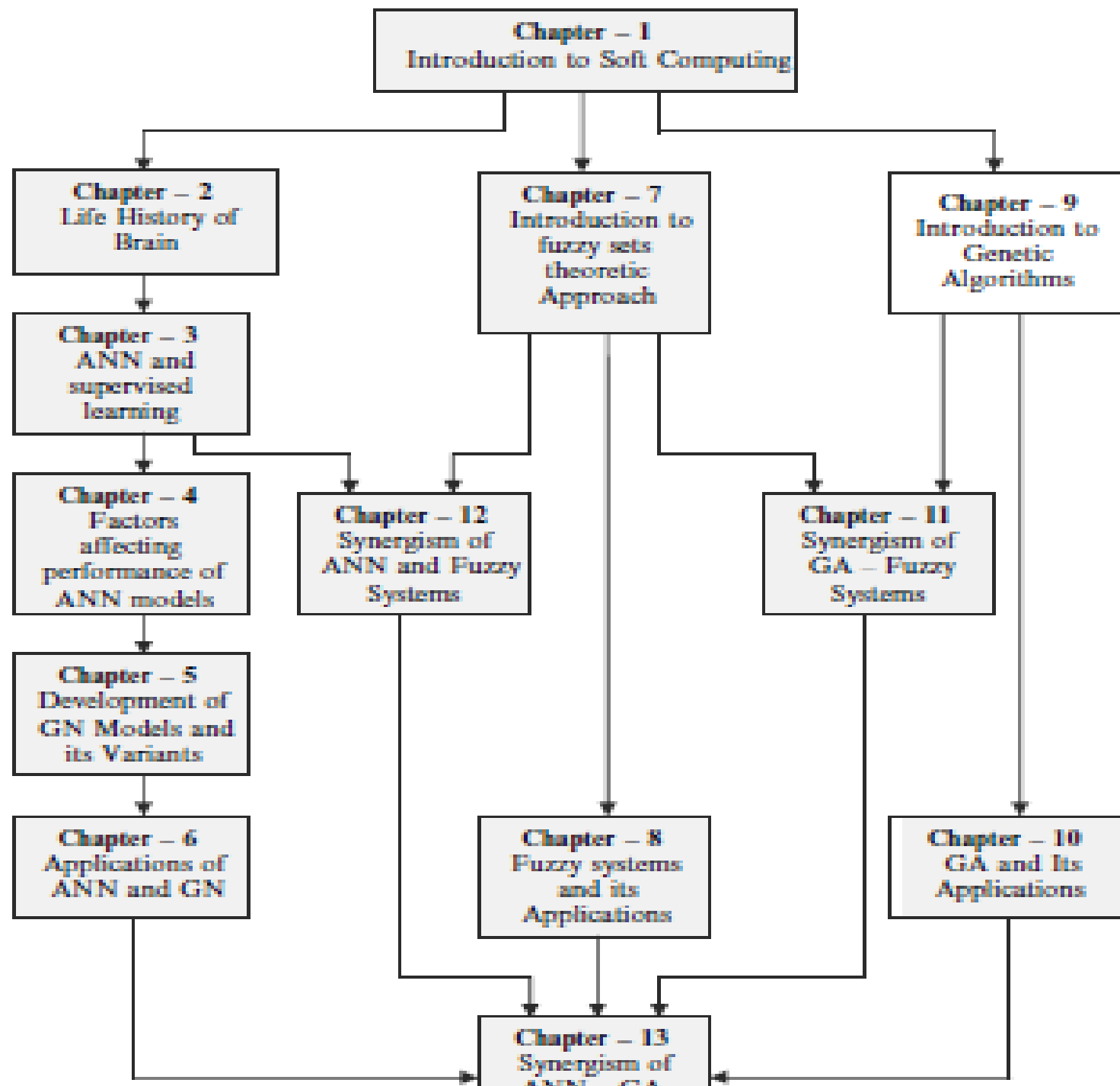


**Lecture – 01**  
**Introduction to soft computing**

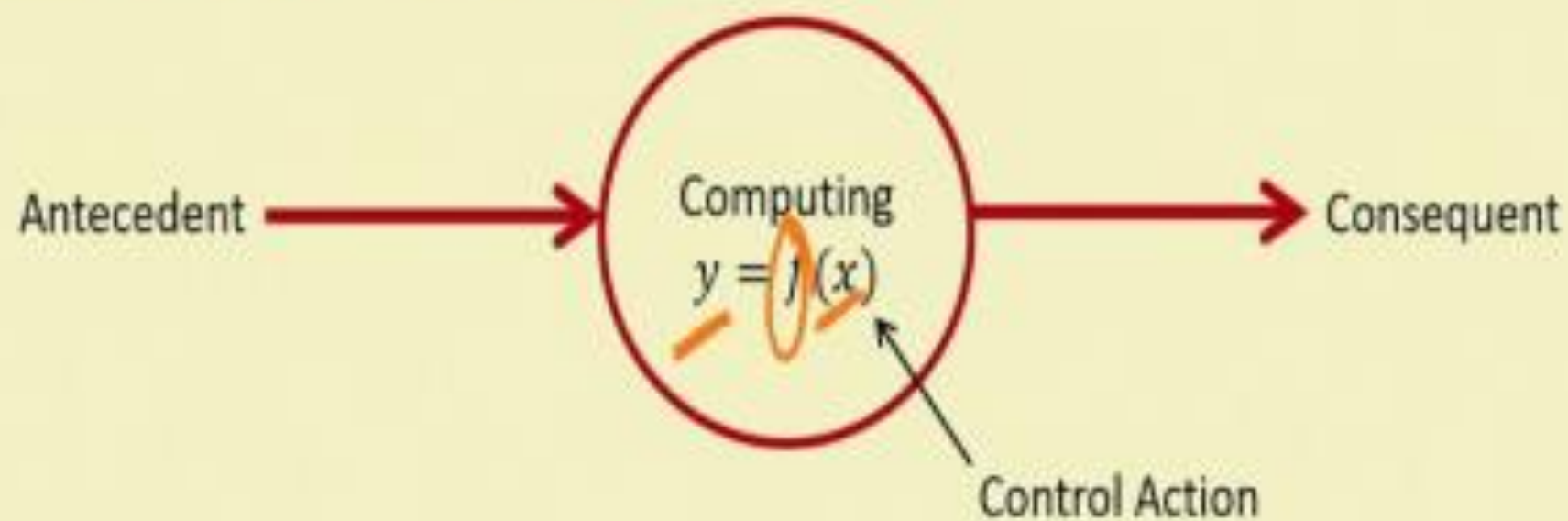
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# INTRODUCTION TO SOFT COMPUTING

- Concept of computation
- Hard computing
- Soft computing
- How soft computing?
- Hard computing vs. Soft computing
- Hybrid computing

# CONCEPT OF COMPUTATION



**Figure:** Basic of computing

$y = f(x)$ ,  $f$  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

- In 1996, L. A. Zade (LAZ) introduced the term **hard computing**.
  - According to LAZ: We term a computing as **Hard** computing, if
    - ✓ **Precise result** is guaranteed.
    - ✓ Control action is **unambiguous**.
    - ✓ Control action is **formally defined** (i.e., with mathematical model or algorithm).
-



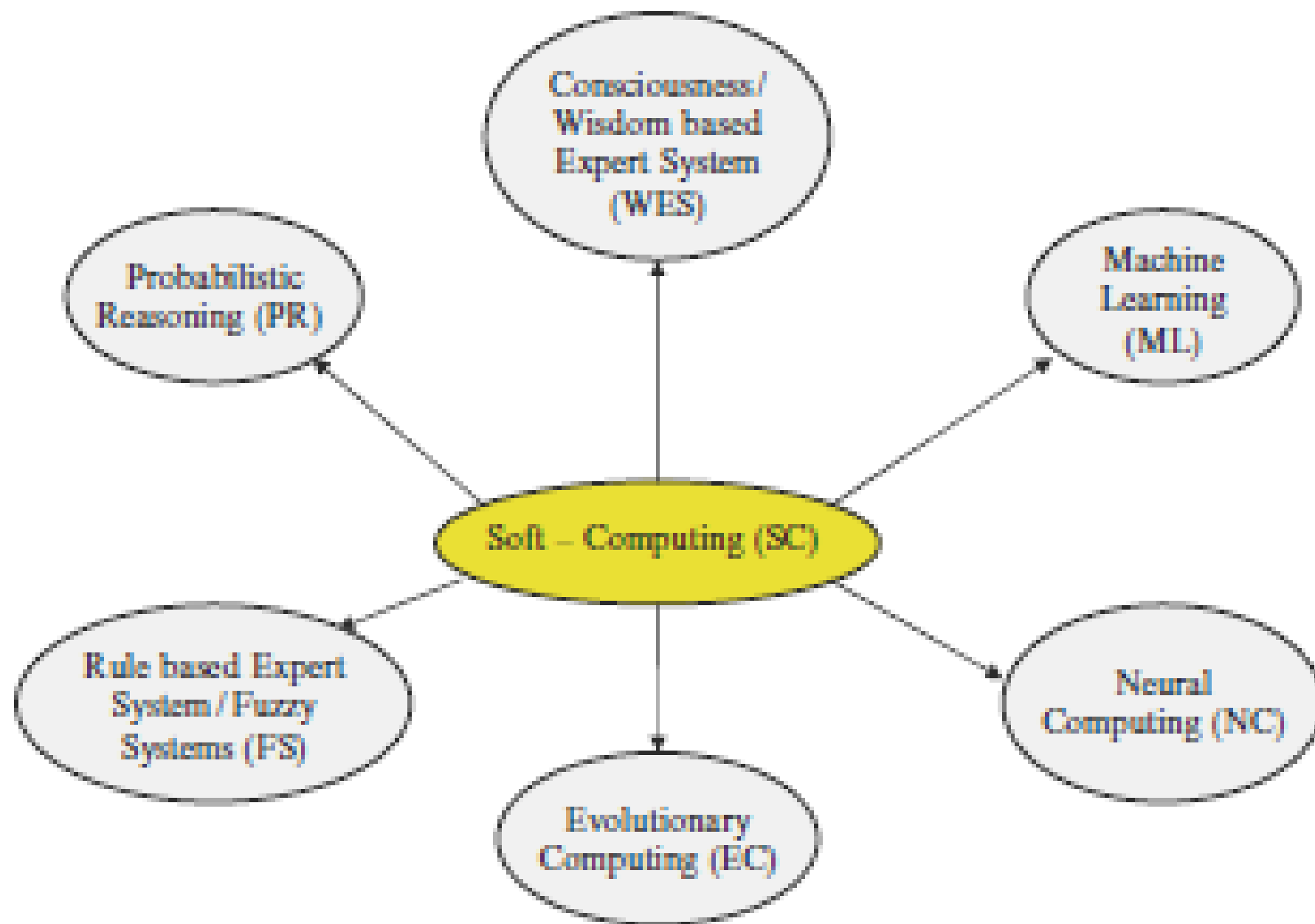
# Examples of hard computing

- Solving **numerical problems** (e.g., roots of polynomials, integration, etc.).
- **Searching and sorting** techniques.
- Solving **computational geometry** problems (e.g., shortest tour in a graph, finding closet pair of points given a set of points, etc.).
- **Many more**

# Soft computing

**Soft computing** could therefore be seen as a series of techniques and methods so that real practical situations could be dealt with in the same way as humans deal with them, i.e. on the basis of intelligence, common sense, consideration of analogies, approaches, etc.





**Fig. 1.2.** Soft-computing techniques

# Soft Computing

Approximate  
Reasoning

Functional  
Approximation/  
Randomized  
Search

Probabilistic  
Models

Multivalued  
&  
Fuzzy Logics

Neural  
Networks

Evolutionary  
Algorithms

## The main goal of Soft Computing

The main goal of Soft Computing is to develop intelligent machines and to solve nonlinear and mathematically unmodelled system problems (Zadeh 1994) and (Zadeh 2001). The applications of Soft Computing have proved two main advantages. First, it made solving nonlinear problems, in which mathematical models are not available, possible. Second, it introduced the human knowledge such as cognition, recognition, understanding, learning, and others into the fields of computing. This resulted in the possibility of constructing intelligent systems such as autonomous self-tuning systems, and automated designed systems.

## 1.4 The Soft Computing – development history

The following two schemes<sup>1</sup> show development history of Soft Computing in brief.

<b>SC</b>	<b>=</b>	<b>EC</b>	<b>+</b>	<b>NN</b>	<b>+</b>	<b>FL</b>
<i>Soft Computing</i>		<i>Evolutionary Computing</i>		<i>Neural Network</i>		<i>Fuzzy Logic</i>
<b>Zadeh 1981</b>		<b>Rechenberg 1960</b>		<b>McCulloch 1943</b>		<b>Zadeh 1965</b>

**EC      =      GP      +      ES      +      EP      +      GA**

*Evolutionary  
Computing*      *Genetic  
Programming*      *Evolution  
Strategies*      *Evolutionary  
Programming*      *Genetic  
Algorithms*

**Rechenberg      Koza      Rechenberg      Fogel      Holland**  
**1960      1992      1965      1962      1970**

# Soft computing

- The term soft computing was proposed by the inventor of fuzzy logic, Lotfi A. Zadeh. He describes it as follows.

## Definition 1: Soft computing

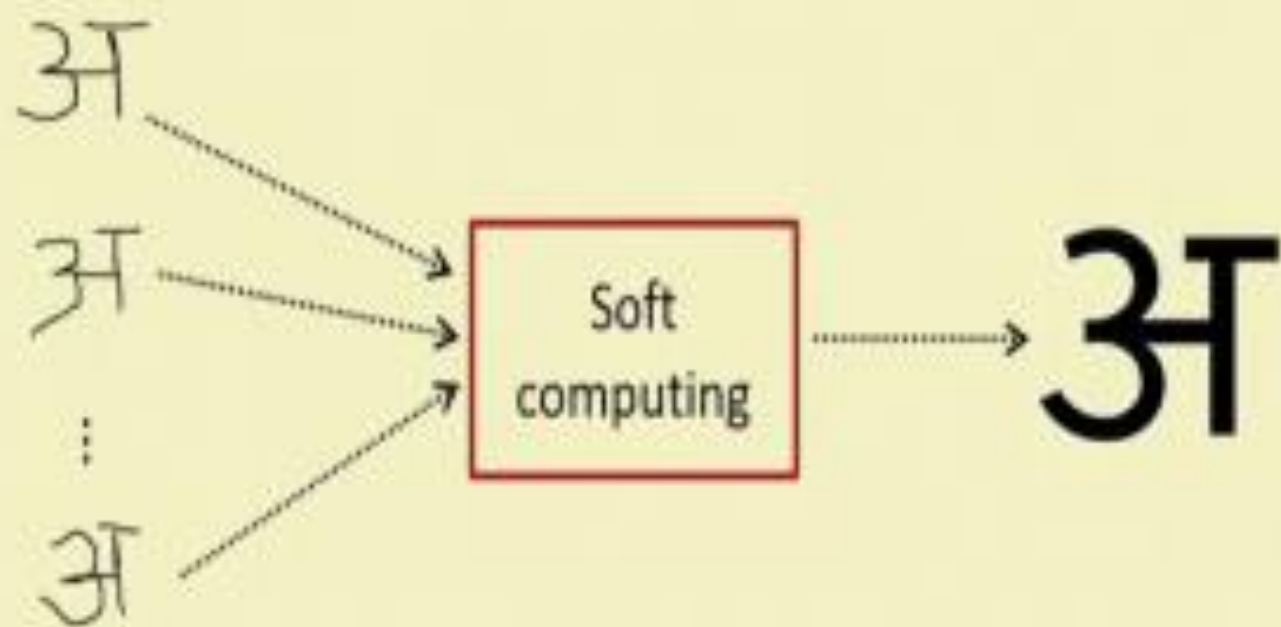
Soft computing is a collection of methodologies that aim to exploit the tolerance for imprecision and uncertainty to achieve tractability, robustness, and low solution cost. Its principal constituents are **fuzzy logic**, **neuro-computing**, and **probabilistic reasoning**. The role model for soft computing is the human mind.



# Characteristics of soft computing

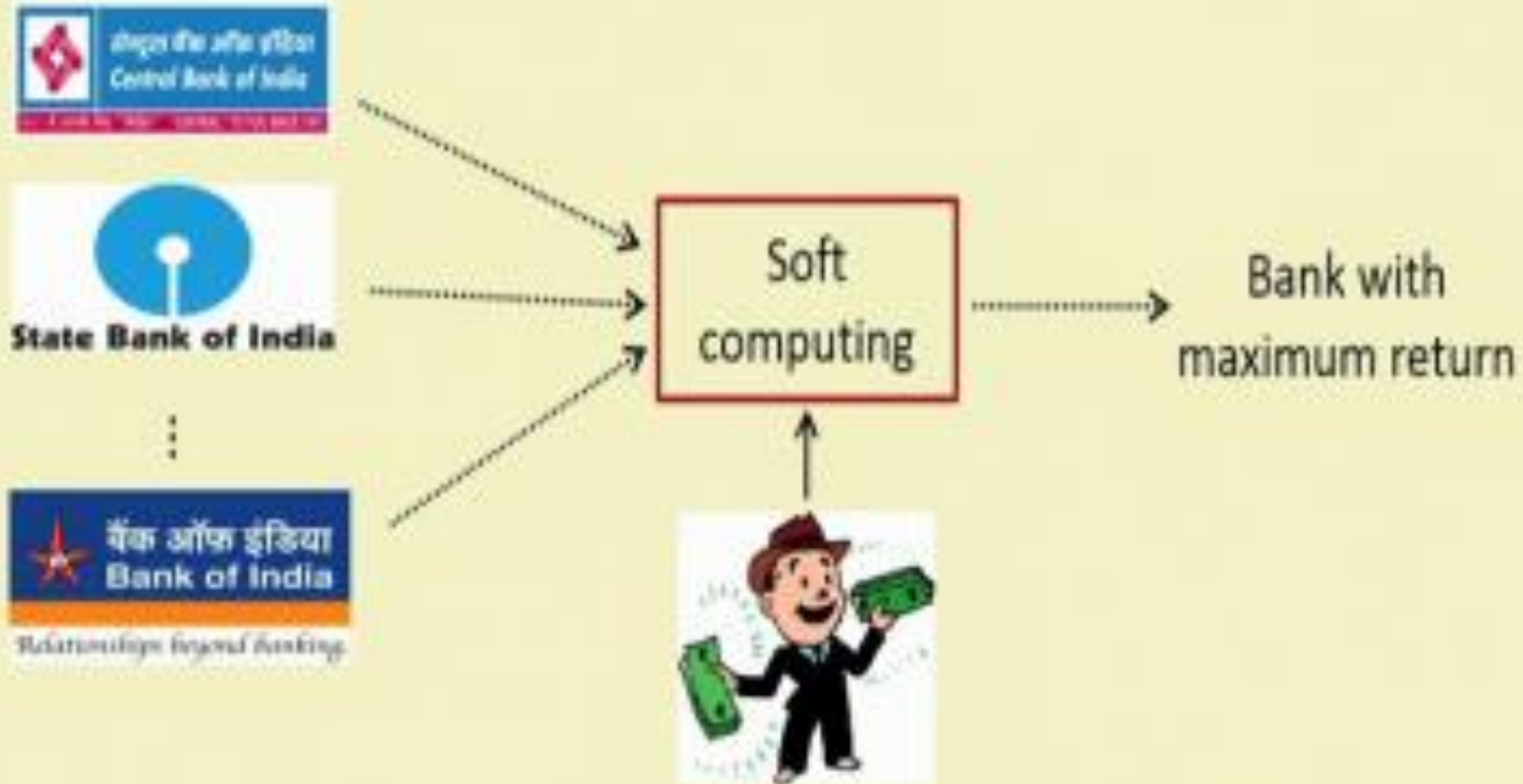
- It does not require any mathematical modeling of problem solving.
- It may not yield the precise solution.
- Algorithms are adaptive (i.e., it can adjust to the change of dynamic environment).
- Use some biological inspired methodologies such as genetics, evolution, Ant's behaviors, particles swarming, human nervous system, etc.).

## Examples of soft computing



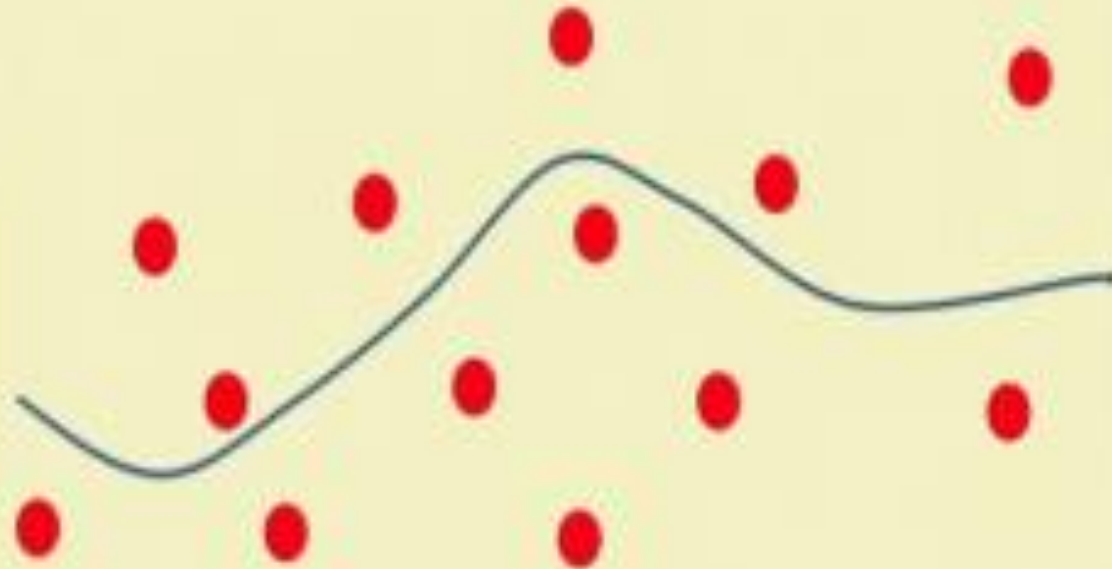
**Example:** Hand written character recognition  
(Artificial Neural Networks)

# Examples of soft computing



**Example : Money allocation problem  
(Evolutionary Computation)**

# Examples of soft computing



**Example : Robot movement  
(Fuzzy Logic)**



# How soft computing?

- How a **student** learns from his **teacher**?
  - Teacher asks questions and tell the answers then.
  - Teacher puts questions and hints answers and asks whether the answers are correct or not.
  - Student thus learn a topic and store in his memory.
  - Based on the knowledge he solves new problems.
- This is the way how human brain works.
- Based on this concept **Artificial Neural Network** is used to solve problems.

# How soft computing?

- How **world** selects the best?
  - It starts with a population (random).
  - Reproduces another population (next generation).
  - Rank the population and selects the superior individuals.
- **Genetic algorithm** is based on this natural phenomena.
  - Population is synonymous to solutions.
  - Selection of superior solution is synonymous to exploring the optimal solution.



# How soft computing?

- How a doctor treats his patient?
  - Doctor asks the patient about suffering.
  - Doctor find the symptoms of diseases.
  - Doctor prescribed tests and medicines.
- This is exactly the way Fuzzy Logic works.
  - Symptoms are correlated with diseases with uncertainty .
  - Doctor prescribes tests/medicines fuzzily.

# Hard computing vs. Soft computing

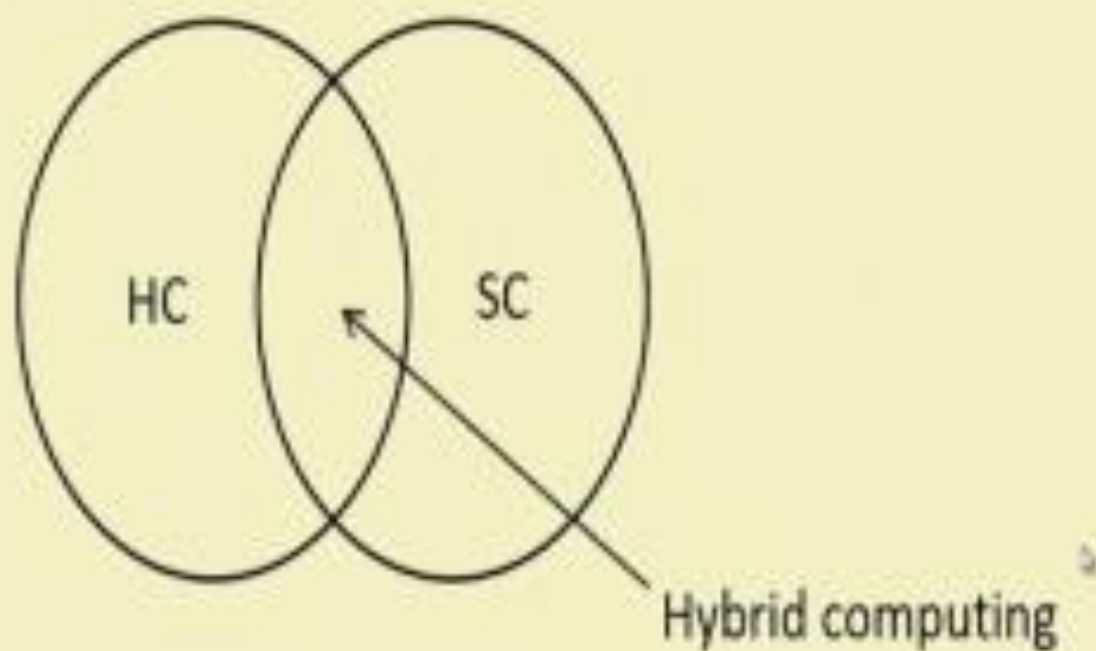
Hard computing	Soft computing
<ul style="list-style-type: none"><li>▪ It requires a precisely stated analytical model and often a lot of computation time.</li></ul>	<ul style="list-style-type: none"><li>▪ It is tolerant of imprecision, uncertainty, partial truth, and approximation.</li></ul>
<ul style="list-style-type: none"><li>▪ It is based on binary logic, crisp systems, numerical analysis and crisp software.</li></ul>	<ul style="list-style-type: none"><li>▪ It is based on fuzzy logic, neural nets and probabilistic reasoning.</li></ul>
<ul style="list-style-type: none"><li>▪ It has the characteristics of precision and categoricity.</li></ul>	<ul style="list-style-type: none"><li>▪ It has the characteristics of approximation and dispositionality.</li></ul>

# Hard computing vs. Soft computing

Hard computing	Soft computing
<ul style="list-style-type: none"><li>▪ It is deterministic.</li></ul>	<ul style="list-style-type: none"><li>▪ It incorporates stochasticity.</li></ul>
<ul style="list-style-type: none"><li>▪ It requires exact input data.</li></ul>	<ul style="list-style-type: none"><li>▪ It can deal with ambiguous and noisy data.</li></ul>
<ul style="list-style-type: none"><li>▪ It is strictly sequential.</li></ul>	<ul style="list-style-type: none"><li>▪ It allows parallel computations.</li></ul>
<ul style="list-style-type: none"><li>▪ It produces precise answers.</li></ul>	<ul style="list-style-type: none"><li>▪ It can yield approximate answers</li></ul>

# Hybrid computing

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



**Figure:** Concept of Hybrid Computing



## In this course...

- You will be able to learn
  - Basic concepts of Fuzzy algebra and then how to solve problems using Fuzzy logic.
  - The framework of Genetic algorithm and solving varieties of optimization problems.
  - How to build an artificial neural network and train it with input data to solve a number of problems, which are not possible to solve with hard