Introduction to Soft Computing

Soft Computing:

- *Soft computing* is an umbrella term used to describe types of algorithms that produce approximate solutions.
- Soft computing, as opposed to traditional computing, deals with approximate models and gives solutions to complex real-life problems.
- The principle of soft computing is to exploit the tolerance for imprecision, uncertainty, partial truth, and approximation to achieve tractability, robustness, and low solution cost. (L.A. Zadeh, 1965)

Hard Computing vs Soft Computing

Hard Computing:

Hard computing is 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

- Based on the clearly written algorithm (structured)
- Based on mathematical formulae
- Mathematical formula (algorithm, program)
- Intelligence is missing
- It is deterministic in nature.
- The input data should be exact and the output will be precise and verifiable.
- Deals with binary logic (0 or 1, true or false) and follows strict mathematical models.

Hard Computing:

Hard computing relies on deterministic algorithms (*produce the same output for a given input every time they are run*) to ensure precision and accuracy.

For example, traditional numerical methods, sorting algorithms, and algorithms for solving linear equations are deterministic and form the backbone of hard computing.

Advantages:

- Accurate solutions can be obtained
- Faster

Disadvantages:

- Not suitable for real-world problems

Soft Computing

Soft computing is the use of approximate calculations to provide imprecise but usable solutions to complex computational problems.

- Emphasizes approximation, uncertainty, and adaptability.
- Suitable for real-world problems where precision is less critical, and flexibility is more important.
- In contrast with hard computing which deals with the models that can provide precise solutions.
- Includes techniques like fuzzy logic, genetic algorithms, neural networks, and probabilistic reasoning.

Soft Computing

- *Prof Lotfi Zadeh* introduced the term, Soft Computing.
- The objective was to emulate the human mind as closely as possible. The word, soft means flexible, adjustable, random, vague, approximate, imprecise, perceivable and non-deterministic.
- Soft computing utilizes non-deterministic algorithms to handle complex, ill-defined problems where an approximate solution is acceptable.
- Fusion of soft and hard computing techniques are also useful in applications such as robotics.

Soft Computing

Advantages:

- Robustness
- Low cost
- Ability to solve complex problem

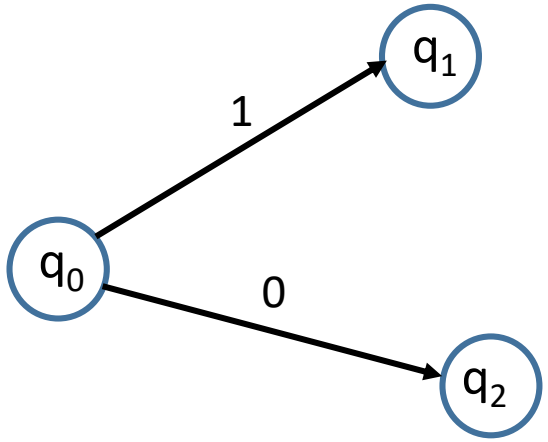
Applications:

It has enormous applications in many application areas such as medical diagnosis, computer vision, handwritten character recondition, pattern recognition, speech recognition, machine intelligence, data compression, weather forecasting, network optimization, VLSI design and many more…

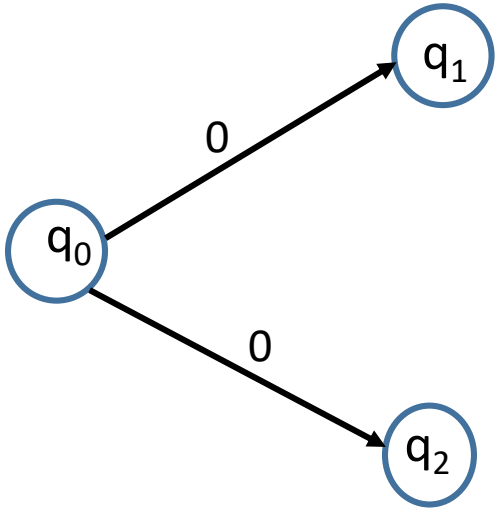
Deterministic vs Non-Deterministic

A deterministic algorithm produces only a single output for the same input even on different runs.

Non-deterministic A non - deterministic algorithm can provide different outputs for the same input on different runs.



Deterministic algorithm



Non - deterministic algorithm

Fuzzy logic and Nondeterminism

Hard computing relies on deterministic algorithms to ensure precision and accuracy. For example, traditional numerical methods, sorting algorithms, and algorithms for solving linear equations are deterministic and form the backbone of hard computing.

Soft computing utilizes non-deterministic algorithms to handle complex, ill-defined problems where an approximate solution is acceptable. These algorithms are adaptive and can learn from data, making them suitable for tasks like pattern recognition, optimization, and decision-making under uncertainty.

*** *Fuzziness is a type of deterministic uncertainty*

Fuzzy Logic and Heuristic

Fuzzy logic focuses on modeling and reasoning with imprecision, often by using degrees of truth. Heuristics, on the other hand, provide practical shortcuts or rules for solving complex problems where precision is less important than finding a workable solution quickly.

Heuristics are particularly useful in solving non-deterministic problems because they provide practical, experience-based methods for finding solutions in uncertain, complex environments. They don't guarantee the optimal solution but are effective for navigating problems where exhaustive, deterministic approaches are impractical or impossible.

Heuristic Approach:

- A heuristic technique, often called simply a heuristic, is any approach to problem solving, learning, or discovery that employs a practical method not guaranteed to be optimal or perfect, but sufficient for the immediate goals.
- Where finding an optimal solution is impossible or impractical, heuristic methods can be used to speed up the process of finding a satisfactory solution.
- Heuristics are a method of problem solving which *uses shortcuts in a given limited time frame* to produce an approximate solution.

Difference between Fuzzy set and Probability ?

- The key difference between fuzzy logic and probability is how they handle uncertainty
  - Fuzzy Sets: Deal with vagueness and imprecision.
  - Probability: Deals with randomness and unpredictability
- Fuzziness describes event ambiguity. It measures the degree to which an event occurs, NOT whether it occurs.
- Randomness describes the uncertainty of event occurrence, an event occurs or not.
- Fuzzy Sets: Use a membership function to assign degrees of membership.
- Probability: Use a probability function to assign likelihoods to events.
- Fuzzy Sets: The degrees of membership of elements in a set do not need to sum to 1.
- Probability: The probabilities of all possible outcomes in a probability space must sum to 1
- Fuzzy Sets: Used in scenarios requiring human-like reasoning and dealing with imprecise information.
- Probability: Used in scenarios involving statistical analysis and prediction of future events based on known data.

(Fuzziness describes the lack of distinction of an event, whereas chance describes the uncertainty in the occurrence of the event. The event will occur or not occur; but is the description of the event clear enough to measure its occurrence or nonoccurrence?)

*** *Fuzziness is a type of deterministic uncertainty*