CS-208:Artificial Intelligence

Topic-20: Natural Language Processing &Expert System

Natural Language Processing

Natural Language Processing (NLP) refers to AI method of communicating with an intelligent system using a natural language such as English. 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 either *Speech* or *Written Text*

Two components of NLP

- **Natural Language Understanding (NLU)** involves mapping the given input in natural language into useful representations and analyzing different aspects of the language.
- **Natural Language Generation (NLG)** is the process of producing meaningful phrases and sentences in the form of natural language from some internal representation and involves
    - (i) Text planning: It includes retrieving the relevant content from knowledge base.
    - (ii) Sentence planning: It includes choosing required words, forming meaningful phrases, setting tone of the sentence and
    - (iii) Text Realization − It is mapping sentence plan into sentence structure.

Difficulties in NLU

The NLU is harder than NLG. 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.

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.

STEPS in NLP

Lexical Analysis: It involves identifying and analyzing the structure of words. Lexicon of a language means the collection of words and phrases in a language. Lexical analysis is dividing the whole chunk of text into paragraphs, sentences, and words.

Syntactic Analysis (Parsing): It involves analysis of words in the sentence for grammar and arranging words in a manner that shows the relationship among the words. The sentence such as “The school goes to boy” is rejected by English syntactic analyzer.

Semantic Analysis: It draws the exact meaning or the dictionary meaning from the text. The text is checked for meaningfulness. It is done by mapping syntactic structures and objects in the task domain. The semantic analyzer disregards sentence such as “hot ice-cream”.

Discourse Integration: The meaning of any sentence depends upon the meaning of the sentence just before it. In addition, it also brings about the meaning of immediately succeeding sentence.

Pragmatic Analysis: During this, what was said is re-interpreted on what it actually meant. It involves deriving those aspects of language which require real world knowledge.

Expert systems

The expert systems are the computer programs developed to solve complex problems in a particular domain, at the level of extra-ordinary human intelligence and expertise. Expert system can solve problem that typically requires an expert knowledge.

Like human experts, it should provide two basic services

- The system should be able to provide realistic solution from relatively incomplete data.
- The system should be able to explain how and why it arrived at a particular solution.

Capabilities of Expert Systems

- Advising
- Instructing and assisting human in decision making
- Demonstrating
- Deriving a solution
- Diagnosing
- Explaining
- Interpreting input
- Predicting results
- Justifying the conclusion
- Suggesting alternative options to a problem

Incapability of Expert Systems

- Substituting human decision makers
- Possessing human capabilities
- Producing accurate output for inadequate knowledge base
- Refining their own knowledge

Components of Expert Systems

- Knowledge Base
- Interface Engine
- User Interface

Knowledge Base

It contains domain-specific and high-quality knowledge. Knowledge is required to exhibit intelligence. The success of any ES mainly depends upon the collection of highly accurate and precise knowledge. Knowledge 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 is the information widely accepted by the Knowledge Engineers and scholars in the task domain. Heuristic Knowledge is about practice, accurate judgment, one's ability of evaluation, and guessing.
- **Knowledge Acquisition***:* The success of any expert system mainly 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.

Interface Engine

Use of efficient procedures and rules by the Interface Engine is essential in deducting a correct, flawless solution. In case of knowledge-based ES, the Interface 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 and resolves rules conflict when multiple rules are applicable to a particular case. The Interface Engine Strategies are:

- **Forward Chaining:** It is a strategy of an expert system to answer the question, “What can happen next?” Here, the interface 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.
- **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 interface 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.

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 form of 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 has following forms:
  - should be adaptable to user's requirements; not the other way round.
  - It should make efficient use of user input.

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.