Expert System

An expert system is a set of program that manipulate encoded knowledge to solve problem in a specialized domain that normally requires human expertise.

- An expert system's knowledge is obtained from expert sources and code in a form suitable for the system to use in its inference process.
- An expert system is an "intelligent" program that solves problem in a narrow problem area by using high-quality, specific knowledge rather than an algorithm.
- Expert systems are used by most of the larger or medium sized organization as a major tool for improving productivity and quality.

Components of expert system

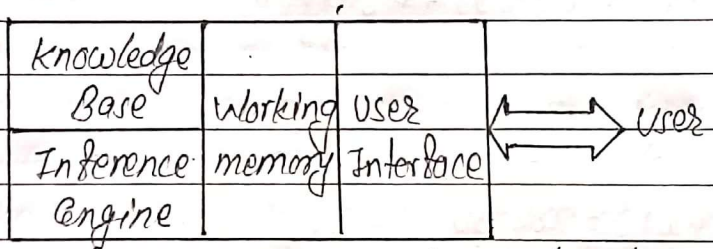


fig: Block diagram of Expert system

1. Knowledge Base:

The component of an expert system that contains the system's knowledge is called its knowledge base. It contains the rules, of in IF-THEN rule.

- The KB contains the knowledge necessary for understanding, formulating & solving problems.
- The KB of an expert system contains both declarative knowledge and procedural knowledge.

2. Inference Engine:

It carries out the reasoning by interplaying the information or facts obtained from the user with the knowledge stored in knowledge base whereby the expert system reaches a solution.

3. Working memory:

It is a data structure which stores information about a specific problem.

4. User interface:

The component of expert system that provides communication between users and expert system is called user interface. The communication performed by user interface is bidirectional. We must be able to describe our problem to the expert system, and the system must be able to respond with its recommendations.

Stages of Expert system development

1. Identification
   - Determining the characteristics of the problem.

2. Conceptualization
   - finding concepts to represent the knowledge.

3. Formalization
   - Designing knowledge structure using knowledge representation techniques.

4. Implementation
   - creating prototypes of expert system.

5. Testing
   - validating the implemented expert system.

Features of an expert system

1. It is useful program / software.
2. It should help users to accomplish their goals in shortest possible way.
3. It should be educational when appropriate.
4. It should be able to respond to simple questions.
5. It should be able to learn new knowledge.
6. It should be easily modified.
7. It should be adaptive and flexible.
8. It should be able to explain its advice.
9. It should be goal oriented.

Advantages of expert system

→ It provides consistent answer for repetitive decisions, processes and tasks.
→ It holds and maintain levels of information.
→ It can tackle very complex problems that are difficult for human expert to solve.
→ It improves the decision quality.
→ It reduces the cost of consulting experts for problem solving.
→ It provides quick and efficient solutions to problem in narrow area of specialization.
→ It can discover new knowledge.
→ It can work steadily without getting emotional, tensed or fatigued.

Disadvantages

→ It lacks common sense needed in decision making.
→ The knowledge base may not be complete.
→ Expensive to build & maintain.
→ Takes long time to develop.
→ Errors in the knowledge base can lead to wrong decisions.
→ Unable to make creative response in an extraordinary situations.

Main players in the Expert system development team

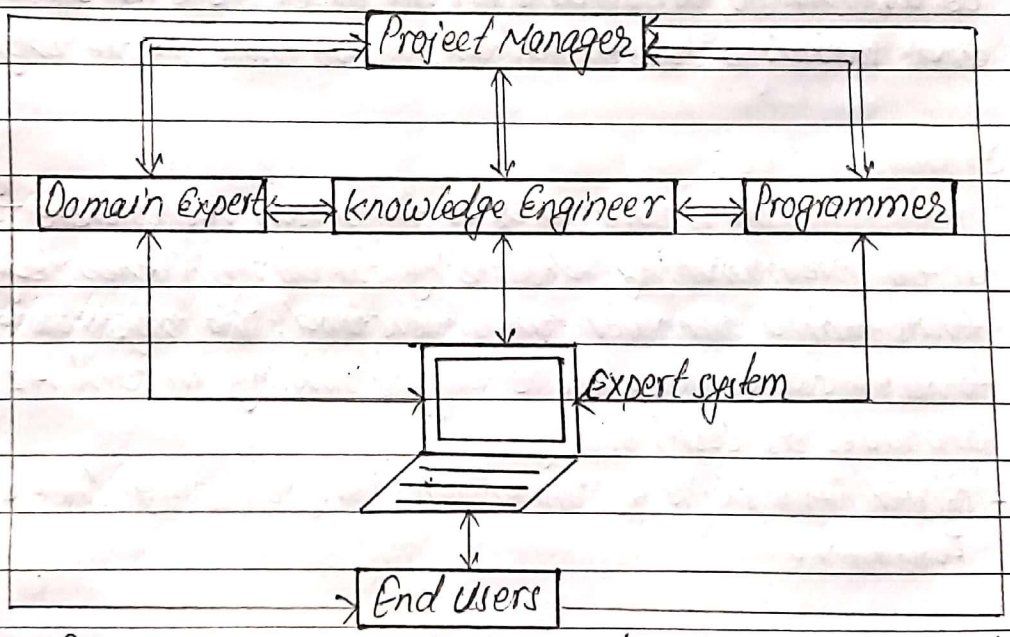


Fig: The main players of the expert system development team.

1. Knowledge Engineer:

The knowledge engineer is someone who is capable of designing, building and testing an expert system.
- knowledge Engineer interviews the domain expert to find out how a problem is solved.

- The knowledge engineer establishes what reasoning methods the expert uses to handle facts and rules and decides how to represent them in the expert system.
- The knowledge engineer then chooses some development software, or an expert system shell or looks at programming languages for encoding the knowledge.

2. Domain Expert:

The domain expert is a knowledgeable and skilled person capable of solving problems in a specific area or domain. This person has the greatest expertise in a given domain. This expertise is to be captured in the expert system. Therefore the expert must be able to communicate his/her knowledge, be willing to participate in the expert system development and commit a substantial amount of time to the project.

3. Programmer:

The programmer is the person responsible for the actual programming, describing the domain knowledge in terms that a computer can understand. The programmer needs to have skills in symbolic programming in such AI languages as LISP, prolog.
- should have skills in conventional programming like C, pascal, FORTRAN.

4. Project Manager:

The project manager is the leader of the expert system development team. He/she makes sure that all deliverables and milestones are met, interacts with the expert, knowledge engineer, programmer and end user.

5. End-user:

The end-user is a person who uses the expert system when it is developed. The user must not only be confident in the expert system performance but also feel comfortable using it.

Ans:

Q: Explain knowledge engineering with a block diagram.

Ans:

Knowledge engineering is a field of AI that creates rules to apply data in order to imitate the thought process of human expert. Knowledge engineering attempts to take challenges and solve problems that would usually require a high level of human expertise to solve.

In general, knowledge engineering is the process of understanding and representing a human knowledge in a computer as a program. knowledge engineering includes:

i) knowledge acquisition
ii) knowledge representation
iii) knowledge validation
iv) Inferencing
v) Explanation and Justification

The interaction between these stages and source of knowledge is shown in the figure below:

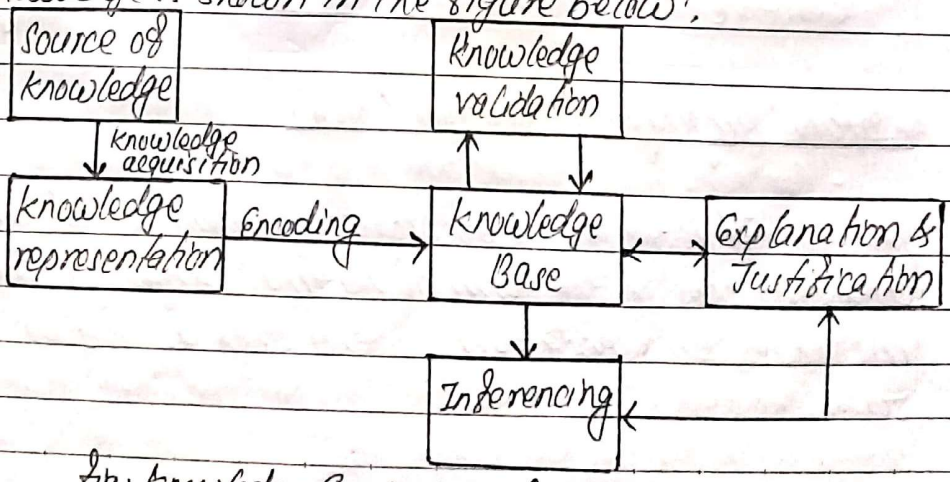
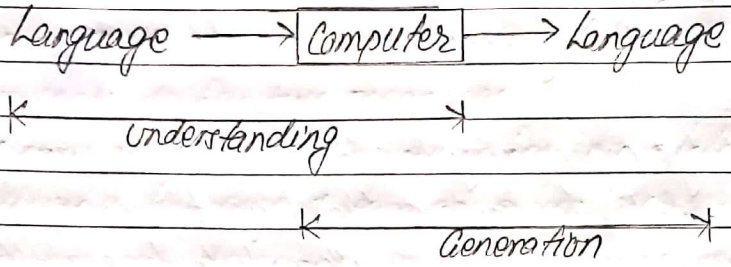


Fig: Knowledge Engineering Process.

Natural Language Processing (NLP)

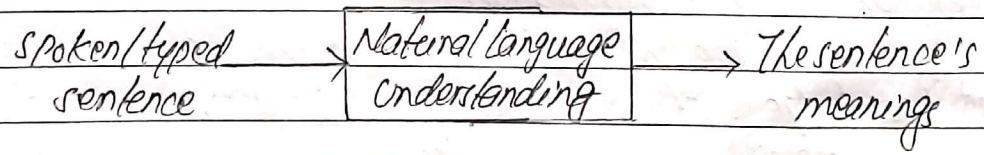
Natural language processing is a technology which involves converting spoken or written human language into a form which can be processed by computers; and vice-versa.



NLP is composed of two parts: NLU (Natural Language understanding) and NLG (Natural Language Generation)

Natural Language Understanding (NLU)

It is the process of mapping the given inputs in natural language into useful representation and 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 a machine representation system such as KB or logical form.

Formal representation → Natural language Generation → English Expression

NLU vs NLG

NLU	NLG
1. NLU is taking some spoken / typed sentence and working out what it means.	1. NLG is taking some formal representation of what you want to say & working out a way to express it in a natural language.
2. In NLU the system needs to disambiguate the input sentence to produce the machine representation language	2. In NLG the system needs to make decisions about how to put a concept into words.
3. Different levels of analysis required: morpological analysis, syntactic analysis, semantic analysis, discourse analysis.	3. Different levels of synthesis required: deep learning (what to say), syntactic generation.
4. NLU is most harder than NLG.	4. NLG is less harder than NLU.

NLP Problems

1. A single word may have multiple meaning.
   E.g. bank = financial institution
   bank = edge of river

2. One sentence may have multiple meaning.
   E.g. "I saw an astronomer with a telescope".
   This sentence has two meanings
   - I saw an astronomer who is having a telescope.
   - Using a telescope I saw an astronomer.

3. There are lots of ways to say the same things.
   E.g. - Ram was born on may 12.
   - Ram's birthday is may 12.

4. Sentence and phrases might have hidden meanings.
   E.g. "out of sight, out of mind" → "Invisible idiot".

5. Use of gramatically incorrect sentence.
   E.g. He rice ets. (syntax issue)

Levels of knowledge used in language Understanding

1. Phonology:
   - Concerns how words are related to the sounds that realize them. A phoneme is the smallest unit of the sound.

2. Morphology:
   - Concerns how words are constructed from more basic meaning units called morphemes. A morpheme is the

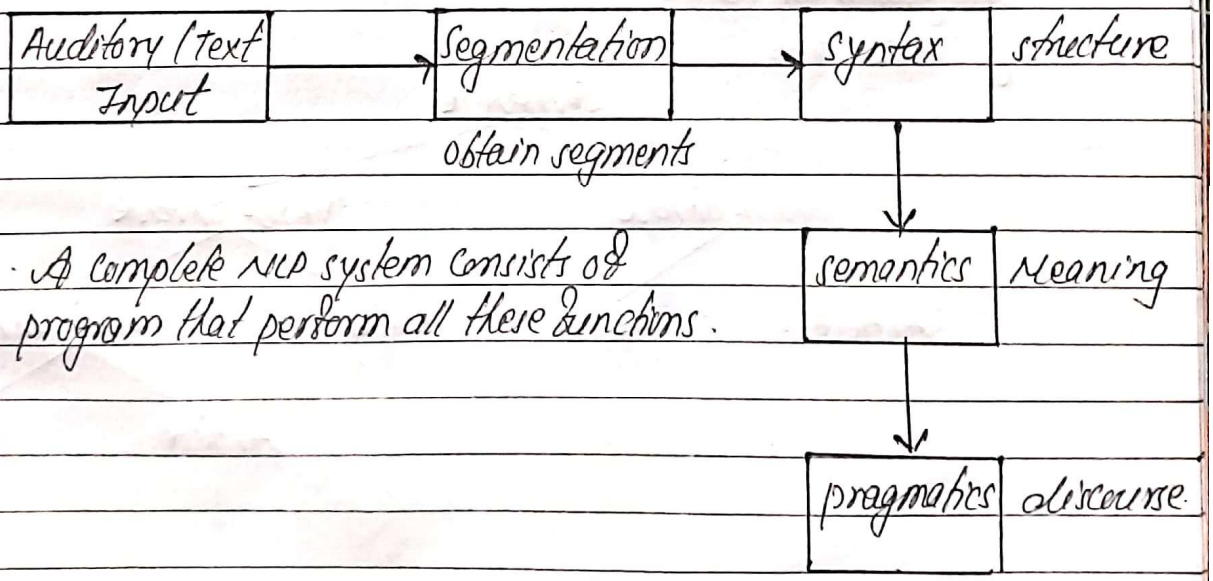
smallest unit of meaning. Eg. friend + ly = friendly

3. Syntax:
- Concerns how words are put together to form grammatically correct sentences in the language.

4. Semantic:
- Concerns with the meaning of words and how to combine words into meaningful phrases & sentences.

5. Pragmatic:
- Concerns how sentences are used in different situations and how use affects the interpretation of the sentence.

NLP steps / processes | Parameters in NLP



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

1) 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.

2) Segmentation:

The text inputs are divided in segments (chunks) and the meaning of individual segments are analyzed.

3) Syntactic Analysis:

Syntactic analysis takes an input sentence and produces a representation of its grammatical structure. A grammar describes the valid parts of speech of a language and how to combine them into phrases.

A computer grammar specifies which sentences are in a language and their parse tree. A parse tree is a hierarchical structure that shows how the grammar applies to the input. Each level of the tree corresponds to the application of one grammar rule.

Eg. Parse tree

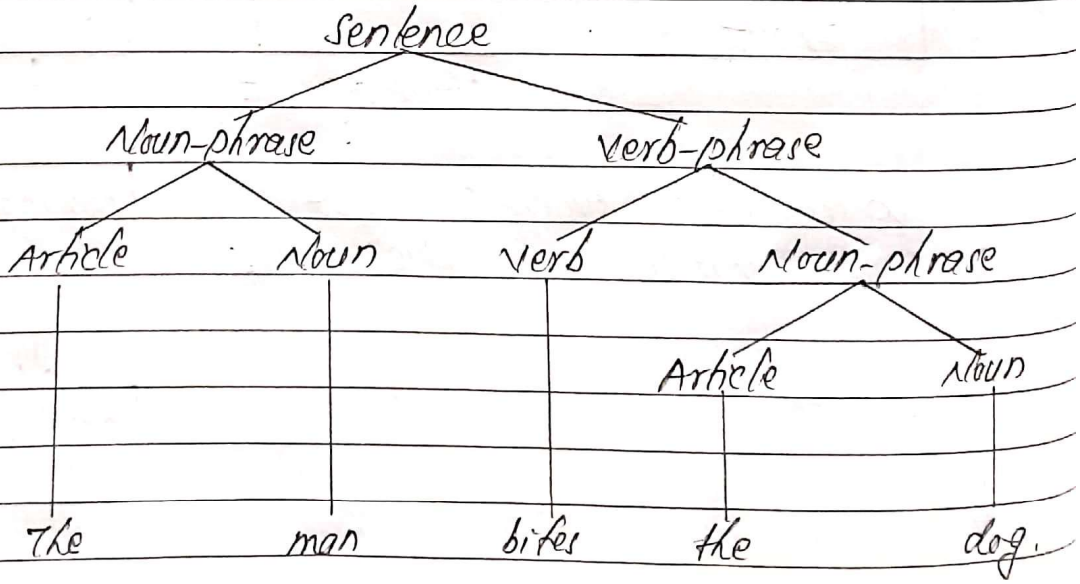


Fig: Parse tree for the sentence "The man bites the dog".

4) Semantic Analysis:

Semantic analysis is a process of converting the syntactic representations into a meaning representation. This involves the following tasks:

- Word sense determination
- sentence level analysis

Word sense:

Words have different meanings in different contexts.

E.g. Mary 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.

E.g. I saw an astronomer with a telescope.

5) Pragmatic Analysis:

It deals with using and understanding sentences in different situations and how the interpretation of the sentence is affected.

- The main focus is on what was said is reinterpreted on what it actually means.

Applications of NLP

1. Voice recognition software
2. Text-to-speech synthesizers
3. Grammar and style checkers
4. Machine translation system

Importance of NLP

→ NLP helps to make communication & handling easy betⁿ the user & computer system.
→ Helps to understand large social data available in the internet.
→ Improve the efficiency and accuracy of documentation and identify the most pertient information from large database.

Machine vision

→ 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.

→ The machine vision system use video cameras, robots or other devices, and computers to visually analyze an operation or activity.

→ Two important specifications in any vision system are the sensitivity and the resolution. Sensitivity is the ability of a machine to see in dim light, or to detect weak impulses at invisible 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, and a computer video analyser.

A typical machine vision system will consists of the following components:

- One or more digital or analogue cameras with suitable optics for acquiring images, such as lenses to focus the desired field of view onto the image sensor and suitable, often very specialized, light sources.
- Input/output hardware (e.g. digital I/O) or communication links (e.g. network connection or RS-232) to report result.
- A synchronizing sensor for part detection to trigger image acquisition and processing and some form of actuators to sort, route or reject defective parts.
- A program to process images and detect relevant features.

Some Questions:

1. What are constraint satisfaction problems? Justify how N-queen problem is a constraint satisfaction problem?
2. Why searching is needed in AI? Show how iterative Deepening search works?
3. What is Bayesian network? Explain how Bayesian network represent and inference the uncertain knowledge.
4. Differentiate between inference and reasoning. Why probabilistic reasoning is important in AI? Explain with example.
5. What is meant by complete and soundness property of inference algorithm?
6. What is script? How knowledge is represented using scripts? Mention components of a script.
7. How can you represent knowledge using conceptual dependency? Illustrate with an example.
8. How can you evaluate the performance of search algorithms? Explain Hill climbing search with example.
9. Why Hill climbing search is called local search? Explain the problems of Hill climbing search.
10. What does it mean to train a neural network? How perceptron learning can be used to train a neural network?
11. Explain how Backpropagation algorithm can be used to train a neural network? Describe with example.
12. How Hebbian algorithm can be used to train neural network? Illustrate with an example.
13. How generalization and specialization tree is constructed in candidate elimination algorithm during learning by examples?
14. What is local maxima problem in hill climbing search? How Simulated annealing handles the problem of local maxima in hill climbing search?
15. How transformational analogy differ derivational analogy? Discuss how the concepts of retrieve, reuse, revise and retain are used in learning by analogy?
16. Define learning. Why learning framework is required? Explain about learning framework with suitable block diagram and examples.
17. Why disjunctive normal form is required? Explain all the steps with examples.
18. Why conjuctive normal form is required? Explain all the steps with examples.
19. What is Bayes' theorem? Explain its application.
20. Explain the advantages and disadvantages of an expert system. Draw the block diagram of expert system and explain its components.
21. How can you construct expert system? Explain knowledge engineering with a block diagram.
22. Describe the role of domain expert, Knowledge engineer and programmer in SDLC of expert system. Explain the features of expert system.
23. What is machine learning? Explain the learning from Analogy and Instance based learning.
24. Explain the different steps involved in the natural language processing (NLP) with block diagram.
25. What is Natural Language Understanding? What are component forms of knowledge needed for an understanding of natural languages?
26. Explain the different issues involved in the natural language processing.
27. Differentiate between natural language understanding (NLU) and natural language generation (NLG).
28. What do you mean by machine vision? Discuss the components of a machine vision system.