Solving Problem by Searching

- **Introduction**

- **General Problem Solving**

PROBLEMS, PROBLEM SPACES AND SEARCH

To solve the problem of building a system you should take the following steps:

1. Define the problem accurately including detailed specifications and what constitutes a suitable solution.

2. Scrutinize the problem carefully, for some features may have a central affect on the chosen method of solution.

3. Segregate and represent the background knowledge needed in the solution of the problem.

4. Choose the best solving techniques for the problem to solve a 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.

A ‘problem space’ is an abstract space.

- The problem space may contain one or more solutions. A solution is a combination of operations and objects that achieve the goals.

A ‘search’ refers to the search for a solution in a problem space.

- Search proceeds with different types of ‘search control strategies’.
- The depth-first search and breadth-first search are the two common search

AI - General Problem Solving

- Problem solving has been the key area of concern for Artificial Intelligence.
- Problem solving is a process of generating solutions from observed or given data.
- Problem-solving methods are categorized as special purpose and general purpose.
- A special-purpose method is tailor-made for a particular problem, often exploits very specific features of the situation in which the problem is embedded.
- A general-purpose method is applicable to a wide variety of problems.

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

- Define the problem precisely – find input situations as well as final situations for an 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 problem-solving technique(s) and apply to the particular problem

PRODUCTION SYSTEMS

Production system has three basic components as enumerated below.

- A **set of rules** each consisting of a left side that determines the applicability of the rule and a right side that describes the operation to be performed if the rule is applied.
- A **database of current facts** established during the process of inference.
- control strategy that specifies the order in which the rules will be compared with facts in the database and also specifies how to resolve conflicts in selection of several rules or selection of more facts.

State Space Search

- A state space represents a problem in terms of states and operators that change states.

A state space consists of:

- A representation of the states the system can be in.

--For example, in a board game, the board represents the current state of the game.

- A **set of operators** that can change one state into another state.

-- In a board game, the operators are the legal moves from any given state.

- **An initial state.**
- **A set of final states**; some of these may be desirable, others undesirable.

The Water Jug Problem

- Problem statement : we have 2 jugs, a 5- gallon (5-g) and the other 3-gallon (3-g) with no measuring marker on them. There is endless supply of water through tap. our task is to get 4-gallon of water in the 5-g jug

- Solution : state space of this problem can be descried as the set of ordered pairs of integers (X,Y) such that X represents the number of gallons of water in 5-g jug and Y for 3-g jug.

1. Start state is (0,0)

2. goal state is (4,n) for any value of n <=3

Rule No	Left of rule	Right of rule	Description
1	$(X, Y \mid X < 5)$	$(5, Y)$	Fill 5-g jug
2	$(X, Y \mid X > 0)$	$(0, Y)$	Empty 5-g jug
3	$(X, Y \mid Y < 3)$	$(X, 3)$	Fill 3-g jug
4	$(X, Y \mid Y > 0)$	$(X,0)$	Empty 3-g jug
5	$(X, Y \mid X + Y \leq 5 \wedge Y > 0)$	$(X + Y, 0)$	Empty 3-g into 5-g jug
6	$(X, Y \mid X + Y \leq 3 \wedge X > 0)$	$(0, X + Y)$	Empty 5-g into 3-g jug
7	$(X, Y \mid X + Y \geq 5 \wedge Y > 0)$	$(5, Y - (5 - X))$ until 5-g jug is full	Pour water from 3-g jug into 5-g jug
8	$(X, Y \mid X + Y \geq 3 \wedge X > 0)$	$(X - (3 - Y), 3)$	Pour water from 5-g jug into 3-g jug until 3-g jug is full

Rule applied	5-g jug	3-g jug	Step No
Start state	0	0	
1	5	0	1
8	2	3	2
4	2	0	3
6	0	2	4
1	5	2	5
8	4	3	6
Goal state	4	–	

Home Work

- Find another solution to the water jug problem

Missionaries and Cannibals Problem

The problem is stated as follows:

- Three missionaries and three cannibals are present at one side of a river and need to cross the river.
- There is only one boat available.
- At any point of time, the number of cannibals should not outnumber the number of missionaries at that bank.
- It is also known that only two persons can occupy the boat available at a
- time.”
- The objective of the solution is to find the sequence of their transfer from one bank of river to other using the boat sailing through the river satisfying these constraints.
- **We can form various production rules as presented in water-jug problem.**
- **Let Missionary is denoted by ‘M’ and Cannibal, by ‘C’. These rules are**
- **described below**

1. Start State: ([3M,3C,1B],[0M,0C,0B]) ,1B means the boat is present,0B means it is absent.
2. Any State: ([n1M,m1C,_],[n2M,m2C,_]) with constraints/Conditions at any state as n1(!=0)>=m1;n2(!=0)>=m2;n1+n2=3,m1+m2=3;boat can be either side.
3. Goal state: ([0M,0C,0B],[3M,3C,1B])

RN	Left side of rule	→	Right side of rule
	Rules for boat going from left bank to right bank of the river		
L1	$([n_1M, m_1C, 1B], [n_2M, m_2C, 0B])$	→	$([(n_1-2)M, m_1C, 0B], [(n_2+2)M, m_2C, 1B])$
L2	$([n_1M, m_1C, 1B], [n_2M, m_2C, 0B])$	→	$([(n_1-1)M,(m_1-1)C,0B],[(n_2+1)M,(m_2+1)C, 1B])$
L3	$([n_1M, m_1C, 1B], [n_2M, m_2C, 0B])$	→	$([n_1M, (m_1-2)C, 0B], [n_2M, (m_2+2)C, 1B])$
L4	$([n_1M, m_1C, 1B], [n_2M, m_2C, 0B])$	→	$([(n_1-1)M, m_1C, 0B],[(n_2+1)M, m_2C, 1B])$
L5	$([n_1M, m_1C, 1B], [n_2M, m_2C, 0B])$	→	$([n_1M, (m_1-1)C, 0B], [n_2M, (m_2+1)C, 1B])$
	Rules for boat coming from right bank to left bank of the river		
R1	$([n_1M, m_1C, 0B], [n_2M, m_2C, 1B])$	→	$([(n_1+2)M, m_1C, 1B], [(n_2-2)M, m_2C, 0B])$
R2	$([n_1M, m_1C, 0B], [n_2M, m_2C, 1B])$	→	$([(n_1+1)M,(m_1+1)C,1B],[(n_2-1)M,(m_2-1)C, 0B])$
R3	$([n_1M, m_1C, 0B], [n_2M, m_2C, 1B])$	→	$([n_1M, (m_1+2)C, 1B], [n_2M, (m_2-2)C, 0B])$
R4	$([n_1M, m_1C, 0B], [n_2M, m_2C, 1B])$	→	$([(n_1+1)M, m_1C,1B],[(n_2-1)M, m_2C, 0B])$
R5	$([n_1M, m_1C, 0B], [n_2M, m_2C, 1B])$	→	$([n_1M, (m_1+1)C, 1B], [n_2M, (m_2-1)C, 0B])$

Table 2.3 Solution Path

Rule number	([3M, 3C, 1B], [0M, 0C, 0B]] ← Start State
L2:	([2M, 2C, 0B], [1M, 1C, 1B])
R4:	([3M, 2C, 1B], [0M, 1C, 0B])
L3:	([3M, 0C, 0B], [0M, 3C, 1B])
R5:	([3M, 1C, 1B], [0M, 2C, 0B])
L1:	([1M, 1C, 0B], [2M, 2C, 1B])
R2:	([2M, 2C, 1B], [1M, 1C, 0B])
L1:	([0M, 2C, 0B], [3M, 1C, 1B])
R5:	([0M, 3C, 1B], [3M, 0C, 0B])
L3:	([0M, 1C, 0B], [3M, 2C, 1B])
R5:	([0M, 2C, 1B], [3M, 1C, 0B])
L3:	([0M, 0C, 0B], [3M, 3C, 1B]) → Goal state

State Space search representation for Missionaries and Cannibals

problem solving process.

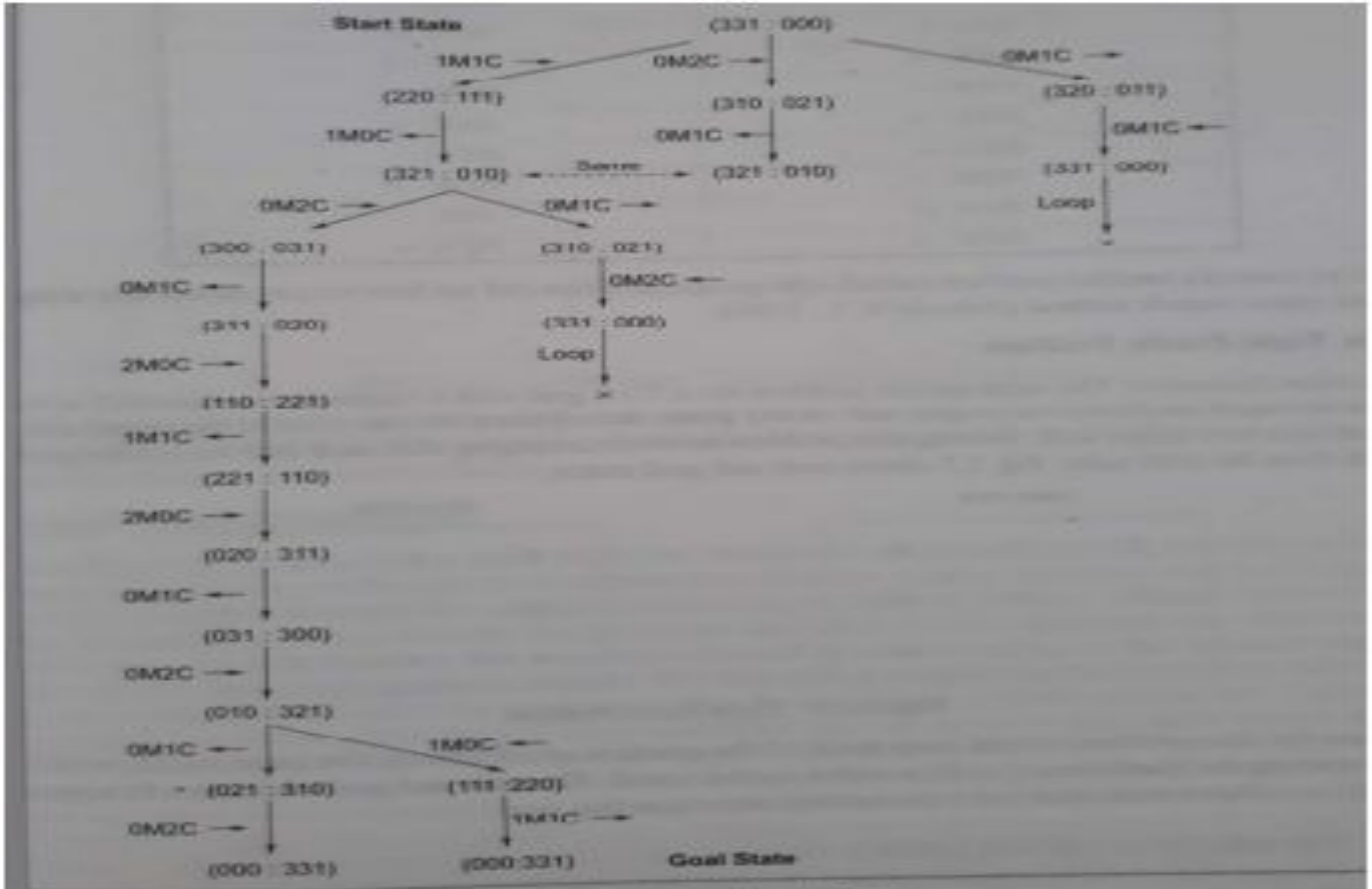


Figure 2.1 Search Space

Eight Puzzle Problem

- The 8-puzzle is a 3 × 3 array containing eight square pieces, numbered 1 through 8, and one empty space.
- A piece can be moved horizontally or vertically into the empty space, in effect exchanging the positions of the piece and the empty space. There are four possible moves, UP (move the blank space up), DOWN, LEFT and RIGHT.
- The aim of the game is to make a sequence of moves that will convert the board from the start state into the goal state:
- This example can be solved by the operator sequence UP, RIGHT, UP, LEFT, DOW

start state

3	7	6
5	1	2
4		8

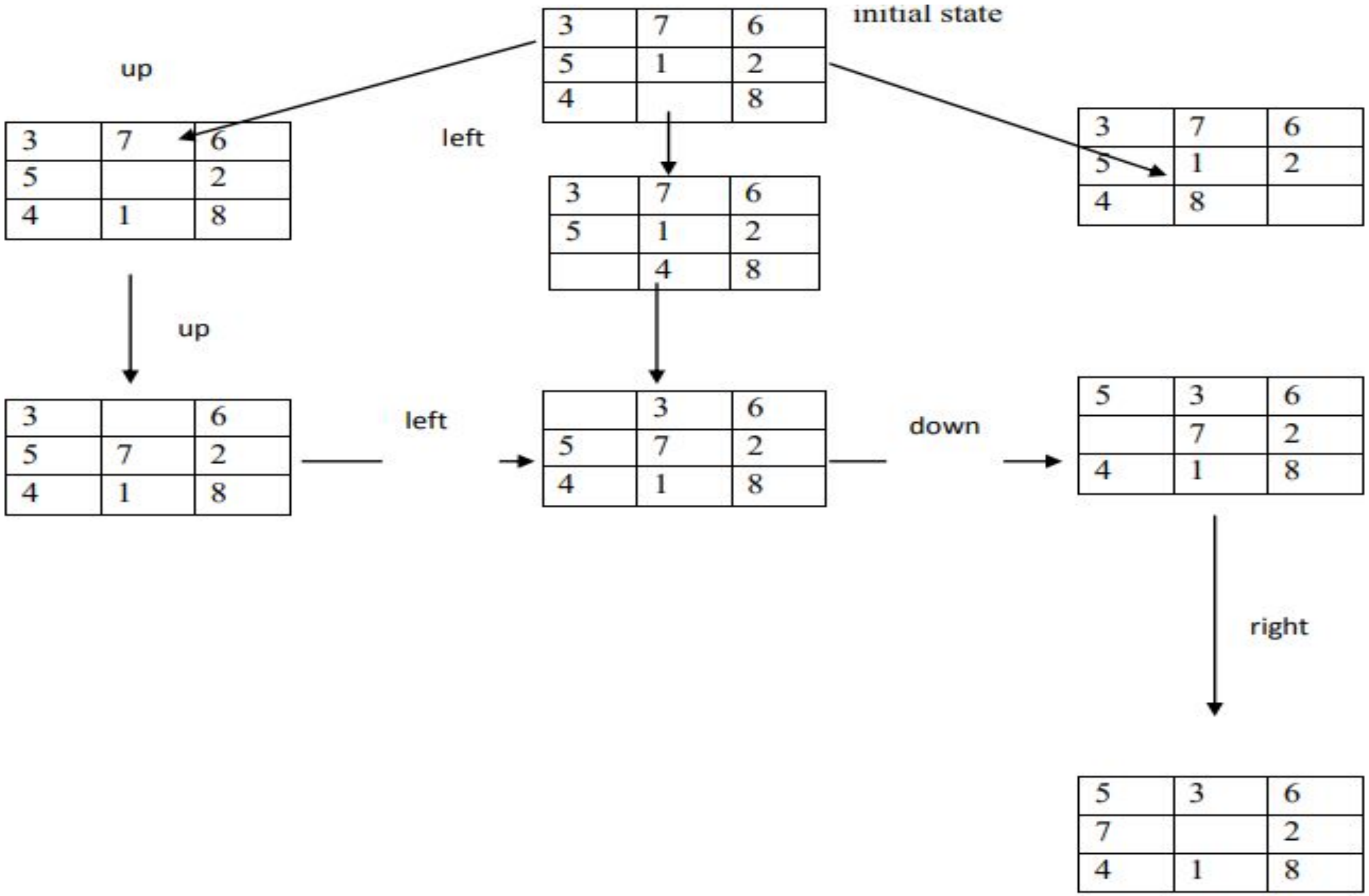
goal state

5	3	6
7		2
4	1	8

1. START state [[3,7,6],[5,1,2],[4,0,8]]

2. the goal state could represent as [[5,3,6],[7,0,2],[4,1,8]]

3. the operators can be thought of moving (up, down, left, right}
the directions in which blank space effectively moves


initial state
up
left
up
left
down
right

Control strategies

Control strategy is one of the most important component of problem solving that describes the order of applications of the rule from the current state.

Control strategy should be such that it causes the motion towards the solution.

It is that it should explore the solution space in a systematic manner.

The following strategies which are used in the control strategy.

1. Exhaustive
2. uninformed
3. blind searches in nature.

- There are two directions in which such a search could proceed.
- Data driven search call forward chaining from the start State.
- Goal driven search called backward chaining from the goal state.
- Forward chaining: The process of forward chaining begins with unknown facts and works towards a conclusion. Rules are expressed in the form of if then rules.
- Backward chaining: Is it Goal directed strategy that begins with the goal state and continuous working backwards generating more sub goals that must also be satisfied to satisfy main goal and till we reach to start State.