Artificial Intelligence

Module -1

Module 1

Introduction to AI and production systems: AI Problem formulation, Problem def nition, Production systems, Problem characteristics, Production system characteristics.

Example AI problems: 8 puzzle problem, Missionary and cannibals problem, Cryptarithmetic problems, Block world problems.

What is Artificial Intelligence?

- Artificial Intelligence (AI) is a branch of Science which deals with helping machines find solutions to complex problems in a more human-like fashion.

- This generally involves borrowing characteristics from human intelligence, and applying them as algorithms in a computer friendly way.

- AI is accomplished by studying how human brain thinks, and how humans learn, decide, and work while trying to solve a problem, and then using the outcomes of this study as a basis of developing intelligent software and systems.

- Artificial Intelligence(AI) is to make computers do things which at the moment people do better.

Applications of artificial intelligence

1. Robotic vehicles

A self-driving car, also known as an autonomous vehicle (AV), driverless car, or robocar is a vehicle that is capable of sensing its environment and moving safely with little or no human input.

Self-driving cars combine a variety of sensors to perceive their surroundings.

Advanced control systems interpret sensory information to identify appropriate navigation paths, as well as obstacles and relevant signage.

2. Speech recognition

Speech recognition is concerned with the recognition and translation of spoken language into text by computers.

It is also known as automatic speech recognition, computer speech recognition or speech to text. Some speech recognition systems require “training” where an individual speaker reads text or isolated vocabulary into the system.

The system analyses the person’s specific voice and uses it to fine-tune the recognition of that person’s speech, resulting in increased accuracy

3. Autonomous planning and scheduling

- NASA's Remote Agent program was the first on-board autonomous planning program to control the scheduling of operations for a spacecraft.
- The Remote Agent generated plans from high-level goals specified from the ground and monitored the execution of those plans - detecting, diagnosing, and recovering from problems as they occurred.
- Successor program MAPGEN planned the daily operations for NASA's Mars Exploration Rovers, and MEXAR2 did mission planning for the European

4. Game playing

IBM’s DEEP BLUE became the first computer program to defeat the world champion in a chess match when it defeated Garry Kasparov in an exhibition match in 1997.

5. Spam fighting

Each day, learning algorithms classify over a billion messages as spam, saving the recipient from having to waste time deleting them.

6. Logistics planning

- During the Persian Gulf crisis of 1991, U.S. forces deployed a Dynamic Analysis and Replanning Tool (DART) to do automated logistics planning and scheduling for transportation.
- This involved up to 50,000 vehicles, cargo, and people at a time, and had to account for starting points, destinations, routes, and conf lct resolution among all parameters.
- The artif icial intelligence planning techniques generated in hours a plan that would have taken weeks with older methods.

7. Robotics

- The iRobot Corporation has sold over two million Roomba robotic vacuum cleaners for home use.
- The company also deploys the more rugged PackBot to Iraq and Afghanistan, where it is used to handle hazardous materials, clear explosives, and identify the location of snipers.

8. Machine translation

There are computer programs that can automatically translate from, say, Arabic to English.

The program uses a statistical model built from examples of Arabic-to- English translations and from examples of English text totalling two trillion words.

Recent applications

The following are some of the recent applications of artificial intelligence.

1. Agriculture

In agriculture new artificial intelligence advancements show improvements in gaining yield and to increase the research and development of growing crops.

New artificial intelligence methods now predict the time it takes for a crop like a tomato to be ripe and ready for picking thus increasing ef ciency of farming.

2. Cybersecurity

- The more advanced of these solutions use artificial intelligence and natural language processing (NLP) methods to automatically sort the data in networks into high risk and low-risk information.
- This enables security teams to focus on the attacks that have the potential to do real harm to the organization, and not become victims of attacks such as denial-of-service (DoS), malware and others.

3. Finance

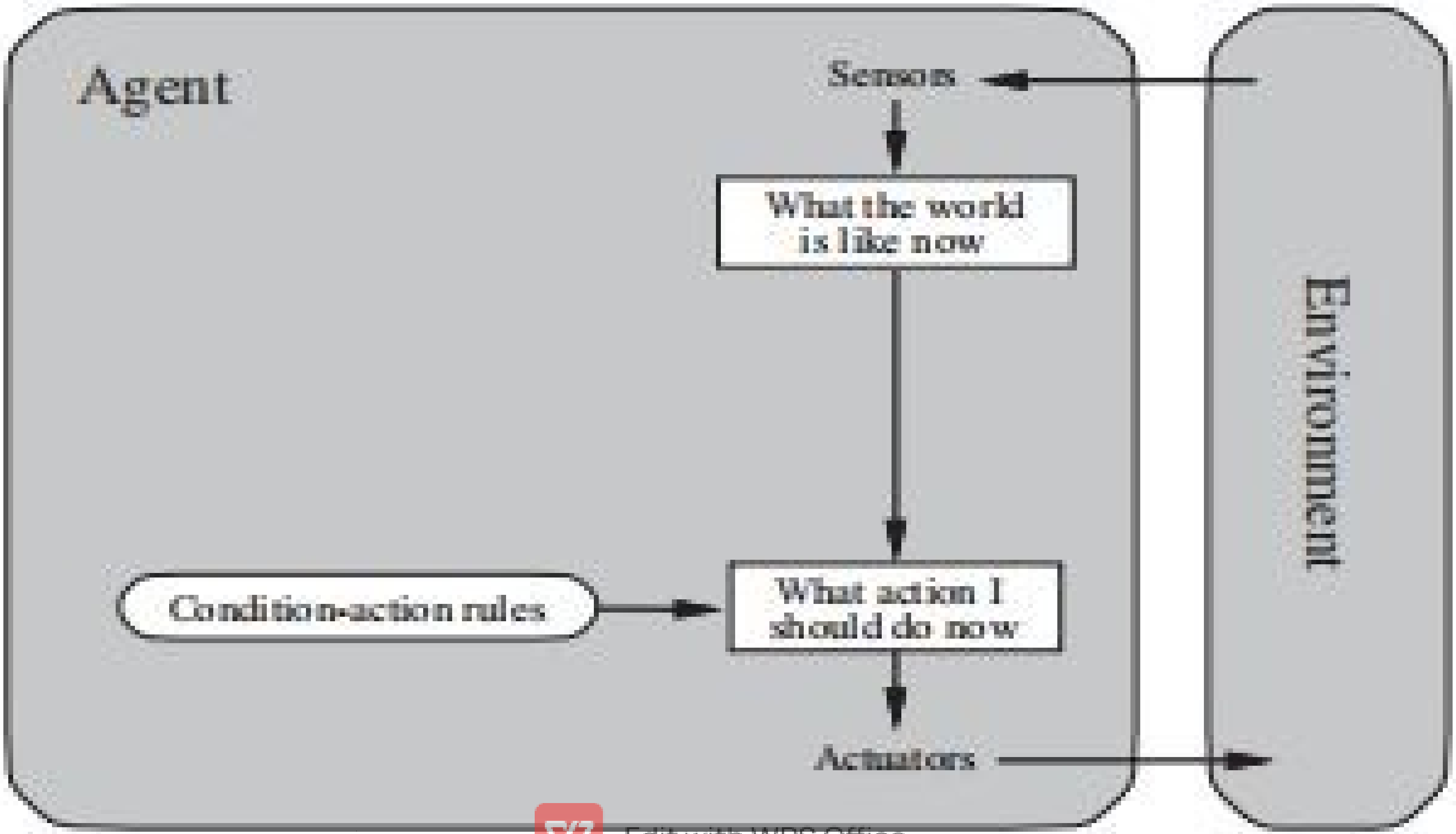
- Banks use artificial intelligence systems today to organize operations, maintain bookkeeping, invest in stocks, and manage properties.
- Artificial intelligence can react to changes overnight or when business is not taking place.

4. Healthcare

- The primary aim of health-related artificial intelligence applications is to analyse relationships between prevention or treatment techniques and patient outcomes.
- Artificial intelligence programs are applied to practices such as diagnosis processes, treatment protocol development, drug development, personalized medicine, and patient monitoring and care.
- Artificial intelligence algorithms can also be used to analyse large amounts of data through electronic health records for disease prevention and diagnosis.

Rational agents

- An agent is anything that can be viewed as perceiving (becoming aware of) its environment through sensors and acting upon that environment through actuators (or effectors)
- Examples
    - A human agent has eyes, ears, and other organs for sensors and hands, legs, vocal tract, and so on for actuators



Schematic diagram of an agent

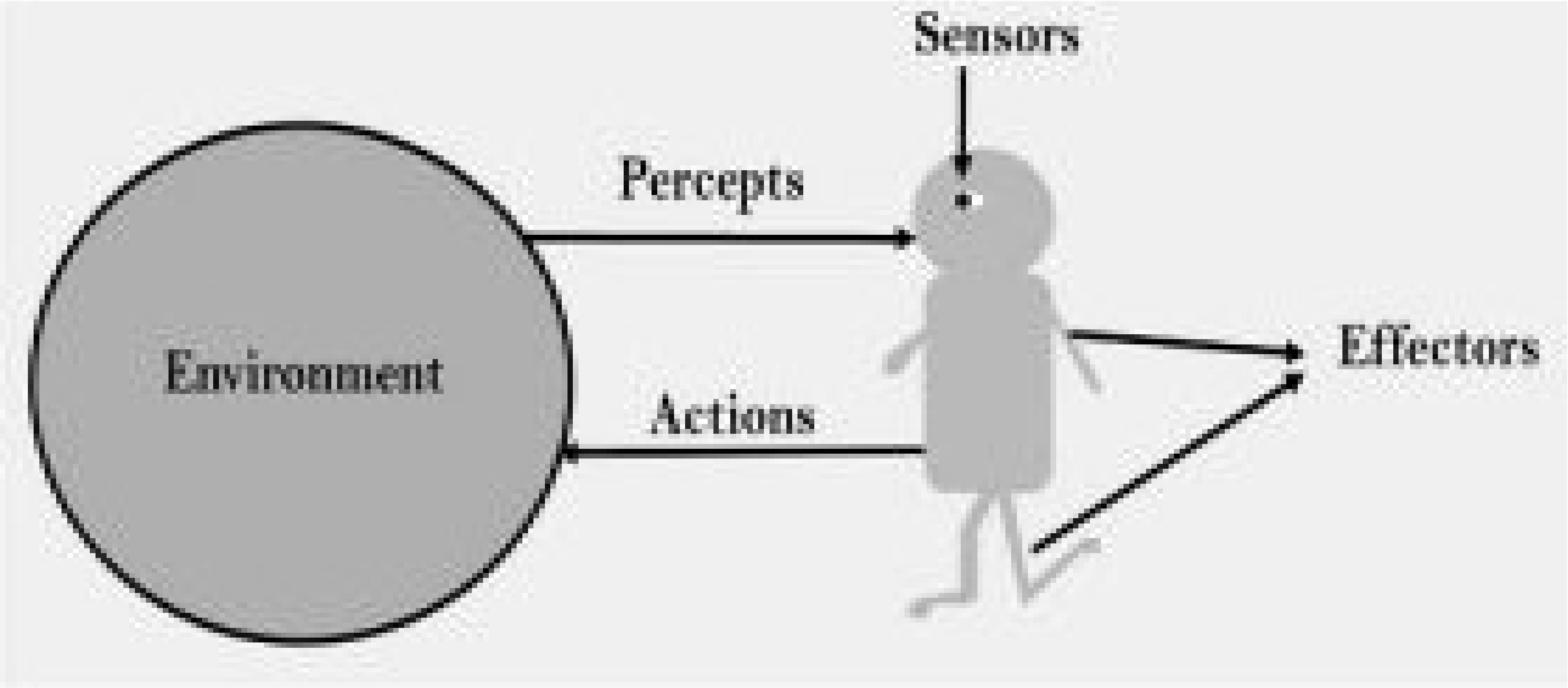


Figure 2.2: Schematic diagram of a human agent

- A robotic agent might have cameras and infrared range finders for sensors and various motors for actuators.
- An agent's behaviour is described by the agent function that maps any given input sequence to an action.
- The agent function for an artificial agent is implemented by an agent program.

Rational agents

- A rational agent is defined as “A rational agent is an agent which, for each possible input sequence sensed by the sensors, selects an action that maximises its expected performance measure.”
- Artificial intelligence is sometimes defined as a study of rational agents. A rational agent could be anything which makes decisions such as a person, firm, machine, or software.

- Problem Solving
- It is the process in which one perceives and tries to arrive at a desired solution from a present situation by taking some path, which is blocked by known or unknown hurdles.
- Problem solving also includes decision making, which is the process of selecting the best suitable alternative out of multiple alternatives to reach the desired goal are available.

- Perception
- It is the process of acquiring, interpreting, selecting, and organizing sensory information.
- Perception assumes sensing. In humans, perception is aided by sensory organs.
- In the domain of AI, perception mechanism puts the data acquired by the sensors together in a meaningful manner.

- Linguistic Intelligence

- It is one's ability to use, comprehend, speak, and write the verbal and written language. It is important in interpersonal communication.

- AI problems are classified as
  - Area of Mathematics
    - To prove Mathematical theorems using games
    - Geometry
  - Commonsense reasoning
    - Reasoning physical objects and their relationships to each other
    - An object can be in only one place at a time
    - Reasoning about actions and their consequences
    - If you let go of something, it will fall to the floor and may be break

PROBLEMS, PROBLEM SPACES & SEARCH

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

1. **Define the problem exactly:** this definition must include precise specification of what the initial situation will be as well as what final situations constitute acceptable solutions to the problem.
2. **Analyze the problem:** A very few important features can have an immense impact on the appropriateness of various possible techniques for solving the problem.

3. Isolate and represent the task knowledge that is necessary to solve the problem.

4.Choose the best problem- solving technique and apply it to the particular problem

Problem

- "It is the question which is to be solved. For solving the problem it needs to be precisely defined. The definition means, defining the start state, goal state, other valid states and transitions".

A problem is defined formally by the following five components:

1. Initial state - The initial state that the agent starts in.

2. Actions - A description of the possible actions available to the agent. Given a particular state s, ACTIONS(s) returns the set of actions that can be executed in s. We say that each of these actions is applicable in s.

3. Transition model - A description of what each action does. The formal name for this is the transition model, specified by a function RESULT(s, a) that returns the state that results from doing action a in state s.

The initial state, the actions, and the transition model all taken together implicitly define **the state space of the problem**

- The set of all states reachable from the initial state by any sequence of actions.
- The state space forms a directed network or graph in which the nodes are states and the links between nodes are actions. A path in the state space is a sequence of states connected by a sequence of actions.

4.Goal test - The goal test, determines whether a given state is a goal state. Sometimes there is an explicit set of possible goal states, and the test simply checks whether the given state is one of them.

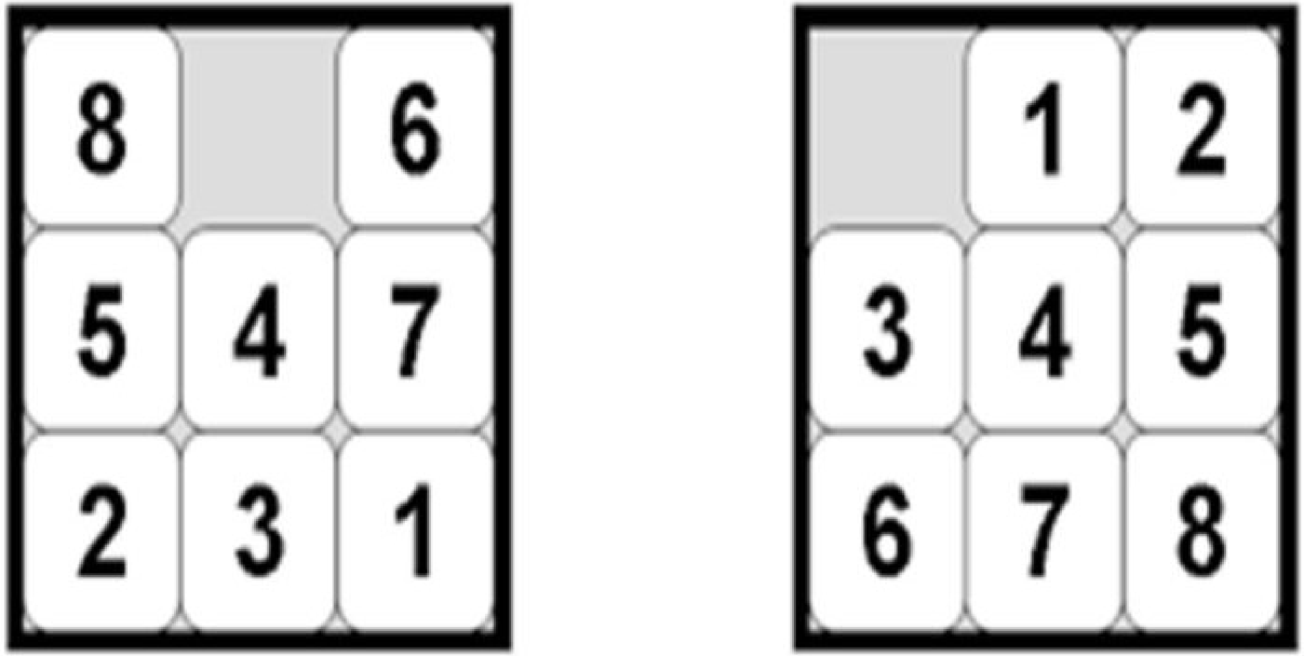
5.Path cost - A path cost function that assigns a numeric cost to each path. We assume that the cost of a path can be described as the sum of the costs of the individual actions along the path.

Solution:

A solution to a problem is an action sequence that leads from the initial state to a goal state. The optimal solution is the solution having the lowest path cost among all solutions

8-puzzle problem

- The 8-puzzle consists of a 3 X 3 board with eight numbered tiles and a blank space. A tile adjacent to the blank space can slide into the space. The objective is to reach a specif ied goal state such as the one shown in Figure by sliding the tiles one at a time, given some initial or start state as in Figure.


8 6
5 4 7
2 3 1
1 2
3 4 5
6 7 8

Standard formulation

- States: A state description specifies the location of each of the eight tiles and the blank in one of the nine squares. (The total number of states is 9! = 362880.)
- Initial state: Any state can be designated as the initial state.
- Actions: Actions may be defined 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, the resulting state has the 8 and the blank cell switched.
- Goal test: This checks whether the state matches the goal configuration shown in Figure.
- Path cost: Each step costs 1, so the path cost is the number of steps in the path.

Missionaries and cannibals problem

- This problem is famous in AI because it was the subject of the first paper that approached problem formulation from an analytical viewpoint.

Description

- Three missionaries and three cannibals are on one side of a river, along with a boat that can hold one or two people. Find a way to get everyone to the other side without ever leaving a group of missionaries in one place outnumbered by the cannibals in that place.

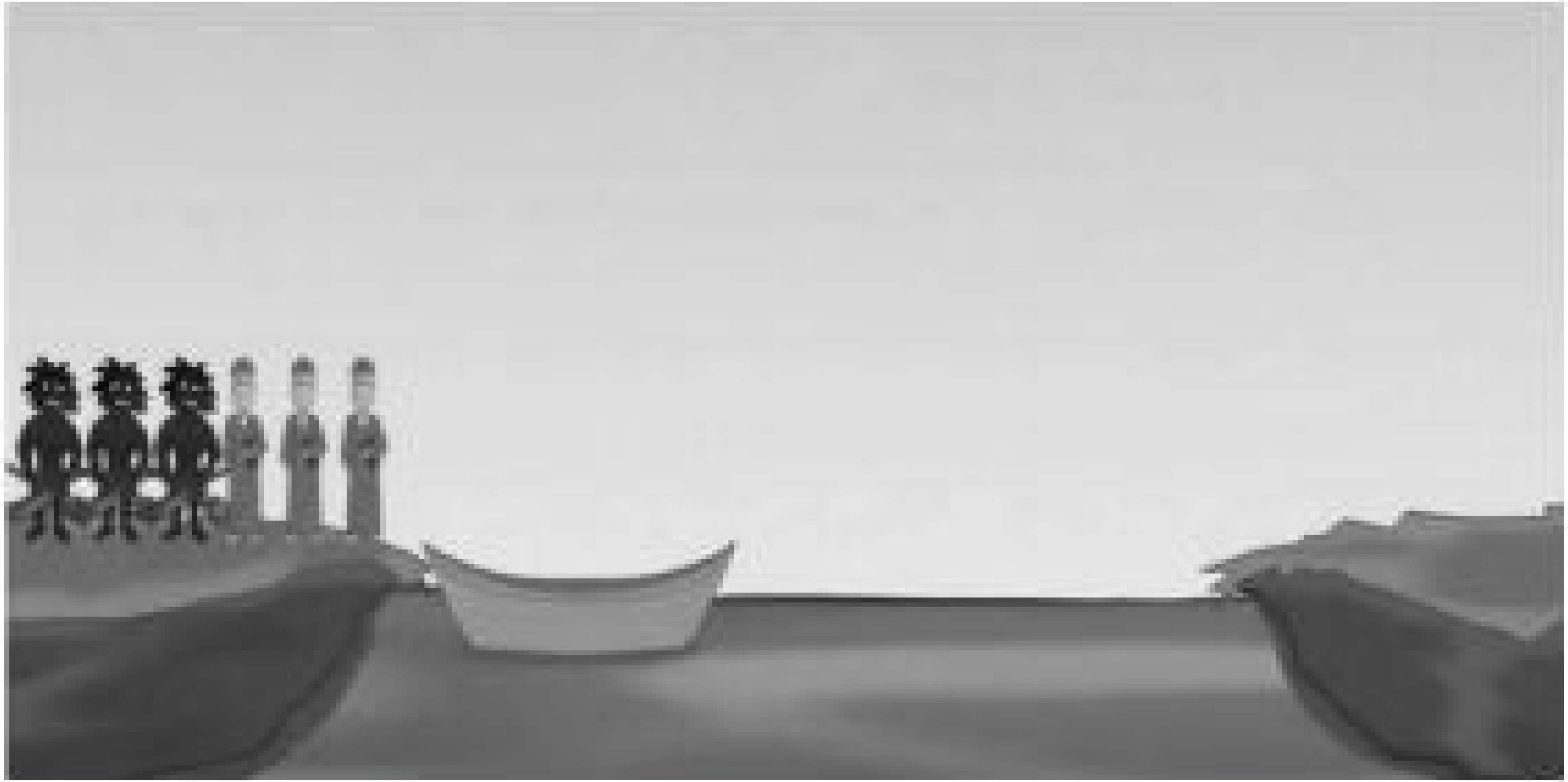


Figure 2.11: The missionaries and cannibals problem

Standard formulation

Ignore all irrelevant parts of the problem (e.g., weather conditions, possible presence of crocodiles in the river, etc.).

States: Each state is represented by an ordered sequence of 3 numbers (x; y; z) where

x : number of missionaries on initial river bank y :

number of cannibals on initial river bank

z : number of boats on initial river bank

For example, if triangles represent missionaries, circles represent cannibals and the left bank is the initial bank then the state shown in Figure is specif ied by the ordered triple (0; 1; 0). Note that the fact that the boat is at the destination bank is indicated by z = 0. Also it may be noted that not all such ordered triples represent legal states. For example, the triple (2; 3; 1) is not allowed because it represents a state where the number of cannibals outnumber the missionaries.

Figure 2.12: The state $(0, 1, 0)$ of the missionaries and cannibals problem

- Initial state: The ordered sequence = (3; 3; 1).
- Actions: Take two missionaries, two cannibals, or one of each across in the boat. We have to take care to avoid illegal states.
- Transition model: Given a state and action, this returns the resulting state; for example, if we apply the action " Take 1 cannibal" to the state (0; 2; 0) the resulting state is (0; 3; 1).
- Goal test: We have reached state (0; 0; 0).
- Path cost: Number of crossings.

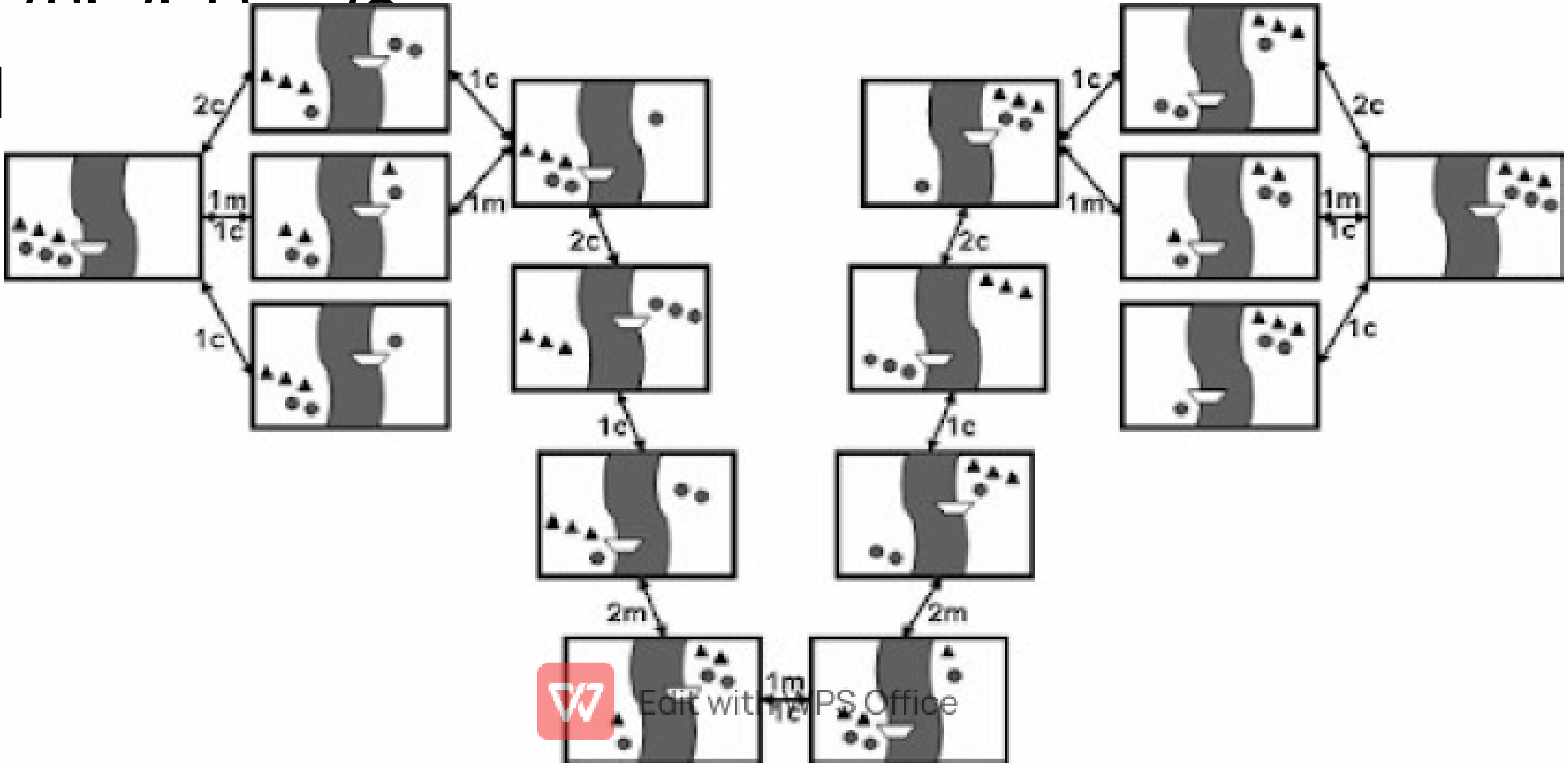
Solution

Figure 2.13 shows the possible legal states reachable from the initial state applying only legal actions. In the figure, the notation “ 2c −→ ” indicates the operation of taking 2 cannibals

from the bank where the boat is currently located to the other bank and the notation “ 2m −→ ” indicates taking two missionaries. From the figure we can easily get the solution to the problem as follows:

(3; 3; 1) −2c (3; 1; 0) −1c (3; 2; 1) −2c (3; 0; 0) −1c (3; 1; 1)
−2m (1; 1; 0) −1m,1c (2; 2; 1) −2m (0; 2; 0) 1c
(0; 2; 1) −2c

(0; 1



Problem characterisitcs and Production systems

Problem characteristics

The following are the important characteristics of a problem.

1. Problem is decomposable to smaller or easier problems.
2. Solution steps can be ignored or undone.
3. The problem universe is predictable.
4. There are obvious good solutions without comparisons to all other possible solutions.
5. Desired solution is a state of the universe or a path to a state.
6. Requires lots of knowledge; or, uses knowledge to constraint solutions.
7. Problem requires periodic interaction between humans and computer.

Is the problem decomposable into a set of independent smaller or easier sub problems?

Consider the problem:

Evaluate the integral $\int (x^2 + \sin^2 x)\, dx$:

We show that this problem is decomposable to smaller sub problems

Since $\int (x^2 + \sin^2 x)\, dx = \int x^2\, dx + \int \sin^2 x\, dx$: the problem can be decomposed into two simpler sub problems.

_ Problem (i): Evaluate $\int x^2\, dx$

_ Problem (ii): Evaluate $\int \sin^2 x\, dx$

Combining the solutions of the sub problems we get a solution of the given problem.

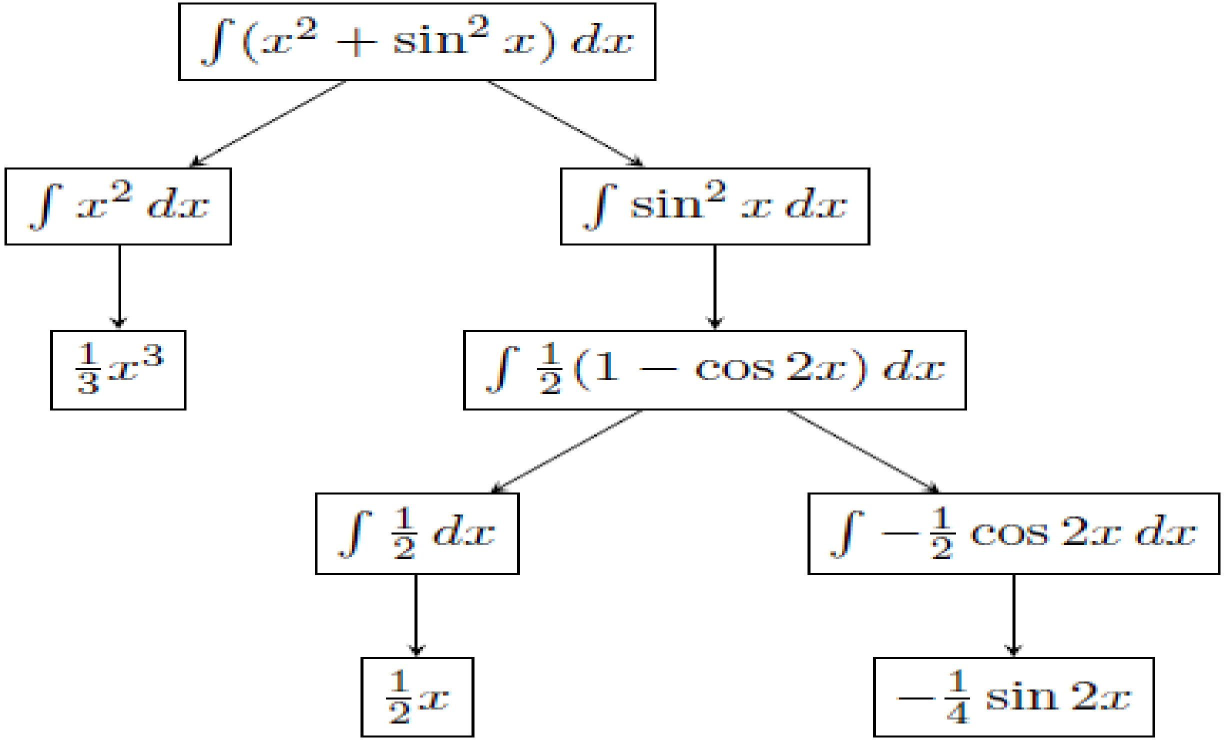


Figure 2.18: Decomposing a problem into smaller subproblems

Solution steps can be ignored or undone.

Example 1

Suppose our goal is to prove a theorem in mathematics. On the way, we prove some preliminary results, say Result 1, Result 2, Result 3, and then finally we prove the theorem. The steps in the proof look like this:

Result 1

Result 2

Result 3

Theorem

Suppose, we later realize that Result 2 is not actually needed in proving the theorem. Then, we may ignore Result 2 and present the steps of the proof as follows:

Result 1

Result 3

Theorem

In this example, the solution steps can be ignored.

Example 2

Consider the 8-puzzle. The solution involves a sequence of moves. In the process of finding a solution, after some moves, we realize that a certain previous move has be reversed. The previous move can be undone by backtracking the moves. In this example, the solution steps can be ignored.

Example 3

Consider the problem of playing chess. If a chess playing programme makes a wrong move, the rules of the game do not permit undoing the move. In this example, the solution steps cannot be undone or ignored.

The problem universe is predictable.

Example 1

In the 8-puzzle, every time we make a move we know exactly what will happen. This means that it is possible to plan an entire sequence of moves. Thus in this problem, the universe is predictable.

Example 2

In a game like bridge, this is not possible because a player does not know where the various cards are and what the other players will do on their turns. In this problem, the universe is unpredictable.

There are obvious good solutions without comparison to all other possible solutions.

Example 1

A “best-path problem” is a problem having no obvious good solutions. The travelling sales man problem is an example for a best-path problem. The travelling salesman problem can be formulated as follows: “Given a list of cities and the distances between each pair of cities, what is the shortest possible route that visits each city exactly once and returns to the origin city?”

Desired solution is a state of the universe or a path to a state.

Example 1

In the missionaries and cannibals problem, if we organise the various states in the form of a tree, it can be seen that the solution to the problem is a path connecting the various states .

Requires lots of knowledge; or, uses knowledge to constrain solutions.

Example 1

Consider the problem of playing chess. The amount of knowledge required to play chess is very little: just the rules of the game! Additional knowledge about strategies may be used to make intelligent moves!!

Example 2

Consider the problem of scanning daily newspapers to decide which are supporting and which are opposing a political party in an upcoming election. It is obvious that a

Problem requires periodic interaction between human and computer.

Solitary: - In which the computer is given a problem description and produces an answer with no demand for an explanation of the reasoning process.

Conversational:- In which there is intermediate communication between person and computer either to provide additional assistance to the computer or to provide additional information to the user or both.

Example

Even in a so called “fully automated system” situations constantly arise that call for human intervention. When the machines get thrown off track, or become faulty, experts have to be summoned to step in and troubleshoot the problems.