Parul® University

ARTIFICIAL INTELLIGENCE II

UNIT-3

Problems, Problems Spaces and Search

What is Problems, Problem Spaces, and Search in AI?

Artificial intelligence (AI) 's initial goal is to build machines capable of carrying out tasks that usually call for human intelligence. Among the core functions of AI is real-life problem-solving. Understanding "problems," "problem spaces," and "search" is fundamental to comprehending how AI systems handle and resolve challenging jobs in the current situation.

Problems in AI

A **problem is a particular task or challenge that calls for decision-making or solution-finding.**

In artificial intelligence, **an issue is simply a task that needs to be completed; these tasks can be anything from straightforward math problems to intricate decision-making situations.**

Artificial intelligence encompasses various jobs and challenges, from basic math operations to sophisticated ones like picture recognition, natural language processing, gameplay, and optimization.

Every problem has **a goal state** that must be attained, **a defined set of initial states, and potential actions or moves.**

Production System in AI

In artificial intelligence (AI), **a production system refers to a type of rule-based system that is designed to provide a structured approach to problem solving and decision-making.**
This framework is particularly influential in the realm of expert systems, where it simulates human decision-making processes using a set of predefined rules and facts.

Let's consider an example of Expert System for Medical Diagnosis
Scenario: A patient comes to a healthcare facility with the following **symptoms:** fever, severe headache, sensitivity to light, and stiff neck.

Mediacal diagnosis operates in the following manner:

Input: A healthcare professional inputs the symptoms into MediDiagnose.

Processing:

MediDiagnose reviews its knowledge base for rules that match the given symptoms.

It identifies several potential conditions but recognizes a strong match for meningitis based on the combination of symptoms.

Output:

The system suggests that meningitis could be a possible diagnosis and recommends further tests to confirm, such as a lumbar puncture.

It also provides a list of other less likely conditions based on the symptoms for comprehensive differential diagnosis.

Key Components of a Production System in AI

Knowledge Base: This is the core repository where all the rules and facts are stored. In AI, the knowledge base is critical as it contains the domain-specific information and the if-then rules that dictate how decisions are made or actions are taken.

Inference Engine: The inference engine is the mechanism that applies the rules to the known facts to derive new facts or to make decisions. It scans the rules and decides which ones are applicable based on the current facts in the working memory. It can operate in two modes:

Forward Chaining (Data-driven): This method starts with the available data and uses the inference rules to extract more data until a goal is reached.

Backward Chaining (Goal-driven): This approach starts with a list of goals and works backwards to determine what data is required to achieve those goals.

Key Components of a Production System in AI

Working Memory: Sometimes referred to as the fact list, working memory holds the dynamic information that changes as the system operates. It represents the current state of knowledge, including facts that are initially known and those that are deduced throughout the operation of the system.

Control Mechanism: This governs the order in which rules are applied by the inference engine and manages the flow of the process. It ensures that the system responds appropriately to changes in the working memory and applies rules effectively to reach conclusions or solutions.

Types of Production Systems

1. Rule-Based Systems

Explanation of Rule-Based Reasoning

Rule-based systems operate by applying a set of pre-defined rules to the given data to deduce new information or make decisions. These rules are generally in the form of conditional statements (if-then statements) that link conditions with actions or outcomes.

Examples of Rule-Based Systems in AI

Diagnostic Systems: Like medical diagnosis systems that infer diseases from symptoms.

Fraud Detection Systems: Used in banking and insurance, these systems analyze transaction patterns to identify potentially fraudulent activities.

Types of Production Systems

2. Procedural Systems

Description of Procedural Knowledge

Procedural systems utilize knowledge that describes how to perform specific tasks. This knowledge is procedural in nature, meaning it focuses on the steps or procedures required to achieve certain goals or results.

Applications of Procedural Systems

Manufacturing Control Systems: Automate production processes by detailing step-by-step procedures to assemble parts or manage supply chains.

Interactive Voice Response (IVR) Systems: Guide users through a series of steps to resolve issues or provide information, commonly used in customer service.

Types of Production Systems

3. Declarative Systems

Understanding Declarative Knowledge

Declarative systems are based on facts and information about what something is, rather than how to do something. These systems store knowledge that can be queried to make decisions or solve problems.

Instances of Declarative Systems in AI

Knowledge Bases in AI Assistants: Power virtual assistants like Siri or Alexa, which retrieve information based on user queries.

Configuration Systems: Used in product customization, where the system decides on product specifications based on user preferences and declarative rules about product options.

How Production Systems Function?

Match: The inference engine checks which rules are triggered based on the current facts in the working memory.

Select: From the triggered rules, the system (often through the control mechanism) selects one based on a set of criteria, such as specificity, recency, or priority.

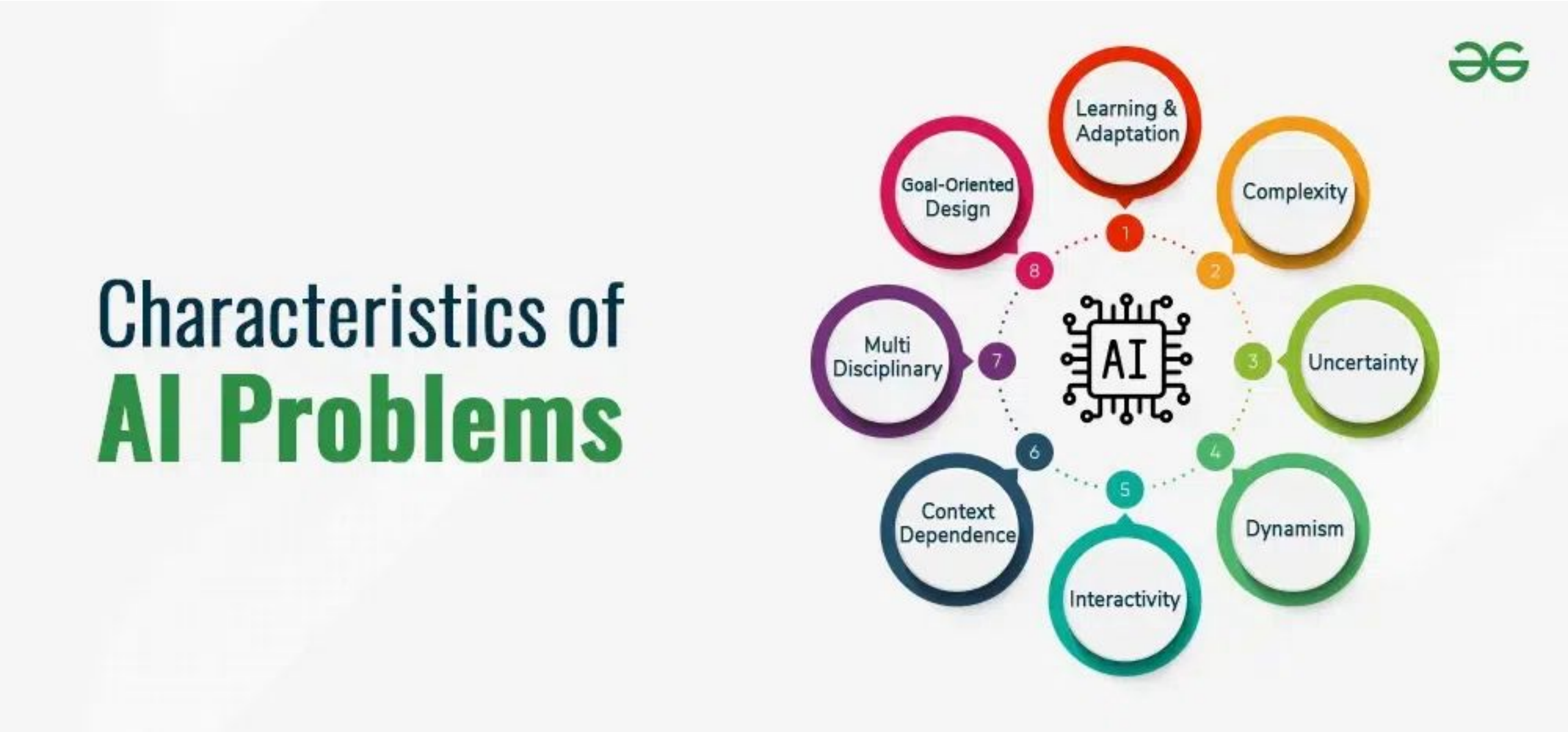
Execute: The selected rule is executed, which typically modifies the facts in the working memory, either by adding new facts, changing existing ones, or removing some.

Applications of Production Systems in AI

Production systems are used across various domains where decision-making can be encapsulated into clear, logical rules:

Expert Systems: For diagnosing medical conditions, offering financial advice, or making environmental assessments.
Automated Planning: Used in logistics to optimize routes and schedules based on current data and objectives.
Game AI: Manages non-player character behavior and decision-making in complex game environments.

CHARACTERISTICS OF AI PROBLEMS



Characteristics of Artificial Intelligence Problems

Learning and adaptation:

AI systems should be capable of learning from data or experiences and adapting their behaviour accordingly. This enables them to improve performance over time and handle new situations more effectively.

Complexity:

AI problems often involve dealing with complex systems or large amounts of data. AI systems must be able to handle this complexity efficiently to produce meaningful results.

Uncertainty:

AI systems frequently operate in environments where outcomes are uncertain or incomplete information is available. They must be equipped to make decisions or predictions under such conditions.

Dynamism:

Environments in which AI systems operate can change over time. These changes may occur unpredictably or according to specific rules, requiring AI systems to continually adjust their strategies or models.

Characteristics of Artificial Intelligence Problems

Interactivity:

Many AI applications involve interaction with users or other agents. Effective AI systems should be able to perceive, interpret, and respond to these interactions in a meaningful way.

Context dependence:

The behavior or performance of AI systems may depend on the context in which they operate. Understanding and appropriately responding to different contexts is essential for achieving desired outcomes.

Multi-disciplinary:

AI problems often require knowledge and techniques from multiple disciplines, including computer science, mathematics, statistics, psychology, and more. Integrating insights from these diverse fields is necessary for developing effective AI solutions.

Goal-oriented Design:

AI systems are typically designed to achieve specific objectives or goals. Designing AI systems with clear objectives in mind helps guide the development process and ensures that the resulting systems are focused on achieving meaningful outcomes.

Addressing the Challenges of AI Problems

Complexity and Uncertainty: AI difficulties are sometimes characterized by highly variable domains that are difficult to predict exactly. Hence, AI algorithms should be installed with the skill of dealing with unclear circumstances and should make decisions that are based on imperfect data or noisy information.

Algorithmic Efficiency: Among the key challenges of this approach are the enormous search spaces, computational resources, and the efficiency of the algorithms in terms of problem-solving. Strategies like caching, pruning, and parallelization are among the most widely used implementations for better algorithmic speed.

Domain Knowledge Integration: Such numerous AI problems involve the ability to capture the rules and reasoning of the real world to model and solve the questions correctly. The AI machines that have been trained with expertise from relevant domains improve the accuracy and effectiveness of the applications in the real world.

Addressing the Challenges of AI Problems

Scalability and Adaptability: AI solutions should be able to process large datasets and complex cases at the same time, and they should also be versatile by responding to shifts in conditions and requirements. Strategies such as machine learning and reinforcement learning allow systems to do more than just perform according to the given tasks at hand; they empower systems to learn and progress over time.

Ethical and Social Implications: AI technologies elicit ethical and social limitations concerning problems of bias, justice, privacy, and responsible office. Taking these implications into account, along with ethical frameworks, compliance frameworks, and stakeholder engagement, is essential. This approach will help position cryptocurrencies as a secure and trustworthy investment.

Interpretability and Explainability: To achieve interpretability and explainability of AI algorithms for the sake of understanding and confidence among users and stakeholders, these algorithms should be knowable and comprehensible enough. Examples like chatbots producing natural-like conversation could better clarify the

Addressing the Challenges of AI Problems

Interpretability and Explainability: To achieve interpretability and explainability of AI algorithms for the sake of understanding and confidence among users and stakeholders, these algorithms should be knowable and comprehensible enough. Examples like chatbots producing natural-like conversation could better clarify the working scheme of AI technology.

Robustness and Resilience: AI machinery should perform against its being hacked or affected by adversarial attacks, inaccuracies (errors), and environmental changes. Robustness testing, the construction of mechanisms for error handling, and the building up of redundancy must be taken seriously by AI systems to ensure their reliability and stability.

Human-AI Collaboration: Successful human-AI entente is the key component to making the most of our advantages as well as artificial intelligence skills. Achieving AI solutions that are capable of supporting human skills and more importantly, preferences will reduce human efforts correspondingly and bring the best performance.

PRODUCTION SYSTEM CHARACTERISTICS

Monotonic Production System (MPS): The Monotonic production system (MPS) is a system in which the application of a rule never prevents later application of the another rule that could also have been applied at the time that the first rule was selected

Non-monotonic Production (NMPS): The non-monotonic production system is a system in which the application of a rule prevents the later application of the another rule which may not have been applied at the time that the first rule was selected, i.e. it is a system in which the above rule is not true, i.e. the monotonic production system rule not true.

Commutative Production System (CPS): Commutative law based production systems is a system in which it satisfies both monotonic & partially commutative.

Partially Commutative Production System (PCPS): The partially commutative production system is a system with the property that if the application of those rules that is allowable & also transforms from state x to state ‗y'.

Important Components of Problems in AI

Initial State: The state of the issue as it first arises.

Goal State: The idealized final state that delineates a problem-solving strategy.

Operators: The collection of maneuvers or actions that can be used to change a state.

Restrictions: Guidelines or limitations must be adhered to to solve the problem.

Let's an example, in a chess game, the pieces' beginning positions on the board represent the initial state, a checkmate is the objective state, the permissible moves made by the pieces represent the operators, and the chess rules represent the constraints.

Problem Spaces in AI

The set of all potential states, actions, and transitions that might arise when trying to solve a particular problem is known as the problem space. It depicts the whole range of feasible fixes and routes from the starting point to the desired destination. An abstract representation of every conceivable state and all possible transitions between them for a particular problem is called a problem space. It is a conceptual landscape in which all points signify various system states, and all possible operations or activities are represented by the paths connecting the points.

States: Every scenario or configuration that could arise within the issue.

State Space: The collection of all states that an operator sequence can apply to get from the starting state.

Paths: Paths are sets of states that connect the starting state to the destination state through operators.

Search in AI

The practice of searching for a set of steps or movements that will get you to the desired outcome or a workable solution is known as a search. Within artificial intelligence, search algorithms are employed to methodically traverse the problem domain and identify routes or resolutions that fulfill the problem's limitations and goals. Search algorithms are used in AI to effectively explore issue domains.

Types of Search in AI

1. Uninformed Search

Apart from the problem definition, these algorithms don't know anything else about the states. Typical ignorant search tactics consist of -

Breadth-First Search (BFS): Before going on to nodes at the next depth level, the Breadth-First Search (BFS) method investigates every node at the current depth.
Depth-First Search (DFS): Investigates a branch as far as it can go before turning around.
Cost Search: To find the lowest-cost solution, uniform cost search expands the least-cost node.

Types of Search in AI

2. Informed Search

These algorithms make use of heuristics or extra information to direct the search more effectively in the direction of the desired state. Typical knowledgeable search tactics consist of -

Greedy Best-First Search: Chooses the node that seems to be closest to the objective using a heuristic.

A*: Sums the projected cost from a node with the cost to get there.