2720719
Artificial Intelligent Application to Power System

Chapter 1
INTRODUCTION

Chintan Patel

Assistant Professor
Department of Electrical Engineering
G. H. Patel College of Engineering and Technology – V V Nagar (Gujarat)
Email : chintanpatel@gcet.ac.in

Prof. Chintan Patel (EE-GCET)

1.1 Introduction

- **Discipline of Artificial Intelligence (AI) has been growing between psychology and computer science.**
- **AI Researchers make computers perform tasks that apparently require intelligence if done by human beings.**
- **AI is a field of study that encompasses computational techniques for performing above tasks.**
- **Fundamental issues of AI**
  - **Knowledge representation**
  - **Search**
  - **Perception**
  - **Inference**
- **Knowledge can be available as a collection of logical assertions, heuristic rules, procedures, statistical co-relations, etc.**

1.2 Intelligence

- What is Intelligence?
- e.g. "Shruti is intelligent" can be interpreted in different ways.
- Some will say, Shruti is intelligent because
  - She knows a lot
    or
  - She thinks fast
- A person possess great amount of knowledge but may not be capable of organizing this knowledge in a creative fashion.
- One satisfactory interpretation of the statement may be Shruti's actions would be appropriate in all situations.

Prof. Chintan Patel (EE-GCET)

1.2 Intelligence

- Important aspects of human intelligence
  - The use of intuition, commonsense, judgment, creativity, goal directedness, plausible reasoning, knowledge and beliefs.
  - Human intelligence is powerful, yet it has some limitations.
  - Humans are intellectually fallible.
  - Humans have limited knowledge bases.
  - Information processing in humans is of serial nature & proceeds very slowly in the brain as compared with computers.

1.2 Intelligence

➢ **The meaning of intelligence is not the human brain's information processing ability but the ability of humans to demonstrate their intelligence by**

- ❖ **Communicating effectively**
- ❖ **Learning.**

➢ **Human beings acquire knowledge by experience, and then demonstrate the knowledge that is acquired by communicating and learning.**

Prof. Chintan Patel (EE-GCET)

1.3 Artificial Intelligence

➢ **Definitions of AI results from different motivations / backgrounds.**

➢ **Intelligent Class of objects: ants, birds, cats, etc.**

➢ **Unintelligent Class of objects: tables, chairs, hardware, etc.**

➢ **AI means the simulation of human behaviour and cognitive processes on a computer.**

➢ **AI is the study of how to make computers do things which at the moment people do better.**

- ❖ **Definition is ephemeral (lasting for a short time)**
- ❖ **Reference to the current state of computer science**

1.3 Artificial Intelligence

- Key issue in the study is **Searching**
- It is to invent brute force algorithms to solve problems.
- An understanding of search techniques can help avoid the combinatorial explosion that swamps brute force attempts.
- **INFERENCE** is the process of creating **explicit** (clear and exact) representations of the knowledge from **implicit** (suggested but indirect) ones.
- **INFERENCE** can be viewed as the creation of knowledge itself.

Prof. Chintan Patel (EE-GCET)

1.3 Artificial Intelligence

- AI is both an **art** and a **science**.
- **Science** – a body of proved principles that have been abstracted from nature through processes of empirical inquiry and logical deduction.
- **Art** – a collection of techniques, developed pragmatically to a sophisticated level, but not necessarily in a logical way.
- Purpose of **AI** to increase man's understanding of
  - reasoning
  - learning
  - perception
- Better understanding is required
  - to build new development tools
  - to achieve a more mature view of human intelligence

1.4 Definitions of AI

- **Bellman, 1978: The automation of activities that we associate with human thinking, activities like decision- making, problem solving, learning, etc.**

- **Haugeland, 1985: The exciting new effort to make computers think….machines with mind, in the full and literal sense.**

- **Kurzweil, 1990: The art of creating machines that perform functions that need intelligence when performed by people.**

- **Winston, 1992: The study of the computations that make it possible to perceive, reason and act.**

Prof. Chintan Patel (EE-GCET)

1.4 Definitions of AI

- **Luger & Stubblefield, 1993: The branch of computer science that is concerned with the automation of intelligent behaviour.**

- **Rich & knight, 2003: The study of how to make computers do things at which, at the moment, people are better.**

- **As per definitions of AI, Computer systems can be classified into the following categories**

  - **Systems that ACT like humans**
  - **Systems that THINK like humans**
  - **Systems that THINK rationally**
  - **Systems that ACT rationally**

1.5 Soft Computing Vs Hard Computing Systems

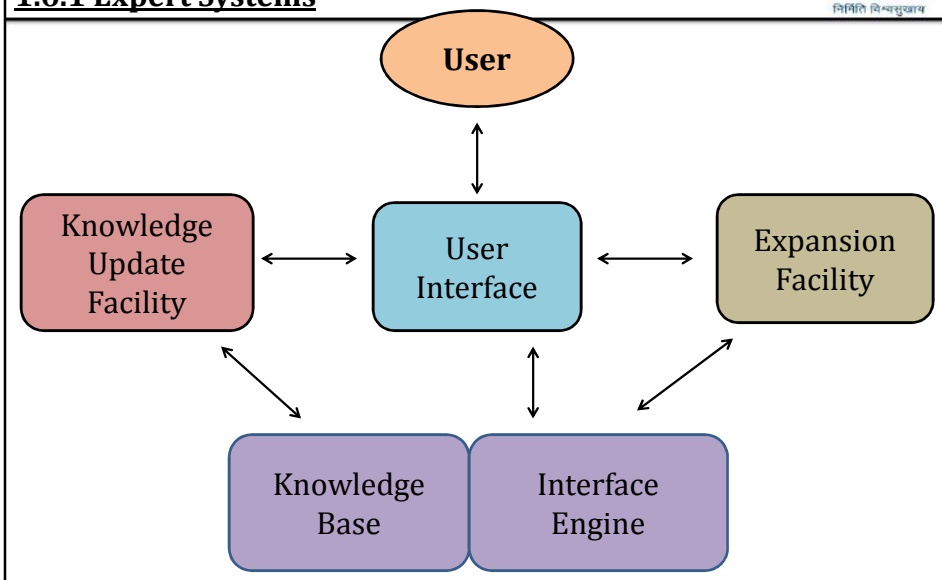
- Soft computing differs from hard computing in its tolerance to **imprecision, uncertainty and partial truth**.
- Hard computing methods are based on mathematical approaches, so demand a high degree of precision and accuracy in their requirements.
- But in most engineering problems, the input parameters cannot be determined with high degree of precision.
- Soft computing techniques, which are based on biological systems, present effective methods for the solution of difficult problems.
- The guiding principle of soft computing is exploit the tolerance for **imprecision, uncertainty and partial truth** to achieve **tractability, robustness and low cost solution**.

Prof. Chintan Patel (EE-GCET)

1.6 Fundamentals of Various IS
1.6.1 Expert Systems

- **ES** is an intelligent computer program that uses knowledge and inference procedures to solve problems which needs human expertise for their solution.
- **ES** is a knowledge-based program that provides expert quality solution to problems in a specific domain.
- Its knowledge is extracted from the human experts in the domain.
- The computer programs cannot learn from experience, their knowledge must be extracted from humans and encoded in a formal language.
- An **ES** simulates the human reasoning process by applying specific knowledge and inferences.

1.6 Fundamentals of Various IS
1.6.1 Expert Systems

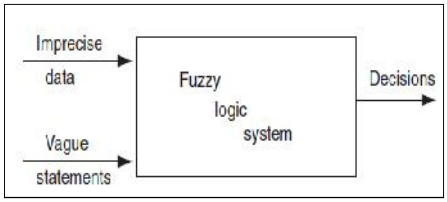


Architecture of an Expert System

Prof. Chintan Patel (EE-GCET)

1.6 Fundamentals of Various IS
1.6.2 Fuzzy Systems

- ***As complexity rises, precise statements lose meaning and meaningful statements lose precision*** – **Lotfi A. Zadeh**
- **In 1965, Zadeh introduced the concept of fuzzy sets.**
- **The fuzzy theory provides a mechanism for representing linguistic constructs such as "many," "low," "medium," "often," "few".**
- **In general, the fuzzy logic provides an inference structure that enables appropriate human reasoning capabilities.**
- **A fuzzy logic system accepts imprecise data and vague statements such as low, medium, high and provides decisions**



1.6 Fundamentals of Various IS
1.6.3 Neural Networks

- An artificial neural network (ANN) is a system that is based on operations of biological neural networks.
- It can be defined as an emulation of biological neural systems.
- A neuron is a simple processing element that receives and combines signals from other neurons through input paths called dendrites.
- If the combined input signal is strong enough, the neuron 'fires', producing an output signal along the axon that connects to the dendrites of many other neurons.
- Each signal coming into a neuron along a dendrite passes through a synapse or a synaptic junction.

Prof. Chintan Patel (EE-GCET)

1.6 Fundamentals of Various IS
1.6.3 Neural Networks

- This junction is a gap in the dendrite which is filled with neurotransmitter fluid that either accelerates or retards the flow of electric charges.
- The fundamental actions of neuron are chemical in nature, and this neurotransmitter fluid produces electric signals that go to the nucleus or soma of the neuron.
- The adjustment or conductance of the synaptic gap is a critically important process.
- As the synaptic strengths of the neurons are adjusted, the brain 'learns' and stores information.
- ANN can model the behaviour of biological neural networks.
- The ANN was developed to exploit parallel-processor computing in place of traditional serial computation.

1.6 Fundamentals of Various IS
1.6.3 Neural Networks

- **NNs are categorized based on**
  - **Architectures (number of layers)**
  - **Topology (connectivity pattern)**
    - **feed-forward,**
    - **recurrent,**
  - **Learning regime**
- **NNs are categorized based on most of the applications in engineering have used multilayered feed-forward networks and error back-propagation learning.**

Prof. Chintan Patel (EE-GCET)

1.6 Fundamentals of Various IS
1.6.4 Genetic Algorithms and Evolutionary Programming

- **Problem solving systems based on the principles of evolution and heredity has been grown during last 30 years.**
- **Such system maintains a population of potential of solutions, a selection process based on the fitness of individuals and certain 'genetic' operators.**
- **One class of such systems is evolution strategies.**
- **They are the algorithms which imitate the principles of natural evolution for parameter optimization problems.**
- **Fogel's EP is a technique used for searching through a space of small finite- state machines.**
- **Glover's scatter search techniques maintain a population of reference points and generate offspring using weighted linear combinations.**

1.6 Fundamentals of Various IS
1.6.4 Genetic Algorithms and Evolutionary Programming

- An evolution program is a probabilistic algorithm which maintains a population $P(t) = \{x_{t1},...,x_{tm}\}$ of individuals for iteration t.
- A typical EP is given below:

```
Procedure evolution program
Begin
        t ← 0
        Initialize P(t)
        Evaluate P(t)
While (not termination-condition) do
Begin
        T ← t + 1
        Select P(t) from P(t-1)
        Alter P(t) through crossover and mutation
        Evaluate P(t)
End
End
```


Prof. Chintan Patel (EE-GCET)

1.7 History
1.7.1 Expert Systems

- In the early 1960s, AI scientists realized that developing general purpose programs was too difficult and ultimately fruitless.
- In 1970s, the following techniques were developed
  - ❖ Representation : how to formulate a problem easily
  - ❖ Search : how to control the search for a given solution efficiently and with less computer memory space
- They realized that problem solving power of a program comes from the knowledge it possesses.

1.7 History
1.7.1 Expert Systems

- To make a program intelligent, provide it with lots of high-quality, specific knowledge about the problem area.
- This led to development of specific purpose computer programs – systems that were experts in narrow problem areas.
- These programs were called **Expert Systems**.
- The process of building an expert system is called **knowledge engineering**.
- It involves a special form of interaction between the expert system builder called **knowledge engineer** and one or more human experts in that problem area.

Prof. Chintan Patel (EE-GCET)

1.7 History
1.7.1 Expert Systems

- Knowledge engineer extracts from the human expert
  - Procedures
  - Strategies
  - Rules of thumb
- The knowledge engineer then converts the knowledge into an expert system.
- The result is a computer program that can solve problems in a manner similar to the human experts.

1.7 History
1.7.2 Fuzzy systems

➢ In 1950s, Lotfi A. Zadeh, Dept. of EE & CS, Uni. of California, believed that all real world problems could be solved with efficient analytical methods and fast computers.

➢ He thought that the traditional system analysis techniques were too precise for complex world problems.

➢ Zadeh proposed the idea of a fuzzy set in 1964.

➢ The idea of 'grade of membership', which is the backbone of fuzzy set theory, occurred to him.

Prof. Chintan Patel (EE-GCET)

1.7 History
1.7.2 Fuzzy systems

➢ Fuzzy sets support a flexible sense of membership of elements to a set.

➢ Some important concepts were developed by Zadeh between 1965 and 1975.

- ❖ fuzzy multistage decision making
- ❖ fuzzy similarity relations
- ❖ fuzzy restrictions
- ❖ linguistic hedges

1.7 History
1.7.2 Fuzzy systems

- Many mathematical structures were fuzzified by generalizing the underlying sets to be fuzzy.
- These structures include
  - logic,
  - relations,
  - functions,
  - graphs,
  - groups,
  - languages,
  - algorithms and programs
- In 1974, Assilian and Mamdani in the UK developed the 1st fuzzy logic controller which was used for controlling a steam generator.

Prof. Chintan Patel (EE-GCET)

1.7 History
1.7.3 Artificial Neural Networks

- ANN has been developed from 1943 onwards.
- McCulloch and Pitts outlined the 1st formal model of an elementary computing neuron.
- Model included all the necessary elements needed to perform logic operations and thus could function as an arithmetic-logic computing element.
- Donald Hebb proposed a learning scheme for updating neuron connections which we now refer to as the Hebbian learning rule.
- He stated that information can be stored in the form of connections.

1.7 History
1.7.3 Artificial Neural Networks

- **Frank Rosenblattt in the 1950s invented a neuron like element called the perceptron.**
- **Perceptron was a trainable machine capable of learning to classify certain patterns by modifying the connections between threshold elements.**
- **In 1960s, a device called ADALINE was introduced.**
- **Bernard Widrow and Marcian Hoff developed a new powerful learning rule called the Widrow-Hoff Learning Rule.**

Prof. Chintan Patel (EE-GCET)

1.7 History
1.7.3 Artificial Neural Networks

- **Applications of ADALINE and its extension MADALINE include**
  - **Pattern recognition**
  - **Weather forecasting**
  - **Adaptive controls**
- **During 1986-87, many new neural network research programs were initiated and are in use even today.**

1.7 History
1.7.4 Genetic Algorithms and Evolutionary Programming

- In 1950s and 1960s, scientists found that the evolution could be used as an optimization tool for engineering problems.
- Concept was to evolve a population of candidate solutions for a given problem using operators inspired by natural genetic variation and natural selection.
- In the 1960s, Rechenberg and then Schwefel developed 'evolution strategies', a method used for optimization real-valued parameters for devices like airfoils.
- John Holland invented Genetic Algorithms in 1960s at University of Michigan.

Prof. Chintan Patel (EE-GCET)

1.7 History
1.7.4 Genetic Algorithms and Evolutionary Programming

- Holland's GA is a method for moving from one population of chromosomes to a new by using a kind of natural selection together with the genetics inspired operators of
  - crossovers,
  - mutation
  - inversion
- Holland was the first to attempt to put computational evolution on a firm theoretical footing.
- Lately the boundaries between GAs, evolutionary strategies, evolutionary programming, and other evolutionary approaches have broken down to some extent.