

AI ENDSEM UNIT – 6 PYQ

➤ **MAY / JUN 2022**

Q7)

a) Analyse various planning approaches in detail. [9]

Various planning approaches in AI are used to generate sequences of actions to achieve specific goals. Below are the main types:

1. Classical Planning

- Assumes a known, deterministic, and fully observable environment.
- Works with states, actions, and goals.
- Example: STRIPS and PDDL-based planning.

2. Hierarchical Planning (HTN - Hierarchical Task Network)

- Decomposes high-level tasks into smaller subtasks.
- Allows abstraction and reuse of plans.
- Efficient for large-scale problems.

3. Conditional Planning

- Handles **uncertainty** in action outcomes or incomplete knowledge.
- Plans include **if-then** conditions and branching.

4. Contingency Planning

- Creates plans considering various **possible future situations**.
- Useful in **nondeterministic environments**.

5. Probabilistic Planning

- Considers probability distributions for uncertain outcomes.
- Uses techniques like **Markov Decision Processes (MDPs)**.

6. Reactive Planning

- No complete planning is done beforehand.
- Agent reacts dynamically based on real-time perception (e.g., subsumption architecture).

7. Planning with Resources and Time

- Considers constraints such as **deadlines**, **durations**, and **resource availability**.
- Used in **real-world scheduling problems**.

b) Discuss AI and its ethical concerns. Explain limitations of AI. [8]

Artificial Intelligence (AI) is a branch of computer science that focuses on building intelligent machines capable of performing tasks that typically require human intelligence, such as learning, reasoning, problem-solving, and decision-making.

1. Ethical Concerns in AI:

a) Bias and Discrimination

- AI models can learn and amplify societal biases present in training data (e.g., gender or racial bias).

b) Privacy Violation

- AI systems like facial recognition or surveillance can intrude on personal privacy.

c) Job Displacement

- Automation through AI may lead to large-scale unemployment in certain sectors.

d) Autonomous Weapons

- Use of AI in military applications can lead to misuse or lack of accountability.

e) Lack of Transparency

- AI algorithms, especially deep learning models, act as “black boxes,” making decisions difficult to explain.
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2. Limitations of AI:

Despite its capabilities, AI has significant limitations:

a) Lack of Common Sense

- AI systems cannot reason like humans or handle unseen situations intelligently.

b) Data Dependency

- Performance depends heavily on the quantity and quality of training data.

c) No True Understanding

- AI lacks consciousness or real understanding—it only processes patterns.

d) High Cost

- Developing and maintaining AI systems can be expensive.

e) Ethical and Legal Challenges

- Ambiguity around responsibility and regulations limits deployment.

Q8

a) Explain the terms for Time and Schedule from the perspective of Temporal Planning. [9]

1. Temporal Planning – Introduction:

Temporal Planning is an extension of classical planning that considers time constraints on actions.

Unlike classical planning (where actions are instantaneous), temporal planning deals with actions that take time to complete and may overlap.

2. Time in Temporal Planning:

- Time refers to the duration and timing of actions in a plan.
- Each action is assigned a start time and duration.
- Temporal planning considers:
 - Action durations (e.g., watering crops takes 10 minutes),
 - Deadlines (e.g., task must finish before 5 PM),
 - Temporal constraints (e.g., Action A must finish before B starts).

3. Schedule in Temporal Planning:

- A Schedule is a timeline that defines when each action starts and ends.
- It ensures that:
 - No conflicting actions overlap improperly.
 - Resource constraints and deadlines are respected.
- Scheduling is often handled using algorithms like Temporal Constraint Networks (TCNs) or Simple Temporal Networks (STNs).

4. Real-World Example:

In a factory automation system:

- Time: Painting a car body takes 30 minutes.
- Schedule: After painting, drying starts immediately and takes 1 hour. The planner schedules these actions to avoid overlap and ensure workflow.

Conclusion:

Temporal planning improves real-world applicability by incorporating time and scheduling constraints into planning. It helps optimize task execution in domains like robotics, manufacturing, and logistics.

Q7

b) Write a detailed note on AI Architecture. [8]

1. AI Architecture:

AI Architecture is a **blueprint for designing and implementing AI systems**. Like traditional software architecture, it consists of components such as **data pipelines, ML algorithms, frameworks, and hardware**, structured to achieve specific goals or solve real-world problems.

2. Similarity to Traditional Architecture:

Just as civil architects consider factors like **climate** or **soil type**, AI architects analyze **data availability, computation power**, and **business needs** to build an effective AI system that aligns with organizational objectives.

3. Key Elements of AI Architecture:

a) Purpose:

To align AI technologies (e.g., ML models, data tools) with **business strategies** and **decision-making goals**.

b) Frameworks:

These help in building and deploying AI systems. Examples include:

- **TensorFlow, PyTorch**, and **Scikit-learn** for training and inference.

Core Components:

Layer	Description
Data Layer	Data sources, databases, data lakes, and cloud storage systems.
Processing Layer	Preprocessing and transforming data using tools like Apache Spark .
Algorithm Layer	Core ML models used for prediction or classification tasks.
Interface Layer	User interface (web app, mobile app, or API) to interact with the AI system.

4. Benefits of AI Architecture:

- **Streamlined Development:** Provides a clear roadmap for teams.
- **Consistency and Cohesion:** Ensures a structured and uniform development process.
- **Faster Time-to-Market:** Speeds up AI deployment by reducing confusion and inefficiencies.

Conclusion:

AI Architecture provides both a **strategic and technical foundation** for building intelligent systems. It ensures all AI components work in harmony and supports long-term scalability and maintainability.

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Q7

a) Write a short note on planning agent, state goal and action representation. [6]

1. Planning Agent:

A **planning agent** is an AI system that **formulates a sequence of actions** (a plan) to achieve specific goals from a given initial state.

- It uses **perception, reasoning, and planning algorithms**.
- Example: A robot planning a path to pick and place objects.

2. State Representation:

The **state** describes the **current condition** of the environment.

- It includes all necessary variables (e.g., position, status, time).
- Represented using logical statements, predicates, or variables.
- Example: $\text{At}(\text{robot}, \text{Room1}) \wedge \text{Has}(\text{robot}, \text{None})$

3. Goal Representation:

The **goal** defines the **desired state** that the agent wants to reach.

- Represented using logical formulas or constraints.
- Example: $\text{At}(\text{robot}, \text{Room2}) \wedge \text{Has}(\text{robot}, \text{Box})$

4. Action Representation:

Actions change the state and move the agent towards the goal.

Each action includes:

- **Preconditions** (what must be true before the action)
- **Effects** (what becomes true after the action)
- Example:

Action: $\text{Move}(\text{Room1} \rightarrow \text{Room2})$

- Precondition: $\text{At}(\text{robot}, \text{Room1})$
- Effect: $\text{At}(\text{robot}, \text{Room2})$

b) Explain different components of planning system. [6]

Components of a Planning System:

1. Initial State

- Describes the starting situation of the agent or the environment.
- Example: A robot is at location A with an empty battery.

2. Goal State

- Describes the desired outcome or condition the agent wants to achieve.
- Example: The robot must reach location D with a fully charged battery.

3. Actions (Operators)

- Each action defines:
 - **Preconditions:** Conditions that must be true to perform the action.
 - **Effects:** Changes in the state after performing the action.
- Example:
Action: $\text{Move}(\text{A}, \text{B})$
Preconditions: $\text{At}(\text{A})$
Effects: $\neg \text{At}(\text{A}), \text{At}(\text{B})$

4. Planner (Planning Algorithm)

- The core engine that computes a sequence of actions from the initial state to the goal state.

- **Examples of planning algorithms:**
 - Forward state-space search
 - Backward search
 - Partial-order planning
 - Heuristic search (e.g., A*)

5. Plan

- A sequence of actions generated by the planner.
- Must be valid (achieves the goal) and efficient (optimized for cost, time, or resources).

6. World Model / State Representation

- Represents the world or environment, typically using logical predicates or state variables.
- Includes facts such as At(Robot, A), Battery(Low).

7. Execution Module

- Responsible for executing the planned actions in the real or simulated environment.
- Monitors the progress and ensures actions are applied correctly.

8. Monitoring and Feedback

- Tracks the state of the world during execution.
- If the environment changes unexpectedly, it alerts the planner to re-plan or adjust.

9. Knowledge Base (Optional)

- Contains domain knowledge like rules, action definitions, constraints, and heuristics that can guide the planning process.

Summary Table.

Component	Role
Initial State	Starting point of the agent/environment
Goal State	Desired outcome to achieve
Actions	Define how the state changes
Planner	Generates a valid plan
Plan	A sequence of executable steps
State Representation	Encodes facts about the world
Execution Module	Carries out the plan
Monitoring	Observes execution and triggers replanning if needed
Knowledge Base	Provides background/domain-specific information

The main components of Artificial Intelligence (AI) include:

1. **Learning:**
It enables AI systems to learn from data and experience.

This includes supervised, unsupervised, and reinforcement learning, allowing systems to improve performance over time.
2. **Reasoning:**
AI systems can make decisions by applying logical rules to the available data.

This includes deduction (from known facts) and induction (learning from examples).
3. **Problem-Solving:**
AI is used to find solutions in complex problem spaces.

It includes search algorithms, planning, and decision-making under constraints and uncertainty.
4. **Perception:**
It allows AI systems to interpret input from sensors (like cameras or microphones) and understand their environment, e.g., in speech or image recognition.
5. **Language Understanding:**
This involves natural language processing (NLP) to interpret, generate, and respond in human language.

It includes tasks like speech recognition and language translation.

b) Explain Classical Planning and its advantages with example. [6]

Classical Planning

Classical planning is a fundamental approach in AI where the planning problem is defined using logic-based models in a simplified environment. It assumes the following:

1. **The environment is fully observable**, meaning the agent has complete and accurate information about the current state of the world.
2. **The environment is deterministic**, so each action has a predictable and known outcome.
3. **The environment is static**, meaning it does not change during the planning process.

In classical planning, the problem is described using:

- **Initial state** – the starting configuration of the world,
- **Goal state** – the desired end configuration,

- **Actions/operators** – rules that describe how to move from one state to another.

Example:

In a block world problem, suppose blocks A, B, and C are placed separately on a table. The goal is to stack A on B and B on C. The planner uses predefined actions like PickUp(A), Stack(A,B), etc., to determine the sequence needed to reach the goal from the initial state.

Advantages of Classical Planning:

1. Simple and easy to implement in structured environments.
2. Efficient in finding goal-directed solutions.
3. Models are reusable across similar domains.
4. Less computationally expensive than complex planning models.

c) Write note on hierarchical task network planning. [5]

HTN Planning is a type of planning in Artificial Intelligence where tasks are broken down into smaller subtasks in a hierarchical manner.

It focuses on what to do rather than how to do each action at the start.

In HTN planning, tasks are organized in a hierarchy where the top-level tasks are abstract and represent goals, while lower-level tasks correspond to concrete actions that can be executed.

Key Features:

1. **Decomposition** – Complex tasks are divided into simpler subtasks until primitive (executable) actions are reached.
2. **Domain Knowledge** – HTN relies heavily on predefined methods that describe how to decompose tasks.
3. **Structured Plans** – It generates plans that follow a logical hierarchy of goals and subgoals.
4. **Realistic Modeling** – It closely mimics human problem-solving where high-level goals are achieved step-by-step.

Example:

If the goal is to "organize a seminar", HTN will decompose it into tasks like "book venue", "send invites", and "arrange refreshments". Each of these can be further broken into smaller subtasks.

Advantages:

- Allows more **control** over the planning process.
 - Suitable for **real-world domains** like robotics, logistics, and workflow management.
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Q7)

a) Explain with an example State Space Planning. [5]

State Space Planning

State Space Planning is a classical approach in Artificial Intelligence where the problem is represented as a search through various states, aiming to find a sequence of actions that transforms the initial state into the goal state. It is based on the idea that planning problems can be viewed as transitions between different configurations or states.

Key Features:

- **State Representation:** A state is a specific configuration in the problem domain.
- **State Space:** The collection of all possible states that can be reached from the initial state.
- **Actions:** Actions are transitions between states and are defined by preconditions and effects.
- **Search:** The planner searches through the state space to find a path from the initial state to the goal state.
- **Optimality:** The planner can be used to find the most optimal solution by exploring different sequences of actions to achieve the goal.

Example:

For a robot in a room, the goal is to move from position A to position B.

- **Initial State:** Robot at position A.
- **Goal State:** Robot reaches position B.
- **Actions:** The robot can move from one position to another (e.g., "Move from A to C").

The state space is a grid, and the planner will explore different action sequences (moves) to find the optimal path to the goal.

Advantages:

- Provides a clear framework for problem-solving.
- Suitable for problems with well-defined states and actions.
- Can be used for various applications like robotics, navigation, and puzzle-solving.

b) Explain with example, how planning is different from problem solving. [5]

Aspect	Planning	Problem Solving
Definition	Planning involves generating a sequence of actions to achieve a specific goal using domain knowledge.	Problem solving focuses on searching for a solution in a state-space without detailed domain knowledge.
Approach	Goal-directed with predefined actions and operators.	Trial-and-error or heuristic-based search.
Domain Knowledge	Uses detailed knowledge about actions and their effects.	Minimal domain-specific knowledge is required.
Output	A structured plan or sequence of actions.	A solution path from initial state to goal.
Efficiency	More efficient in complex, structured environments.	Can be inefficient for large or dynamic problems.

Example:

- **Planning:** In a delivery scenario, planning determines a full delivery route and schedule before execution (e.g., deliver package A → then B → recharge).
- **Problem Solving:** A robot finds a path in a maze using search algorithms like A*, without prior route knowledge.

c) Explain AI components and AI architecture. [8]

- AI Component - already explained !!

- AI architecture - baki aahe !!

Q8)

a) Explain Planning in non deterministic domain. [8]

Planning in Non-deterministic Domains

In a **non-deterministic domain**, the outcome of an action is **not guaranteed** — the same action can produce different results depending on the situation or environment.

Hence, the planner must account for **multiple possible outcomes** and plan accordingly.

Key Characteristics:

1. **Uncertain Outcomes:**
Actions may lead to multiple successor states due to uncertainty in sensors, actuators, or the environment.
2. **Contingency Planning:**
The planner must generate plans that can **handle different scenarios**, often using conditional branches (if-then-else logic).
3. **Representation:**
States, actions, and their **possible effects** are represented using models like **AND-OR graphs**.
4. **Execution Monitoring:**
The system must **monitor the outcome** of actions during execution and adjust the plan if needed.
5. **Goal Achievement:**
Plans should ensure that **the goal is eventually reached**, regardless of which action outcomes occur.

Example:

Imagine a **robot trying to pick up a box**. The PickUp(Box) action might:

- **Succeed**, if the robot's arm works correctly.
- **Fail**, if the box is too heavy or the arm slips.

So, the robot needs a **contingent plan**:

- If pick up fails → try using two arms or ask for human help.

Planning Methods Used:

- **AND-OR Graph Search**
- **Conditional Planning**
- **Policy-based Planning (as in MDPs)**

Applications:

- Robotics in dynamic environments
- Autonomous vehicles
- AI in healthcare and disaster response

b) Explain : [8]

i) Importance of planning .

ii) for classical planning.

i) Importance of Planning :

1. **Goal-Oriented Behavior:**
Planning helps AI agents achieve long-term goals by deciding the correct sequence of actions.
2. **Efficient Decision Making:**
It enables systems to reason about the future, reducing random trial-and-error.
3. **Resource Optimization:**
Planning allows optimal use of time, energy, and other resources.
4. **Autonomous Functioning:**
Planning empowers AI agents (e.g., robots, virtual assistants) to act independently in complex environments.

ii) Algorithm for Classical Planning

A common algorithm for classical planning is **Forward State-Space Search**:

Steps:

1. **Start from Initial State**
Use a queue to store the current state and expand possible actions.
2. **Apply Actions**
Use action preconditions and effects to generate successor states.
3. **Goal Test**
Check if the current state satisfies the goal conditions.
4. **Search Algorithm**
Use BFS, DFS, or A* to explore the state space.

Example (Simple):

- Initial State: Robot at room A

- Goal State: Robot at room C
- Actions: Move(A→B), Move(B→C)

The planner searches the sequence: $A \rightarrow B \rightarrow C$

C) Explain Limits of AI and Future Opportunities with AI. [5]

Limits of AI:

1. **Lack of Common Sense:**

AI cannot reason like humans or handle novel, real-world situations with flexibility.

2. **Data Dependency:**

AI performance relies heavily on the quality and quantity of training data.

3. **No True Understanding:**

AI does not possess consciousness or emotions—it only follows patterns in data.

4. **Bias and Fairness Issues:**

AI systems can inherit and amplify biases present in the training data.

5. **Ethical and Legal Concerns:**

Issues related to accountability, privacy, and misuse restrict widespread adoption.

Future Opportunities with AI:

1. **Healthcare:**

AI can revolutionize diagnosis, drug discovery, and personalized treatment.

2. **Education:**

Intelligent tutoring systems and adaptive learning platforms will enhance education.

3. **Agriculture:**

AI-based monitoring, prediction, and automation can increase crop yield and efficiency.

4. **Transportation:**

Self-driving vehicles and traffic optimization can make travel safer and faster.

5. **Sustainability:**

AI can help in energy optimization, climate modeling, and resource management.

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Q7)

a) Explain with an example Goal Stack Planning (STRIPS algorithm). [5]

Goal Stack Planning is a method of planning where a **stack data structure** is used to manage goals and subgoals. It starts with the final goal and works **backward**, pushing required actions and conditions onto the stack until all are satisfied using available operators.

STRIPS (Stanford Research Institute Problem Solver):

STRIPS represents a planning problem using:

- **Initial State**
- **Goal State**
- **Operators/Actions** (with Preconditions and Effects)

Example: Block World Problem

Initial State:

On(A, Table), On(B, Table), On(C, A), Clear(B), Clear(C)

Goal:

On(B, C)

Steps using Goal Stack Planning:

1. Push goal On(B, C) onto the stack.
2. Push action Move(B, Table, C) (an operator that achieves On(B, C)).
3. Push preconditions of this action: Clear(B), Clear(C), On(B, Table).
4. Check each precondition in the initial state. All are satisfied.
5. Apply the action Move(B, Table, C) → achieves goal On(B, C).

Conclusion:

Goal Stack Planning decomposes complex goals into smaller subgoals using a stack and applies STRIPS operators to reach the final goal from the initial state

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ALL question's are repeated !
i.e already covered !!

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Q7

a) Describe the differences and similarities between problem solving and planning. [5]

Aspect	Planning	Problem Solving
Definition	Planning involves generating a sequence of actions to achieve a specific goal using domain knowledge.	Problem solving focuses on searching for a solution in a state-space without detailed domain knowledge.
Approach	Goal-directed with predefined actions and operators.	Trial-and-error or heuristic-based search.
Domain Knowledge	Uses detailed knowledge about actions and their effects.	Minimal domain-specific knowledge is required.
Output	A structured plan or sequence of actions.	A solution path from initial state to goal.
Efficiency	More efficient in complex, structured environments.	Can be inefficient for large or dynamic problems.

Aspect	Similarity
Goal-Oriented	Both aim to reach a specific goal state from a given initial state.
Action-Based	Both involve selecting and applying a sequence of actions.
Search Process	Both can be implemented using search techniques and algorithms.
AI Techniques	Both use AI strategies like heuristic search or state-space search.
Solution Construction	Both generate solutions step-by-step through reasoning or inference.

Q8

a) What are Planning Approaches? [6]

1. Classical Planning

- Assumes a known, deterministic, and fully observable environment.
- Works with states, actions, and goals.
- Example: STRIPS and PDDL-based planning.

2. Hierarchical Planning (HTN - Hierarchical Task Network)

- Decomposes high-level tasks into smaller subtasks.

- Allows abstraction and reuse of plans.
- Efficient for large-scale problems.

3. Conditional Planning

- Handles **uncertainty** in action outcomes or incomplete knowledge.
- Plans include **if-then** conditions and branching.

4. Contingency Planning

- Creates plans considering various **possible future situations**.
- Useful in **nondeterministic environments**.

5. Probabilistic Planning

- Considers probability distributions for uncertain outcomes.
- Uses techniques like **Markov Decision Processes (MDPs)**.

6. Reactive Planning

- No complete planning is done beforehand.

Agent reacts dynamically based on real-time perception (e.g., subsumption architecture).

b) The Blocks World in Detail [6]

Blocks World is a classic AI planning problem involving a set of blocks and a table. The objective is to rearrange the blocks from an initial configuration to a desired goal configuration using a robot arm.

Key Elements:

1. **Blocks:** Usually labeled A, B, C, etc.
2. **States:** Define positions of blocks (on-table, on top of another, clear).
3. **Actions:**
 - **Pick up:** Lifting a block.
 - **Put down:** Placing a block on the table.
 - **Stack:** Putting one block on another.
 - **Unstack:** Removing a block from the top of another.

Example:

Initial State: A on B, B on table, C on table

Goal State: C on A, A on B, B on table

The planner finds a valid sequence of moves (actions) to reach the goal.

Q8 c) What are the different types of planning? How planning algorithm can be represented as state space search? [8]

Different Types of Planning:

Type	Description
1. Classical Planning	Assumes a fully known, deterministic environment.
2. Conditional Planning	Handles uncertainty by using condition-based actions.
3. Hierarchical Planning (HTN)	Breaks down tasks into simpler subtasks (task decomposition).
4. Probabilistic Planning	Considers probabilistic outcomes of actions (used in stochastic domains).
5. Temporal Planning	Considers timing and duration of actions.
6. Reactive Planning	Responds to changes in environment dynamically.
7. Contingency Planning	Prepares alternative plans based on possible failures or uncertainties.

Planning as State Space Search:

Planning can be modeled as a **State Space Search** problem where:

- **Initial State:** Describes the starting conditions of the environment.
- **Goal State:** Describes the desired conditions to be achieved.
- **Operators (Actions):** Define how the agent moves from one state to another.
- **State Space:** All possible states reachable by applying valid actions.
- **Search Algorithm:** Used to find a path (sequence of actions) from initial to goal state.

Example (Blocks World):

- **Initial State:** A on B, B on table, C on table
- **Goal State:** C on A, A on B
- **Operators:** Stack, Unstack, Pickup, Putdown

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- **Search:** BFS, DFS, or A* used to explore the state tree