

UNIT II PROBLEM SOLVING AND SEARCH TECHNIQUES

2.1 Problem Formulation:

- Problem formulation in artificial intelligence (AI) is the process of structuring a realworld issue into a well-defined computational problem that an AI system can solve.
- It is a critical step in AI development, as it defines the objectives, constraints, and possible actions the AI agent can take to reach an optimal solution.
- By formulating a problem correctly, AI systems can efficiently apply search algorithms, optimization techniques, and decision-making models to achieve their goals.
- The effectiveness of an AI solution largely depends on how well the problem is defined, as improper problem formulation can lead to inefficiencies, inaccurate results, or excessive computational complexity.

For example, in AI-based route planning, an intelligent system must define its initial state (starting location), goal state (destination), available actions (routes to take), and optimization criteria (shortest distance, least traffic, etc.). By structuring the problem effectively, the AI can determine the most efficient route while adapting to real-time constraints like traffic conditions.

Problem formulation is widely used in robotics, game AI, autonomous systems, and intelligent search algorithms, making it an essential aspect of AI-driven decision-making.

Key Components of Problem Formulation

Problem formulation in AI consists of several key components that define the structure of a problem, enabling AI systems to determine optimal solutions efficiently.

These components help an AI agent understand its environment, evaluate possible actions, and work toward achieving a predefined goal.

1. Initial State

The initial state represents the starting point of the AI system, from where it begins its decision-making process.

It provides the foundational data or conditions that define the problem's context.

Example: In a chess game, the initial state is the starting board configuration, where all pieces are placed in their default positions before the game begins. The AI analyzes this state to determine possible moves and strategies.

2. Action Set (Successor Function)

The action set, also known as the successor function, defines all possible actions that the AI can take from a given state.

The availability of actions varies based on environmental conditions and system constraints.

Example: In a self-driving car, the AI has a set of possible actions, such as:

- Accelerate to increase speed.
- Brake to slow down or stop.
- Turn left or right to navigate intersections.
- Stay in lane to maintain direction.

Each action influences the AI's path and decision-making, contributing to achieving the goal. 3.

3. Transition Model

The transition model describes how the AI moves from one state to another after performing an action.

It helps in predicting the outcome of different actions, enabling the AI to make informed decisions.

Example: In a GPS navigation system, when a user selects a route, the AI determines state transitions as the vehicle moves from one city to another. The transition model accounts for distance, road conditions, and traffic updates to refine its decision-making.

4. Goal State

The goal state defines the desired end state or solution that the AI aims to achieve.

Without a clearly defined goal, the AI system lacks direction and cannot effectively evaluate its success.

Example: In a maze-solving AI, the goal state is reaching the exit. The AI processes available paths, evaluates obstacles, and determines the most efficient way to navigate toward the goal.

5. Path Cost Function

The path cost function measures the cost associated with reaching the goal, ensuring the AI selects the most efficient solution.

The cost could be measured in time, distance, energy consumption, or computational complexity, depending on the application.

Example: In Google Maps, the AI considers multiple routes and evaluates the shortest path based on factors such as:

- Distance between start and destination.
- Traffic conditions to avoid congestion.
- Estimated travel time to find the fastest route.

By integrating these key components, AI systems can effectively formulate, analyze, and solve problems across various domains, from autonomous navigation to strategic game playing.

Steps in Problem Formulation

The process of problem formulation in AI involves structuring a real-world issue into a well-defined computational problem that an AI system can solve. This requires defining the problem's scope, specifying possible actions, and setting constraints to guide the AI toward an optimal solution. Below are the essential steps in problem formulation.

Step 1: Define the Problem Statement

- The first step is to clearly define the problem AI needs to solve. This involves identifying the real-world challenge, its objectives, and constraints.
- A well-defined problem helps AI agents apply the appropriate algorithms for efficient decision-making.

Example: In an AI-based package delivery system, the problem statement could be:

- Deliver a package from Warehouse A to Customer B.
- Minimize delivery time and fuel consumption.
- Adapt to traffic conditions and weather changes.

Clearly defining the problem allows the AI to establish the variables, dependencies, and constraints influencing the solution.

Step 2: Establish the Initial State and Goal State

Once the problem is defined, the AI must identify.

- The initial state: The starting conditions of the system.
- The goal state: The desired outcome after executing AI-driven actions. For the package delivery AI, the:
 - Initial state is the package at Warehouse A.
 - Goal state is the successful delivery to Customer B within the shortest possible time. Defining these states helps the AI understand the starting conditions and evaluate when the goal is reached.

Step 3: Determine Available Actions and State Transition Model

Next, AI must determine what actions it can take and how those actions impact the problem state.

- Available actions: The AI's possible moves in response to real-world conditions.
- State transition model: How each action modifies the AI's state. For the package delivery AI, actions include:
 - Move forward (advance to the next road segment).
 - Turn left or right (change direction at intersections).
 - Stop (wait for traffic signals or customer confirmation).

The transition model helps AI predict the next state based on chosen actions, ensuring logical and efficient problem-solving.

Step 4: Define Constraints and Path Cost

The final step is defining constraints and optimization criteria, which guide the AI's decisionmaking.

- Constraints: Conditions that restrict available solutions (e.g., traffic rules, package weight limits, or delivery deadlines).
- Path cost function: A metric used to determine the most optimal solution based on the least cost (e.g., shortest path, lowest fuel consumption). For the package delivery AI, optimization factors may include:
 - Shortest distance to the destination.

- Minimized fuel consumption.
- Avoiding congested roads for faster delivery.

By following these steps, AI systems can systematically analyze, structure, and optimize problem-solving approaches, leading to better efficiency, accuracy, and automation.