## INTRODUCTION TO AI AND PRODUCTION SYSTEMS

Problem formulation, Problem Definition

- Problem solving is fundamental to many AI-based applications.
- There are two types of problems.
  - The Problems like, computation of the sine of an angle or the square root of a value. These can be solved using deterministic procedure and the success is guaranteed
  - In the real world, very few problems lend themselves to straightforward solutions.

# Problem solving as a process

- 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.

# **PROBLEM FORMULATION**

- 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 of a problem lies in Problem Space, if it exists.
  - It can be a single State (Point) of Sequence of State (Path).

#### Key Idea

Solution is a combination of operations and objects that achieve the goals.

Search refers to the search for a solution in a problem space. Search proceeds with different types of search control strategies. The depthfirst search and breadth-first search are the two common search strategies.

Problem solving is a process of generating solutions from observed or given data. It is however not always possible to use direct methods (ie go directly from data to solution). Instead, problem solving often need to use indirect or model-based methods.

# **Problem Solving Process**

Define the problem precisely – find input situations as well as final situations for acceptable solution to the problem. Analyze the problem – find few important features that may have impact on the appropriateness of various possible techniques for solving the problem.

Isolate and represent task knowledge necessary to solve the problem

Choose the best problemsolving technique(s) and apply to the problem

# PROBLEM DEFINITION

Problem is defined by its elements and their relations.

Define a state space that contains all the possible configurations of the relevant objects, including some impossible ones.

Specify one or more states, that describe possible situations, from which the problem- solving process may start. These states are called initial states.

Specify one or more states that would be acceptable solution to the problem. These states are called goal states.

 Specify a set of rules that describe the actions (operators) available



### Important Point

The problem can then be solved by using the rules, in combination with an appropriate control strategy, to move through the problem space until a path from an initial state to a goal state is found. This process is known as search.



### Search

- Search is fundamental to the problem-solving process.
- Search is a general mechanism that can be used when more direct method is not known.
- Search provides the framework into which more direct methods for solving subparts of a problem can be embedded.

# Problem space

- A problem space is represented by directed graph, where nodes represent search state and paths represent the operators applied to change the state.
- Graphs can be converted into tree in most cases.



# Problem-solving methods

- Special-purpose method is tailor-made for a particular problem, often exploits very specific features of the situation in which the problem is embedded.
- General-purpose method is applicable to a wide variety of problems. One general- purpose technique used in AI is "means-end analysis". It is a step-bystep, or incremental, reduction of the difference between current state and final goal.



#### Example 1 : Tower of Hanoi puzzle



### Tower of Hanoi puzzle Formulation.

This puzzle may involve a set of rings of different sizes that can be placed on three different pegs.

- The puzzle starts with the rings arranged as shown in Fig. 1
- The goal of this puzzle is to move them all as to Fig. 7
- Condition : Only the top ring on a peg can be moved, and it may only be placed on a smaller ring, or on an empty peg.

In this Tower of Hanoi puzzle the set of all possible configurations of rings on the pegs is called problem space.

# States and Successor Function

- States A state is a representation of elements at a given moment. Initial state is the start point – Final state is the goal state
- Change is by Successor Function. The successor function moves one state to another state.
- Successor Function
  - Is a description of possible actions; a set of operators
  - Is a transformation function on a state representation, which converts that state into another state
  - Defines a relation of accessibility among states.
  - Represents the conditions of applicability of a state and corresponding transformation function

#### State space



### Structure of a State Space

- The structure of state space are trees and graphs. Tree is a hierarchical structure in a graphical form and Graph is a nonhierarchical structure.
- Tree is a hierarchical structure in a graphical form and Graph is a nonhierarchical structure.
- Tree has only one path to a given node; i.e., a tree has one and only one path from any point to any other point
- Graph consists of a set of nodes (vertices) and a set of edges (arcs). Arcs establish relationships (connections) between the nodes; i.e., a graph has several paths to a given node. Operators are directed arcs between nodes.

### Search process

Search process explores the state space. In the worst case, the search explores all possible paths between the initial state and the goal state.

State space is defined explicitly or implicitly. Initial state is start state. Goal state is the conditions it has to fulfill. A description of a desired state of the world; the description may be complete or partial. Operators are to change state. Operators do actions that can transform one state to another.

#### A game of 8-puzzle

- State space configuration of 8-tiles on the board
- Initial state any configuration
- Goal state tiles in a specific order
- Action 'blank moves'
- Condition: the move is within the boardTransformation: blank moves Left, Right, Up, DownSolution- Optimal sequence of operators





#### A game of n-queen puzzle (n=8)

- State space : configurations n = 8 queens on the board with only one queen per row and column
- Initial state : configuration without queens on the board
- Goal state : configuration with n = 8 queens such that no queen attacks any other
- Operators or actions : place a queen on the board
- Condition : the new queen is not attacked by any other already placed
- Transformation: place a new queen in a particular square of the board.



Next Lecture:

#### **PRODUCTION SYSTEMS**