MODULE -1

Artificial Intelligence is defined as the process where a machine tries to make decisions like a human brain. A collection of technologies known as artificial intelligence (AI) enables computers to carry out a range of complex tasks, such as the ability to **see**, **hear**, **interpret**, and **translate spoken** and **written language**, **analyze data**, **generate suggestions**, and more

What is Artificial Intelligence?

Artificial Intelligence is the practice of transforming digital computers into working robots (physical & non-physical) activities. They are designed in such a way that they can perform any dedicated tasks and also take decisions based on the provided inputs. The reason behind its hype around the world today is its act of working and thinking like a human being.

Besides this, Artificial Intelligence is a branch of computer science that was introduced with the idea to make things simpler and automotive which humans can't (in most cases). The algorithm fits in artificial intelligence to learn from the provided data so that future predictions can be made for effective business.

Applications of Artificial Intelligence(AI)

The major applications of AI are in E-Commerce, Education, Robotics, Healthcare, social media, etc. So, here we have listed the top 20 AI Applications with examples.

1. *Artificial Intelligence in E-Commerce*

Artificial Intelligence is widely used in the field of E-commerce as it helps the organization to establish a good engagement between the user and the company. Artificial Intelligence helps to make appropriate suggestions and recommendations as per the user search history and view preferences. There are also **AI chatbots** that are used to provide customer support instantly and help to reduce complaints and queries to a great extent. Let's take a closer look at AI applications in E-commerce.

- **Personalization:** Using this feature, customers would be able to see those products based on their interest pattern and that eventually will drive more conversions.
- **Enhanced Support:** It's very important to attend to every customer's query to reduce the churn ratio and to empower that AI-powered chatbots are well capable of handling most of the queries that too 24×7
- **Dynamic Pricing Structure:** It's a smart way of fluctuating the price of any given product by analyzing data from different sources and based on which price prediction is being done.
- **Fake Review Detection:** A report suggested that 9 out of 10 people tend to go through customer reviews first before they actually place any order.
- **Voice Search:** With the introduction of this feature, many applications and websites are using voice-over searches in their system. Today, 6 out of 10 prefer to use this feature for online shopping. In addition to this, alone in the USA, the market growth has risen up to 400% in just 2 years, i.e. from 4.6 USD Billion to 20 USD Billion.

2. AI in Education Purpose

Educational sectors are totally organized and managed by human involvement till some years back. But these days, the educational sector is also coming under the influence of Artificial Intelligence. It helps the faculty as well as the students by making course recommendations, Analysing some data and some decisions about the student, etc. **Making automated message**s to the students, and parents regarding any vacation, and test results are done by Artificial Intelligence these days. Let's take a closer look at AI applications in Education.

- **Voice Assistant:** With the help of AI algorithms, this feature can be used in multiple and broad ways to save time. provide convenience, and can assist users as and when required.

- **Gamification:** This feature has enabled e-learning companies to design attractive game modes into their system so that kids can learn in a super fun way. This will not only make kids engage while learning but will also ensure that they are catching the concepts and all thanks to AI for that.
- **Smart Content Creation:** AI uses algorithms to detect, predict and design content & provide valuable insights based on the user's interest which can include videos, audio, infographics, etc. Following this, with the introduction of AR/VR technologies, e-learning companies are likely to start creating games (for learning), and video content for the best experience.

3. Artificial Intelligence in Robotics

Artificial Intelligence is one of the major technologies that provide the **robotics** field with a boost to increase their efficiency. AI provides robots to make decisions in real time and increase productivity. For example, suppose there is a warehouse in which robots are used to manage good packages. The robots are only designed to deliver the task but Artificial Intelligence makes them able to analyze the vacant space and make the best decision in real-time. Let's take a closer look at AI applications in Robotics.

- **NLP:** Natural Language Processing plays a vital role in robotics to interpret the command as a human being instructs. This enables AI algorithms & techniques such as sentimental analysis, syntactic parsing, etc.
- **Object Recognition & Manipulation:** This functionality enables robots to detect objects within the perimeter and this technique also helps robots to understand the size & shape of that particular object. Besides this, this technique has two units, one is to identify the object & the other one refers to the physical interaction with the object.
- **HRI:** With the help of AI algorithms, HRI or Human-Robotics Interaction is being developed that helps in understanding human patterns such as gestures, expressions, etc. This technique helps maximize the performance of robots and ensures that it reaches and maintains its accuracy.

4. GPS and Navigations

GPS technology uses Artificial Intelligence to make the best route and provide the best available route to the users for traveling. This is also suggested by research provided by the **MIT Institute** that AI is able to provide accurate, timely, and real-time information about any specific location. It helps the user to choose their type of lane and roads which increases the safety features of a user. GPS and **navigation** use the **convolutional** and **graph neural network** of Artificial Intelligence to provide these suggestions. Let's take a closer look at AI applications in GPS & Navigation.

- **Voice Assistance:** This feature allows users to interact with the AI using a hands-free feature & which allows them to drive seamlessly while communicating through the navigation system.
- **Personalization (Intelligent Routing):** The personalized system gets active based on the user's pattern & behavior of preferred routes. Irrespective of the time & duration, the GPS will always provide suggestions based on multiple patterns & analyses.
- **Traffic Prediction:** AI uses a Linear Regression algorithm that helps in preparing and analyzing the traffic data. This clearly helps an individual in saving time and alternate routes are provided based on congestion ahead of the user.
- **Positioning & Planning:** GPS & Navigation requires enhance support of AI for better positioning & planning to avoid unwanted traffic zones. To help with this, AI-based techniques are being used such as Kalman, Sensor fusion, etc. Besides this, AI also uses prediction methods to analyze the fastest & efficient route to surface the real-time data.

5. Healthcare

Artificial Intelligence is widely used in the field of **healthcare and medicine**. The various algorithms of Artificial Intelligence are used to build precise machines that are able to detect minor diseases inside the human body. Also, Artificial Intelligence uses the medical history and current situation of a particular human being to predict future diseases. Artificial Intelligence is also used to find the current vacant beds in the hospitals of a city that saves the time of patients who are in emergency conditions. Let's take a closer look at AI applications in Healthcare.

- **Insights & Analysis**: With the help of AI, a collection of large datasets, that includes clinical data, research studies, and public health data, to identify trends and patterns. This inversely provides aid in surveillance and public health planning.
- **Telehealth:** This feature enables doctors and healthcare experts to take close monitoring while analyzing data to prevent any uncertain health issues. Patients who are at high risk and require intensive care are likely to get benefitted from this AI-powered feature.
- **Patient Monitoring:** In case of any abnormal activity and alarming alerts during the care of patients, an AI system is being used for early intervention. Besides this, RPM, or Remote Patient Monitoring has been significantly growing & is expected to go up by USD 6 Billion by 2025, to treat and monitor patients.
- **Surgical Assistance:** To ensure a streamlined procedure guided by the AI algorithms, it helps surgeons to take effective decisions based on the provided insights to make sure that no further risks are involved in this while processing.

6. Automobiles

Artificial Intelligence is bringing revolutionary changes in the field of **automobiles**. From speedometers to self-driving cars, Artificial Intelligence is really doing a significant difference in these sectors. AI is sued to detect the traffic on the street and provide the best route out o the present all routes to the driver. It uses **sensors**, **GPS technology**, and **control signals** to bring the vehicle the best path. Let's take a closer look at AI applications in Automobiles.

- **ADAS:** Advanced Driving Assistance System or ADAS is an AI algorithm that is known for processing some of major and sensitive data that includes driving assistance, crash detection, parking assistance, and so on. The algorithm has been designed in such a way that it automatically starts alarming to prevent any collisions.
- **Traffic Management:** With the help of AI systems, now it has become easier to analyze traffic data from various sources, including vehicles, sensors, and cameras. This feature helps in boosting driving assistance by offering alternate routes. This AI algorithm has been designed in such a way that it is well capable of assisting users with real-time traffic insight and by offering the fastest route as an alternative to users to save time efficiently.
- **Emission Reduction:** This feature detects and learns patterns from the given inputs i.e. from the driving pattern of the user and based on this it strategizes to perform efficient driving patterns by reducing emissions. This algorithm is well capable of analyzing routes, traffic, car performance patterns, and so on.
- **Autonomous Driving:** This AI approach enables automatic driving and navigating vehicles without actual human intervention. Sensors like LIDAR, RADAR, and other sensors help in collecting additional data to analyze the surroundings for taking optimal decisions in the real world.

7. Agriculture

Artificial Intelligence is also becoming a part of **agriculture** and farmers' life. It is used to detect various parameters such as the **amount of water and moisture**, **amount of deficient nutrients**, etc in the soil. There is also a machine that uses AI to detect where the weeds are growing, where the soil is infertile, etc. Let's take a closer look at AI applications in Agriculture.

- **Stock Monitoring:** To have rigorous monitoring, and ensure that crops that not being affected by any disease, AI uses CN to check crop feeds live and alarms when any abnormality arises.
- **Supply Chain:** The AI algorithm helps in analyzing and preparing the inventory to maintain the supply chain stock. Although it's not new, for the agriculture field, it does help farmers to ensure the demands are being met with minimal loss.
- **Pest Management:** AI algorithms can analyze data from multiple sources to identify early warnings to their respective farmers. This technology also enables less usage of harmful pesticides by offering the best resources for pest management.
- **Forecasting:** With the help of AI, analyzing the weather forecast and crop growth has become more convenient in the field of agriculture and the algorithms help farmers to grow crops with effective business decisions.

8. Human Resource

As we know, much of the **hiring processes** are done online these days. The online selection processes are done using the voice and camera permission of the candidate's device. Here Artificial Intelligence is used to **detect any kind of malpractice behavior** and many other things. It is also used to detect any candidate's personality in some cases. This reduces the effort of the hiring team and also enhances the efficiency of the selection process. Let's take a closer look at AI applications in Human Resources.

- **Screening:** With the help of AI, the screening process of candidates can be automated to reduce the timeframe and eliminate excess resources for this task. This helps shortlist potential candidates, and resumes and assess other insightful information in no time.
- **Onboarding:** Offering a personalized onboarding kit has become famous in many tech companies and this enables HR professionals to complete the initial paperwork in a short time.
- **Performance:** This feature enables HR professionals to perform an exercise to evaluate the employee's performance based on the derived data and provide insights where the scope of improvement is required. This process generally takes time if attempted manually, with the help of AI algorithms, all the desired outputs can be derived in the shortest possible time.
- **Workforce Planning:** To predict future work plans and align resources, AI can be helpful in the human resource sector. This requires a predictive analysis based on which workforce planning is being performed.

9. Lifestyle

Artificial Intelligence has a great impact on our lifestyle. There is various day to day that we do easily are possible due to the use of Artificial Intelligence. Some examples are **spam filters** in the mail, **fraud call detection**, **face unlock of mobile**, **fingerprint sensors** in our mobile and laptops, etc are only possible due to Artificial Intelligence. Let's take a closer look at AI applications in Lifestyle.

- **Personalized Recommendation:** AI algorithms analyze user purchasing patterns & based on which offer personalized recommendations for different categories which include books, clothing, and other products. The main objective of AI in lifestyle is to offer tailored solutions for its customer to experience the best experience that cannot be replaced by other substitutes.
- **Shopping Experience:** People have now shifted towards online shopping and the market size is likely to reach ***USD$ 71 Trillion by 2028 (between 2022-2028)***, and AI has a very significant role in this. By offering customizable recommendations, and offers, they target specific segment audiences to drive more sales.
- **Virtual Assistance:** There are certain apps now that have started offering enriched customer experience by adding virtual assistance to their ecosystem. AI-powered virtual assistants like Siri, Google Assistant, Alexa, and Cortana play a crucial part in this. With the help of NLP, and AI & ML algorithms, these assistants respond to customers' queries and act accordingly.
- **Language Translation:** To drive more sales & traffic, companies have now started implementing multiple language support systems to target vast audiences irrespective of the country.

10. Social media

There are various use of Artificial Intelligence in the field of social media. Some social media platform such as **Facebook**, **Instagram**, etc uses Artificial Intelligence to show relevant content to the user. It uses the search history and view history of a user to show relevant content. Let's take a closer look at AI applications in Social Media Platforms.

- **Fraud Detection:** AI uses algorithms to spot and remove any fake accounts that are associated with any social media platform. Fraudsters generally use those accounts to perform unethical activities. This includes phishing, threats, or any other suspicious behaviors.
- **Insights:** Most of the brands have become active on social media platforms to advertise their products, this not only create awareness but also helps to gather customer's review & feedback to enrich better customer experience.
- **Sentiment Analysis:** People are more connected and likely to spend more time on social media platforms. It definitely adds value to an individual's life and is connected with their emotions. AI uses its algorithm to determine the pattern to provide a better experience while maintaining awareness.

- **Moderation:** Due to an increase in social media engagements, active content moderation has become a key to controlling any disruption. Ai uses algorithms to filter and moderate such content across different social media platforms. It marks the flag and eliminates any such content that violates the community guideline.

11. Gaming

Artificial Intelligence is really dominating the field of the **gaming** industry. Artificial Intelligence is used to make a human-like simulation in gaming. This enhances the gaming experience. Apart from that, AI is also used to **design games**, **predict human behavior**, to make the game more realistic. Various modern games use real-world simulation for gaming using AI. Let's take a closer look at AI applications in Gaming Sector.

- **Quality Assurance:** Testing games & ensuring their performance gets easier allows testers to perform rigorous testing in comparatively less time. It empowers and fixes all the game mechanics and any other potential bugs that can hinder performance.
- **Game Assistance:** AI algorithms offers virtual assistance during gaming sessions that include tips, tutorials, and other useful resources. This feature help players to be in the game & understand the metrics during the whole time session.
- **Animation:** To make games more realistic, machine learning and artificial intelligence algorithms are being used in today's gaming industry. Techniques such as Neural network empowers stimulation and facial expressions for an immersive experience.

12. Astronomy

In recent years, Artificial intelligence is also expanding its application in the field of astronomy. AI is used to investigate galaxy mergers and stars to predict the future of human beings. The movement of stars in the sky is recorded for the whole day and night over a large time to read the changes using AI. It creates about **80 terabytes of data** for one round f the rotation of the earth and records the changes in the galaxy and stars in the cosmos. Let's take a closer look at AI applications in Astronomy.

- **Analysis:** It uses various classifiers, and identifier and extracts insights from time series, based on different incidents.
- **Detection & Classification:** AI uses its algorithms to predict incidents by performing analysis from exoplanets and other subsidies. They are well capable of performing various other astronomical patterns based on large datasets.
- **Survey:** AI uses its algorithms to plan and execute large datasets to derive abstract real-time events. This enables users to extract useful insight from various resources.

13. Chatbots

Chatbots are defined as a tool that is used to respond to the text that is given to them as input. In it, the customer or user sends the query according to their need and the chatbot gives the most appropriate output to provide the best solution according to the input. Let's take a closer look at AI applications in Chatbots.

- **NLP:** Natural Language Processing empowers chatbots to interact with humans over chat in a more interactive way by offering quick resolution to their queries in no time. It also allows chatbots to process text or speech inputs, and extract meaning to generate the desired response.
- **Multi-Language:** AI-powered chatbots are capable of handling multiple languages to provide support to users worldwide. NLP algorithms enable chatbots to understand and generate responses in different languages to cater to a vast community for extensive support.
- **Adaptation:** AI uses algorithms to continuously improve and learn over a period of time. Through machine learning techniques, chatbots can analyze and identify areas for improvement, and update themselves based on the shared details.

14. Surveillance

Artificial intelligence is also used in the field of **surveillance** by **recognizing far faces and objects**. Then the event recognition capabilities are used to enhance these faces and objects. This helps the military to protect their areas and prevent any attack in real time. Let's take a closer look at AI applications in Surveillance.

- **Object Detection:** With the help of CN, AI algorithms help in tracking objects of interest in real time. This feature allows the system to detect any object's movement as & when required for further analysis.
- **Predictive Analysis:** AI in surveillance can analyze historical data and patterns to make effective decisions. This can be achieved by empowering different techniques used in machine learning, deep learning, and artificial intelligence.
- **Behavior Analysis:** Body gesture says it all & that's why AI in surveillance can analyze human behavior patterns, such as gesture recognition or body language analysis, to assess potential threats or suspicious activities.

15. Finance

According to some recent surveys, **80% of banks accept that AI can provide them benefits** according to their decisions in finance. From providing corporate finance advice to predicting the future outcome relate to finance, AI is capable of them Also it is used to send automated tests and mail, predict risk in loans, and detect any unwanted transactional activities, of the targeted customers. **Spam** and **fraud filters**, **uncharacterized actions**, **responding to threats**, etc are the tools that help in the field. Let's take a closer look at AI applications in Finance.

- **Fraud Detection:** AI algorithms can analyze large volumes of financial data to identify patterns and anomalies that can lead to any fraudulent activity. By continuously learning from historical data, AI is well capable of handling & working with such datasets & it enables the ability to prevent from any future threats.
- **Risk Assessment:** AI algorithms help in enabling safeguard risk assessment models by analyzing large datasets and identifying potential risks in real-time.
- **Forecasting:** AI-powered tools can assist in financial planning and forecasting that can create easy opportunities for businesses to make effective business decisions. This can be achieved by analyzing historical data, market trends, and economic indicators.

16. Data Security

Data security is one of the major concerns for any tech company, as it keeps the information about many users' credentials secret information of a company. There are many AI application that is used o keep these data safe and prevent form any kind of vulnerable threat and attacks. Let's take a closer look at AI applications in Data Security.

- **Threat Detection:** AI algorithms can analyze and work on large datasets from various sources, such as network logs, user behavior, system activities, and so on. This helps in the early detection of malware, or any unknown threats.
- **Vulnerability Management:** AI can assist in detecting any vulnerabilities in systems by analyzing code, configurations, and network infrastructure. With the help of AI algorithms, anyone having access can start the scanning process automatically for known vulnerabilities and prioritize them based on the potential impact.
- **Malware Detection:** AI algorithms can predict & analyze the pattern of malware to provide a shield against any new threats. By allowing machine learning and deep learning techniques & algorithms, AI can easily identify previously unknown malware to prevent future attacks.

17. Travel and Transport

There is an intelligent transport system that uses Artificial Intelligence to improve the quality and experience of travelers. **Truck platooning** which is used to transport heavy loads uses Artificial Intelligence to manage their loads in an efficient manner. **Travel routing** and ride-sharing which used **real-time traffic** for a specific ride are possible due to the use of Artificial Intelligence. Let's take a closer look at AI applications in Travel and Transport.

- **Planning & Personalization:** AI uses customer's historic data along with the real-time data to offer any customized flexible plan under their budget. This helps in driving more sales & matches individual needs.

- **Predictive Analysis (Pricing)**: AI algorithms can analyze historical travel data, market trends, and other variables. This provides aid to predict demand patterns. Companies use this strategy to offer accommodations & travel assistance at higher rates.
- **Route Analysis:** AI uses its algorithms to detect & alarm users about any upcoming traffic during their usual route to improve user experience. This works on real-time data and is being highly used nowadays by all segments of the public.

18. Marketing

Artificial Intelligence is very dominating in the field of **marketing** as it is used to make an engagement with consumers using AI. AI is used to make make the reach by targeting the appropriate audience for a particular product. AI is used in the ad sense as it uses the search and purchase history to recommend the products. Apart from that. th chatbots are used to resolve the consumer issue in less time. Let's take a closer look at AI applications in Marketing.

- **Segmentation:** AI uses algorithms to work on large sets of data to identify and visualize customer's pattern and their behavior. This also helps companies to segregate the user base on different metrics such as age, gender, purchasing history, etc.
- **Content Creation:** AI uses NLP to generate curated content. Besides this, AI is also well capable of generating different segments of content in a flick of time.
- **Advertising:** AI enhances advertising campaigns by optimizing targeting, bidding, and creative elements that can boost their advertising strategy. It can also help in analyzing users' sentiments and patterns based on different factors and datasets.

19. Entertainment

AI is also used in the field of movies and entertainment. This field uses artificial intelligence for tagging various content to a specific person. Also, the entertainment industry used artificial intelligence for the categorization and classification of content according to the user. Let's take a closer look at AI applications in Entertainment.

- **Recommendation:** AI technologies can analyze vast amounts of data, that includes viewing patterns, and user preference, and extracts historic data. Now this data is being used to provide personalized recommendations to keep up the engagement ratio and watch time.
- **Audience Insight:** AI helps entertainment companies analyze large volumes of data, and this can become mainstream for companies to make effective business decisions. By using AI, it shows the audience watching pattern, and engagement ratio.
- **Real-Time Engagement:** This has become one of the most prominent ways of keeping their user engaged by analyzing real-time data & based on which it offers personalized content recommendations.

20. Military

Artificial Intelligence is also about to help defense and the military in the coming days. The government is planning to use artificial intelligence for various military operational support. Also, it will help in some **automatic artilleries** and **weapons**. Let's take a closer look at AI applications in the Military.

- **Decision Support:** AI algorithms can analyze large amounts of data, including sensor inputs, intelligence reports, and historical information. These insights provide aid while taking an effective decision that includes stock management, resource allocation, and so on without actual human intervention.
- **Cyberattack:** AI plays a crucial role in detecting and responding to cyber threats in military networks. AI algorithms are capable enough to handle and manage vast datasets that can detect any abnormal activity before it actually occurs.
- **Training:** AI uses algorithms to train their staff in different situations that can make it more or less realistic. This can help them in making the right decision at the moment and strategies their plan effectively.

*Representation and search are fundamental concepts in the field of Artificial Intelligence (AI). They play a crucial role in problem-solving, decision-making, and various other cognitive tasks performed by intelligent systems. Let's delve into an introduction to representation and search in AI:

Representation in AI:

Definition:

Representation in AI refers to the way information is modeled and stored within a system to make it accessible and manipulable for problem-solving or decision-making. Effective representation is crucial for capturing the essential features of a problem domain and facilitating intelligent reasoning.

Types of Representations:

1. **Symbolic Representation:**

   - Involves using symbols and rules to represent knowledge.

   - Common in rule-based systems and expert systems.

2. **Connectionist Representation:**

   - Utilizes interconnected nodes or neurons to represent information.

   - Common in neural networks and parallel distributed processing models.

3. **Structured Representation:**

   - Represents knowledge in a structured form, often using graphs, hierarchies, or frames.

   - Facilitates organizing and understanding complex relationships.

4. **Semantic Representation:**

   - Focuses on capturing the meaning of information.

   - Utilizes semantic networks or ontologies

Importance:

Effective representation is crucial for building intelligent systems that can understand, reason, and solve problems. The choice of representation can significantly impact the efficiency and accuracy of AI algorithms.

Search in AI:

Definition:

Search in AI involves exploring a space of possible solutions to find a path or configuration that satisfies a certain criterion. This process is central to problem-solving and decision-making in AI applications.

***Components of Search:**

1. **State Space:**

   - Represents all possible configurations or states that the system can be in.

   - The search process navigates through this space to find a solution.

2. **Operators:**

- Actions or transformations that can be applied to move from one state to another.

- Define the possible moves in the search space.

3. **Initial State:**

- The starting point of the search process.

- The AI system begins exploring from this state.

4. **Goal State:**

- The desired configuration or solution.

- The search process aims to find a path leading to the goal state.

Search Algorithms:

- **Uninformed Search Algorithms:** Blind search methods like Breadth-First Search and Depth-First Search.

- **Informed Search Algorithms:** Guided search methods like A* (A-star) algorithm, which uses heuristic information to guide the search efficiently.

Importance:

Search algorithms are fundamental for solving problems, making decisions, and optimizing solutions in various AI applications. The efficiency and effectiveness of the search process directly impact the performance of intelligent systems.

In summary, **representation and search** are key pillars in the development of AI systems, enabling them to model knowledge effectively and find solutions to complex problems. The choice of representation and search algorithms greatly influences the capabilities and performance of AI applications.

Propositional logic in Artificial intelligence

Propositional logic (PL) is the simplest form of logic where all the statements are made by propositions. A proposition is a declarative statement which is either true or false. It is a technique of knowledge representation in logical and mathematical form.

Example:

1. a) It is Sunday.
2. b) The Sun rises from West (False proposition)
3. c) 3+3= 7(False proposition)
4. d) 5 is a prime number.

Following are some basic facts about propositional logic:

- Propositional logic is also called Boolean logic as it works on 0 and 1.
- In propositional logic, we use symbolic variables to represent the logic, and we can use any symbol for a representing a proposition, such A, B, C, P, Q, R, etc.
- Propositions can be either true or false, but it cannot be both.

- Propositional logic consists of an object, relations or function, and **logical connectives**.
- These connectives are also called logical operators.
- The propositions and connectives are the basic elements of the propositional logic.
- Connectives can be said as a logical operator which connects two sentences.
- A proposition formula which is always true is called **tautology**, and it is also called a valid sentence.
- A proposition formula which is always false is called **Contradiction**.
- Statements which are questions, commands, or opinions are not propositions such as "**Where is Rohini**", "**How are – you**", "**What is your name**", are not propositions.

Syntax of propositional logic:

The syntax of propositional logic defines the allowable sentences for the knowledge representation. There are two types of Propositions:

a. **Atomic Propositions**

b. **Compound propositions**

- **Atomic Proposition:** Atomic propositions are the simple propositions. It consists of a single proposition symbol. These are the sentences which must be either true or false.

Example:

1. a) 2+2 is 4, it is an atomic proposition as it is a **true** fact.
2. b) "The Sun is cold" is also a proposition as it is a **false** fact.

- **Compound proposition:** Compound propositions are constructed by combining simpler or atomic propositions, using parenthesis and logical connectives.

Example:

1. a) "It is raining today, and street is wet."
2. b) "Ankit is a doctor, and his clinic is in Mumbai."

Logical Connectives:

Logical connectives are used to connect two simpler propositions or representing a sentence logically. We can create compound propositions with the help of logical connectives. There are mainly five connectives, which are given as follows:

1. **Negation:** A sentence such as ¬ P is called negation of P. A literal can be either Positive literal or negative literal.
2. **Conjunction:** A sentence which has ∧ connective such as, P ∧ Q is called a conjunction.
   Example: Rohan is intelligent and hardworking. It can be written as,

P= Rohan is intelligent,

Q= Rohan is hardworking. → P∧ Q.

3. **Disjunction:** A sentence which has ∨ connective, such as **P ∨ Q.** is called disjunction, where P and Q are the propositions.

   Example: "Ritika is a doctor or Engineer",

   Here P= Ritika is Doctor. Q= Ritika is Doctor, so we can write it as **P ∨ Q.**

4. **Implication:** A sentence such as P → Q, is called an implication. Implications are also known as if-then rules. It can be represented as

   If it is raining, then the street is wet.

   Let P= It is raining, and Q= Street is wet, so it is represented as P → Q

5. **Biconditional:** A sentence such as **P⇔ Q is a Biconditional sentence, example If I am breathing, then I am alive**

   P= I am breathing, Q= I am alive, it can be represented as P ⇔ Q.

Following is the summarized table for Propositional Logic Connectives:

Connective symbols	Word	Technical term	Example
∧	AND	Conjunction	A ∧ B
∨	OR	Disjunction	A ∨ B
→	Implies	Implication	A → B
⇔	If and only if	Biconditional	A⇔ B
¬ or ~	Not	Negation	¬ A or ¬ B

Truth Table:

In propositional logic, we need to know the truth values of propositions in all possible scenarios. We can combine all the possible combination with logical connectives, and the representation of these combinations in a tabular format is called **Truth table**. Following are the truth table for all logical connectives:

For Negation:

P	¬ P
True	**False**
False	**True**

For Conjunction:

P	Q	P∧ Q
True	True	**True**
True	False	**False**
False	True	**False**
False	False	**False**

For disjunction:

P	Q	P ∨ Q.
True	True	**True**
False	True	**True**
True	False	**True**
False	False	**False**

For Implication:

P	Q	P→ Q
True	True	**True**
True	False	**False**
False	True	**True**
False	False	**True**

For Biconditional:

P	Q	P⇔ Q
True	True	**True**
True	False	**False**
False	True	**False**
False	False	**True**

Truth table with three propositions:

We can build a proposition composing three propositions P, Q, and R. This truth table is made-up of 8n Tuples as we have taken three proposition symbols.

P	Q	R	¬R	Pv Q	PvQ→¬R
True	True	True	False	True	False
True	True	False	True	True	True
True	False	True	False	True	False
True	False	False	True	True	True
False	True	True	False	True	False
False	True	False	True	True	True
False	False	True	False	False	True
False	False	False	True	False	True

Precedence of connectives:

Just like arithmetic operators, there is a precedence order for propositional connectors or logical operators. This order should be followed while evaluating a propositional problem. Following is the list of the precedence order for operators:

Precedence	Operators
First Precedence	Parenthesis
Second Precedence	Negation
Third Precedence	Conjunction(AND)
Fourth Precedence	Disjunction(OR)
Fifth Precedence	Implication
Six Precedence	Biconditional

Note: For better understanding use parenthesis to make sure of the correct interpretations. Such as ¬R∨ Q, It can be interpreted as (¬R) ∨ Q.

Logical equivalence:

Logical equivalence is one of the features of propositional logic. Two propositions are said to be logically equivalent if and only if the columns in the truth table are identical to each other.

Let's take two propositions A and B, so for logical equivalence, we can write it as A⇔B. In below truth table we can see that column for ¬A∨ B and A→B, are identical hence A is Equivalent to B

A	B	¬A	¬A∨ B	A→B
T	T	F	**T**	**T**
T	F	F	**F**	**F**
F	T	T	**T**	**T**
F	F	T	**T**	**T**

Properties of Operators:

- **Commutativity:**
  - P∧ Q= Q ∧ P, or
  - P ∨ Q = Q ∨ P.
- **Associativity:**
  - (P ∧ Q) ∧ R= P ∧ (Q ∧ R),
  - (P ∨ Q) ∨ R= P ∨ (Q ∨ R)
- **Identity element:**
  - P ∧ True = P,
  - P ∨ True= True.
- **Distributive:**
  - P∧ (Q ∨ R) = (P ∧ Q) ∨ (P ∧ R).
  - P ∨ (Q ∧ R) = (P ∨ Q) ∧ (P ∨ R).
- **DE Morgan's Law:**
  - ¬ (P ∧ Q) = (¬P) ∨ (¬Q)
  - ¬ (P ∨ Q) = (¬ P) ∧ (¬Q).
- **Double-negation elimination:**
  - ¬ (¬P) = P.

Limitations of Propositional logic:

- We cannot represent relations like ALL, some, or none with propositional logic. Example:

a. **All the girls are intelligent.**

b. **Some apples are sweet.**

- Propositional logic has limited expressive power.
- In propositional logic, we cannot describe statements in terms of their properties or logical relationships.

Predicate Calculus deals with predicates, which are propositions containing variables.

Predicate

A predicate is an expression of one or more variables defined on some specific domain. A predicate with variables can be made a proposition by either assigning a value to the variable or by quantifying the variable.

Consider the following statement.

> Ram is a student.

Now consider the above statement in terms of Predicate calculus.

> Here "is a student" is a predicate and Ram is subject.
> Let's denote "Ram" as x and "is a student" as a predicate P then we can write the above statement as P(x).
> Generally a statement expressed by Predicate must have at least one object associated with Predicate. In our case, Ram is the required object with associated with predicate P.

Statement Function

Earlier we denoted "Ram" as x and "is a student" as predicate P then we have statement as P(x). Here P(x) is a statement function where if we replace x with a Subject say Sunil then we'll be having a statement "Sunil is a student."

Thus a statement function is an expression having Predicate Symbol and one or multiple variables. This statement function gives a statement when we replaced the variables with objects. This replacement is called substitution instance of statement function.

Quantifiers

The variable of predicates is quantified by quantifiers. There are two types of quantifier in predicate logic − Universal Quantifier and Existential Quantifier.

Universal Quantifier

Universal quantifier states that the statements within its scope are true for every value of the specific variable. It is denoted by the symbol ∀.

∀ x P(x) is read as for every value of x, P(x) is true.

Example − "Man is mortal" can be transformed into the propositional form ∀ x P(x) where P(x) is the predicate which denotes x is mortal and ∀ x represents all men.

Existential Quantifier

Existential quantifier states that the statements within its scope are true for some values of the specific variable. It is denoted by the symbol ∃.

∃ x P(x) is read as for some values of x, P(x) is true.

Example – "Some people are dishonest" can be transformed into the propositional form ∃ x P(x) where P(x) is the predicate which denotes x is dishonest and ∃ x represents some dishonest men.

Predicate Formulas

Consider a Predicate P with n variables as $P(x_1, x_2, x_3, ..., x_n)$. Here P is n-place predicate and $x_1, x_2, x_3, ..., x_n$ are n individuals variables. This n-place predicate is known as **atomic formula** of predicate calculus. For Example: P(), Q(x, y), R(x,y,z)

Well Formed Formula

Well Formed Formula (wff) is a predicate holding any of the following –

All propositional constants and propositional variables are wffs
If x is a variable and Y is a wff, ∀ x Y and ∀ x Y are also wff
Truth value and false values are wffs
Each atomic formula is a wff
All connectives connecting wffs are wffs

Free and Bound variables

Consider a Predicate formula having a part in form of (∃ x) P(x) of (x)P(x), then such part is called x-bound part of the formula. Any occurrence of x in x-bound part is termed as bound occurrence and any occurrence of x which is not x-bound is termed as free occurrence. See the examples below -

(∃ x) (P(x) ∧ Q(x))
(∃ x) P(x) ∧ Q(x)

In first example, scope of (∃ x) is (P(x) ∧ Q(x)) and all occurrences of x are bound occurrences. Whereas in second example, scope of (∃ x) is P(x) and last occurrence of x in Q(x) is a free occurrence.

Universe of Discourse

We can limit the class of individuals/objects used in a statment. Here limiting means confining the input variable to a set of particular individuals/objects. Such a restricted class is termed as Universe of Discourse/domain of individual or universe. See the example below:

Some cats are black.

C(x) : x is a cat.
B(x) : x is black.
(∃ x)(C(x) ∧ B(x))

If Universe of discourse is E = { Katy, Mille } where katy and Mille are white cats then our third statement is false when we replace x with either Katy or Mille where as if Universe of discourse is E = { Jene, Jackie } where Jene and Jackie black cats then our third statement stands true for Universe of Discourse F.

Rules of Inference in Artificial intelligence

Inference:

In artificial intelligence, we need intelligent computers which can create new logic from old logic or by evidence, **so generating the conclusions from evidence and facts is termed as Inference**.

Inference rules:

Inference rules are the templates for generating valid arguments. Inference rules are applied to derive proofs in artificial intelligence, and the proof is a sequence of the conclusion that leads to the desired goal.

In inference rules, the implication among all the connectives plays an important role. Following are some terminologies related to inference rules:

- **Implication:** It is one of the logical connectives which can be represented as P → Q. It is a Boolean expression.
- **Converse:** The converse of implication, which means the right-hand side proposition goes to the left-hand side and vice-versa. It can be written as Q → P.
- **Contrapositive:** The negation of converse is termed as contrapositive, and it can be represented as ¬ Q → ¬ P.
- **Inverse:** The negation of implication is called inverse. It can be represented as ¬ P → ¬ Q.

From the above term some of the compound statements are equivalent to each other, which we can prove using truth table:

P	Q	P → Q	Q→ P	¬ Q → ¬ P	¬ P → ¬ Q.
T	T	T	T	T	T
T	F	F	T	F	T
F	T	T	F	T	F
F	F	T	T	T	T

Hence from the above truth table, we can prove that P → Q is equivalent to ¬ Q → ¬ P, and Q→ P is equivalent to ¬ P → ¬ Q.

Types of Inference rules:

1. Modus Ponens:

The Modus Ponens rule is one of the most important rules of inference, and it states that if P and P → Q is true, then we can infer that Q will be true. It can be represented as:

Notation for Modus ponens: $\frac{P \rightarrow Q, \quad P}{\therefore Q}$

Example:

Statement-1: "If I am sleepy then I go to bed" ==> P→ Q

Statement-2: "I am sleepy" ==> P

Conclusion: "I go to bed." ==> Q.

Hence, we can say that, if P→ Q is true and P is true then Q will be true.

Proof by Truth table:

P	Q	$P \rightarrow Q$
0	**0**	**0**
0	**1**	**1**
1	**0**	**0**
1	**1**	**1**

2. Modus Tollens:

The Modus Tollens rule state that if P→ Q is true and **¬ Q is true, then ¬ P** will also true. It can be represented as:

Notation for Modus Tollens: $\frac{P \rightarrow Q, \quad \sim Q}{\sim P}$

Statement-1: "If I am sleepy then I go to bed" ==> P→ Q

Statement-2: "I do not go to the bed."==> ~Q

Statement-3: Which infers that "**I am not sleepy**" => ~P

Proof by Truth table:

P	Q	$\sim P$	$\sim Q$	$P \rightarrow Q$
0	**0**	**1**	**1**	**1**
0	**1**	**1**	**0**	**1**
1	**0**	**0**	**1**	**0**
1	**1**	**0**	**0**	**1**

3. Hypothetical Syllogism:

The Hypothetical Syllogism rule state that if P→R is true whenever P→Q is true, and Q→R is true. It can be represented as the following notation:

Example:

Statement-1: If you have my home key then you can unlock my home. **P→Q**

Statement-2: If you can unlock my home then you can take my money. **Q→R**

Conclusion: If you have my home key then you can take my money. **P→R**

Proof by truth table:

P	Q	R	$P \rightarrow Q$	$Q \rightarrow R$	$P \rightarrow R$	
0	0	0	1	1	1	←
0	0	1	1	1	1	←
0	1	0	1	0	1	
0	1	1	1	1	1	←
1	0	0	0	1	1	
1	0	1	0	1	1	
1	1	0	1	0	0	
1	1	1	1	1	1	←

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4. Disjunctive Syllogism:

The Disjunctive syllogism rule state that if P∨Q is true, and ¬P is true, then Q will be true. It can be represented as:

Notation of Disjunctive syllogism: $\frac{P \vee Q, \ \neg P}{Q}$

Example:

Statement-1: Today is Sunday or Monday. ==>P∨Q

Statement-2: Today is not Sunday. ==> ¬P

Conclusion: Today is Monday. ==> Q

Proof by truth-table:

P	Q	$\neg P$	$P \vee Q$	
0	0	1	0	
0	1	1	1	←
1	0	0	1	
1	1	0	1	

5. Addition:

The Addition rule is one the common inference rule, and it states that If P is true, then P∨Q will be true.

Notation of Addition: $\frac{P}{P \vee Q}$

Example:

Statement: I have a vanilla ice-cream. ==> P

Statement-2: I have Chocolate ice-cream.

Conclusion: I have vanilla or chocolate ice-cream. ==> (P∨Q)

Proof by Truth-Table:

P	Q	$P \vee Q$	
0	0	0	
1	0	1	←
0	1	1	
1	1	1	←

6. Simplification:

The simplification rule state that if **P∧ Q** is true, then **Q or P** will also be true. It can be represented as:

Notation of Simplification rule: $\frac{P \wedge Q}{Q}$ Or $\frac{P \wedge Q}{P}$

Proof by Truth-Table:

P	Q	$P \wedge Q$	
0	0	0	
1	0	0	
0	1	0	
1	1	1	←

7. Resolution:

The Resolution rule state that if P∨Q and ¬ P∧R is true, then Q∨R will also be true. **It can be represented as**

Notation of Resolution $\frac{P \vee Q, \quad \neg P \wedge R}{Q \vee R}$

Proof by Truth-Table:

P	¬ P	Q	R	$P \vee Q$	¬ P∧R	$Q \vee R$	
0	1	0	0	0	0	0	
0	1	0	1	0	0	1	
0	1	1	0	1	1	1	←
0	1	1	1	1	1	1	←
1	0	0	0	1	0	0	
1	0	0	1	1	0	1	
1	0	1	0	1	0	1	
1	0	1	1	1	0	1	←

* logic-based financial advisor application

Creating a **logic-based financial advisor application** using AI involves combining financial knowledge, decision-making algorithms, and user interaction. Here's a high-level outline of how you could approach building such an application:

1. **Define Objectives and Scope:**

- Clearly define the goals of your financial advisor application. Determine the scope of financial advice it will provide, such as budgeting, investment planning, debt management, retirement planning, etc.

2. **Data Collection and Integration:**

- Gather relevant financial data from users, such as income, expenses, assets, liabilities, investment preferences, risk tolerance, and financial goals.

- Integrate external data sources like market data, economic indicators, and financial news to enhance decision-making.

3. **Algorithm Development:**

- Develop algorithms based on established financial principles, models, and rules. This can include algorithms for budgeting, portfolio optimization, risk assessment, and other financial planning aspects.

- Utilize machine learning techniques for predicting market trends, assessing risk, and personalizing recommendations over time.

4. **User Interaction:**

- Design a user-friendly interface for users to input their financial information, preferences, and goals.

- Implement conversational AI to allow users to interact with the application through natural language processing. This could involve using chatbots or voice interfaces.

5. **Financial Planning Modules:**

   - Implement specific modules for different financial planning aspects, such as:

     - **Budgeting:** Assist users in creating and managing a budget based on their financial situation.

     - **Investment Planning:** Provide investment recommendations based on risk tolerance, financial goals, and market conditions.

     - **Debt Management:** Offer strategies for managing and reducing debt.

     - **Retirement Planning:** Help users plan for their retirement by analyzing savings, investment, and withdrawal strategies.

6. **Risk Assessment:**

   - Develop algorithms to assess the risk tolerance of users and recommend investment strategies accordingly.

7. **Regular Updates:**

   - Keep the application up-to-date with the latest market trends, economic indicators, and financial regulations.

8. **Security and Compliance:**

   - Implement robust security measures to protect users' financial data.

   - Ensure compliance with financial regulations and privacy standards.

9. **User Feedback and Improvement:**

   - Incorporate user feedback to continuously improve the application's recommendations and user experience.

   - Monitor the performance of the algorithms and adjust them as needed based on real-world outcomes.

10. **Testing:**

    - Thoroughly test the application for accuracy, reliability, and security before making it publicly available.

Remember to comply with relevant financial regulations and to communicate clearly to users about the limitations of the AI advice provided. Additionally, always prioritize user privacy and data security.