

ARTIFICIAL INTELLIGENCE

***Fuzzy Logic Systems
Natural Language Processing
Expert Systems***



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Fuzzy Logic Systems

What is Fuzzy Logic?

□ FL is a method of reasoning that resembles human reasoning.

- *The approach of FL imitates the way of decision making in humans that involves all intermediate possibilities between digital values YES and NO.*
- *The conventional logic block that a computer can understand takes precise input and produces a definite output as TRUE or FALSE, which is equivalent to human's YES or NO.*
- *The inventor of fuzzy logic, Lotfi Zadeh, observed that unlike computers, the human decision making includes a range of possibilities between YES and NO, such as –*

CERTAINLY YES
POSSIBLY YES
CANNOT SAY
POSSIBLY NO
CERTAINLY NO

- The fuzzy logic works on the levels of possibilities of input to achieve the definite output.



Fuzzy Logic Systems

Implementation

- *It can be implemented in systems with various sizes and capabilities ranging from small micro-controllers to large, networked, workstation-based control systems.*
- *It can be implemented in hardware, software, or a combination of both.*

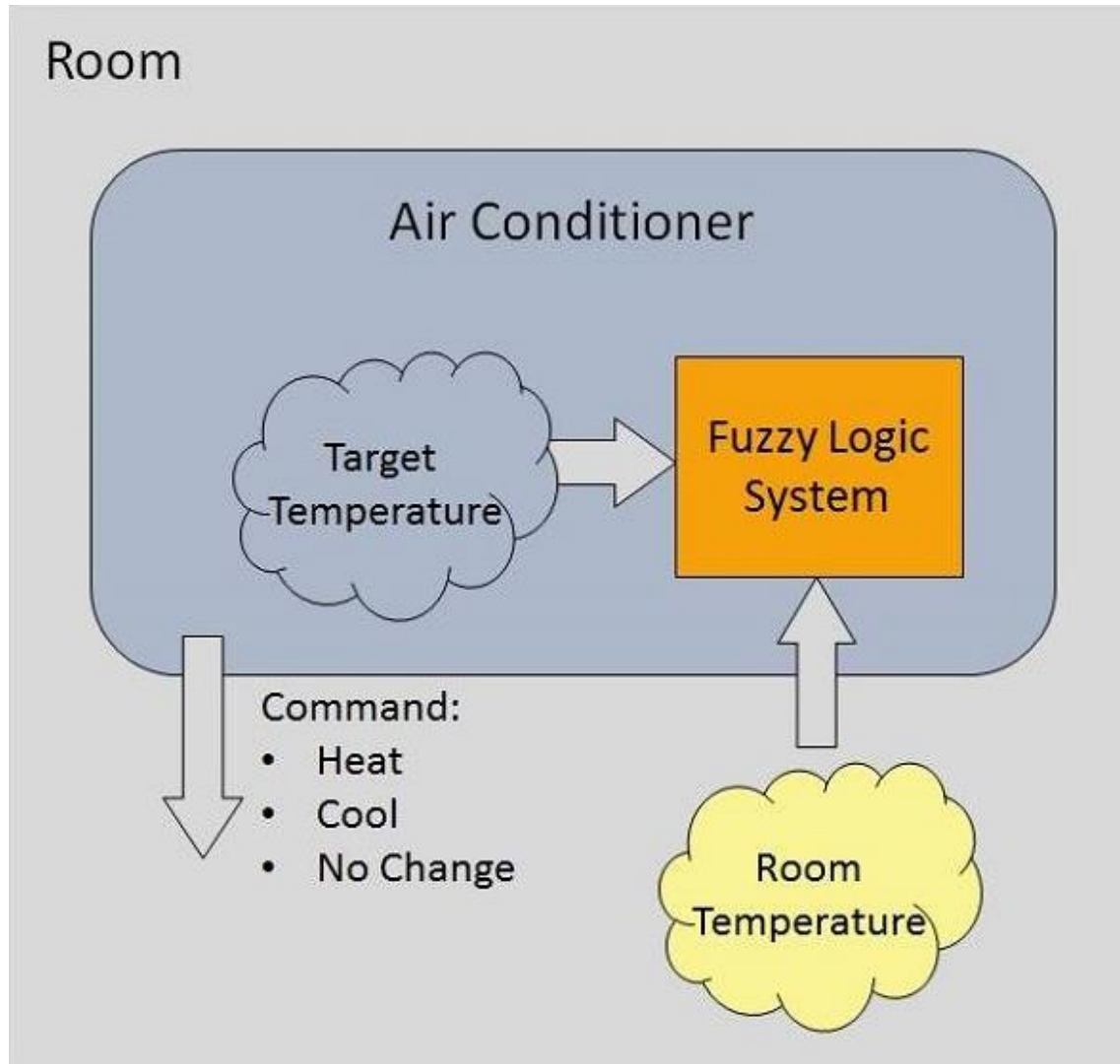
Why Fuzzy Logic?

- *Fuzzy logic is useful for commercial and practical purposes.*
- *It can control machines and consumer products.*
- *It may not give accurate reasoning, but acceptable reasoning.*
- *Fuzzy logic helps to deal with the uncertainty in engineering*



Fuzzy Logic Systems - Example

an air conditioning system with 5-level fuzzy logic system.
This system adjusts the temperature of air conditioner by comparing the room temperature and the target temperature value



Application Areas of Fuzzy Logic

- **Automotive Systems**
 - *Automatic Gearboxes*
 - *Four-Wheel Steering*
 - *Vehicle environment control*
- **Consumer Electronic Goods**
 - *Hi-Fi Systems*
 - *Photocopiers*
 - *Still and Video Cameras*
 - *Television*
- **Domestic Goods**
 - *Microwave Ovens*
 - *Refrigerators*
 - *Toasters*
 - *Vacuum Cleaners*
 - *Washing Machines*
- **Environment Control**
 - *Air Conditioners/Dryers/Heaters*
 - *Humidifiers*



Advantages & Disadvantages FLSs

Advantages	Disadvantages
Mathematical concepts within fuzzy reasoning are very simple	There is no systematic approach to fuzzy system designing.
You can modify a FLS by just adding or deleting rules due to flexibility of fuzzy logic.	They are understandable only when simple
Fuzzy logic Systems can take imprecise, distorted, noisy input information	They are suitable for the problems which do not need high accuracy
FLSs are easy to construct and understand.	
Fuzzy logic is a solution to complex problems in all fields of life, including medicine, as it resembles human reasoning and decision making	

Natural Language Processing



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Natural Language Processing

What is Natural Language Processing?

- NLP refers to AI method of communicating with an intelligent systems using a natural language such as English.
- *Processing of Natural Language is required when you want an intelligent system like robot to perform as per your instructions, when you want to hear decision from a dialogue based clinical expert system, etc.*



The field of NLP involves making computers to perform useful tasks with the natural languages humans use. The input and output of an NLP system can be –

- *Speech*
- *Written Text*

Natural Language Processing

NLP Components

There are two components of NLP given as:

□ Natural Language Understanding (NLU)

- *Understanding involves the following tasks –*
- *Mapping the given input in natural language into useful representations.*
- *Analyzing different aspects of the language.*

□ Natural Language Generation (NLG)

- *It is the process of producing meaningful phrases and sentences in the form of natural language from some internal representation.*

• It involves –

- ***Text planning*** – *It includes retrieving the relevant content from knowledge base.*
- ***Sentence planning*** – *It includes choosing required words, forming meaningful phrases, setting tone of the sentence.*
- ***Text Realization*** – *It is mapping sentence plan into sentence structure.*
- *The NLU is harder than NLG.*



Natural Language Processing

Difficulties in NLU

NL has an extremely rich form and structure.

It is very ambiguous. There can be different levels of ambiguity –

- **Lexical ambiguity** – It is at very primitive level such as word-level.
 - *For example, treating the word “board” as noun or verb?*
- **Syntax Level ambiguity** – A sentence can be parsed in different ways.
 - *For example, “He lifted the beetle with red cap.” – Did he use cap to lift the beetle or he lifted a beetle that had red cap?*
- **Referential ambiguity** – Referring to something using pronouns.
 - *For example, Rima went to Gauri. She said, “I am tired.” – Exactly who is tired?*
- One input can mean different meanings.
- Many inputs can mean the same thing.



Natural Language Processing

NLP Terminology

- **Phonology** – It is study of organizing sound systematically.
- **Morphology** – It is a study of construction of words from primitive meaningful units.
- **Morpheme** – It is primitive unit of meaning in a language.
- **Syntax** – It refers to arranging words to make a sentence. It also involves determining the structural role of words in the sentence and in phrases.
- **Semantics** – It is concerned with the meaning of words and how to combine words into meaningful phrases and sentences.
- **Pragmatics** – It deals with using and understanding sentences in different situations and how the interpretation of the sentence is affected.
- **Discourse** – It deals with how the immediately preceding sentence can affect the interpretation of the next sentence.
- **World Knowledge** – It includes the general knowledge about the world.



EXPERT SYSTEMS



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Expert Systems

Expert systems (ES) are one of the prominent research domains of AI.

- *It is introduced by the researchers at Stanford University, Computer Science Department.*

What are Expert Systems?

- *The expert systems are the computer applications developed to solve complex problems in a particular domain, at the level of extra-ordinary human intelligence and expertise.*



Characteristics of Expert Systems

- *High performance*
- *Understandable*
- *Reliable*
- *Highly responsive*

Advantages & Disadvantages FLSs

Capability	Incapability
Advising	Substituting human decision makers
Instructing and assisting human in decision making	
Demonstrating	Possessing human capabilities
Deriving a solution	
Diagnosing	Producing accurate output for inadequate knowledge base
Explaining	
Interpreting input	Refining their own knowledge
Predicting results	
Justifying the conclusion	
Suggesting alternative options to a problem	



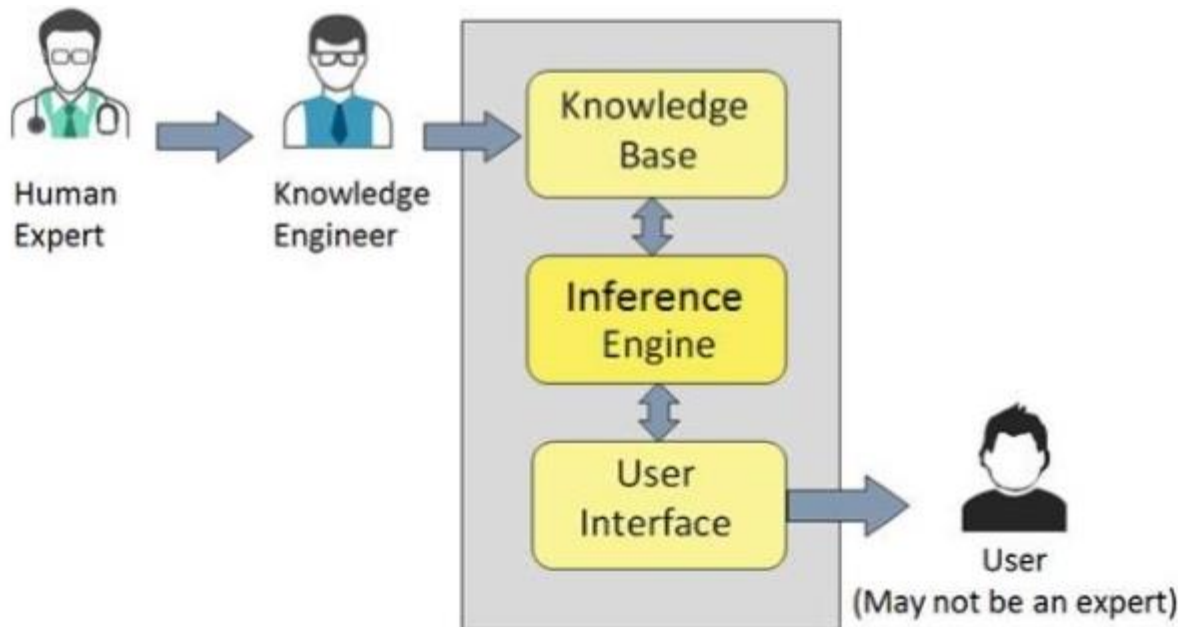
Expert Systems

Components of Expert System

The components of ES include –

- *Knowledge Base*
- *Inference Engine*
- *User Interface*

Let us see them one by one briefly



Expert Systems - Components

❑ Knowledge Base

- *It contains domain-specific and high-quality knowledge.*
- *Knowledge is required to exhibit intelligence. The success of any ES majorly depends upon the collection of highly accurate and precise knowledge.*

❑ What is Knowledge?

- *The data is collection of facts. The information is organized as data and facts about the task domain. **Data, information, and past experience** combined together are termed as knowledge.*

❑ Components of Knowledge Base

- ❑ *The knowledge base of an ES is a store of both, factual and heuristic knowledge.*

- ***Factual Knowledge*** —

It is the information widely accepted by the Knowledge Engineers and scholars in the task domain.

- ***Heuristic Knowledge*** —

It is about practice, accurate judgement, one's ability of evaluation, and guessing.

- ***Knowledge representation***

It is the method used to organize and formalize the knowledge in the knowledge base. It is in the form of IF-THEN-ELSE rules.



Expert Systems - Components

□ Knowledge Acquisition

- The success of any expert system majorly depends on the quality, completeness, and accuracy of the information stored in the knowledge base.
- The knowledge base is formed by readings from various experts, scholars, and the **Knowledge Engineers**. The knowledge engineer is a person with the qualities of empathy, quick learning, and case analyzing skills.
- He acquires information from subject expert by recording, interviewing, and observing him at work, etc. He then categorizes and organizes the information in a meaningful way, in the form of IF-THEN-ELSE rules, to be used by interference machine. The knowledge engineer also monitors the development of the ES.



Expert Systems - Components

□ Inference Engine

Use of efficient procedures and rules by the Inference Engine is essential in deducting a correct, flawless solution.

In case of knowledge-based ES, the Inference Engine acquires and manipulates the knowledge from the knowledge base to arrive at a particular solution.

- In case of rule based ES, it –

- *Applies rules repeatedly to the facts, which are obtained from earlier rule application.*
- *Adds new knowledge into the knowledge base if required.*
- *Resolves rules conflict when multiple rules are applicable to a particular case.*

To recommend a solution, the Inference Engine uses the following strategies –

- *Forward Chaining*
- *Backward Chaining*

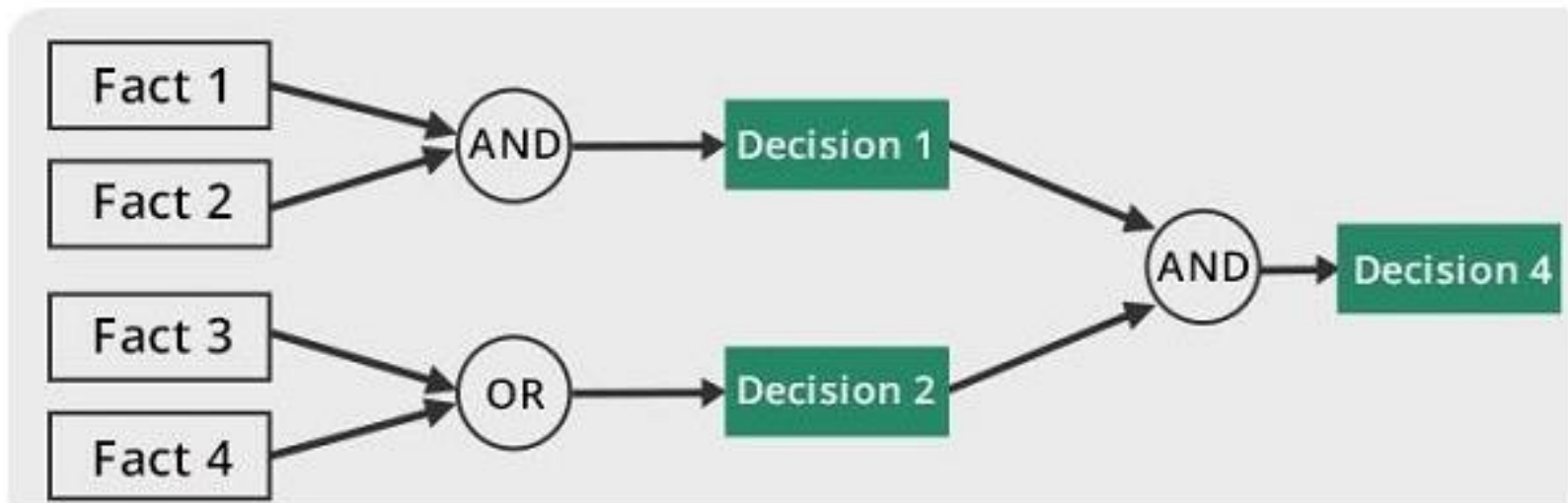


Expert Systems - Components

❑ Inference Engine

❑ *Forward Chaining*

- *It is a strategy of an expert system to answer the question, “What can happen next?”*
- *Here, the Inference Engine follows the chain of conditions and derivations and finally deduces the outcome. It considers all the facts and rules, and sorts them before concluding to a solution.*
- *This strategy is followed for working on conclusion, result, or effect. For example, prediction of share market status as an effect of changes in interest rates.*

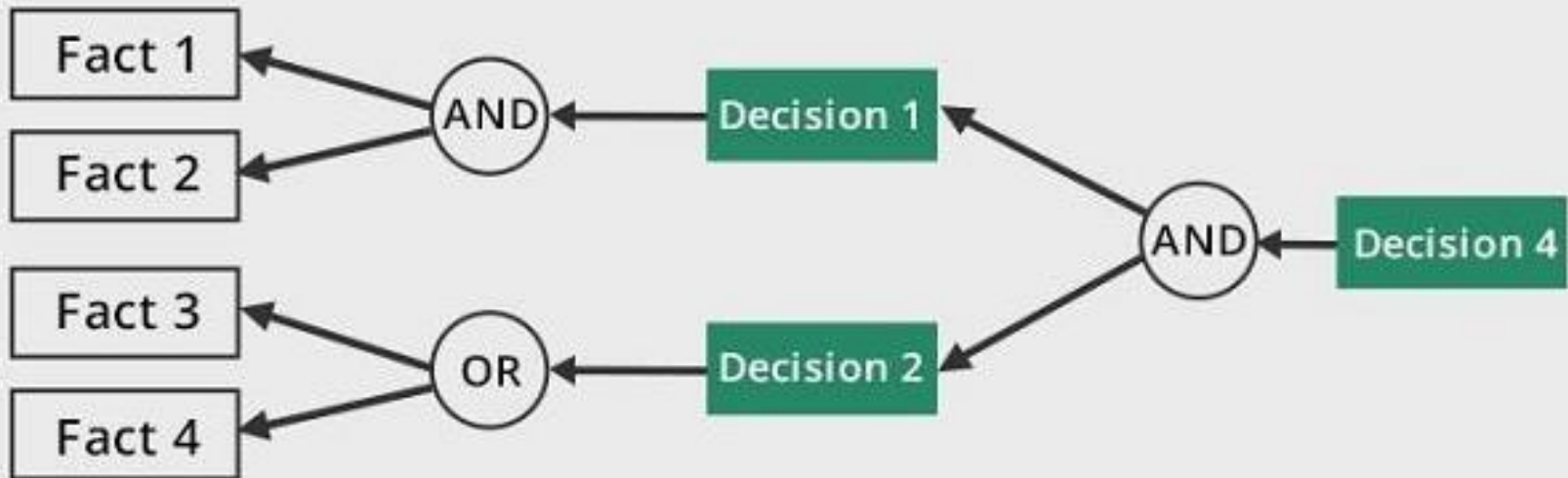


Expert Systems - Components

❑ Inference Engine

❑ Backward Chaining

- *With this strategy, an expert system finds out the answer to the question, “Why this happened?”*
- *On the basis of what has already happened, the Inference Engine tries to find out which conditions could have happened in the past for this result. This strategy is followed for finding out cause or reason. For example, diagnosis of blood cancer in humans.*



Expert Systems - Components

□ User Interface

- *User interface provides interaction between user of the ES and the ES itself. It is generally Natural Language Processing so as to be used by the user who is well-versed in the task domain. The user of the ES need not be necessarily an expert in Artificial Intelligence.*

It explains how the ES has arrived at a particular recommendation. The explanation may appear in the following forms –

- *Natural language displayed on screen.*
- *Verbal narrations in natural language.*
- *Listing of rule numbers displayed on the screen.*

The user interface makes it easy to trace the credibility of the deductions.

• Requirements of Efficient ES User Interface

- *It should help users to accomplish their goals in shortest possible way.*
- *It should be designed to work for user's existing or desired work practices.*
- *Its technology should be adaptable to user's requirements; not the other way round.*
- *It should make efficient use of user input.*



Expert Systems Limitations

- No technology can offer easy and complete solution.
- Large systems are costly, require significant development time, and computer resources.
- ESs have their limitations which include –

☐ *Limitations of the technology*

☐ *Difficult knowledge acquisition*

☐ *ES are difficult to maintain*

☐ *High development costs*



Benefits of Expert Systems

- ❑ **Availability** – They are easily available due to mass production of software.
- ❑ **Less Production Cost** – Production cost is reasonable. This makes them affordable.
- ❑ **Speed** – They offer great speed. They reduce the amount of work an individual puts in.
- ❑ **Less Error Rate** – Error rate is low as compared to human errors.
- ❑ **Reducing Risk** – They can work in the environment dangerous to humans.
- ❑ **Steady response** – They work steadily without getting motional, tensed or fatigued.



Applications of Expert System

Application	Description
Design Domain	Camera lens design, automobile design.
Medical Domain	Diagnosis Systems to deduce cause of disease from observed data, conduction medical operations on humans.
Monitoring Systems	Comparing data continuously with observed system or with prescribed behavior such as leakage monitoring in long petroleum pipeline.
Process Control Systems	Controlling a physical process based on monitoring.
Knowledge Domain	Finding out faults in vehicles, computers.
Finance/Commerce	Detection of possible fraud, suspicious transactions, stock market trading, Airline scheduling, cargo scheduling.



Assignment 3

- *Difference between Human and Machine Intelligence*
- *State the Advantages & Disadvantages Fuzzy Logic Systems*

