Unit 5 : Applications of AI (Milan)

Natural Language Processing

- **Definition**: Natural Language Processing (NLP) is a branch of Artificial Intelligence (AI) that studies how machines understand human language. Its goal is to build systems that can make sense of text and perform tasks like translation, grammar checking, or topic classification.
- **Functionality**:
  - It is the technology that enables machines to understand, analyze, manipulate, and interpret human languages.
  - It helps developers organize knowledge for performing tasks such as:
    - Translation
    - Automatic summarization
    - Named Entity Recognition (NER)
    - Speech recognition
    - Relationship extraction
    - Topic segmentation
- **Tasks**: The field of NLP involves making computers perform useful tasks with the natural languages humans use. The input and output of an NLP system can be:
  - **Speech**
  - **Written Text** – HCR

Role of Knowledge in NLP

- **Importance of Knowledge Representation**: Knowledge representation is crucial in AI as it allows computers to understand, store, and manipulate human knowledge, enabling them to solve complex problems, make decisions, and perform tasks that require intelligence.

- **Knowledge Graphs**: Knowledge graphs enable NLP systems to interpret the context behind words and phrases. For example, in a sentence mentioning "Apple," a knowledge graph helps the system determine whether it refers to the fruit or the technology company based on surrounding context.

Components of NLP

There are two components of NLP as given:

Natural Language Understanding (NLU)

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

Natural Language Generation (NLG)

- **Definition**: It is the process of producing meaningful phrases and sentences in the form of natural language from some internal representation.
- **Involves**:
  - **Text Planning**: Retrieving the relevant content from the knowledge base.
  - **Sentence Planning**: Choosing required words, forming meaningful phrases, and setting the tone of the sentence.
  - **Text Realization**: Mapping the sentence plan into sentence structure.
- **Complexity**: NLU is harder than NLG.

Examples of NLP

- Email filters
- Smart assistants
- Search results
- Predictive text
- Language translation
- Digital phone calls

- Data analysis: Converts unstructured text data into meaningful data
- Text analytics

How to Build an NLP Pipeline

There are the following steps to build an NLP pipeline:

Step 1: Sentence Segmentation

- **Description**: Sentence segmentation is the first step for building the NLP pipeline. It breaks the paragraph into separate sentences.
- **Example**: Consider the following paragraph:

  "Independence Day is one of the important festivals for every Indian citizen. It is celebrated on the 15th of August each year ever since India got independence from the British rule. The day celebrates independence in the true sense."

- **Result**:

  1. "Independence Day is one of the important festivals for every Indian citizen."
  2. "It is celebrated on the 15th of August each year ever since India got independence from the British rule."
  3. "This day celebrates independence in the true sense."

Step 2: Word Tokenization

- **Description**: Word tokenization is used to break the sentence into separate words or tokens.
- **Example**:

  "GLS offers BCA and MCA."

- **Result**:

  "GLS", "offers", "BCA", "and", "MCA", ".”

Step 3: Stemming

- **Description**: Stemming is used to normalize words into their base form or root form. For example, "celebrates," "celebrated," and "celebrating" all originate from the root word "celebrate." However, stemming may produce root words that do not have any meaning.
- **Example**:

  "intelligence," "intelligent," and "intelligently" all originate from the root word "intelligen," which does not have any meaning in English.

Step 4: Lemmatization

- **Description**: Lemmatization is similar to stemming but produces a root word (lemma) that has a meaning.
- **Example**:

  In lemmatization, "intelligence," "intelligent," and "intelligently" have the root word "intelligent," which has a meaning.

Step 5: Identifying Stop Words

- **Description**: In English, many words appear frequently, such as "is," "and," "the," and "a." NLP pipelines will flag these words as stop words, which might be filtered out before performing any statistical analysis.
- **Example**:

  "He is a good boy."

Step 6: Dependency Parsing

- **Description**: Dependency parsing is used to find how all the words in the sentence are related to each other.
- **Example**:
  - "Rohan and Raj are friends."
  - "Rohan: Raj is my friend."
  - "Rohan: He is a good boy."

Step 7: POS Tags

- **Description**: POS stands for parts of speech, which include noun, verb, adverb, and adjective. It indicates how a word functions with its meaning as well as grammatically within sentences. A word can have one or more parts of speech based on the context in which it is used.
- **Example**:

  "Google is a search engine."

  "Google" can be used as a verb, as in "Google something on the Internet."

Step 8: Named Entity Recognition (NER)

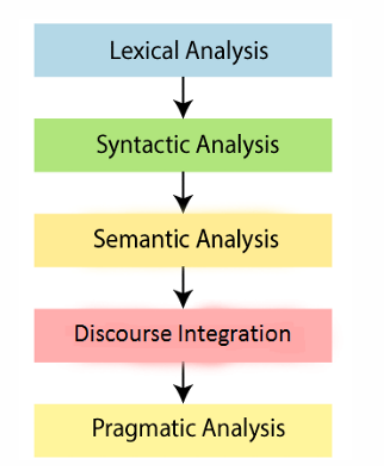
- **Description**: Named Entity Recognition (NER) is the process of detecting named entities such as person names, movie names, organization names, or locations.
- **Example**:

  "Steve Jobs introduced the iPhone at the Macworld Conference in San Francisco, California."

Step 9: Chunking

- **Description**: Chunking is used to collect individual pieces of information and group them into larger pieces of sentences.

Phases of NLP



1. Lexical Analysis and Morphological

- **Description**: The first phase of NLP is Lexical Analysis. This phase scans the source code as a stream of characters and converts it into meaningful lexemes. It divides the whole text into paragraphs, sentences, and words.

2. Syntactic Analysis (Parsing)

- **Description**: Syntactic Analysis is used to check grammar, word arrangements, and shows the relationship among the words.
- **Example**: "Agra goes to the Poonam. "In the real world, "Agra goes to the Poonam" does not make any sense, so this sentence is rejected by the syntactic analyzer.

3. Semantic Analysis

- **Description**: Semantic analysis is concerned with meaning representation. It mainly focuses on the literal meaning of words, phrases, and sentences.

4. Pragmatic Analysis

- **Description**: Pragmatic analysis is the last phase of NLP. It helps you to discover the intended effect by applying a set of rules that characterize cooperative dialogues.
- **Example**: "Open the door" is interpreted as a request instead of an order.

Robotics

- Robotics is a branch of engineering and computer science that involves the conception, design, manufacture, and operation of robots.

Define Robots

A robot is a programmable, mechanical device designed to perform tasks autonomously or semi-autonomously, often mimicking human actions and behaviors. Robots can range from simple machines carrying out repetitive

actions to advanced systems capable of complex decision-making and interactions.

Key Characteristics of Robots

- **Sensors**: Robots use sensors to gather information from their environment. These sensors can include cameras, touch sensors, temperature sensors, and more.
- **Actuators**: Actuators are mechanisms that allow robots to manipulate their surroundings. They can be motors, servos, or any other mechanical components that enable movement.
- **Controllers**: Robots are equipped with control systems, often based on software and algorithms, that process sensor data and determine appropriate actions.
- **Programming**: Robots are programmed to perform specific tasks. This programming can range from simple instructions to complex algorithms.
- **Autonomy**: Many robots have the ability to operate autonomously, meaning they can make decisions and perform actions without constant human intervention.
- **Adaptability**: Some robots can adapt to changing environments or tasks, adjusting their behavior based on new information.

Types of Robots

- **Industrial Robots**: Used in manufacturing for tasks like welding, assembling, and packaging.
- **Mobile Robots**: Robots that move from one location to another using locomotion.
- **Autonomous Robots**: Include self-driving cars and drones that navigate without human control.
- **Remote Controlled Robots**: Designed for performing complicated and undetermined tasks that autonomous robots cannot perform due to uncertainty of operation.

Mobile Robots

● Mobile robots are able to move from one location to another location using locomotion. It is an automatic machine that is capable of navigating an uncontrolled environment without any requirement of physical and electromechanical guidance devices.

● Mobile Robots are of two types:

(a) Rolling robots - Rolling robots require wheels to move around. They can easily and quickly search. But they are only useful in flat areas.

(b) Walking robots - Robots with legs are usually used in condition where the terrain is rocky. Most walking robots have at least 4 legs.

(a) Rolling robots

(b) Walking robots

Industrial Robots

● Industrial robots perform same tasks repeatedly without ever moving. These robots are working in industries in which there is requirement of performing dull and repeated tasks suitable for robot.

● An industrial robot never tired, it will perform their works day and night without ever complaining.

Autonomous Robots

● Autonomous robots are self-supported. They use a program that provides them the opportunity to decide the action to perform depending on their surroundings.

● Using artificial intelligence these robots often learn new behavior. They start with a short routine and adapt this routine to be more successful in a task they perform. Hence, the most successful routine will be repeated.

Remote Controlled Robots

● Remote controlled robot used for performing complicated and undetermined tasks that autonomous robot cannot perform due to uncertainty of operation.

● Complicated tasks are best performed by human beings with real brainpower. Therefore a person can guide a robot by using remote. Using remote controlled operation human can perform dangerous tasks without being at the spot where the tasks are performed.

A NASA robot designed to explore volcanoes via remote control.

Robot Locomotion

● Locomotion is the method of moving from one place to another. The mechanism that makes a robot capable of moving in its environment is called as robot locomotion.

● There are many types of locomotion:

- Wheeled
- Legged
- Tracked slip/skid
- Combination of legged and wheeled locomotion

Legged locomotion

● It comes up with the variety of one, two, four, and six legs. If a robot has multiple legs then leg coordination is required for locomotion.

● Legged locomotion consumes more power while demonstrating jump, hop, walk, trot, climb up or down etc.

● It requires more number of motors for accomplish a movement.

● It is suited for rough as well as smooth terrain where irregular or too smooth surface makes it consume more operational power. It is little difficult to implement because of stability issues.

● The total number of possible gaits (a periodic sequence of release and lift events for each of the total legs) a robot can travel depending upon the number of robot legs.

Hence, there are six possible different events:

- Lifting the Right leg
- Lifting the Left leg

- Releasing the right leg
- Releasing the left leg
- Releasing both the legs together
- Lifting both the legs together

Wheeled Locomotion

● It requires less number of motors for accomplishing a movement. It is little easy to implement as there are lesser stability issues in case of more number of wheels. It is more power efficient as compared to legged locomotion.

● Castor wheel: It rotates around the offset steering joint and wheel axle.

● Standard wheel: It rotates around the contact and the wheel axle.

● Ball or spherical wheel: This wheel is technically difficult to implement due to architectural complexity. It is an Omni directional wheel with only one directional movement is allowed.

● Swedish 45 and Swedish 90 wheels: It is an Omni-wheel, which rotates around the contact point, around the wheel axle, and around the rollers.

Slip/Skid Locomotion

● In Slip/Skid locomotion the vehicles use tracks as available in a tank. The robot is steered by moving tracks with different speeds in the same or opposite direction. It offers stability because of large contact area of ground and track.

AI in Robotics:

- With the invention of machines or computers, their capability to perform different tasks went on increasing exponentially. Humans have developed the power of computer systems in terms of diverse working domains, with increasing speed, and reducing size with respect to time.

Introduction of various Robotics sensor:

1. Ultrasonic sensor
2. Sound Sensor

3. Light Searching sensor
4. PIR Motion sensor

Ultrasonic Sensor

- An ultrasonic sensor uses sound waves to measure distance.
- The sensor has a transmitter (i.e., speaker) that produces high-frequency sound (beyond the range of human hearing).
- The sensor has a receiver (i.e., microphone) that detects the echo of the high-frequency sound when it reflects back from an object.
- You can calculate the distance between the sensor and the closest object by measuring how much time it takes for the echo to arrive.
- The ultrasonic sensor is useful for detecting objects that are some distance away from the robot.
- However, unlike the touch sensor, the ultrasonic sensor does not rely on physical contact.
- The distance gives more space in which to respond.

Sound Sensor

- The sound sensor is one type of module used to notice the sound. Generally, this module is used to detect the intensity of sound.
- The applications of this module mainly include switch, security, as well as monitoring.
- The accuracy of this sensor can be changed for the ease of usage.
- This sensor employs a microphone to provide input to buffer, peak detector and an amplifier.
- This sensor notices a sound, & processes an o/p voltage signal to a microcontroller. After that, it executes required processing.

Light Searching Sensor

- The two main light sensors used in robots are:
  - Photovoltaic cells
  - Photo resistor
- Other kinds of light sensors like phototransistors, phototubes are rarely used.
- The type of light sensors used in robotics are:
  - Photo resistor - It is a type of resistor used for detecting the light.

PIR Motion Sensor

- A passive infrared sensor (PIR sensor) is an electronic sensor that measures infrared (IR) light radiating from objects in its field of view.
- They are most often used in PIR-based motion detectors. PIR sensors are commonly used in security alarms and automatic lighting applications.
- PIR sensors detect general movement, but do not give information on who or what moved. For that purpose, an imaging IR sensor is required.
- PIR sensors are commonly called simply "PIR", or sometimes "PID", for "passive infrared detector". The term passive refers to the fact that PIR devices do not radiate energy for detection purposes.
- They work entirely by detecting infrared radiation (radiant heat) emitted by or reflected from objects.

Applications of robotics:

1. Customer Service
2. Accounting
3. Financial Services
4. Healthcare
5. Human Resources
6. Supply Chain Management

Interfacing sensors with board

- The concept of interfacing sensors is giving input from sensors to microcontroller or input systems in a way which they can understand and act accordingly.
- Most of the sensors give output in analog form but the microcontroller or microprocessor needs input as digital so now comparators act as interfacing sensors where they convert analog signals to digital signals.

Computer Vision

- Computer vision is the science and technology of machines that see.
- Humans use their eyes and their brains to see and visually sense the world around them. Computer vision is the science that aims to give a similar, if not better, capability to a machine or computer.
- Computer vision is concerned with the automatic extraction, analysis and understanding of useful information from a single image or a sequence of images.
- It involves the development of a theoretical and algorithmic basis to achieve automatic visual understanding.

Applications of Computer Vision

- Agriculture
- Augmented reality
- Autonomous vehicles
- Biometrics
- Character recognition
- Forensics
- Industrial quality inspection
- Face recognition
- Gesture analysis

- Medical image analysis

Computer Vision in AI

- One of the most interesting uses of computer vision, from an AI standpoint, is image recognition, which gives a machine the ability to interpret the input received through computer vision and categorize what it “sees.”
- Computer vision, an AI technology that allows computers to understand and label images, is now used in convenience stores, driverless car testing, daily medical diagnostics, and in monitoring the health of crops and livestock.
- Top technology companies such as Amazon, Google, Microsoft, and Facebook are investing billions of dollars in computer vision research and product development.

Introduction to Chatbot

- A chatbot is defined as a conversational application that aids in customer service, engagement, and support by replacing or augmenting human support agents with artificial intelligence (AI) and other automation technologies that can communicate with end-users via chat.
- A chatbot communicates similarly to instant messaging.
- A chatbot is software that simulates human conversations. It enables the communication between a human and a machine, which can take the form of messages or voice commands.
- A chatbot is designed to work without the assistance of a human operator.
- AI chatbot responds to questions posed to it in natural language as if it were a real person.
- It responds using a combination of pre-programmed scripts and machine learning algorithms.

- For instance, you could be browsing an e-commerce platform to purchase an item on your computer when a window appears on your monitor asking whether you require assistance.
- Alternatively, a person may use voice input to order a beverage from a nearby retail outlet and receive an alert indicating when the order would be ready and how much it would cost.

Working of Chatbot

How Chatbot Work?

- The three mechanisms that require your attention are rules-based processes and AI-driven decision-making.
- Depending on a chatbot’s mechanism, its functionality will be slightly different.

Rule Based Process

- A rule-based bot can only comprehend a limited range of choices that it has been programmed with.
- Predefined rules define the course of the bot’s conversation.
- Rule-based chatbots are easier to build as they use a simple true-false algorithm to understand user queries and provide relevant answers.

AI Based Chatbot

- This bot is equipped with an artificial brain, also known as artificial intelligence.
- It is trained using machine-learning algorithms and can understand open-ended queries.
- Not only does it comprehend orders, but it also understands the language.
- As the bot learns from the interactions it has with users, it continues to improve.

- The AI chatbot identifies the language, context, and intent, which then reacts accordingly.

Applications of Chatbot

1. **Retail and E-Commerce**
    - Personalized product recommendations
    - Cart recovery
    - Inventory checks
    - Order tracking
2. **Travel and Hospitality**
    - Booking assistance
    - Local recommendations
    - Real-time travel updates
    - Multilingual communications
    - Loyalty programs and promotions
3. **Banking, Financial Services, and Insurance (BFSI)**
    - Instant transaction updates
    - Personalized financial updates
    - Fraud alert and security
    - Loan and insurance queries
    - Effortless account management
4. **Healthcare**
    - Billing and insurance claims automation
    - Conversational self-service
    - Finding the right specialist
    - Automated appointment scheduling
5. **Automotive Industry**
    - Vehicle recommendations

- Booking test drives
- Service and maintenance reminders and scheduling
- Conversational FAQs
- Financing and leasing information
- Parts and accessories inquiry

6. **Education**
    - Onboarding and administrative support
    - Course enrollment assistance
    - Personalized learning paths
    - Mental health support
    - Exam preparation and mock test