Integrated MCA
Semester-V
ARTIFICIAL INTELLIGENCE

Unit 2

Introduction to Problem Solving through AI

- The reflex agent of AI directly maps **states into action**.
- Whenever these agents fail to operate in an environment where the state of mapping is too large and not easily performed by the agent, then the stated problem dissolves and **sent to a problem-solving domain** which **breaks the large stored problem into the smaller storage area** and resolves one by one.
- Goal-based agents, consider future actions and the desirability of their outcomes.

- Goal-based agent called a problem-solving agent
- **Problem formulation** is the process of deciding what actions and states to consider, given a goal.
- The process of looking for a sequence of actions that reaches the goal is called **search**.
- A search algorithm takes a problem as input and returns a solution in the form of an action **sequence**.
- Once a solution is found, the actions it recommends can be carried out. This is called the **execution phase**.

State Space Search

- **State space search** is a **problem-solving technique to find the solution path from the initial state to the goal state** by exploring the various states.
- The state space search approach searches through **all possible states** of a problem to find a solution.
- To locate a solution, ***state space search*** entails methodically going through every potential state for an issue.
- This approach can be used to solve a variety of AI issues, including pathfinding, solving puzzles, playing games, and more.

- **State:** A specific configuration of the problem.
- **Initial State:** The starting point of the search.
- **Goal State:** The desired end configuration.
- **Transition:** An action that changes one state to another.
- **Path:** A sequence of states connected by transitions.
- **Search Strategy:** The method used to explore the state space.

There are basically three types of problem in artificial intelligence:

1. **Ignorable**: In which solution steps can be ignored.
2. **Recoverable**: In which solution steps can be undone.
3. **Irrecoverable**: Solution steps cannot be undo.

Introduction to Problem Solving through AI

- The method of solving problem through AI involves the process of defining the search space, deciding start and goal states and then finding the path from start state to goal state through search space.
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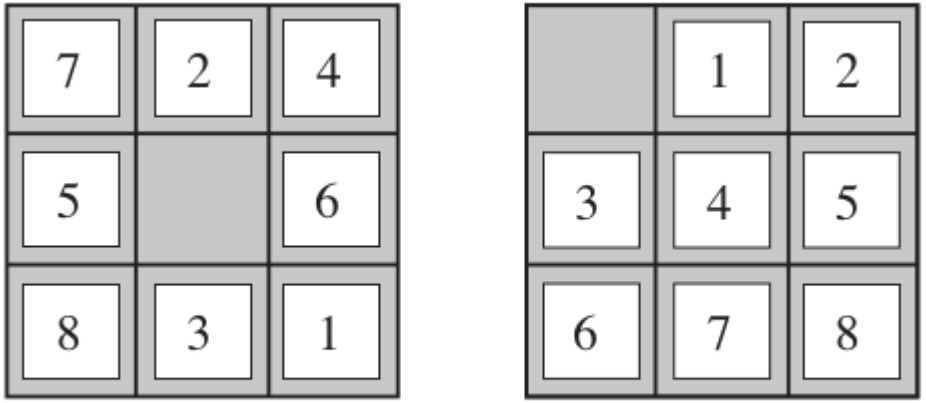


- **States**: A state description specifies the location of each of the eight tiles and the blank in one of the nine squares.
- **Initial state**: Any state can be designated as the initial state. Note that any given goal can be reached from exactly half of the possible initial states (Exercise 3.4).
- **Actions**: The simplest formulation defines the actions as movements of the blank space Left, Right, Up, or Down. Different subsets of these are possible depending on where the blank is.
- **Transition model:** Given a state and action, this returns the resulting state; for example, if we apply Left to the start state in Figure 3.4, the resulting state has the 5 and the blank switched.
- **Goal test:** This checks whether the state matches the goal.
- **Path cost**: Each step costs 1, so the path cost is the number of steps in the path.

Intro: Search and AI

- In solving problems, we sometimes have to search through many possible ways of doing something.
  - We may know all the possible actions our robot can do, but we have to consider various sequences to find a sequence of actions to achieve a goal.
  - We may know all the possible moves in a chess game, but we must consider many possibilities to find a good move.
- Many problems can be formalized in a general way as search problems.

Problems

Initially, researchers thought that creating an AI would be simply writing programs for each and every function an intelligence performs! As they went on with this task, they realized that this approach was too shallow. Even simple functions like face recognition, spacial sense, pattern recognition and language comprehension were beyond their programming skills!

They understood that to create an AI, they must delve deeper into natural intelligence first. They had to understand what understanding really means!

Problem Solving

Problem solving is fundamental to many AI-based applications.

- ***There are two types of problems:***

  1) The Problems like, computation of the sine of an angle or the square root of a value. These can be solved through the use of ***deterministic procedure*** and the **success is guaranteed**.

  − In the real world, very few problems lend themselves to *straightforward solutions.*

- 2) Most real world problems **can be solved only by searching for a solution**. **AI is concerned with these type of problems solving.**

Problem Solving

The problem of AI is directly associated with the nature of humans and their activities. So we need a number of finite steps to solve a problem which makes human easy works.

These are the following steps which require to solve a problem :

- **Problem definition**: Detailed specification of inputs and acceptable system solutions.
- **Problem analysis**: Analyse the problem thoroughly.
- **Knowledge Representation**: collect detailed information about the problem and define all possible techniques.
- **Problem-solving**: Selection of best techniques.

Solving through AI

- Define ***search space***
- Decide ***start*** and ***goal states***
- Find ***path*** from start to goal state through search space
- The movement from start state to goal state is guided by ***set of rules*** specifically designed for that particular problem (called as production rules)

Terms related to AI problem solving

- Problem
- Search space (complete set of states)
- Search (finding the solution of problem)
- Well defined problem - initial state,middle state, goal state
- Solution of problem –

1) Problem

Question to be solved. Define the problem. Which means start state , goal state, other valid states and transitions

2) Search space

set of states including start and goal states, where the answer of the problem is to be searched

3) Search

Process of finding solution in search space. Input to search space algorithm is problem and output is solution in form of action sequence

4) Well defined problem

Problem has three major components :

Initial state

Final state

Space including transition function and path function. Path function assigns numeric value to each path which indicates goodness of that path

5) Solution

path from initial state to goal state. It is guided by transition rules. Among all solution whichever has least path cost is called optimal solution.

- ***Problem solving is a process of generating solutions***
  - ***from observed data.***

- ***A problem is characterized by:***
- a set of goals,
- a set of objects, and
- a set of operations.
- These could be ill-defined and may evolve during problem solving.

- Problem space is an abstract space.
- A problem space encompasses all valid states that can be generated by the application of any combination of operators on any combination of objects.
- The problem space may contain one or more solutions.
- ***Solution is a combination of operations and objects that achieve the goals.***

Introduction to Problem Solving

To build a system to solve a particular problem, we need to do four things:

- **Define the problem precisely** (Initial state, final state, or acceptable solutions)
- **Analyze the problem:** Various possible Techniques for solving the problem
- **Isolating Task**: Isolate and represent the task knowledge (necessary to solve problem)
- **Finding Solution**: Choose the best problem-solving technique(s) and apply it(them).

Isolating task oriented knowledge

- Solving the problem, knowledge related to the field is required.
- As per the nature of AI applications, knowledge and there representation varies and so does the representation techniques.
- Various knowledge representation (KR) techniques are designed in this phase.

Finding the solution

- After representation of problem and knowledge in suitable format, the appropriate methodology is chosen which uses knowledge and transforms the start goal to end goal.
- The techniques of finding the solution are called search techniques.

Representation of AI problems

- Problem representation refers to the process of **transforming real-world situations** or scenarios into a format that can be processed by machines.
- The way a problem is represented determines how well it can be **understood and solved by an AI system.**
- Representation in AI is a fundamental concept that enables machines to **reason, learn, and make decisions.**
- It involves defining the **initial state**, the **goal state or states**, the set of possible states, and the operators that enable **transitions** between states. An effective problem representation is crucial as it greatly influences the efficiency and effectiveness of the state space search.

- For example, a problem in the field of **natural language processing language** processing may require a representation that **captures semantic meaning**, while a problem in **computer vision** may require a representation that **captures visual features**.
- There are various types of problem representation methods, each suited to different types of problems.

Types of Problem representation

- 1. **SYMBOLIC REPRESENTATION -** uses **symbols to represent objects, concepts, and relationships**. It involves **defining a set of rules and operations** that manipulate these symbols to solve problems.
- can be expressed in terms of **logic and reasoning, such as puzzle-solving, theorem proving, and expert systems.**

2. CONNECTIONIST REPRESENTATION

- also known as **neural network representation**, models problem-solving using interconnected artificial neurons.
- It mimics the functioning of the human brain, where information is processed in parallel and distributed across a network of interconnected nodes.

- 3. PROBABILISTIC REPRESENTATION – It deals with representing **uncertainty and probability** in problem solving.
- such as decision-making under uncertainty, risk assessment, and statistical analysis.
- **Deciding which type of problem representation to use depends on the nature of the problem and the capabilities of the AI system. In some cases, a combination of different representation methods may be necessary to effectively solve a particular problem.**

Types of Problem representation

Representation Method	Description
Symbolic	Uses symbols and rules to represent objects and relationships
Connectionist	Models problem-solving using interconnected artificial neurons
Probabilistic	Represents uncertainty and probability in problem solving

PROBLEM REPRESENTATION IN COMPUTER VISION

- Problem representation in computer vision involves **capturing the visual data** in a format that a machine can understand and process.
- It includes converting the **raw pixel values of an image into feature vectors that represent important characteristics or patterns in the image.**
- For example, if the goal is to recognize objects in an image, a common approach is to represent **each object as a bounding box** and assign a label to it.
- This allows the computer to identify and classify objects based on their visual characteristics.

PROBLEM REPRESENTATION IN NLP

- **text classification, sentiment analysis, named entity recognition, machine translation, and question-answering systems**.
- It enables NLP models to analyze and understand natural language data, making predictions, generating summaries, or answering user queries.

Production System in AI

- An AI system developed for solution of any problem is called production system.
- Once the problem is defined, analyzed and represented in a suitable formalism, the production system is used for application of rules and obtaining the solution.
- A production system in AI **helps create AI-based computer programs**. With the help of it, the automation of various types of machines has become an easy task.
- The **types of machines can be a computer, mobile applications, manufacturing tools**, or more.

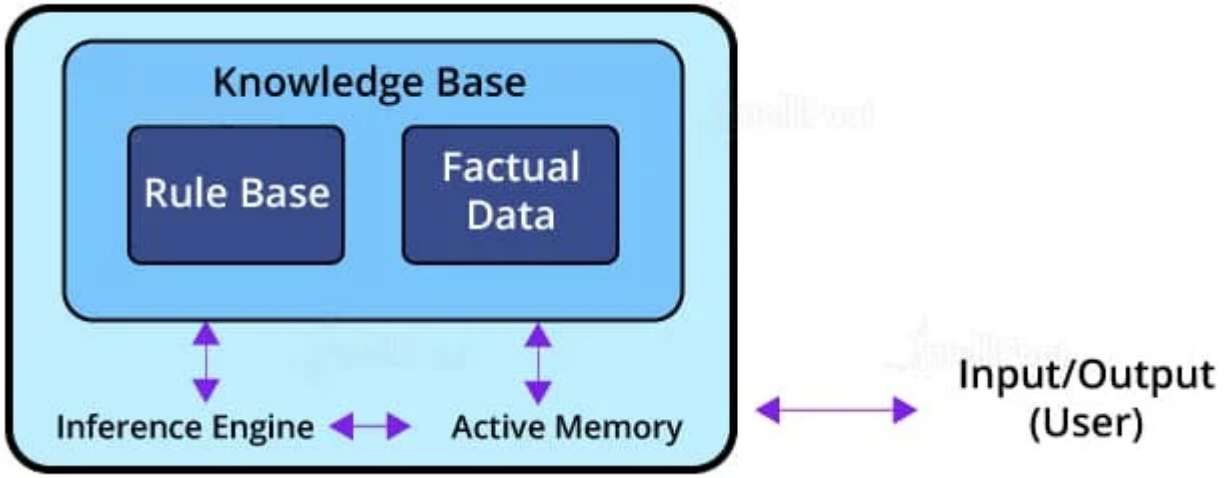
- The **set of rules** in a production system in Artificial Intelligence defines the **behavior of the machine**. It helps the machine respond to the surroundings.
- Production system or production rule system is a **computer program** typically used to provide some form of artificial intelligence, which **consists primarily of a set of rules** about behavior but it **also includes the mechanism** necessary to follow those rules as the system responds to states of the world

Example of Production System

Scenario: A patient comes to a healthcare facility with the following symptoms: fever, severe headache, sensitivity to light, and stiff neck.

- **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.

Basic architecture of production systems in AI



Components of AI

- **A set of production rules -** The production rules operate on the global database. Each rule usually has a precondition that is either satisfied or not by the global database. **If the precondition is satisfied, the rule is usually be applied.** The application of the rule changes the database.
- **Database -** One or more knowledge/databases, that contains all the appropriate information for a particular task.

- **A Control Strategy**: specifies order in which the rules will be compared to the database of rules and ways of resolving conflicts.
- A **rule applier**, which checks the applicability of rule by matching the current state with LHS of the rule and finds the appropriate rule from the database of rules.

Features of Production rules

1) Expressiveness and intuitiveness: The production rules tells us what to do in a given situation. This type of situation can be coded in If-Then form. Examples: Expert systems and rule-based systems.

2) Simplicity: The uniform structure of IF-THEN-ELSE coding structure of rule-based system provides simplicity in knowledge representation.

3) Modularity and Modifiability: Modularity means , production rules code the knowledge available in discrete pieces. Modifiability stands for facility of modifying the rule.

4) Knowledge intensive: The knowledge base of production system stores extensive and pure knowledge. This part contains no control or programming information. The problem of semantics is resolved by representing the knowledge in proper structure.

5) Opacity: Along with the advantages, there are certain disadvantages also associated with production systems. Opacity is the problem generated by combination of production rules. Though, the individual production rules may be models of clarity, the combined operation and effects of controlprogram may be opaque.

6) Inefficiency: Sometimes, several of the rules become active during execution. A well devised control strategy reduces this problem.

As the rules of production system are large in number and they are hardly written in hierarchical manner, it requires exhaustive search through all the production rules for each cycle of control program. It makes the functioning inefficient.

7) Absence of learning: The simple rule based production system does not store the results of computations for later use. Hence, it does not exhibit any type of learning capabilities.

- 8) Conflict Resolution: The rules in ideal production system should not
- have any type of conflict. The new rule whenever added in the database
- should ensure that it does not have any conflict with the existing rules.
- If conflict is found, it should be resolved in following ways:
- (i) Assign priority to the rules and fire the rule with the highest priority.
- This method is used in many expert systems.
- (ii) Use a longest matching strategy. This means that fire a rule having
- largest number of matching constraints. A rule with more constraints
- provides more knowledge.
- (iii) Choose most recently used rule for firing. Its advantage is that it
- represents a depth first search, which follows the path of greatest
- activity

Applications of Production Systems in AI

- **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.