Unit-6 : Application of AI

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* Expert systems

An expert system is a computer program that uses AI technologies to solve complex problems & to provide decision-making ability like a human agent. It performs this by extracting knowledge from its knowledge base using the reasoning and inference rules according to the user queries

The systems help in decision making for complex problems by using both facts & heuristics like a human expert. Its performance is based on the expert's knowledge stored in it's knowledge base. They are used by most of the larger or medium scaled organizations as a major tool for improving productivity & quality.
Ex: Suggestion of spelling errors while doing Google search.

* Components of Expert system

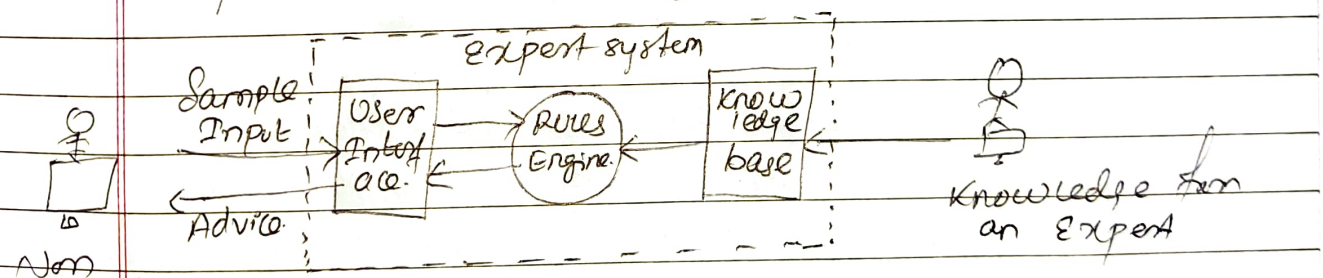

fig: Block diagram of E.S.

The components of expert system are

- User Interface
- Inference Engine (Rules Engine)
- Knowledge base.
- Working memory.

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1.) User Interface.

It is the component of expert system that communicates with the user. The communication performed by the user is bidirectional. At the simplest level, we must be able to describe our problem to the expert system, & the system must be able to respond with its recommendations. The UI takes queries as an input, & passes it to the inference engine. After getting response from inference engine, it displays the output to the user.

2) Inference Engine (Rules Engine)

It is known as the brain of the expert system. Simply, having a knowledge base doesn't make an expert system intelligent, it must have another component that directs the implementation of knowledge. That component is called I E. It applies inference rules to the knowledge base to derive a conclusion & helps in deriving an error-free solution of queries asked by the user.

3). Knowledge Base.

It is the component of ES that contains the system's knowledge. It stores knowledge acquired from different experts of the particular domain. The more the knowledge base, the more precise will be the expert system. It is similar to the database that contains information & rules of a particular domain or subject. It is so critical to the way most expert systems are constructed that they are also popularly known as knowledge-based systems.

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b) Working Memory

It contains the data that is received from the user during the expert system session. The elements of the WM reflect the current state of the world. It typically contains information about the particular instance of the problem being addressed. Ex. In a TV troubleshooting expert system, the WM could contain the details of the particular TV being looked at.

* Development of Expert Systems

An expert system typically is developed & refined over a period of several years. We can divide its development into five distinct stages:-

Note: In practice it may not be possible to break down the development but this is just for some insight.

1) Identification

It is the process of determining the characteristics of the problems. Before we can begin to develop an expert system, it is important that we describe, with as much precision as possible, the problem that the system is intended to solve. We must determine the exact nature of the problem & state the precise goals that indicate how exactly we expect system to contribute to the solution.

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2) Conceptualization

It is the process of finding concepts to represent the knowledge. It involves analyzing the problem further to ensure that its specifics, as well as its generalities are well understood. Here, the problem is divided into a series of sub-problems & the knowledge engineer creates a diagram to represent the relationship among the pieces of each sub-problem & the relationship among the various sub-problems.

3) Formalization

It is the process of designing structures to organize the knowledge. During the 1st two process (stages), the focus is entirely on understanding the problem. Now, during the formalization stage, the problem is connected to its proposed solution, an expert system, by analyzing the relationships depicted in conceptualization (stage). It is important that the knowledge engineer be familiar with various techniques of knowledge representation and heuristic search used in expert systems.

4) Implementation.

It is the process of formulating the rules that embody the knowledge. Here, the formalized concepts are programmed onto the computer that has been chosen for the system development using the predetermined tools & techniques. Theoretically, if the methods of previous stage have been followed with diligence & care the implementation of prototype should be as much an art as it is a science because following the rules doesn't guarantee that the system will work for the first time.

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5 Testing

It is the process of validating the rules and the implemented expert system. It provides opportunities to identify the weakness in the structure & implementation of the system and to make the appropriate decisions. Depending upon the types of problems encountered, the testing procedure may indicate how the system works.

* Features of an Expert system

- Able to respond to simple questions.
- Able to learn new knowledge
- Can be easily modified
- Can be adaptive & flexible.
- Able to explain its advice
- Goal oriented

* Natural Language Processing.

Natural Language Processing (NLP) is a branch of AI that enables machines to understand the human language. Its goal is to build systems that can make sense of text and automatically perform tasks like translation, spell check, or topic classification. It involves converting spoken or written language into a form which can be processed by computers & vice-versa.

Language → [computer] → Language.

← understanding

← Generation.

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The most popular example of NLP in action are virtual assistants, like Google Assist, Siri and Alexa. Another well-known application is Chatbots. NLP is composed of two parts: NLU (Natural Language Understanding) and NLG (Natural language Generation)

i) Natural Language Understanding (NLU):

It is a subset of NLP, which uses syntactic & semantic analysis of text and speech to determine the meaning of a sentence. It also establishes a data structure which specifies the relationships between words & phrases. Developing programs that understand a natural language is a difficult problem. Natural languages are large.

Spoken/typed Sentence → [Natural language Understanding] → The sentences meanings.

ii) Natural Language Generation (NLG):

It is another subset of Natural language processing. It is the process of producing meaningful phrases & sentences in the form of natural language from a machine representation system such as knowledge base or logical form. It produces a human language text response based on some data input. This text can also be converted into a speech through text-to-speech service. In a sense, one can say that, NLG system is like a translator that converts a computer based representation into a natural language representation.

formal representation → [Natural language Generation] → English Expression.

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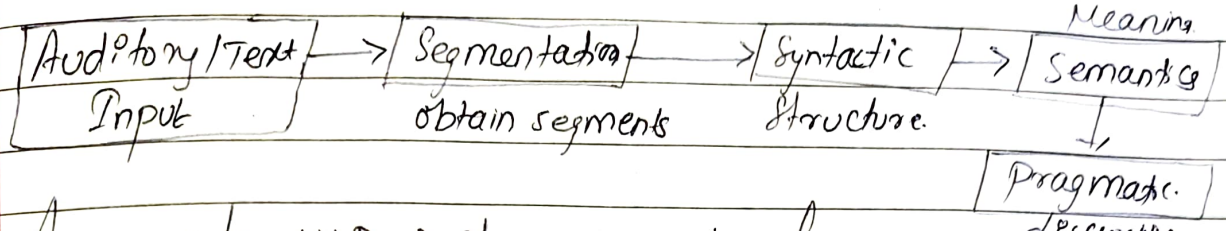
* Steps of Natural Language Processing.

The Steps of NLP are:



A complete NLP system consists of program that performs all these functions.

- Input / source → The input of a NLP system can be written text or speech. Quality of input decides the possible errors in language processing that is high quality input leads to correct language understanding.

- ~~Segmentation~~ 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. It involves.

Segmentation → It is the process of dividing the whole chunk of text into paragraphs, sentences & words.

Morphological analysis → It studies the structure of words. It identifies how a word is produced through a use of morphemes. A morpheme is a basic unit of the English language.

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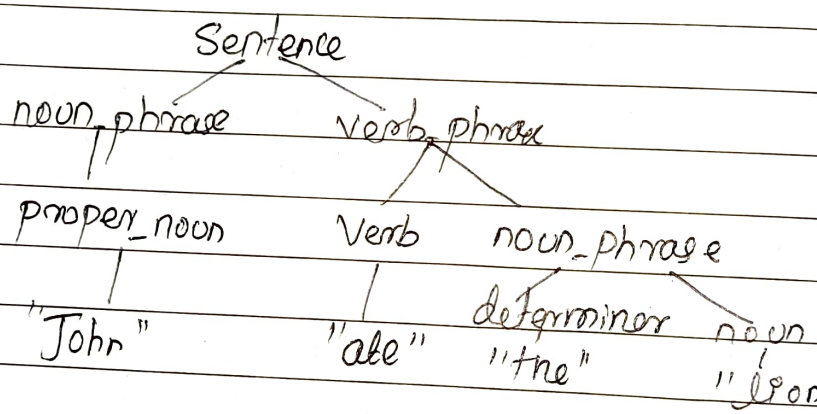
- **Syntactic analysis (parsing)**

It involves analysis of words in the sentence for grammar and arranging words in a manner that shows the relationship among words. The sentence such as "The School goes to boy" is rejected by English Syntactic analyzer. Here, it takes an input sentence & produces a representation of its grammatical structure. It uses a parse tree that illustrates the syntactic structure of the sentence.

Ex: John ate the lion.



- **Semantic analysis**

It draws the exact meaning of 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". This involves the following tasks:-

→ Word Sense determination

→ Sentence level analysis

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Word sense → Words have different meanings in different contexts

Ex: Sushmita had a bat in her office.
bat = "a baseball thing"
bat = "a flying mammal"

Sentence level analysis → Once the words are understood the sentence must be assigned some meaning.

Ex: I saw an astronomer with a telescope.

Pragmatic Analysis

During this what was said is re-interpreted on what it actually meant. It involves deriving those aspects of language which require the real world knowledge. It basically deals with using and understanding sentences in different situations and how the interpretation of the sentence is affected.

Ex: When is the next flight to Sydney?
Does it have any seat left?

Here, "it" refers to a particular flight to Sydney, not Sydney itself.

Machine Translation

It is the task of automatically converting one natural language into another, preserving the meaning of the input text, and producing fluent text in the output language. Ex: Google translator.

It is widely used software by Google to translate human languages. It can also be used in speech recognition in different languages.

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The translation quality of the machine translation can be improved by pre-editing & post-editing. Pre-editing means adjusting the input by making prefixes, suffixes, clause boundaries etc. Post-editing means conforming the vocabulary to the output of the MT.

Types of machine translation

i) Rule based machine translation (RBMT).

It translates on the basis of grammatical rules. It conducts a grammatical analysis of the source language and the target language to generated the translated sentence. It can translate the source language directly to the target language

ii) Statistical Machine translation (SMT)

It offers good solution to ambiguity problem when a word in one language can be translated in more than one way to another language. SMT are robust & work well even if there are errors & presence of new data. It aims to determine the correspondence between a word from a source language & a word from targeted language

iii) Hybrid Machine Translation (HMT)

It is the blend of RBMT & SMT. It holds a translation memory, making it far more effective in terms of quality. However, even HMT has its drawbacks, the main drawback is need for extensive editing. Human translations will be required.

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(vi) Neural machine translation (NMT)

It depends on neural network models (based on human brain) to develop statistical models for the purpose of translation. The primary benefit of NMT is that it provides a single system that can be trained to decode the source & target text. NMT is an end-to-end translation system. It doesn't depend on specialized systems that are common to other machine translation systems, especially SMT.

* Importance of Natural Language Processing.

→ It helps to make communication easier between the user and computer system
→ It helps to understand large social data available in the internet
→ It improves the efficiency & accuracy of documentation & identify the most relevant information from large database

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* Machine vision concepts:

Machine vision is the ability of a computer to "see". A machine vision system employs one or more video cameras, analog-to-digital conversion and digital signal processing. The resulting data goes to a computer or robot controller. It uses different components to visually analyze an operation or activity.

The important specifications in any vision system are the sensitivity & the resolution. Sensitivity is the ability of a machine to see in dim light, or to detect weak impulses at visible wavelengths. Resolution is the extent to which a machine can differentiate between objects. Machine vision systems have two primary hardware elements: the camera, which serves as the eye of the system & a computer video analyzer.

Components:

- One or more digital or analog cameras with suitable optics for acquiring images such as lenses to focus the desired field of view, image sensor which is responsible for analyzing captured images or presence of defects
- Input/Output hardware eg Digital I/O) or Communication links (e.g. network connection or RS-232) to report result.

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- A synchronizing sensor for part detection to trigger image acquisition & processing & some form of actuators to sort, route or reject defective parts.
- A program to process images & detect relevant features

Applications:

-> Electric component analysis
-> Signature identification
-> Optical Character recognition
-> Handwriting recognition
-> Object recognition
-> Pattern recognition
-> Face recognition
-> Medical Image analysis

Robotics

Robotics is a branch of engineering & science that deals with the design, construction, operation, and use of robots, as well as computer systems for their control, sensory feedback, and information processing.

The advantage of using robots is that they can get information that a human can't. They can perform tasks without any mistake & have great efficiency & as well as fast. It's disadvantage is that it takes over human jobs & need high maintenance

Robotic hardware.

A robot hardware generally consists of 5 basic components.

i) Controller

Every robot is connected to a computer controller, which regulates the components of arm & keeps them working together. Almost all robots are pre-programmed but in future controllers with AI would allow robots to think on their own, even program themselves

ii) Arm

The arm is the part of the robot that positions the end-effectors & sensors to do their pre-programmed business. Many are built to resemble human arms & work like human arms

iii) Drive:

The links (the sections between the joints) are moved into their desired position by the drive. Typically a drive is powered by hydraulic pressure or electricity

iv) End-Effector.

The end effector could be thought of as the "hand" on the end of robotic arm. There are many possible end-effectors like gripper, vacuum pump, welder, spray gun etc. that help it to do its job

v) Sensor: The Sensors give the robot controller information about its surroundings & lets it to know the exact position of the arm, or the state of the world around it. Robot sensors can detect infrared radiation to "see" in the dark.

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Robotic perceptions

Robotic perception is related to many applications in robotics where sensory data & artificial intelligence/ machine learning techniques are involved. Ex:- object detection, environment representation, scene understanding, activity recognition etc.

It contains the algorithms & techniques that empower robots to learn from sensory data & based on learned models, to react & take decisions accordingly. Robotic perception systems are evolving in a way that new applications & tasks are becoming a reality.

Questions asked from this Chapter

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Q What is expert system? How it works? Mention the roles of inference engine in it. (2078 - 5 marks)

Q How semantic and Pragmatic analysis are done in natural language processing? (2078 - 5 marks)

Q How the concept of machine vision are used in Robotics to configure Sensors of robots? (2074 - 5 marks)

Q. How Syntactic & semantic analysis are used in Robotics to configure Sensors of Robots? (2076 - 5 marks)

Q. Differentiate between Natural language understanding & natural language generation. Why do we have to study NLP? Explain (2069 - 6 marks)

Q Define NLP. Explain different issues involved in it. (2067 - 5 marks) (2073 - 5 marks)

Q Explain the steps of NLP (2071 - 5 marks)

Q. How can you construct expert system? Explain Knowledge engineering with a block diagram. (2067 - 5 marks) (2075 - 5 marks)