Module 6

CHAPTER 6

AI Applications

Syllabus

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B. Robotics - Robots, Robot hardware, Problems Robotics can solve
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6.1 INTRODUCTION

Communication is an important act that agent can perform so as to exchange information with the environment. Communication can be carried out by producing and percepting certain signs drawn from a shared system of conventional signs.

In a partially observable world, communication can help agents to learn information that is observed or inferred by others. This information can make agent more successful.

Language is meant for communicating about the world. By studying language, we can come to understand more about the world. We can test our theories about the world by how well they support our attempt to understand language.

And, if we can succeed at building a computational model of language, we will have a powerful tool for communicating about the world. In this chapter, we look at how we can exploit knowledge about the world, in combination with linguistic facts, to build computational natural language systems."

6.2 OVERVIEW OF NLP TASK

GQ. Give general approaches to natural language process. **OR** Write short note on NLP.

(1) Natural language processing (NLP) is the ability of a computer program to understand human speech as it is spoken. NLP is a component of artificial intelligence (AI).

(2) The development of NLP applications is challenging because computers traditionally require humans to "speak" to them in a programming language that is precise, unambiguous and highly structured or, perhaps through a limited number of clearly-enunciated voice commands. Human speech, however, is not always precise - it is often ambiguous and the linguistic structure can depend on many complex variables, including slang, regional dialects and social context.

(3) Current approaches to NLP are based on machine learning, a type of artificial intelligence that examines and uses patterns in data to improve a program's own understanding. Most of the research being done on natural language processing revolves around search, especially enterprise search.

6.2.1 Common NLP Tasks in Software Programs

- Sentence segmentation, part-of-speech tagging and parsing.
- Deep analytics.
- Named entity extraction.
- Co-reference resolution.

The advantage of natural language processing can be seen when considering the following two statements :

"Cloud computing insurance should be part of every service level agreement (SLA)"and "A good SLA ensures an easier night's sleep -- even in the cloud".

If you use national language processing for search, the program will recognize that cloud computing is an entity, that cloud is an abbreviated form of cloud computing and that SLA is an industry acronym for service level agreement. The ultimate goal of NLP is to do away with computer programming languages altogether. Instead of specialized languages such as Java or Ruby or C, there would only be "human."

6.2.2 Evolution of NLP Systems or History of NLP

GQ. Discuss the evolution of NLP systems **Or** Given a brief history of NLP.

(1) The work related to NLP was started with machine translation (MT) in 1950s. Alan Turing proposed is called the Turing test in 1950s. It is the testing ability of the machine program to have written conversation with human.

(2) This program should be written so well so that one would find it difficult to determine whether the conversation is with a machine or it is with the other person actually. During the same period, cryptography and language translation took place. Later on, syntactic structures came up along with linguistics. Further, the sentences were considered with knowledge augmentation and semantics. In 1960s, EI.IZA (the most common NLP system) was developed that gained popularity.

(3) It was the simulation of a psychotherapist. At a very later stage, it was the case grammars that came up. Now, there has been a complete revolution in the NLP with the machine learning approaches coming up. Many NLP systems have been developed till today and a lot of competitions are being organized that are based on the Turing test.

6.2.3 Components of NLP

There are two components of NLP : Mapping the given input in the natural language into a useful representation. Different level of analysis required: morphological analysis, syntactic analysis, semantic analysis, discourse analysis.

(1) **Natural language generation :** Producing output in the natural language from some internal representation. Different level of synthesis required: deep planning (what to say), syntactic generation

(2) **NL understanding :** NL Understanding is much harder than NL Generation. But, still both of them are hard.

Planning : Planning problems are hard problems. They are certainly nontrivial. Method which we focus on ways of decomposing the original problem into appropriate subparts and on ways of handling interactions among the subparts during the problem-solving process are often called as planning. Planning refers to the process of computing several steps of a problem-solving procedure before executing any of them.

6.2.4 Two Major Methods of NLP Analysis

GQ. Write the name of two major method of NLP analysis. **Or** Eenumerale different approaches for exploring the semantics of parsed natural language sentences.

There are several techniques used in analyzing natural language processing. Some of them can be briefly described as follows :

1. **Pattern matching :** The idea here is an approach to natural language processing is to interpret input statements as a whole further than building up their interpretation by combining the structure and meaning of words or other lower level constituents. That means the interpretations are obtained by matching patterns of words against the input statements. For a deep level of analysis in pattern matching a large number of patterns are required even for a restricted domain. This problem can be improved by hierarchical pattern matching in which the input is gradually canonical through pattern matching against sub phrases. Another way to reduce the number of patterns is by matching with semantic primitives instead of words.
2. **Syntactically driven parsing :** Syntax means ways that words can fit together to form higher level units such as phrases, clauses and sentences. Therefore syntactically driven parsing means interpretation of larger groups of words are built up out of the interpretation of their syntactic constituent words or phrases. In a way this is the opposite of pattern matching as here the interpretation of the input is done as a whole.
3. **Semantic grammars :** Natural language analysis based on semantic grammar is bit similar to syntactically driven parsing except that in semantic grammar the categories used are defined semantically and syntactically. There here semantic grammar is also involved.
4. **Case frame instantiation :** Case frame instantiation is one of the major parsing techniques under active research today. It has some very useful computational properties such as its recursive nature and its ability to combine bottom-up recognition of key constituents with top-down instantiation of less structured constituents.

6.2.5 The NLP Tasks

NLP problem can be divided into two tasks :

1. Processing written text, using lexical, syntactic knowledge, and
2. Semantic knowledge of the language as well as the required real world information.

Processing spoken language, using all the information needed above plus additional knowledge about phonology as well as enough added information to handle the further ambiguities that arise in speech.

6.2.6 Different Levels of NLP

UQ. What are the levels of knowledge used in language understanding? Also write down the techniques used in NLP. **(MU - Q. 6(b), Dec. 15, 10 Marks)**

UQ. Write short note on : Steps in Natural Language Processing. **(MU - Q. 6, May 17, 10 Marks)**

UQ. What are steps involved in natural language processing (NLP) of an English sentence ? **(MU - Q. 6(i), Dec. 17, 10 Marks)**

UQ. What are steps involved in natural language processing (NLP) of an English sentence ? Explain with an example sentence. **(MU - Q. 5(b), May 18, Q. 6(a), Dec. 18, Q. 6(b), May 19, 10 Marks)**

1. **Morphology** : It is the analysis of individual words that consist of morphemes the smallest grammatical unit. Generally, words with 'ing', 'ed' change the meaning of the word. This analysis becomes necessary in the determination of tense as well.

2. **Syntax :** Syntax is concerned with the rules. It includes legal formulation of the sentences to check the structures. (Some aspects are covered in compiler's phase of syntax analysis that you must have studied). For example, 'Hari is good not to'. The sentence structure is totally invalid here.
3. **Semantic :** During this phase, meaning check is carried out and the way in which the meaning is conveyed is analyzed. The previous example is syntactically as well as semantically wrong. Now, consider one more example, i.e., 'The table is on the ceiling.' This is syntactically correct, but semantically wrong.
4. **Discourse integration :** In communication or even in text formats, often the meaning of the current sentence is dependent on the one that is prior to it. Discourse analysis deals with the identification of discourse structure.
5. **Pragmatic :** In this phase, analysis of the response from the user with reference to what actually the language meant to convey is handled. So, it deals with the mapping for what the user has interpreted from the conveyed part arid what was actually expected. For a question like "Do you know how long it will take to complete the job?", the expected answer is the number of hours rather than a yes or no.
6. **Prosody :** It is an analysis phase that handles rhythm. This is the most difficult analysis that plays an important role in the poetry or shlokus (chants involving the name of God) that follow a rhythm.
7. **Phonology :** This involves analysis of the different kinds of sounds that are combined. It is concerned with speech recognition. Can the analysis levels discussed be overlapped or interrelated? Yes. It is very much possible to have an analysis actually forming a fuzzy structure. They can work in stages, where the second level makes use of the analysis or the outcomes of the first level. We now study them in detail.

6.2.7 Basic Steps of Natural Language Processing

GQ. Describe the basic steps of natural language processing.

There are general five 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.

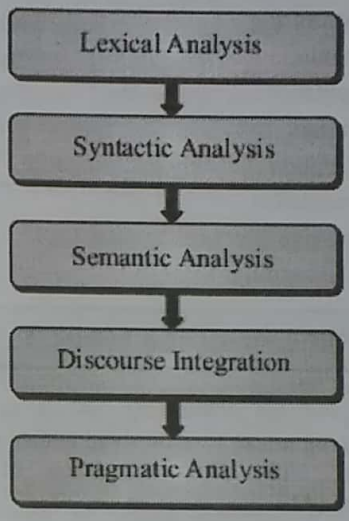

Fig. 6.2.1 : Basic steps of NLP

- **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.

6.2.8 Applications of NLP

GQ. Explain application of NLP.

1. Spelling and grammar checking.
2. Optical character recognition (OCR).
3. Screen readers for blind and partially sighted users.
4. Augmentative and alternative communication (i.e., systems to aid people who have difficulty communicating because of disability).
5. Machine aided translation (i.e., systems which help a human translator, e.g., by storing translations of phrases and providing online dictionaries integrated with word processors, etc.).

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6. Lexicographers tools.
7. Information retrieval.
8. Document classification (filtering, routing).
9. Document clustering.
10. Information extraction.
11. Question answering.
12. Summarization.
13. Text segmentation.
14. Exam marking.
15. Report generation (possibly multilingual).
16. Machine translation.
17. Natural language interfaces to databases.
18. E-mail understanding.

6.3 NLP-LANGUAGE MODELS

- Natural Language Processing (NLP) ability of a computer programme to understand human speech as it is spoken. NLP is a component of Artificial Intelligence (AI).
- Approaches to NLP are based on machine learning, a type of artificial intelligence that examines and uses patterns in data to improve a program's our understanding. Most of the research on natural language processing revolves around enterprise search.

6.3.1 Challenges with Language Modelling

- Formal language (like a programming language) are precisely defined. All the words and their usage are predefined in the system.
- Anyone who knows a specific programming language can understand what is written without any formal specification.
- Natural language, on the other hand is not designed. It evolves according to the convenience and learning of an individual. There are several terms in natural language that can be used in a number of ways. This introduces ambinguity but still can be understand by humans.
- Machines only understand the language of numbers for creating language models, it is necessary to convert all the words into a sequence of numbers. This is known as Encodings.
- Generally, a number is assigned to every word and this is called label-encoding in the sentence. "I love to play Tennis on weekends", every word is assigned a number [1, 2, 3, 4, 5, 6]. This is an example how encoding is done.

6.3.2 Types of Language Models

There are primarily two types of language models :

1. Statistical Language Models
2. Neural Language Models

6.3.3 Statistical Language Models

Statistical models include the development of probabilistic models that are able to predict the next word in the sequence, given the words that precede it. A number of statistical language models are in use already. We consider some of the popular models.

6.3.4(I) N-Gram

This is one of the simplest approaches to language modeling. Here, a probability distribution for a sequence of 'n' is created, where n can be any number and defines the size of the gram (or sequence of words being assigned a probability). If n = 4, a gram may look like : "can you help me". Basically, n is the amount of context that the model is trained to consider. There are different types of N-gram models such as unigrams, bigrams, trigrams, etc.

(1) **Unigram :** The unigram is the simplest type of language models. It does not look at any conditioning context in its calculations. It evaluates each word or term independently. Unigram models commonly handle language processing tasks such as information retrieval. The unigram is the foundation of more specific model variant called the query likelihood model, which uses information retrieval to examine a pool of documents and match the most relevant one to a specific query.

(2) **Bidirectional** : Unlike n-gram models, which analyse text in one direction (backwards), bidirectional models analyse text in both directions, backwards and forwards. These models can predict any word in a sentence or body of text by using every other word in the text. Examining text bidirectionally increases result accuracy. This type is often utilized in machine learning and speech generation applications. For example, Google uses a bidirectional model to process search queries.

(3) **Exponential :** This type of statistical model evaluates text by using an equation which is a combination of n-grams and feature functions. Here the features and parameters of the desired results are already specified. The model is based on the principal of entropy, which states that probability distribution with the most entropy is the best choice. Exponential models have

fewer statistical assumptions which mean the chances of having accurate results are more.

(4) **Continuous Space :** In this type of statistical model, words are arranged as a non-linear combination of weight in a neural network. The process of assigning weight to a word is known as word embedding. This type of model proves helpful in scenarios where the data set of words continues to become large and include unique words.

In case where the data set is large and consists of rarely used or unique words, linear models such as n-gram do not work. This is because, with increasing words, the possible word sequences increase, and thus the patterns predicting the next word become weaker.

6.3.5 (II) Neural Language Models

- These language models are based on neural networks and are often considered as an advanced approach to execute NLD tasks.
- Neural language models overcome the shortcomings of classical models such as n-gram and are used for complex tasks such as speech recognition or machine translation.
- Language is significantly complex and keeps on evolving. Therefore, the more complex the language is, the better it would be at performing NLP tasks. Comparing to the n-gram model, an exponential or continues space-model proves to be a better option for NLP tasks because they are designed to handle combiguity and language variation.
- Meanwhile, language models should be able to manage dependencies. For example, a model should be able to understand words derived from different languages.

6.3.6 Some Common Examples of Language Models

Language models are the cornerstone of Natural Language Processing (NLP) technology. We have made the best of language models in our routine, without even realising it. We consider some of the examples of language models.

1. **Speech Recognition :** Voice assistants such as siri and Alexa are examples of how language models help machines in processing speech audio.
2. **Machine Translation :** Google Translator and Microsoft translate are examples of how NLP models can help in translating one language to another.
3. **Sentiment Analysis :** This helps in analysing the sentiments behind a phrase. This use-case of NLP models is used in products that allow businesses to understand a customer's intent behind opinions or attitudes expressed in the text. Hubspot's Service Hub is an example of how language models can help in sentiment analysis.
4. **Text Suggestions :** Google services such as Gmail or Google Docs use language models to help users get text suggestions while they compose an email or create long text documents respectively.
5. **Parsing tools :** Parsing involves analyzing sentences or words that comply with syntax or grammar rules. Spell checking tools are perfect examples of language modeling and parsing.

6.3.7 Synthetic and Semantic Analysis in NLP

NLP Analysis (problems) can be written in two parts :

(1) Processing written text, using syntactic knowledge, and

(2) Semantic knowledge of the language as well as the required real world information.

Processing spoken language using all the information needed as well as added information to handle the ambiguities that arise in speech.

Levels of NLP

1. **Morphology :** It is the analysis of individuals words that consists of smallest grammatical unit. Generally, words with 'ing' 'red' 'change the meaning of the word'. This analysis is necessary in the determination of tense also.
2. **Syntax :** Syntax is concerned with rules. It includes legal formulation of the sentences to check the structures ('Hari is good not to'. The sentence structure is totally invalid here.)
3. **Semantic :** During this phase, meaning is checked and the way in which the meaning is conveyed is analysed (The above example is syntactically as well as semantically wrong.). Consider an example, 'The table is on the ceiling'. This is syntactically correct, but semantically wrong.
4. **Discourse integration :** In communication, often the meaning of the current sentence is dependent on the one that is prior to it. Discourse analysis deals with the identification of discourse structure.
5. **Pragmatic :** In this phase, analysis of the response from the user with reference to what actually the language meant to convey is handled. For example, a question like "Do you know how long it will take to complete the job?", the expected answer is the number of hours rather than a yes or no.

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6.3.8 Plan to Use Language Models

There are several innovative ways in which language models can support NLP tasks. An AI expert can create language models for executing simple to complex NLP tasks.

6.4 BERT MODEL

BERT model is best for NLP. BERT stands for Bidirectional Encoder Representations from Transformers. BERT is a pre-trained model designed to drive the context of a word from both sides of it, the left and the right.

BERT represents a new era for NLP because, although very accurate, it is basically based on two simple ideas. Using bidirectional capability, BERT pre-trained on two different, but related NLP tasks (i) Masked Language Modelling and (ii) Next Sentence Prediction.

6.4.1(I) Masked Language Model (MLM)

The objective of MLM training is to hide a word in a sentence and then have the program predict what word has been hidden (masked) based on the hidden word's context.

6.4.2(II) Next Sentence Prediction (NSP)

The objective of NSP is to have the program predict whether two given sentences have a logical, sequential connection or whether their relationship is simply random.

6.4.3 Method of 'BERT ' Works

- The goal of any given NLP technique is to understand human language as it is spoken naturally.
- In BERT's case, this typically means predicting a word in a blank. To do this, models typically need to train using a large repository of specialized, labeled training data. This necessitates laborious manual **data labeling.**
- But BERT is pretrained using only an unlabelled, plain text corpus. It continues to learn unsupervised from the unlabelled text and improve even as its being used in practical applications (i.e. Google Search).
- It pretraining serves as a base layer of 'knowledge' to build from. From there, BERT can adapt to the ever-growing body of searchable content and queries and be fine-turned to a user's specifications. This process is known as 'transfer learning.'
- BERT is made possible by Google's research on Transformers. The transformer is the part of the model that gives BERT its increased capacity for understanding context and ambiguity in language.
- The transformer does this by processing any given word in relation to all other words in a sentence, rather than processing them one at a time.
- By looking at all surrounding words, the transformer allows the BERT model to understand the full context of the word, and therefore better understand searcher intent.
- This is contrasted against the traditional method of language processing known as word embedding, in which previous models would map only one dimension.
- BERT uses a method of masked language modelling to keep the word with a fixed meaning, independent of its context. BEST then identifies the masked. Word based on the context alone. In BERT words are defined by their surroundings, not by a pre-fixed identify.
- BERT relies solely on 'self-attention' mechanism. And this is possible by the bidirectional transformers at the centre of BERT's design.
- BERT accounts for the meaning by reading bidirectionally accounting for the effect of all other words in a sentence on the focus word.

6.4.4 Uses of 'BERT'

BERT is used at Google to optimize the interpretation of user search queries. BERT excels at several functions, including :

(i) Sequence-to-sequence based language generation tasks such as :
   - Question-answering
   - Abstract-summation
   - Sentence-prediction
   - Conventional response generation

(ii) Natural language
   - Understanding tasks such as :
   - Polysemi and coreference (words that sound or look the same but have different meanings resolution)
   - Word sense disambiguation
   - Natural language inference
   - Sentiment classification

BERT is expected to have a large impact on voice search as well as text-based search, which is error-prone with Google's NLP - techniques.

Because of BERT's proficiency in understanding context, it can interpret patterns that different languages share without understanding the language completely.

Thus, BERT has the potential to improve artificial intelligence systems across the board. BERT is open source, meaning any one can use it.

6.5 GRAMMARS IN A.I.

A grammar is a declarative representation that defines the syntactic facts of a language. The most common way to represent grammars is as a set of production rules, and the simplest structure for them to build is a parse tree which records the rules and how they are matched.

6.5.1 Different Types of Grammars Languages

Grammar type	Grammar accepted	Language accepted
Type 0	Unrestricted grammar	Recursive enumerated language
Type 1	Context-sensitive grammar	Context-sensitive language
Type 2	Context-free grammar	Context-free language
Type 3	Regular grammar	Regular language

6.5.2 Types of Grammar

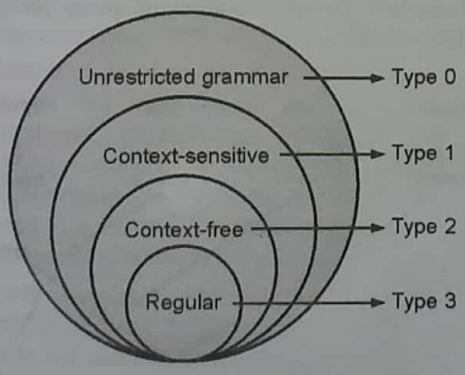

Fig. 6.5.1 : Types of Grammar

6.5.3 Grammars and Languages

- The types of grammars that exist are Noam Chomsky invented a hierarchy of grammars.
- The hierarchy consists of four main types of grammars.
- The simplest grammars are used to define regular languages.
- A regular language is one that can be understood by a finite state automation. Such languages are very simplistic and allow sentences such as aaabbbbcc"
- Recall that a finite state automation consists of a finite number of states, and rules that define how the automation can transit from one state to another.
- A finite state automation could be designed that defines the language and that consisted of a string of one or more occurrences of the letter a.
- Hence, the following strings would be valid strings in this language

aaa

a

aaaaaaaaaa

- Regular languages are of interest to computer scientists, but are not of great interest to the field of natural language processing because they are not so powerful to represent even simple formal language. And more complex natural languages are out of question.
- Sentences defined by a regular grammar are often known as regular expressions. The grammar that we defined above using rewrite rules is a context free grammar.
- It is context free because it does not specify the way that words should agree with each.

For example

- A state dog climbs mount Kanchanganga. Also, it follows the sentence, which is grammatically incorrect. They eats
- Thus, a content-free grammar can have only at most one terminal symbol on the right hand side of its rules.
- But for a context-sensitive grammar can have more than one terminal symbol on the right hand side. This enables the grammar to specify number, case, tense and gender agreement.

Rewrite rules for context-sensitive grammars have the following form :

$$A X B \rightarrow A Y B$$

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Which means that in the context of A and B, X can be rewritten as Y.

Each of A, B, X and Y can be either a terminal or a non-terminal symbol.

- Context-sensitive grammars are most usually used for natural language processing because they use the kinds of grammars that natural languages use.
- But they involve a much larger number of rules and make them harder for human developers to design than context-free grammars.
- The final class of grammars in Chomsky's hierarchy consists of recursively enumerable grammars (also known as unrestricted grammar)
- An unrestricted grammar can define any language and it has no restrictions on the structure of its rewrite rules.
- Computer scientists are interested in such grammars but not of use to the study of natural language processing.

6.6 PARSING : SYNTACTIC ANALYSIS

- We have seen that morphologic analysis can be used to determine to which part of speech each word in a sentence belongs. Now we examine how this information is used to determine the syntactic structure of s sentence.
- The process, in which we convert a sentence into a tree that represents the sentences syntactic structure, is known as '**parsing**'. Parsing a sentence tells us whether it is a valid sentence, defined by our grammar. If a sentence is not a valid sentence, then it cannot be parsed.
- Again, parsing a sentence involves producing a tree. We consider an example. The black cat crossed the road.

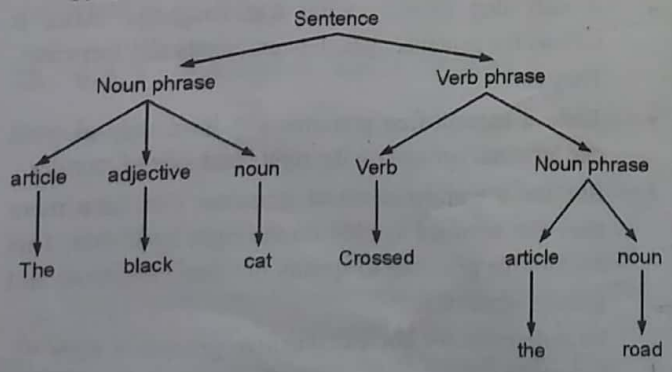
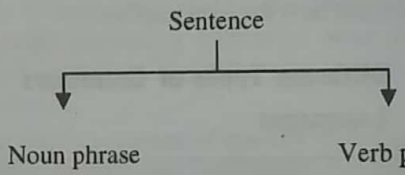


Fig. 6.6.1

- This tree shows how the sentence is made up of a noun phrase and a verb phrase. The noun phrase consists of an article, an adjective, and a noun.
- The verb phrase consists of a verb and a further noun phrase, which is turn consists of an article and a noun.
- Parse trees can be built in a bottom-up fashion or in a top-down fashion. When a parse tree is built from the top-down, it is known as a derivation tree.

Remark

- Building a parse tree from the top down involves starting from a sentence and determining which possible words can be applied to the sentence.
- In this case, sentence would be rewritten as



- Then the verb phrase and noun phrase would be broken down in the same way, until only terminal symbols are left.

6.6.1 Bottom-up Parsing

- Bottom up parsing is also known as shift-reduce parsing. Bottom up parsing is used to construct a parse tree for an input string.
- In the bottom-up parsing the parsing starts with the input symbol and construct the parse tree up to the start symbol by tracing out the rightmost derivations of string in reverse.

Example : To write bottom up parse for sentence 'Meera ate the apple'

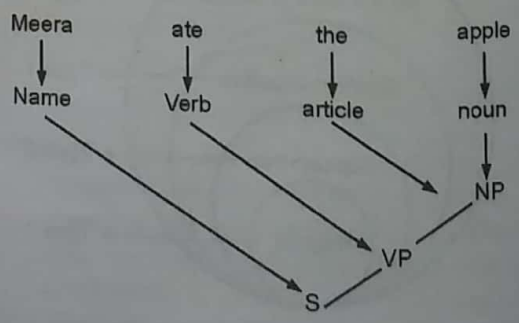


Fig. 6.6.2

6.6.2 Comparison between Top-down and Bottom-up Parsing

Sr. no.	Top-down parser	Bottom-up parser
1.	Parser starts with the sentence S and rewrite into a sequence of terminal symbols that matches the classes of the words in the input sentence	A bottom up parser starts with the terminal symbols in the input sentence. The parser successively rewrite a sequence of terminal symbols and left hand side with the grammar rule.
2.	It starts at the root of derivation tree and fill in.	It starts at the leaves and fill in.
3.	It picks and tries to match the input.	It starts in a state valid for legal first tokens.
4.	The top-down strategy never wastes time in exploring trees that cannot result in S.	In bottom-up strategy, no lead to S.

6.7 ROBOTICS

- Robotics is 'an interdisciplinary branch of computer science and engineering'. Robotics involves design, construction, operation and use of robots. The goal of robotics is to design machines than can help and assist humans.
- Robotics covers fields of mechanical engineering, electrical engineering, information engineering, mechatronics, electronics bioengineering, computer engineering, control engineering, software engineering, mathematics etc.
- Robots can be used in many situations for many purposes, but today many are used in dangerous environment (including inspection of radioactive materials, bomb detection and deactivation), manufacturing processes or where humans cannot survive (e.g. in space, underwater, in high heat, and containment of hazardous materials and radiation).
- Robots can take on any form, but some are made to resemble humans in appearance. This is claimed to help in the acceptance of robots in certain behaviours which are usually performed by people. Such robots attempt to replicate walking, lifting, speech or any other human activity.
- Certain robots require user input to operate while other robots function automatically. The concept of creating robots that can operate automatically is to serve various practical purposes, whether domestically, commercially or militarily. Many robots are built to do jobs that are hazardous to people, such as defusing bombs, finding survivors in unstable ruins, exploring mines and shipwrecks. Robotics is also used in STEM. (Science, technology, engineering and mathematics) as a teaching aid.

6.7.1 Robotics Aspects

There are many types of robots; they are used in many different environment and for many different uses. Although being very diverse in application and form, they all share three basic similarities when it comes to their construction

1. **Robots all have some kind of mechanical construction**, a frame, form or shape designed to achieve a particular task. For example, a robot designed to travel across heavy dirt or mud, might use caterpillar tracks. The mechanical aspect is mostly the creators solution to completing the assigned task and dealing with the physics of the environment around it. Form follows function.
2. **Robots have electrical components** that power and control machinery. For example, the robot with caterpillar tracks would need some kind of power to move the tracker treads. That power comes in the form of electricity, which will have to travel through a wire and originate from a battery, a basic electrical circuit.

   Even petrol powered machines, that get their power mainly from petrol still require an electric current to start the combustion process which is why most petrol-powered machines like cars, have batteries.

   The electrical aspect of robots is used for movement (through motors), sensing (where electrical signals are used to measure things like heat, sound, position and energy status) and operation (robots need some level of electrical energy supplied to their motors and sensors in order to activate and perform basic operation)
3. **All robots contain some level of computer programming code**. A robot that needs to move across a muddy road may have the correct mechanical construction and receive the correct amount of power from its battery, but must not 90 anywhere without a program telling it to move.

   Programs are the core essence of a robot, it could have excellent mechanical and electrical construction, but if its program is poorly constructed, its performance will be very poor.

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There are three different type, of robotic programs : remote control, artificial intelligence and hybrid.

A robot with remote-control programming has a preexisting set of commands, that it will only perform if and when it receives a signal from a control source, typically a human being with a remote control. It is perhaps more appropriate to view devices; controlled primarily by human commands as falling in the discipline of automation rather than robotic. Robots that use artificial intelligence interact with their environment on their own without a control source, and can determine reactions to objects and problems they encounter using their preexisting programming.

- Hybrid is a form of programming that incorporates AI and RC functions in them.

6.8 APPLICATIONS OF ROBOTICS

- As more and more robots are designed for specific tasks, the method of classification is more relevant. For example, many robots are designed for assembly work, which may not be able to function for other applications. They are termed as **'assembly robots'**
- For seam welding, some suppliers provide complete welding systems with the robot i.e. the welding equipment along with other material handling facilities like turntables etc. as an integrated unit. Such an integrated robotic system is called a **'welding robot'**
- Some robots are specifically designed for heavy load manipulation and labelled as **'heavy-duty robots.'**

Current and Potential Applications are as follows :

(1) Industrial Robots

Robots are increasingly used in manufacturing. Automotive industry is the main customer of industrial robots with 52% of sales in the auto industry, they can amount for more than half of the 'labour'. There are even "lights off" factories such as an IBM keyboard manufacturing factory in Texas that is fully automated.

(2) Construction Robots

- Construction robots can be separated into three types :
  (a) traditional robots (b) robotic arm
  (c) robotic exoskeleton
- Construction robots are a sub-set of industrial robots used for building and infrastructure construction at site. These robots have to be able to move and fix itself to the working zone, handle construction materials and interact with humans and other machineries. These robots have been successful to do works such as finishing the exterior, steel placement, construction of masonary wall reinforcement concrete etc.
- The main challenges to use robots in site is due to limitation in work-space.

(3) Military Robots

- Military robots are autonomous robots or remote controlled mobile robots designed for military applications, from transport to search and rescue and attack. Some such systems are currently in use and many are under development.
- Artillergy has seen promising research with an experimental weapons system named "Dragon fire II" which automates loading and ballistics calculations required for accurate predicted fire, providing a 12-seconds response time to fire support requests. However, military weapons are prevented from being fully autonomous; they require human input at certain intervention points to ensure that targets are not within restricted fire areas.
- There have been some developments towards developing autonomous fighter jets and bombers. The use of autonomous fighters and bombers to destroy enemy target is especially promising because of the lack of training required for robotic pilots, autonomous planes are capable of performing tasks which otherwise cannot be done by pilots. Plane design does not require a life support system and loss of a plane does not mean a loss of a pilot.
- But the largest drawback to robotics is their inability to accommodate for non-standard conditions.

(4) Space Exploration

- There are many things in space that are very dangerous for astronauts to do. Astronaut cannot room on mars all day to collect soil samples or work on repairing a space-ship from the outside while it is in deep space.
- In these situations, robots are a great choice because there are no chances for the loss of human life. So space institutions like NASA frequently use robots and autonomous vehicles to do things that humans cannot for example. Mars Rover is an autonomous Robot that travels on Mars and takes pictures of Martian Rock formation that are important and then sends them back on Earth for NASA scientists to study.

(5) Entertainment

- Robots also play important role in the entertainment industry. They can be used behind the sets in movies and serials to manage the camera, provide special effects, etc. They can be used for boring repetitive tasks that are not suitable for a human. Robots can also be used to do stunt work that is very dangerous for humans but looks pretty good in an action movie.

- Theme parks like Disney World are also using autonomous robots to enhance the magical experience of their customers.

(6) Agriculture

- Agriculture is the sector that is the basis of human civilization. However, agriculture is also a seasonal sector that is dependent on ideal weather conditions, optimal soil etc.
- Moreover, there are many repetitive tasks in agriculture that are a waste of farmers time, and can be performed more suitable by robots. These include seeding used control, harvesting etc. robots are usually used for harvesting the crops which allow farmers to be more efficient.
- An example of a robot that is used to remove weeds in farms is the Ecorobotix. It is powered by solar energy and can be used to target and spray weeds using a complex camera system.

(7) Underwater Exploration

- Robots are a great option for exploring places that humans cannot reach easily, like the depths of the ocean. There is a lot of water pressure deep in the ocean which means humans cannot go that down and machines such as submarines can only go to a certain depth as well. A deep underwater is a mysterious place that can finally be explored using specially designed robots.
- These robots are remote-controlled, and they can go into depths of the ocean to collect data and images about the aquatic plant and animal life.

(8) Security

- If the security quards are robots, then even thieves would be scared ! That is why robots are being proposed as security agents as they can protect humans, and they would not be in danger like human security guards would be. Currently, robotics companies are working on pairing robot guards with human security consultants.
- The company Knight scope in the United states is a very famous company in this field. It has autonomous security robots capable assisting human security guards with real-time, actionable intelligence. These robots can help with crimes such as armed robberies, burglaries, domestic violence, fraud, hit and runs etc.

(9) Food Preparation

- There are robots that even can cook and create complete meals. These robots chefs can create food using hundreds of different recipes.
- All humans need to do is choose the recipe they want and provide the robot with prepackaged containers of all the ingredients that are needed for that recipe.
- The robot can then cook the food on its own. Moley Robotics is the company that has created a robotic kitchen with a robot and the robot can cook like a master chef. Thus, now a robot can cook food for you.

(10) Manufacturing

- There are many repetitive and common tasks in the manufacturing industry that don't require any usage of mind or imagination. The tasks like welding, assembly, packing etc. These tasks can be easily done by robots.
- These robots can be trained to perform these repetitive and monotonous tasks with precision under the guidance and supervision of a human.
- This option is also best for the manufacturing processes that are dangerous and may be harmful to humans.

(11) Customer Service

- There are robots that are developed to look exactly like humans for cosmetic purposes. These robots are primarily used in the field of customer service in high visibility area to promote robotics.
- One example is Nadine, a humanoid robot in Singapore that can recognize people from previous visits, make eye contact, shake hands, continue chatting based on previous meetings etc. Another such customer service robot is Junko Chihira in Japan, a humanoid robot working at the tourist information centre.
- So far we have seen various applications of robot, in different industries. Robots are used these days for everything, ranging from security guards, chets, doctor's assistants, customer service agents, and even a one – man army in war ! Because of their precision and programming to perform various tasks that are dangerous, boring or repetitive to humans.
- Robots can do all the physically demanding tasks that are difficult or impossible for humans, and they are becoming smarter with the advances in artificial intelligence. Thus Robots can be the perfect helper for humans and solve many problems in different industries.

6.9 FUTURE APPLICATIONS OF ROBOTICS

- Based on the current trends, robotics can transform our future. Here we discuss some of the ways.
- Even residents in rural countries in the U.S. have access to such robots. This is just one example of how AI affects, the way we live.

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- Based on the current trends, here are 10 ways we can expect robotics to transform our future.

6.9.1 Robotics in Public Security

- Artificial technology for predicting and detecting crime might appear for away from possibility, but it is quite possible for the future we are looking at.
- Drone footage, for instances, will make that happen soon. In addition 'automatic recognition of suspicious activities' is already a reality for camera based security systems.
- This technology is going to change society in a very important way: it will allow law enforcement officials to act quickly whenever a suspicious behaviour is spotted.

6.9.2 Robots in Education

- In classroom learning, there is a gap between individual learning settings and the teacher. An educational expert Kendra Roberts explains "A single teacher does not have the capacity to meet the needs of personalized learning for every single student in the classroom".
- Computer based learning is already changing things in that matter. It is not replacing the teacher, but it enables students to learn at their own pace.
- Robots are supposed to boost the process of personalized learning. The humanoid robot NAO is already forming bonds with students from around the world. It comes with important senses of natural interaction, including moving, listening, speaking and connecting.

6.9.3 Robots at Home

- These robots are called as 'Cloud connected home robots'.
- These robots are already becoming part of our livers. We can set up the vacuum cleaner to do the work for us, and we can also schedule a warm-home cooked meal to be ready by the time we are finished with work. Multi-function robotic cookers are able to fry, steam, bake, slow cook, and perform any other action without our intervention. We have to just set them up.
- These 'cloud-connected robots' are likely to evolve into more advanced version. We expect to see speech comprehension and increased interactions with humans in upcoming years. These developments may end up changing the entire look and feel of our homes.

6.9.4 Robots as Co-workers

- Robots will have a profound effect on the workplace of the future. They shall become capable of taking on multiple roles in an organization, so it is time for us to start thinking about the way we shall interact with our new coworkers.
- The machines will likely evolve more in terms of voice recognition, so we shall be communicating with them through voice commands.
- Futurist Nikolas Badminton expects to develop things : "You are probably going to walk into an office and your system has been wandering over the last couple of hours considering what is being going on in business , your role, your job, what you need to do that day and probably offer up several ideas about the right direction of what to do". It sounds like a pretty achievable future" !

6.9.5 Robots might take our Jobs

- Robots have already replaced many people in their jobs. The jobs in office administration, logistics and transport are also at risk of being replaced.

  In the coming future, we might see the robots in the form of big trucks on the roads.
- A study of Ball state university predicted that many occupations are at risk of being automated, including insurance underwriters, telemarketers, and tax-return preparers. To be more precise, robots are expected to take over half of all low-skilled jobs.

6.9.6 They Create Jobs, Too

- Technology is changing fast and it does have economic imbalances. Driverless cars, for instance, are highly likely to replace cab drivers in the future.
- Hence 'Robots will take our jobs!' is perhaps the most common fear surrounding robotics development.
- In the near future 'artificial intelligence' will most likely replace tasks, not jobs. The good news is that it will also create new markets and hence jobs. We might need additional education and retraining for those jobs, but the opportunities will be definitely there.

6.9.7 Autonomous Cars

- Self driving cars still require some human intervention, but we are getting closer to the day when they wait.
- Wayno, the company that aroce from the self-driving car project by Google, no longer has a monopoly on this industry. On the contrary, every significant automobile producer is pursuing this technology.

- Uber is one of the strongest players in this field. The users of this service can now get matched with a 'self-driving uber' when they request the service, so they can get a glimpse of the future.
- As companies continue to invest in this trend, we shall live to see a different face of public transport by 2030.

6.9.8 Healthcare Robots

- With robots, we shall be having a different future for healthcare. Instead of visiting a primary care physician who will give us check-up with a simple stethoscope, we shall have intelligent robots performing these tasks. They will interact with patients, check on their conditions, and evaluate the need for further appointments.
- Pharmabotics will bring more huge changes. They shall be like ATM's for medicines, so that we can have the medications we require, while avoiding the inconvenience of talking to a stronger about our health issues.

6.9.9 Robotics for Entertainment

Robots are getting more personalized and engaging than ever. With the growth of this industry, virtual reality will enter our homes in the near future. We shall be able to interact with our home entertainment systems through conversations, and they will respond to our attempts to communicate.

6.9.10 Robots will Boost our Standard of Living

Throughout the past we have witnessed that automation and mechanization boosts the overall standard of living. We have seen it with Industrial Revolution, and it is going to happen again. According to estimates from United Nations, poverty has been reduced to a greater extent over the past five decades than in the previous 50. That is because the global economy grew sevenfold, and technology played a huge part in that progress.

With software automating all kinds of work, we are looking at a more comfortable future for ourselves.

6.10 FIELD PROGRAMMABLE GATE ARRAYS (FPGA) IN ROBOTICS

- FPGA is Field Programmable Gate Arrays as semiconductor devices that are based around a matrix of configurable logic blocks (CLBS) connected via programmable interconnects.
- FPGA can be reprogrammed to desired application or functionally requirements after manufacturing.
- Increasingly sophisticated tools are enabling embedded control system designers to more quickly create and more easily adapt FDGA-based applications.
- In manufacturing and automation contents, FPGAs are well-suited for use in robotics and machine-tool applications, as well as for fan, pump, compressor and conveyer control.
- FPGA are often used to configure I/O module functionality.

Remark

I/O module stands for Input/Output module, which is a device that acts as the connective bridge between a computer system at one end and an I/O or peripheral device of some kind at the other, such as printer, webcam or scanner.

6.10.1 Technology in FPGA

For commercial FPGAs, the main switch technologies are antifuses (e.g. Actel) and static RAM cells (e.g. Xilinx). For commercial CPLDs, the main switch technologies are Erasable Programmable ROM (EPROM) transistors and Electrically Erasable PROM (EEO-ROM) transistors.

6.10.2 Planning Algorithms

- Planning algorithms for teams of robots fall into two categories :
  (i) Centralized algorithms, in which a single computer makes decisions for the whole team, and
  (ii) Decentralized algorithms, in which each robot makes its own decisions based on local observations.

  With centralized algorithms, if the central computer goes offline, the whole system falls down.
- Decentralized algorithms handle erratic communications better, but they are harder to design, because each robot is essentially guessing what the others will do.
- Most research on decentralized algorithms has focused on making collective decision-making more reliable and has deferred the problem of avoiding obstacles in the robots environment.
- In simulations involving squadrons of minihelicopters, the decentralised algorithm came up with the same flight plans that a centralized version did.

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- The drones generally preserved an approximation of their preferred formation, a square at a fixed altitude - although to accomodate obstacles the square rotated and the distances between the drones contracted,
- In a typical decentralized group planning algorithm, each robot might broadcast its observations of the environment to its teammates, and all the robots would then execute the same planning algorithm, on the basis of same information.
- The main idea is that each robot on the basis of its own observations, maps out an obstacle-free region in its immediate environment and passes that map to its nearest neighbors. When a robot receives a map from a neighbor, it calculates the intersection of that map with its own and passes that on.
- Each robot ends up with a map that reflects all of the obstacles detected by all the team members.

6.10.3 Four Dimensions

- The maps have not three dimensions, but four-the fourth being time. This is how the algorithm accounts for moving obstacles.
- The four dimensional map describes how a three dimensional map would have to change to accommodate the obstacle's change of location, over a span of few seconds. And it does it in a mathematically compact manner.
- Each robot updates its map several times a second a short enough span of time, assuming that the velocity of an accelerating object will not change suddenly.
- On the basis of its latest map, each robot calculates the trajectory that will maximize both its local goal staying information and its global goal.

6.10.4 Components of Robots

Some of the important components of Robots are as follows

1. **Manipulator :** Just like the human arm, the robot consists of what is called a manipulator having several joints and links.
2. **Endeffector :** The base of the manipulator is fixed to base support and at its other free end, the endeffector is attached. The Endeffector is expected to perform tasks by the palm and finger arrangement of the human arm.
3. **The Locomotion Device :** In case of human-beings the power for the movement of the arm, the palm and finger is provided by muscles. For the robot the power for the movement (locomotion) is provided by the motors. The motors used for providing locomotion in robots are of three types depending on the source of energy : Electric, Hydraulic or Pneumatic.
4. **The controller :** The digital computer (both the hardware and the software) acts as a controller to the robots. The controller functions in a manner analogous to the human brain. With the help of this controller, the robot is able to carry out the assigned task. The controller directs and controls the movements of the manipulator and the Endeffector. In short, the controller controls the robot.
5. **The sensors :** Without the data supplied by the sense organs, the brain would be incapable of intelligence. In other words the controller of the robot cannot do any meaningful task, if the robot is not with a component analogous to the sense organs, of the human body. Thus, the most important component of the robot is the set of sensors. Sensors are nothing but measuring instruments which measures quantities such as position, velocity, force, torque, proximity and temperature etc.

6.11 ROBOT HARDWARE

- A hardware robot is an 'appliance working or implementing mechanical energy and having different characters, each with a specific function and together doing a special task.
- It is all about managing physical methods. It includes managing mechanical devices and control systems to automate jobs in a technical manner.
- Hardware side of Robotics includes 'processor, buses, memory and peripherals like co-processors, sensors, robotic arm, controllers etc.

6.11.1 Software "Robots" V/S Hardware Robots in RPA

- The world of computer science and technology is full of software robots and hardware robots which are responsible for bringing automation.
- RDA is a kind of business process automation that enables anyone to describe a set of directions for a robot to give error-free solutions.
- Hardware robots are employed to automate some real tasks, such as in construction. But many kinds of software robots in RPA have nothing to do with hardware robots. Also many parts of robotics have nothing to do with automation.

6.11.2 Difference between Software Robots and Hardware Robots

Sr. No.	Software Robots	Hardware Robots
1.	Software robots use a blend of automation, computer perception, and machine learning to automate monotonous, high volume jobs that are custom focused.	Hardware robot is a piece of machinery utilising or implementing automatic power and having different sections each with a specific function and currently. .
2	Trigger pressed there are many varieties of automation or software robots, varying from the completely standardized to the completely implicit, and extremely easy to the mind blowing complex'	Executing a special task Hardware robot is a part of engineering which includes various methods to create, develop, program and apply robotic machines
3.	This requires using software to complete tasks which people normally perform when they are utilizing computer programs.	It includes a system of tools that uses the actuator data to perform a particular purpose or output of actions and undertaking.
4.	RPA has nothing to do with hardware robots. It applies to "software robots" which are coded to apply for computer programs in the same style as a human operator would. They are simpler to blend into the current business methods.	These comprise computer sensors resularly that monitor the execution of these hardware robots, that can design change in these different engineering systems.
5.	It can be described as an expansion of RPA which utilizes AI to determine how humans complete tasks when applying for a computer program. This enables "software robots" to work more effectively.	In this, microprocessor operate by having installed the software developed into them. Without that software, a microprocessor control application will not run.
6.	Software robots can log into applications, transfer files applications, transfer files and folder, copy and paste data, edit forms, derive structured and semi-structured information from documents and more.	A hardware robot is an appliance working or implementing mechanical energy, and having different characters, each with a specific function and together doing a special task.
7.	It is all about managing physical methods. It includes managing mechanical devices and control systems to automate jobs in a technical manner.	Hardware robots are heterogeneous systems that consist of fundamental components, and devices, control parts, interfaces for beneficial applications, anything from auto-mobiles and airplanes.
8.	Software robots employ the user interface to catch data and manage applications just like people do.	Robot element companies still need a basic set of policies to support when creating the interfaces of their robot hardware devices.

6.12 APPLICATIONS OF A.I. IN HEALTH CARE

AI is transforming health-care. AI in Health Technology applications encourage healthier behaviour in individuals and help with the proactive management of a healthy lifestyle.

Additionally, AI increases the ability for healthcare professionals to better understand the day-to-day patterns and needs of the people they care, for better feedback, guidance and support.

6.12.1 Health Monitoring

- Tools to Support interventions and Healthy Behaviours monitors heart rate and activity levels. They can send alerts to the user to get more exercise and can share this information to doctors. Medical chatbots can offer relevant high quality information, reassurance, answers and ways of thinking about the situations related to human behaviour.
- Artificial Intelligence in Health AI is already being used to detect disease, such as Cancer, more accurately and in their early stages. Using AI for digital retinopathy screening will allow non-clinicians to be trained on retinal imaging, obtaining interpretation of the images within minutes and thus giving patients instant feedback.

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6.12.2 Medical Imaging

- Machine learning algorithms can process unimaginable amounts of information in the blink of an eye and provide more precise than humans in spotting even the smallest detail in medical imaging.
- It can find every sign of potential conditions such as osteoporosis, breast cancer and many more with a 90% accuracy rate. As people approach 'end of life' they feel loneliness. AI have conversations and other social interactions with people to keep aging minds sharp.

6.12.3 AI Robot assisted Surgery

Robots have been used in medicine for more than 40 years. Surgical robots can either aid a human surgeon or execute operations by themselves. They are also used in hospitals and labs for repetitive tasks, in rehabilitation, physical therapy and in support of those with long-term conditions.

6.13 OTHER APPLICATIONS

6.13.1 Retail

- Artificial Intelligence (AI) is reinventing the retail landscape from using computer vision to customize promotion in real time to applying machine learning for 'inventory management' retailers can harness AI to connect with their customers and operate more efficiently.
- AI is enabling retail systems to work together to optimise customer experiences, forecasting, inventory management, and more. AI technologies like computer vision bring near-real-time intelligence to brick and mortar stores.
- That same data, when analysed in the cloud, can provide additional business insights.
- Digital transformation in retail is about more than connecting things. It is about converting data into insights, which inform actions that drive better business outcomes.
- AI in retail including machine learning and deep learning – are key to generating these insights. For retailers, that leads to incredible customer experiences, opportunities to grow revenues, fast innovations and smart operations all of which help differentiate one from the competitions.
- A special type of AI deep learning in retail known as computer vision is gaining traction at brick and mortar. Computer vision "sees" and interprets visual data, giving one eyes where one needs them.
- And it is opening the door for new retail use cases across customer experience demand forecasting, inventory management, and more.

6.13.2 AI Applications in Banking

Artificial Intelligence is the future of banking as it brings the power of advanced data analytics to combat fraudulent transactions and improve compliance.AI accomplishes anti-money laundering activities in few seconds, which otherwise takes hours and days.

AI also enables banks to manage huge volumes of data at record speed to derive valuable insights from it. Features such as digital payment advisers and biometric fraud detection mechanisms lead to a higher quality of services to a wider customer base. All this translates to increased revenue, reduced costs and boots in profits.

6.13.3 Prediction of Future Trends

- With its power to predict future scenarios by analyzing past behaviours, AI helps banks predict future outcomes and trends. This helps banks to identify fraud, detect anti-money laundering pattern and make customer recommendations.
- Money launderers, through a series of actions, portray that the source of their illegal money is legal. With its power of Machine Learning and cognition, AI identifies these hidden actions and helps save millions banks.
- Similarly, AI is able to detect suspicious data patterns among volumes of data to carry out fraud management. Further, with its key recommendation engines, AI studies past to predict future behaviour of data points, which helps banks to successfully up-sell and cross-sell.

6.13.4 Robotic Automation of Processes

- AI reviews and transforms processes by applying Robotic Process Automation (RPA).
- This enables automation of about 80% of repetitive work processes, allowing knowledge workers to dedicate their time in value - add operations that require high level of human intervention.
- By adapting AI, leaders in the banking sector have already taken actions with due diligence to reap the above mentioned benefits.

Chapter Ends...

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