Expert System and Natural Language Processing

Unit 9.4

Introduction

An Expert System is a collection of programmes or Computer Software that solves problems in the domain of interest.

It is called system because it consists of both problem solving component and a support component.

The process of building Expert System is called knowledge engineering and is done by knowledge Engineer

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

A computer system that simulates the decision- making process of a human expert in a specific domain.

An expert system’s knowledge is obtained from expert sources and coded in a form suitable for the system to use in its inference or reasoning processes. The expert knowledge must be obtained from specialists or other sources of expertise, such as texts, journals, articles and data bases.

An expert system is an “intelligent” program that solves problems in a narrow problem area by using high-quality, specific knowledge rather than an algorithm.

Expert systems provide the following important features:

Facility for non-expert personnel to solve problems that require some expertise

Speedy solution

Reliable solution

Cost reduction

Power to manage without human experts

Wider areas of knowledge

Use of expert system is especially recommended when

Human experts are difficult to find

Human experts are expensive

Knowledge improvement is important

The available information is poor, partial, incomplete

Problems are incompletely defined There is lack of knowledge among all those who need it The problem is rapidly changing legal rules and codes

Block Diagram

There is currently no such thing as "standard" expert system. Because a variety of techniques are used to create expert systems, they differ as widely as the programmers who develop them and the problems they are designed to solve. However, the principal components of most expert systems are **knowledge base, an inference engine, and a user interface,** as illustrated in the figure.

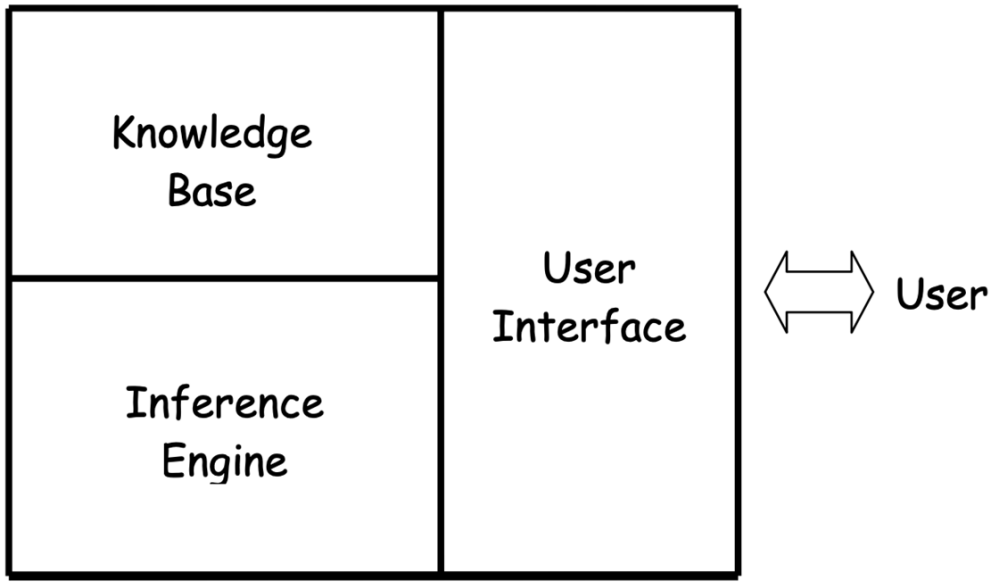


Fig: Block Diagram of expert system

1. Knowledge Base

The component of an expert system that contains the system's knowledge is called its knowledge base. This element of the system is so critical to the way most expert systems are constructed that they are also popularly known as *knowledge-based systems*

A knowledge base contains both declarative knowledge (facts about objects, events and situations) and procedural knowledge (information about courses of Depending on the form of knowledge representation chosen, the two

knowledge may be separate or integrated. Although many knowledge representation techniques have been used in expert systems, the most prevalent form of knowledge representation currently used in expert systems is the *rule-based production* system approach.

To improve the performance of an expert system, we should supply the system with some knowledge about the knowledge it posses, or in other words, meta-knowledge.

2. Inference Engine

Simply having access to a great deal of knowledge does not make you an expert; you also must know how and when to apply the appropriate knowledge.

Similarly, just having a knowledge base does not make an expert system intelligent.

The system must have another component that directs the implementation of the knowledge. That element of the system is known variously as the *control structure*, the *rule interpreter*, or the *inference engine*.

The inference engine decides which heuristic search techniques are used to determine how the rules in the knowledge base are to be applied to the problem.

In effect, an inference engine “runs” an expert system, determining which rules are to be invoked, accessing the appropriate rules in the knowledge base, executing the rules , and determining when an acceptable solution has been found.

3. User Interface

The component of an expert system that communicates with the user is known as the *user interface*.

The communication performed by a user interface is bidirectional.

At the simplest level, we must be able to describe our problem to the expert system, and the system must be able to respond with its recommendations.

We may want to ask the system to explain its “reasoning”, or the system may request additional information about the problem from us.

Beside these three components, there is a Working Memory - a data structure which stores information about a specific run. It holds current facts and knowledge.

Stages of expert system development

Although great strides have been made in expediting the process of developing an expert system, it often remains an extremely time consuming task.

It may be possible for one or two people to develop a small expert system in a few months; however the development of a sophisticated system may require a team of several people working together for more than a year.

An expert system typically is developed and refined over a period of several years.

We can divide the process of expert system development into five distinct stages.

In practice, it may not be possible to break down the expert system development cycle precisely.

However, an examination of these five stages may serve to provide us with some insight into the ways in which expert systems are developed.

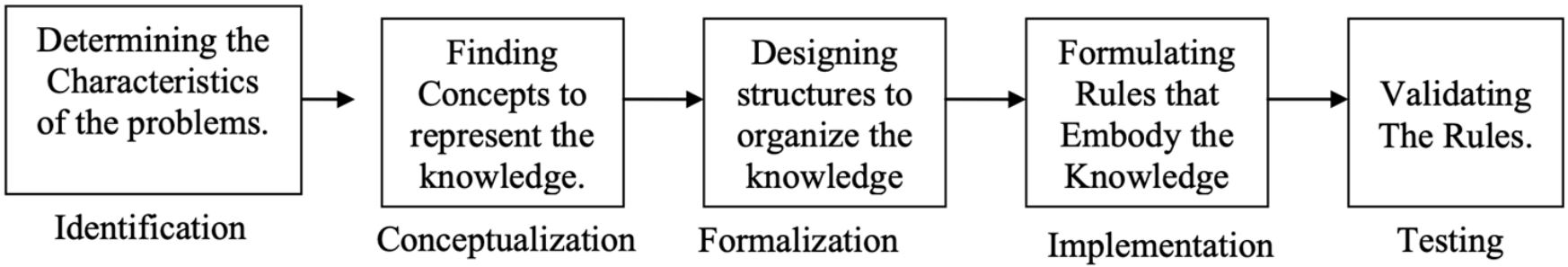


Fig: Different phases of expert system development

Identification:

Beside 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.

It is not enough simply to feel that the system would be helpful in certain situation; we must determine the exact nature of the problem and state the precise goals that indicate exactly how we expect the expert system to contribute to the solution.

Conceptualization:

Once we have formally identified the problem that an expert system is to solve, the next stage involves analyzing the problem further to ensure that its specifics, as well as it generalities, are understood.

In the conceptualization stage the knowledge engineer frequently creates a diagram of the problem to depict graphically the relationships between the objects and processes in the problem domain.

It is often helpful at this stage to divide the problem into a series of sub-problems and to diagram both the relationships among the pieces of each sub-problem and the relationships among the various sub-problems.

Formalization:

In the preceding stages, no effort has been made to relate the domain problem to the artificial intelligence technology that may solve it. During the identification and the conceptualization 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 the conceptualization stage.

During formalization, it is important that the knowledge engineer be familiar with the following:

The various techniques of knowledge representation and heuristic search used in expert systems.

The expert system “tools” that can greatly expedite the development process. And

Implementation:

During the implementation stage, the formalized concepts are programmed onto the computer that has been chosen for system development, using the predetermined techniques and tools to implement a “first pass” prototype of the expert system.

Theoretically, if the methods of the previous stage have been followed with diligence and care, the implementation of the prototype should be as much an art as it is a science, because following all rules does not guarantee that the system will work the first time it is implemented.

Many scientists actually consider the first prototype to be a “throw-away’ system, useful for evaluating progress but hardly a usable expert system.

Testing:

Testing provides opportunities to identify the weakness in the structure and implementation of the system and to make the appropriate corrections.

Depending on the types of problems encountered, the testing procedure may indicate that the system was

Features of an expert system

What are the features of a good expert system? Although each expert system has its own particular characteristics, there are several features common to many systems. The following list from Rule-Based Expert Systems suggests seven criteria that are important prerequisites for the acceptance of an expert system .

1. “The program should be useful.” An expert system should be developed to meet a specific need, one for which it is recognized that assistance is needed.

2. “The program should be usable.” An expert system should be designed so that even a novice computer user finds it easy to use .

3. “The program should be educational when appropriate.” An expert system may be used by non-experts, who should be able to increase their own expertise by using the system.

4. “The program should be able to explain its advice.” An expert system should be able to explain the “reasoning” process that led it to its conclusions, to allow us to decide whether to accept the system’s recommendations.

5. “The program should be able to respond to simple questions.” Because people with different levels of knowledge may use the system , an expert system should be able to answer questions about points that may not be clear to all users.

6. “The program should be able to learn new knowledge.” Not only should an expert system be able to respond to our questions, it also should be able to ask questions to gain additional information.

7. “The program’s knowledge should be easily modified.” It is important that we should be able to revise the knowledge base of an expert system easily to correct errors or add new

Machine Vision

Machine vision is a technology that enables automatic inspection and analysis for applications including automatic inspection, process control, and robotic guidance by using image processing. It’s important to know that when mentioning machine vision it can be in reference to many different technologies, software and hardware products, integrated systems, actions, methods, and expertise.

Machine vision is a technical capability that is integrated with existing technologies in new ways and applies it with the aim to solve real-world problems.

Machine vision is a systems engineering discipline and can be considered distinct from computer vision which is a form of computer science and not done through a tangible piece of hardware such as a vision box or camera attached to a robot.

Machine vision is the body of a system and computer vision is the intelligence of the system, similar to how a computer is a frame for what goes inside such as the computer chips that power up the computer.

Machine vision is the ability of a computer to "see." A machine-vision system employs one or more video cameras, analog-to-digital conversion (ADC), and digital signal processing (DSP).

The resulting data goes to a computer or robot controller.

Machine vision is similar in complexity to voice recognition .

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

Typical uses include automated inspection, optical character recognition and other non-contact applications.

One of the most common applications of Machine Vision is the inspection of manufactured goods such as semiconductor chips, automobiles, food and pharmaceuticals.

Just as human inspectors working on assembly lines visually inspect parts to judge the quality of workmanship, so machine vision systems use digital cameras, smart cameras and image processing software to perform similar inspections.

Machine vision systems have two primary hardware elements: the camera, which serves as the eyes of the system, and a computer video analyser.

The recent rapid acceleration in the development of machine vision for industrial applications can be attributed to research in the areas of computer technologies.

The first step in vision analysis is the conversion of analog pixel intensity data into digital format for processing.

Next, an appropriate computer algorithm is employed to understand the image data and provide appropriate analysis or action.

A typical machine vision system will consist of most of the following components:

One or more digital or analogue cameras (black-and-white or colour) 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 results

A synchronizing sensor for part detection (often an optical or magnetic sensor) to trigger image acquisition and processing and some form of actuators to sort, route or reject defective parts

The aim of a machine vision inspection system is typically to check the compliance of a test piece with certain requirements, such as prescribed dimensions, serial numbers, presence of components, etc.

The complete task can frequently be subdivided into independent stages, each checking a specific criterion. These individual checks typically run according to the following model:

1. Image Capture
2. Image Preprocessing
3. Definition of one or more (manual) regions of interest
4. Segmentation of the objects
5. Computation of object features
6. Decision as to the correctness of the segmented objects

Machine vision is used in various industrial and medical applications. Examples include:

- Electronic component analysis
- Signature identification
- Optical character recognition
- Handwriting recognition
- Object recognition
- Pattern recognition
- Materials inspection

Natural language processing

Machine is considered intelligent if it can understand and manipulate Natural Language

The language spoken by people : Natural Language

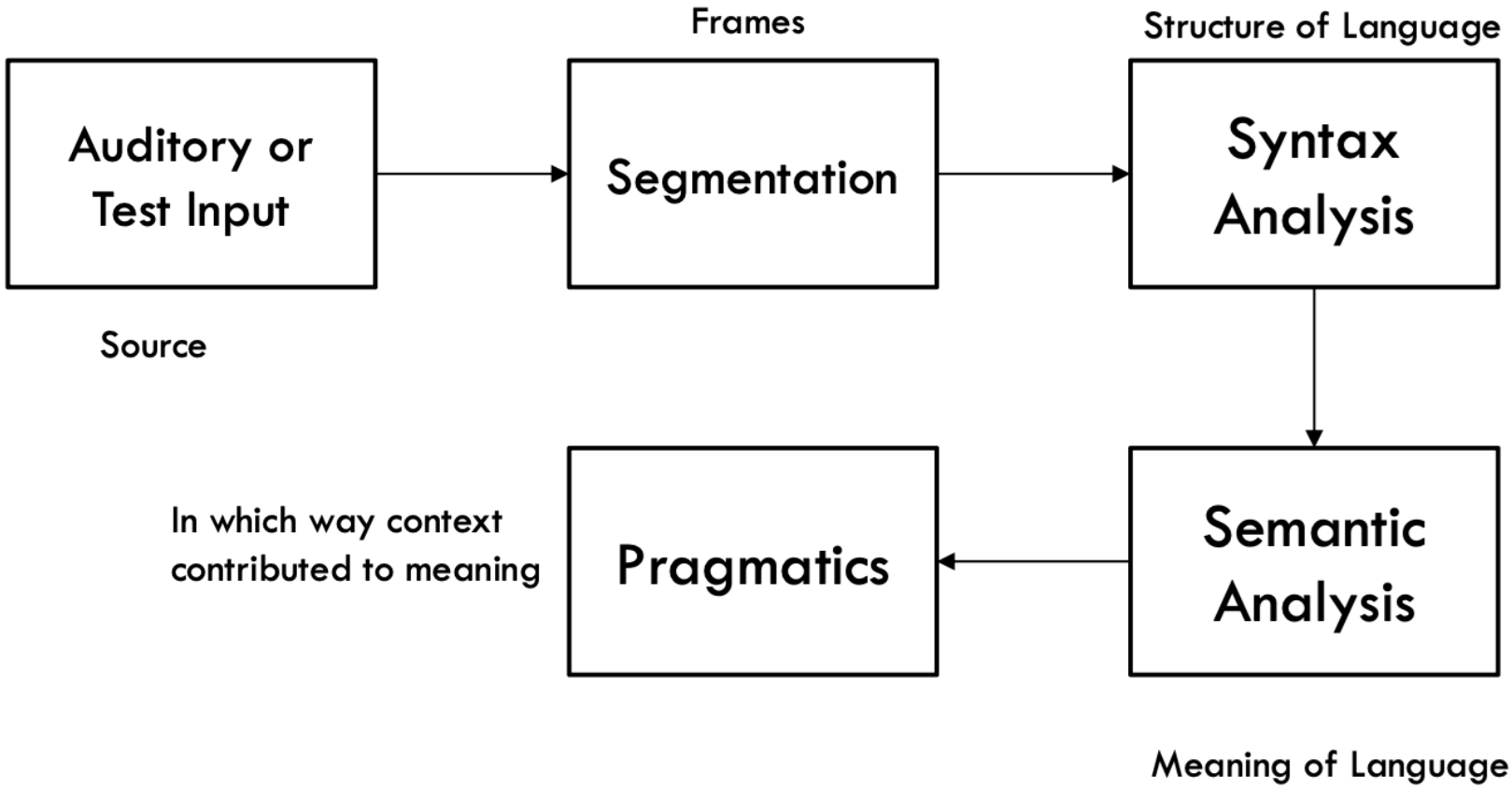
Natural language processing

NLP is one of the field of AI that processes or analyses written or spoken language

NLP=NLG+NLU, where NLG is about generation and NLU is about understanding the natural language

Understanding language requires a lot of knowledge

NLP Processes



Machine is considered intelligent if it can understand and manipulate Natural Language

The language spoken by people : Natural Language

NLPAI method of communicating with an intelligent systems using Natural Language

NLP is required when an intelligent system like robot to perform as per your instructions

EX: getting result from Dialog Based clinical ES

NLP

NLP involves making computers to perform useful tasks with the natural languages human use

I/O encompasses Speech

Written Text

NLP Components

Natural Language Understanding

Understanding involves the following tasks

- Mapping the given input in natural language into useful representations.
- Analyzing different aspects of the language

NLP Component

Natural Language Generation

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.

NLP Component

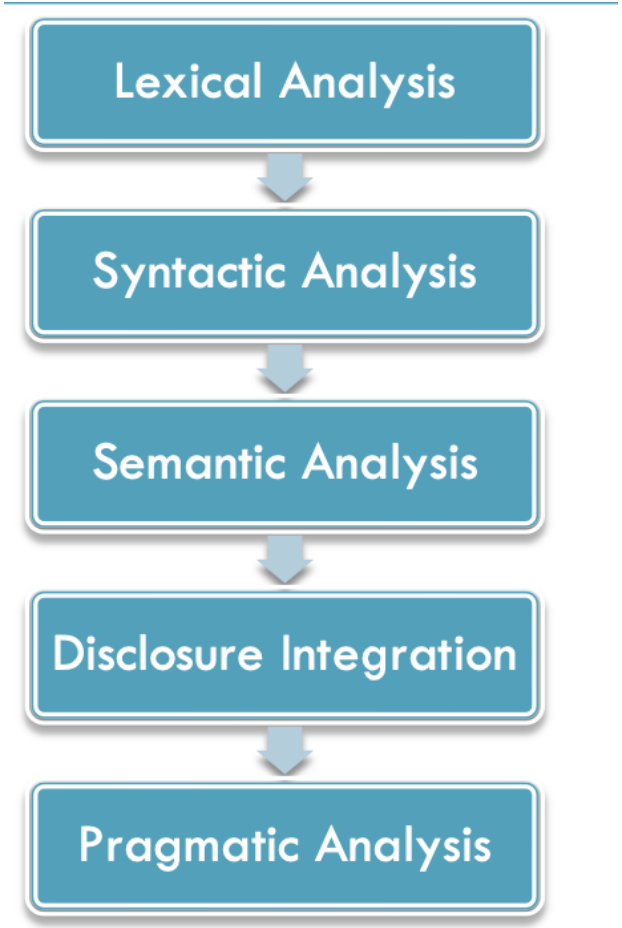
Lexical ambiguity − It is at very primitive level such as word-level. For example, treating the word “board” as noun or verb?

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.

NLP Steps


Lexical Analysis
Syntactic Analysis
Semantic Analysis
Disclosure Integration
Pragmatic Analysis

NLP Steps

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.

NLP Steps

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 icecream”.

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.

Morphological and Lexical Analysis

- The lexicon of a language is its vocabulary that includes its words and expressions
- Morphology depicts analyzing, identifying and description of structure of words
- Lexical analysis involves dividing a text into paragraphs, words and the sentences

Syntactic Analysis

- Syntax concerns the proper ordering of words and its affect on meaning
- This involves analysis of the words in a sentence to depict the grammatical structure of the sentence
- The words are transformed into structure that shows how the words are related to each other
- Eg. “the girl the go to the school”. This would definitely be rejected by the English syntactic analyzer

Semantic Analysis

- Semantics concerns the (literal) meaning of words, phrases, and sentences
- This abstracts the dictionary meaning or the exact meaning from context
- The structures which are created by the syntactic analyzer are assigned meaning
- E.g.. “colorless blue idea” .This would be rejected by the analyzer as colorless blue do not make any sense together

Discourse Integration

- Sense of the context
- The meaning of any single sentence depends upon the sentences that precedes it and also invokes the meaning of the sentences that follow it
- E.g. the word “it” in the sentence “she wanted it” depends upon the prior discourse context

Pragmatic Analysis

- Pragmatics concerns the overall communicative and social context and its effect on interpretation
- It means abstracting or deriving the purposeful use of the language in situations
- Importantly those aspects of language which require world knowledge
- The main focus is on what was said is reinterpreted on what it actually means
- E.g. “close the window?” should have been interpreted as a request rather than an order

Parsing

- The first task for any NLP-based system is to *read (or to parse)* the text
- Parsing depends on three components of a language-

1. Lexicon
2. Categorization
3. Grammar Rules

Lexicon

stench | breeze | glitter | nothing | wumpus | pit | pits | gold | east | ..

is | see | smell | shoot | feel | stinks | go | grab | carry | kill | turn | …

right | left | east | south | back | smelly | …

here | there | nearby | ahead | right | left | east | south | back | …

me | you | I | it | S=HE | Y'ALL …

John | Mary | Boston | UCB | PAJC | …

the | a | an | …

to | in | on | near | …

and | or | but | …

0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9

Categorization

Noun > stench | breeze | glitter | nothing | wumpus | pit | pits | gold | east | ..

Verb > is | see | smell | shoot | feel | stinks | go | grab | carry | kill | turn | …

Adjective > right | left | east | south | back | smelly | …

Adverb > here | there | nearby | ahead | right | left | east | south | back | …

Pronoun > me | you | I | it | S=HE | Y'ALL …

Name > John | Mary | Boston | UCB | PAJC | …

Article > the | a | an | …

Preposition > to | in | on | near | …

Conjunction > and | or | but | …

Digit > 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9

Grammar Rules

- “The large cat”
- This phrase can be parsed by an NLP-system if it has a grammar like

  Noun Phrase -> Determiner + Adjective + Noun
- If your system finds a phrase or sentence that has a pattern not mentioned in its set of Grammar Rules it won’t be able to parse them.

Therefore…

- Parsing is the process of using grammar rules to determine whether a sentence is legal,
- and to obtain its Syntactic Tree

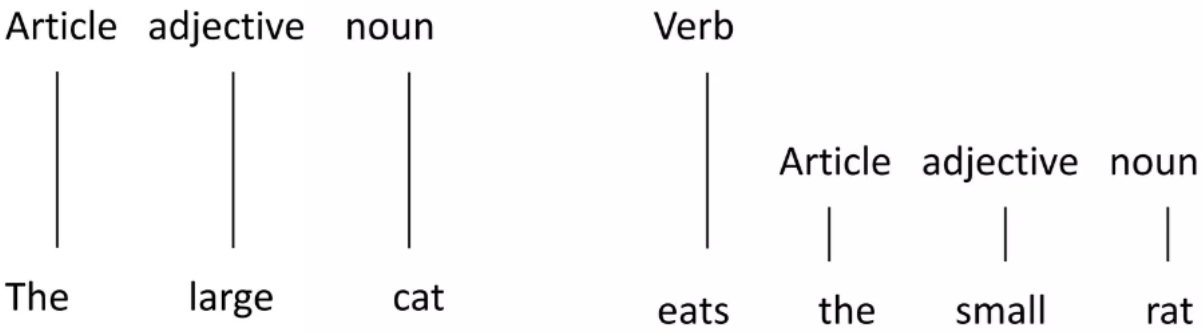
Syntactic Tree

'The large cat eats the small rat'

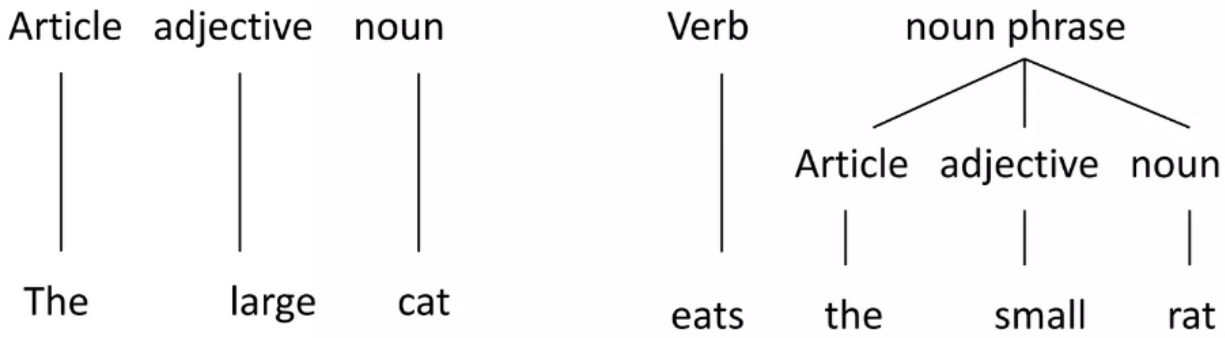
Syntactic Tree

The large cat eats the small rat

Syntactic Tree



Syntactic Tree



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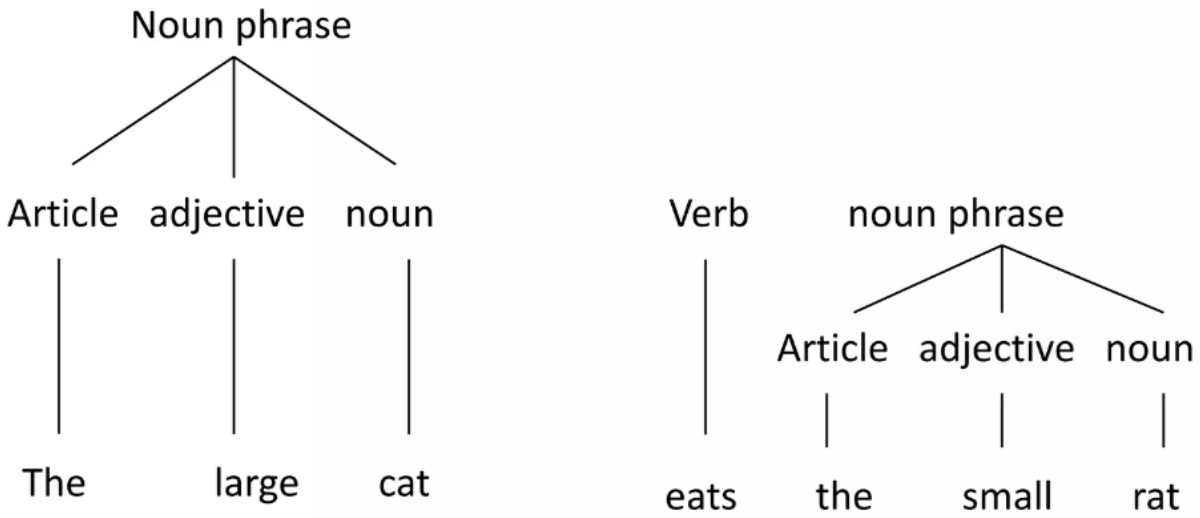

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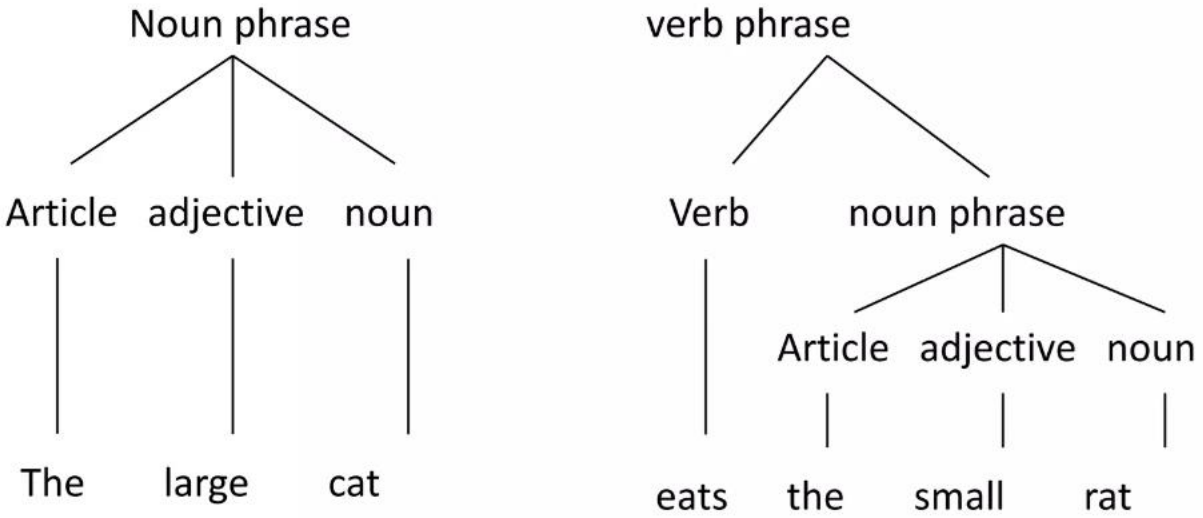

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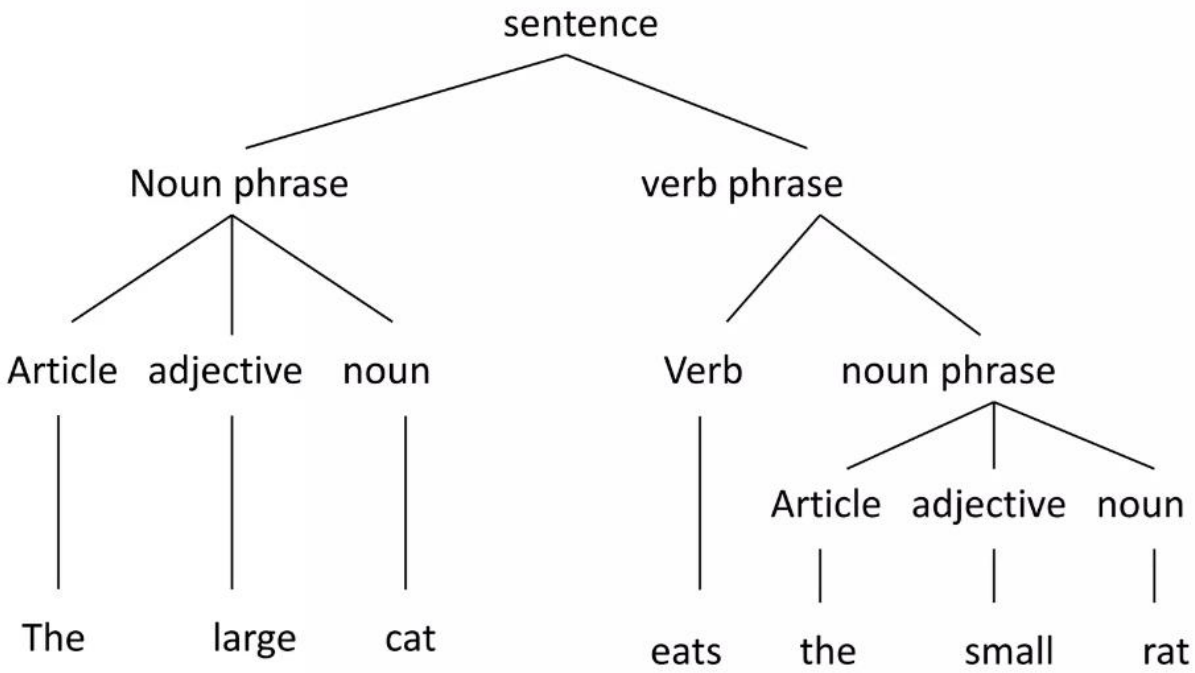
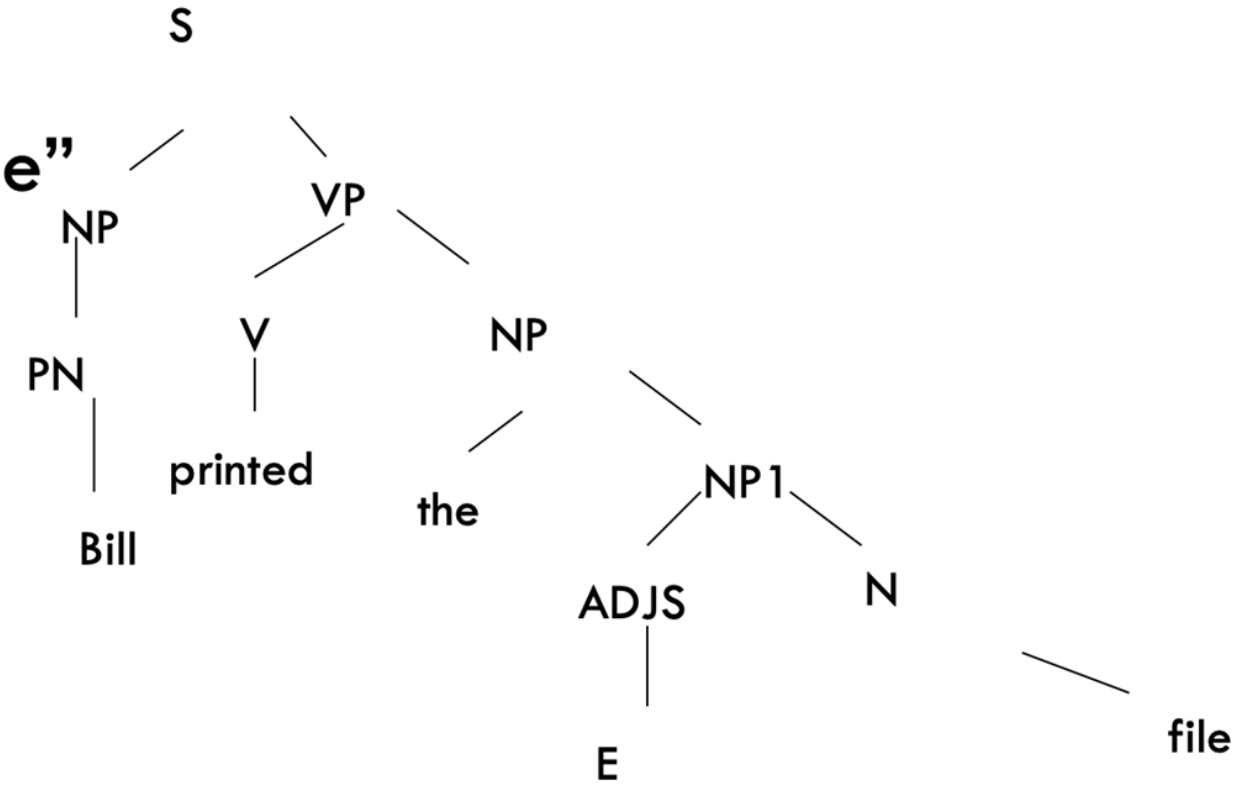


NLP

- Parse Tree

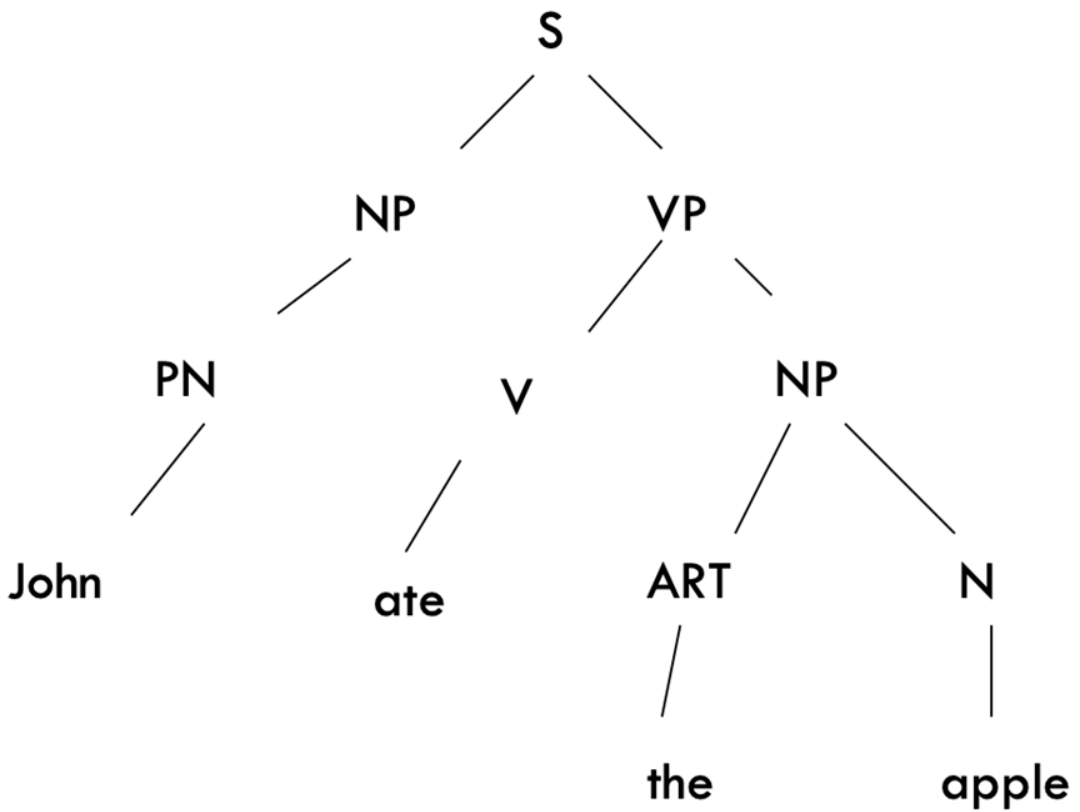
"Bill Printed the file"



A parse tree :

John ate the apple.

1. S -> NP VP
2. VP -> V NP
3. NP -> NAME
4. NP -> ART N
5. NAME -> John
6. V -> ate
7. ART-> the
8. N -> apple



MCQ

1. What is an Expert System?

   a) A general-purpose system for automating tasks

   b) A system that mimics human intelligence

   c) A system that mimics human experts in specific domains

   d) A system that handles only mathematical problems

   Answer: c)

MCQ

2. Which component of an expert system is responsible for drawing inferences?

a) User Interface

b) Inference Engine

c) Knowledge Base

d) Database

Answer: b)

MCQ

3. Which of the following is a characteristic of expert systems?

a) Self-learning

b) General purpose

c) Domain-specific knowledge

d) No user interaction

Answer: c)

MCQ

4. Which of the following is NOT a component of an expert system?

a) Knowledge Base

b) Inference Engine

c) Hardware Interface

d) User Interface

Answer: c)

MCQ

5. What does the knowledge base of an expert system contain?

a) Algorithms and procedures

b) Factual and heuristic knowledge

c) Source code

d) User queries

Answer: b

MCQ

6. What is knowledge acquisition in the context of expert systems?

a) The process of extracting knowledge from experts to store in the system

b) The process of solving problems using the expert system

c) The process of acquiring data from sensors

d) The process of learning through machine learning algorithms

Answer: a)

MCQ

7. Which of the following methods is commonly used for knowledge acquisition?

a) Decision trees

b) Interviewing human experts

c) Neural networks

d) Data mining

Answer: b)

MCQ

8. Which of the following is true about declarative knowledge?

a) It focuses on "how to do" something

b) It is difficult to update

c) It focuses on "what is" knowledge

d) It is used for dynamic processing

Answer: c)

MCQ

9. Procedural knowledge refers to:

a) Factual information

b) Instructions on how to perform tasks

c) Hypothetical information

d) Sensory inputs

Answer: b)

MCQ

10. What is a major challenge in developing expert systems?

a) Building the user interface

b) Acquiring domain-specific knowledge

c) Implementing algorithms

d) Handling input/output

Answer: b)

MCQ

11. The process of encoding the expert's knowledge into a computer system is known as:

a) Programming

b) System development

c) Knowledge engineering

d) Testing

Answer: c)

MCQ

12. What does NLP stand for?

a) Neuro-Learning Processing

b) Natural Learning Procedures

c) Natural Language Processing

d) Non-Linear Processing

Answer: c)

MCQ

13. In NLP, what is tokenization?

a) Splitting a sentence into words

b) Merging different sentences

c) Translating words into codes

d) Classifying documents

Answer: a)

MCQ

14. Which of the following best describes Natural Language Understanding (NLU)?

a) Generating human-like responses

b) Converting language into a format understandable by machines

c) Translating languages

d) Understanding and deriving meaning from text

Answer: d)

MCQ

15. Natural Language Generation (NLG) involves:

a) Translating text into another language

b) Generating coherent sentences from structured data

c) Parsing sentences into parts of speech

d) Tokenizing sentences

Answer: b)

MCQ

16. What is the first step in Natural Language Processing (NLP)?

a) Semantic Analysis

b) Syntactic Analysis

c) Tokenization

d) Pragmatic Analysis

Answer: c)

MCQ

17. Which step in NLP involves parsing sentences to check for grammatical correctness?

a) Tokenization

b) Semantic Analysis

c) Syntactic Analysis

d) Pragmatic Analysis

Answer: c)

MCQ

18. Which of the following is an application of NLP?

a) Speech recognition systems

b) Game development

c) Computer-aided design

d) Image processing

Answer: a)

MCQ

19. Which of these systems is a practical use of NLP?

a) Optical character recognition (OCR)

b) Self-driving cars

c) Chatbots

d) Network security

Answer: c)

MCQ

20. One major challenge in NLP is dealing with:

a) Syntax errors

b) Ambiguity in human language

c) Memory management

d) Algorithmic design

Answer: b)

MCQ

21. Which of the following is a linguistic challenge in NLP?

a) Parsing complexity

b) Converting text to speech

c) Generating new language models

d) Data encryption

Answer: a)

MCQ

22. What is the primary goal of machine vision?

a) Image enhancement

b) Understanding and interpreting visual information

c) Creating 3D animations

d) Improving image quality

Answer: b)

MCQ

23. Which of the following is an essential function of a machine vision system?

a) Image compression

b) Object recognition

c) Text generation

d) Audio processing

Answer: b)

MCQ

24. Which is the correct sequence of stages in machine vision?

a) Image acquisition → Processing → Analysis

b) Processing → Image acquisition → Analysis

c) Image acquisition → Analysis → Processing

d) Processing → Analysis → Image acquisition

Answer: a)

MCQ

25. Image segmentation in machine vision refers to:

a) Enhancing the image

b) Dividing the image into meaningful parts

c) Increasing image resolution

d) Converting images to grayscale

Answer: b)

MCQ

26. Which of the following is a primary component of a robot?

a) Software algorithms

b) Sensor, actuator, and controller

c) Input/output devices

d) Data warehouse

Answer: b)

MCQ

27. What is the primary purpose of a sensor in a robot?

a) To control movement

b) To perform computations

c) To detect environmental changes

d) To power the robot

Answer: c)

MCQ

28. What is a manipulator in robotics?

a) A mechanical arm that can move objects

b) A control unit for decision-making

c) A sensor for detecting motion

d) A processing unit

Answer: a)

MCQ

29. In robotics, the control system responsible for directing the robot’s behavior is called the:

a) Central Processing Unit (CPU)

b) Actuator

c) Controller

d) Transmitter

Answer: c)

MCQ

30. Which of the following is a common challenge in the field of robotics?

a) High cost of sensors

b) Lack of computing power

c) Complex programming languages

d) Efficient power management

Answer: d)

MCQ

31. What is a Semantic Net?

a) A network for machine learning

b) A graphical representation of knowledge using nodes and links

c) A statistical model for language processing

d) A type of search engine algorithm

Answer: b)

MCQ

32. In a Semantic Net, the nodes represent:

a) Objects or concepts

b) Only verbs

c) Connections between concepts

d) Data tables

Answer: a)

MCQ

33. What do the links in a Semantic Net represent?

a) The physical storage of data

b) Relationships between concepts

c) Memory addresses

d) Computational steps

Answer: b)

MCQ

34. What is a Frame in artificial intelligence?

a) A method to capture sequences of actions

b) A structure for representing stereotyped situations

c) A graphical user interface

d) A type of data array used in deep learning

Answer: b)

MCQ

35. Which of the following is a key component of a Frame?

a) Inference rules

b) Slots that can hold values

c) Mathematical formulas

d) Audio inputs

Answer: b)

MCQ

36. In Frame-based systems, the "slot" refers to:

a) A method to process images

b) A variable or attribute that holds specific data

c) A memory space for images

d) A rule-based inference mechanism

Answer: b)

MCQ

37. In propositional logic, what is a proposition?

a) A statement that can be either true or false

b) A mathematical function

c) A question

d) A set of rules

Answer: a)

MCQ

38. In inference using resolution, what is the purpose of resolution?

a) To find a contradiction

b) To translate natural language into logical formulas

c) To compare two knowledge bases

d) To check if a system is consistent

Answer: a)

MCQ

39. What does the existential quantifier (∃) mean in predicate logic?

a) Every object satisfies the predicate

b) At least one object satisfies the predicate

c) The predicate is always true

d) The predicate is always false

Answer: b)

MCQ

40. What is unification in predicate logic?

a) The process of checking if two logical sentences are identical

b) A method to combine two logical models

c) The process of making two expressions identical by substitution

d) A type of variable used in logic programming

Answer: c)

MCQ

41. In FOPL, resolution refutation is used to:

a) Prove a sentence by deriving a contradiction

b) Simplify a logical expression

c) Translate natural language sentences

d) Evaluate the truth of a formula

Answer: a)

MCQ

42. Bayes' Rule is used to calculate:

a) The likelihood of an event based on prior knowledge

b) The shortest path in a graph

c) The average of a dataset

d) The maximum likelihood of a parameter

Answer: a)

MCQ

43. What is a Bayesian Network?

a) A statistical model to predict outcomes

b) A graphical model that represents probabilistic relationships among variables

c) A neural network architecture

d) A rule-based expert system

Answer: b)

MCQ

44. Which of the following is true about Bayesian Networks?

a) They can only represent deterministic relationships

b) They capture dependencies between variables using conditional probabilities

c) They are used only for data classification

d) They require labeled datasets to work

Answer: b)