learns on its own with the input pattern.

③ Reinforcement learning -

→ It is a form of supervised learning.
→ It receives the feedback from environment.
→ And action perform on the basis of positive or negative feedback.
→ In this learning, there is no answer like supervised learning, but reinforcement agent decides what to do to perform the task.
→ It learns from its experience.

Activation Function in Neural Network :-

→ It is the mathematical equations that determines the output of a Neural Network model.

→ It helps to normalize the output in the range b/w 1 to -1 or 0 to 1.

→ It reduce the computation time.

→ It decide whether a neuron should be activate or not.

→ It helps in acheiving the exact output.

⇨ Types of Activation Function -

① Identity Function :
- It is used in linear function.
- It is defined as - $f(x) = x$ for all x.

② Binary step Function :
- It is defined as

$$f(x) = \begin{cases} 1 & \text{if } x >= \alpha \\ 0 & \text{if } x < \alpha \end{cases}$$

α = threshold Value

③ Bipolar Function :
- It is defined as

$$f(x) = \begin{cases} 1 & \text{if } x \geq \alpha \\ -1 & \text{if } x < \alpha \end{cases}$$

④ Sigmoid Function :
- It is used in back-propagation.
- It is two types -

Ⓘ Binary sigmoid -
- It is known as Unipolar sigmoid function.

$$f(x) = \frac{1}{1+e^{-\lambda x}}$$

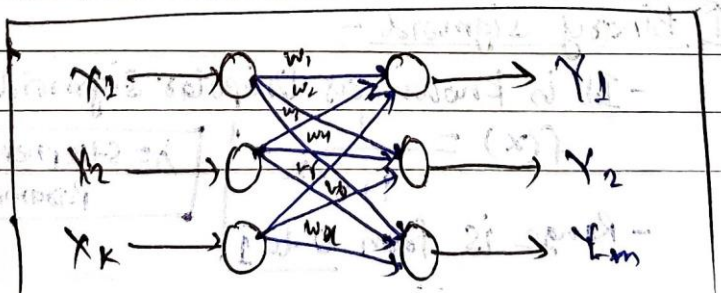
λ = steepness Parameter

- Range is from 0 to 1.

Hamming Net -

- It is used to determine which of the exemplar vector is most similar to an input vector.
- It uses unsupervised learning.
- The input can be either binary (0,1) or bipolar (-1,1).
- It is used to find the distance b/w two vectors.

Architecture.



⇨ Find Hamming distance b/w two vectors.

a = no. of component in which vector agree
d = no. of " " vector disagree.
a-d = Hamming distance.

$$n = a + d$$

$$\boxed{d = n - a}$$

$$x \cdot y = a - d$$
$$x \cdot y = a - (n - a)$$
$$x \cdot y = a - n + a$$
$$x \cdot y = 2a - n$$
$$2a = x \cdot y + n$$

$$\boxed{a = \frac{x \cdot y}{2} + \frac{n}{2}} \quad \text{or} \quad \boxed{\frac{1}{2}(x \cdot y) + \frac{1}{2}(n)}$$