Concept of Computation

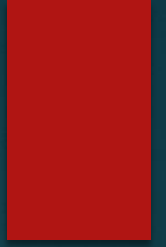Antecedent $\longrightarrow$ **Computing y=f(x)** Consequent $\longrightarrow$

(Basic of Computing)

y = f(x) where **f** is a mapping function

f is also called a formal method or an algorithm to solve a problem

Important Characteristics of Computing

➤ Should provide precise solution.

➤ Control action should be unambiguous and accurate.

➤ Suitable for problem which is easy to model mathematically.

Hard Computing

We term a computing as Hard computing, if:

✔ Precise result is guaranteed.

✔ Control action is unambiguous.

✔ Control action is formally defined with mathematical model or algorithm.
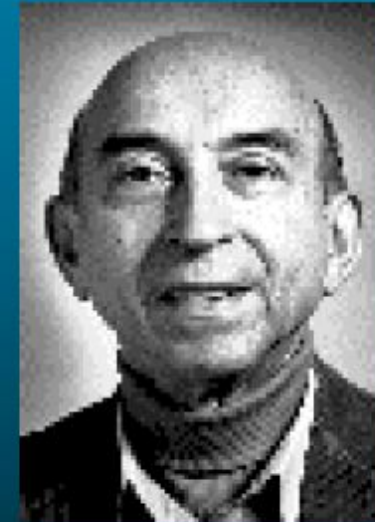
Examples of hard computing

► Solving numerical problems (e.g. roots of polynomials, integration etc.)

► Searching and sorting techniques

► Solving Computing geometry problems (e.g. shortest tour in a graph, finding closest pair of points given a set of points, etc.)

► many more.

Soft Computing

➤ The term soft computing was proposed by L. A. Zadeh. He described it as follows:

"Soft computing is a collection of methodologies that aim to exploit the tolerance for imprecision and uncertainity to achieve tractability, robustness and low solution cost."

➤ Its principal constituents are fuzzy logic, neuro computing, probabilistic reasoning and many others.

➤ Role model for soft computing is the human mind.

Basic Characteristics of Soft Computing

- It does not require any mathematical modeling of problem solving.

- It may not yield the precision solution.

- Algorithms are adaptive (i.e. it can adjust to the change of dynamic environment).

- Use some biological inspired methodologies such as genetic, evolution, ant's behavior, particles' swarming, human nervous system, etc.

Examples of Soft Computing

- ► Hand written character recognition (ANN)

- ► Money allocation problem (Evolutionary computing, GA)

- ► Robot movement through the shortest path detected between a source point to destination point without or minimum collision with obstacles in between (Fuzzy Logic)

A Neural Character Recognizer with a Knowledge Base
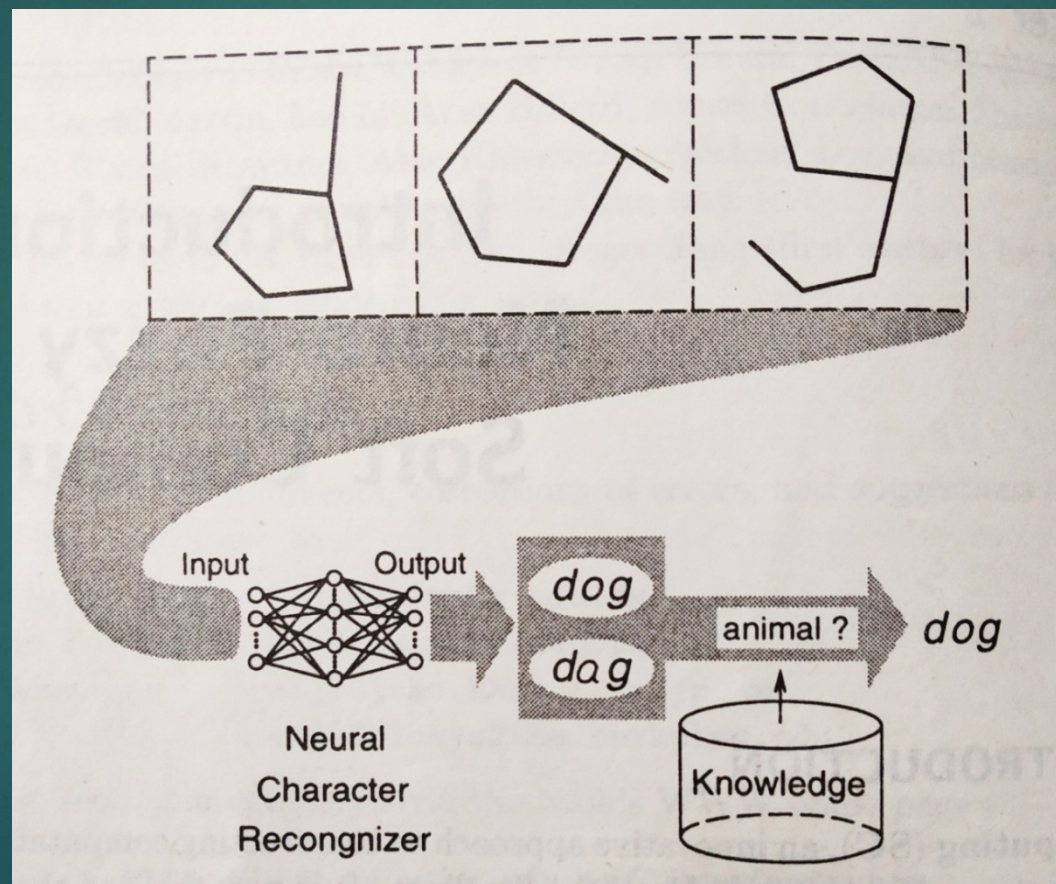
ANN Learning concept

How does a student (*ANN*) learn from a teacher (*Supervisor*, having the knowledge of inputs and outputs)?

- Teacher asks questions and tells the answers.

- Teacher puts questions to student and hints answers and asks whether the answers are correct or not.

- Student thus learns a topic and stores in his / her memory.

- Based on this knowledge, he or she solves new problems.

GA Optimization concept

- ► How does world select the best?
- ☐ It starts with a initial random population.
- ☐ Reproduces another population (next gen.)
- ☐ Ranks the population and selects the superior individuals.

 Genetic Algorithm is based on this natural phenomena (probabilistic reasoning). Here population is synonymous to solutions. Selection of superior solution is synonymous to exploring the optimal solution.

Concept of Fuzzy Logic

How does a doctor treats his patient?

➤ Doctor asks the patient about suffering.

➤ Doctor finds the symptoms of disease.

➤ Doctor prescribes tests and medicines.

This is exactly the way Fuzzy Logic works. Symptoms are correlated with inputs with uncertainty. Doctor's prescription on tests and medicines correlates fuzzy output.

Hard Computing vs. Soft Computing

Hard Computing	Soft computing
• It requires a precisely stated analytical model and often a lot of computation time.	• It is tolerant of imprecision, uncertainty, partial truth and approximation.
• It is based on binary logic, crisp system, numerical analysis and crisp software.	• It is based on fuzzy logic, neural nets and probabilistic reasoning.
• It has the characteristics of precision and categoricity.	• It has the characteristics of approximation and dispositionality (varieties, types, no. of inputs)

Hard Computing vs. Soft Computing

Hard computing	Soft computing
• It is deterministic.	• It incorporates stochasticity.
• It requires exact input data.	• It can deal with ambiguous and noisy data.
• It is strictly sequential.	• It allows parallel computation
• It produces precise answers	• It can yield approximate answers

Hybrid Computing

- It is a combination of the conventional hard computing and emerging soft computing.

- *Example*: Civil Engineering problems dealing with engineering and design vs. labour management.

Introduction to neuro-fuzzy and soft computing

Artificial Intelligence

What is intelligence?

➤ Real intelligence is what determines the normal thought process of a human.

➤ Artificial intelligence is a property of machines which gives it ability to mimic the human thought process.

➤ The intelligent machines are developed based on the intelligence of a subject, of a designer, of a person, of a human being.

➤ Artificial Intelligence is concerned with the design of intelligence in an artificial device.

➤ The term was coined by McCarthy in 1956.

Artificial Intelligence

Typical AI problems

- Examples of common-place tasks include

– *Recognizing people, objects.*

– Communicating (through *natural language)*.

– *Navigating around obstacles on the streets*

- These tasks are done matter of factly and routinely by people and some other animals.

- Expert tasks include:

-Medical diagnosis.
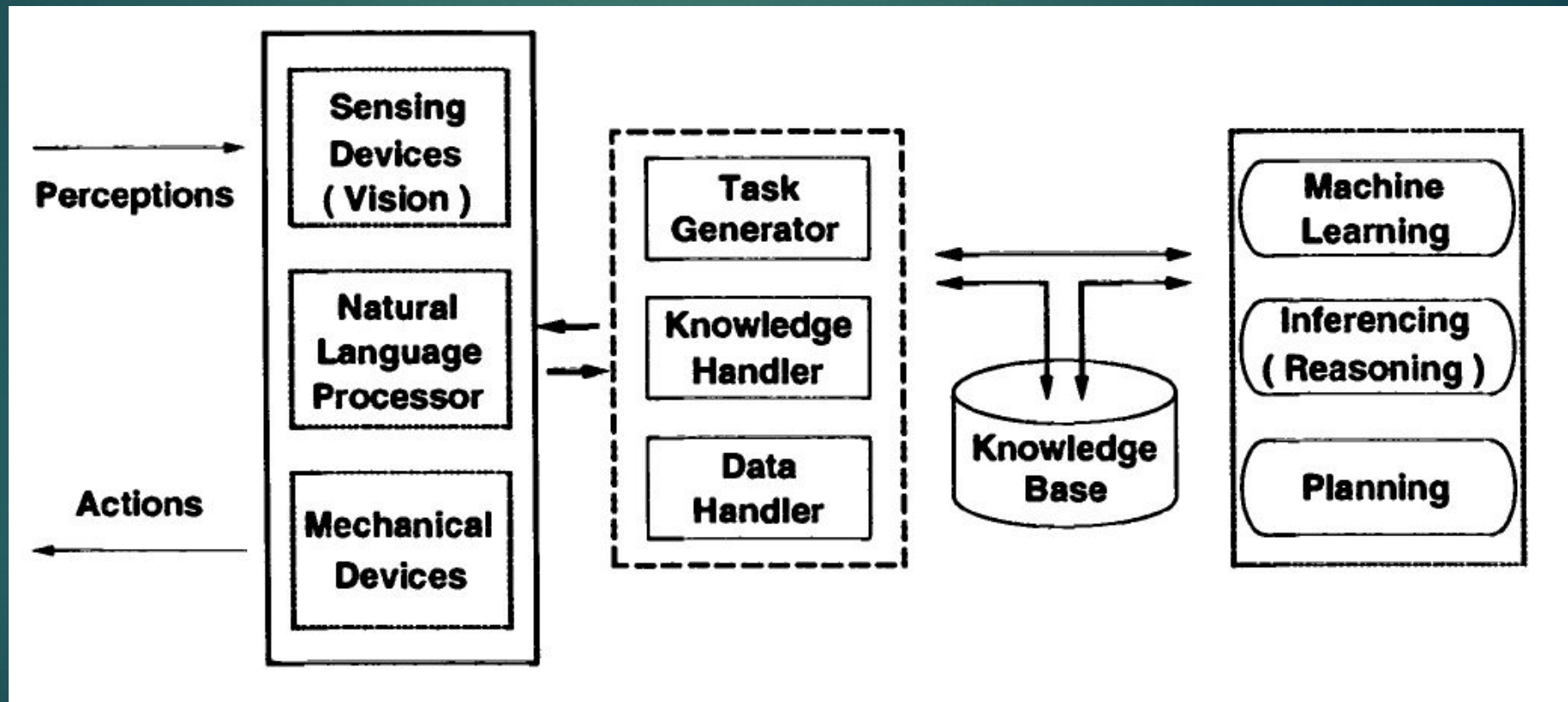
-Mathematical problem solving

-Playing games like chess

Artificial Intelligence

► An Expert System: One of AI Products
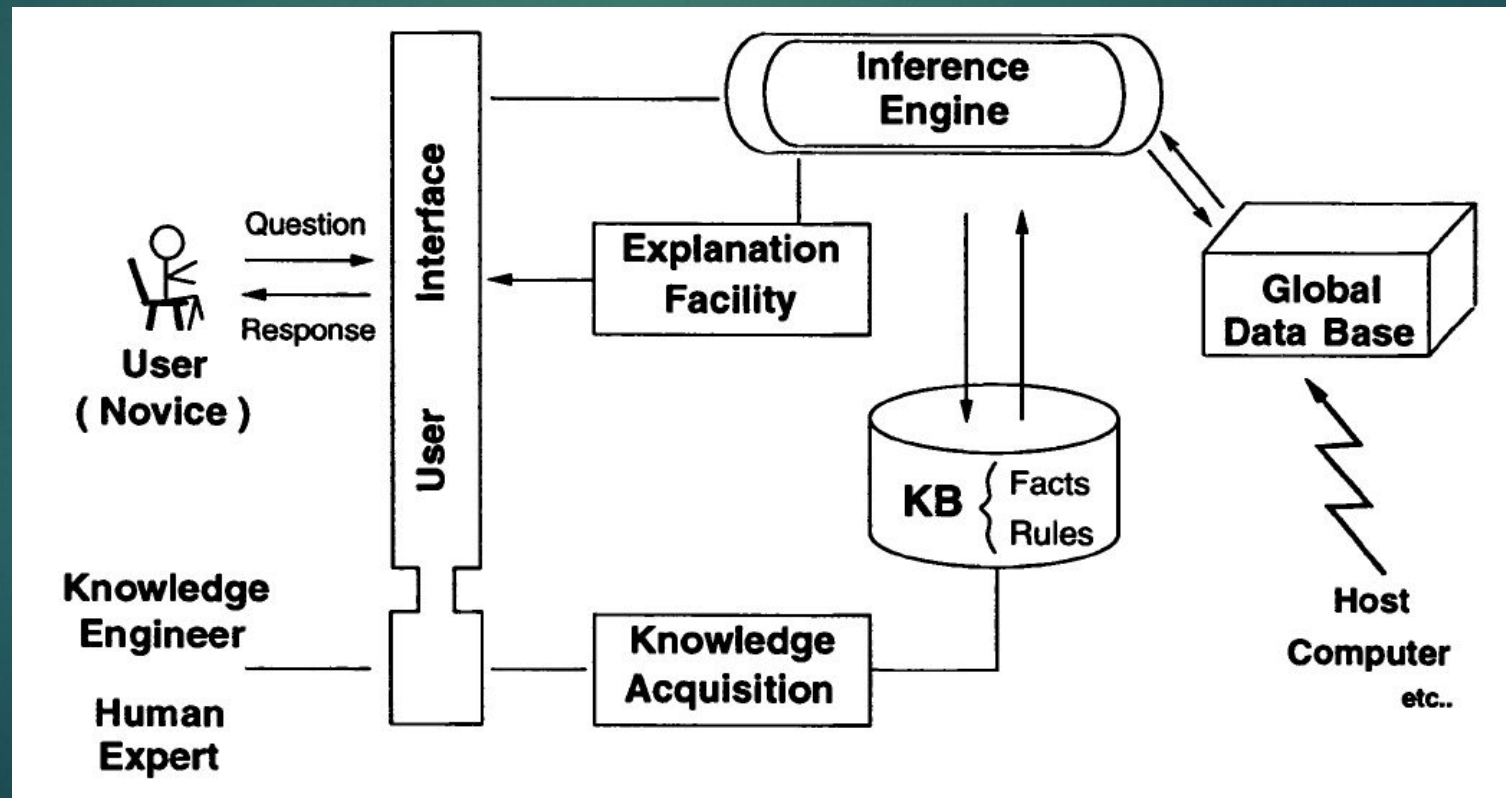
Artificial Intelligence

► An Intelligent System

Artificial Intelligence

Intelligent behaviour

► Some of these tasks and applications are:

1. Perception involving image recognition and computer vision

2. Reasoning

3. Learning

4. Understanding language involving natural language processing, speech processing

5. Solving problems

6. Robotics

Soft Computing

What is soft computing?

➤ An approach to computing which parallels the remarkable ability of the human mind to reason and learn in an environment of uncertainty and imprecision.

➤ It is characterized by the use of inexact solutions to computationally hard tasks such as the solution of nonparametric complex problems for which an exact solution can't be derived in polynomial of time.

Soft Computing

Why soft computing approach?

► Mathematical model & 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.

► Soft computing deals with imprecision, uncertainty, partial truth and approximation to achieve tractability, robustness and low solution cost.

► Typically human can:

1. Take decisions

2. Inference from previous situations experienced

3. Expertise in an area

4. Adapt to changing environment

5. Learn to do better

6. Social behaviour of collective intelligence

Soft Computing

Characteristics of Neuro-Fuzzy & Soft Computing:

1. Human Expertise

2. Biologically inspired computing models

3. New Optimization Techniques

4. Numerical Computation

5. New Application domains

6. Model-free learning

7. Intensive computation

8. Fault tolerance

9. Goal driven characteristics

10. Real world applications

Fuzzy

Fuzzy logic:

► Most of the time, people are fascinated about fuzzy logic controller.

► Its popularity is such that it has been applied to various engineering products.

► When we say fuzzy logic, that is the variables that we encounter in physical devices, fuzzy numbers are used to describe these variables and using this methodology when a controller is designed, it is a fuzzy logic controller.
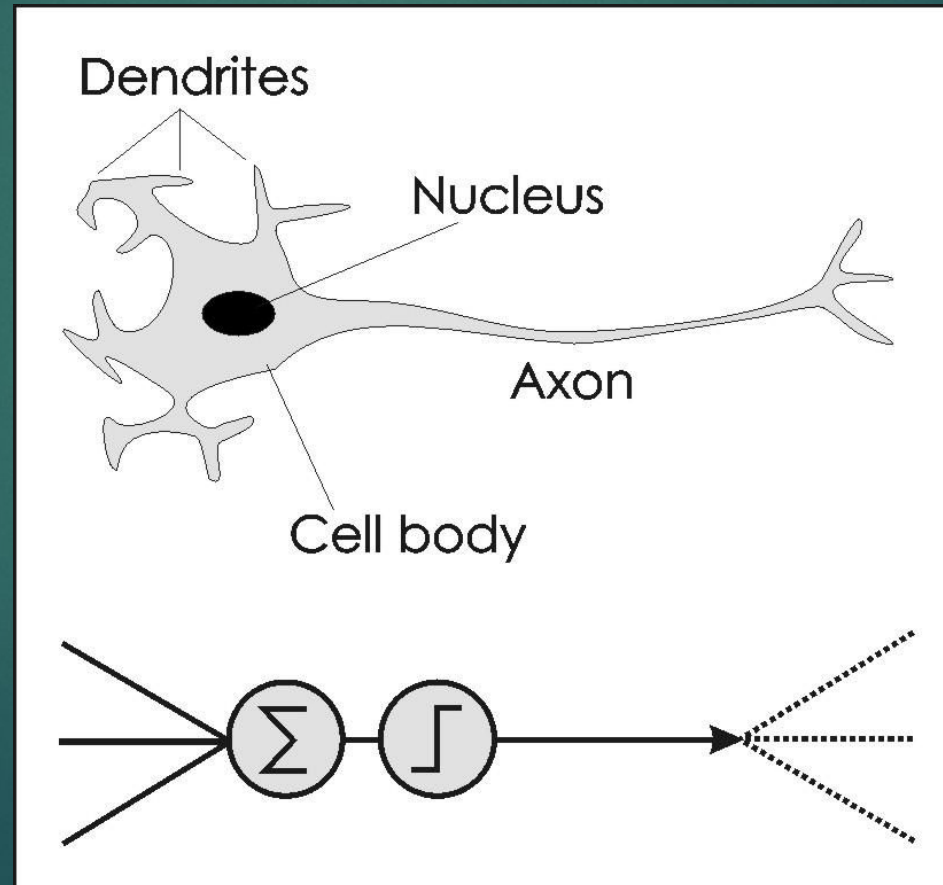
Neural network

Neural networks :

- ► Neural networks are basically inspired by various way of observing the biological organism.

- ► Most of the time, it is motivated from human way of learning. It is a learning theory.

- ► This is an artificial network that learns from example and because it is distributed in nature, fault tolerant, parallel processing of data and distributed structure.

- ► The basic elements of artificial Neural Network are: input nodes, weights, activation function and output node.

- ► Inputs are associated with synaptic weights. They are all summed and passed through an activation function giving output y.

- ► In a way, output is summation of the signal multiplied with synaptic weight over many input channels.

Neural network

► **Analogy of biological neuron and artificial neuron**

Neural network

Features of Artificial Neural Network (ANN) models:

1. Parallel Distributed information processing

2. High degree of connectivity between basic units

3. Connections are modifiable based on experience

4. Learning is a continuous unsupervised process

5. Learns based on local information

6. Performance degrades with less units

Evolutionary algorithms

Evolutionary algorithms:

- ► These are mostly derivative free optimization algorithms that perform random search in a systematic manner to optimize the solution to a hard problem.

- ► In this course Genetic Algorithm being the first such algorithm developed in 1970 will be discussed in detail.

- ► The other algorithms are swarm based that mimic behaviour of organisms, or any systematic process.