- 4 hrs.

Chapter-2

PROBLEM SOLVING

⇒ A problem is a situation which is experienced by an agent and is solved by a sequence of action.

⇒ That reduce the difference between the initial situation and the goal.

Problem solving

⇒ A systematic search through a range of possible actions in order to reach some predefined goal or solution is called problem solving.

⇒ There are 4 step of problem solving:

1. Goal formulation:
   Helps to organize behaviour by isolating and representing the task knowledge necessary to solve problem.

2. Problem formulation:
   Defines the problem precisely with initial state, final state and acceptable solutions.

3. Searching:
   Find the most appropriate technique of sequence of among all possible technique.

4. Execution:
   Once the search algorithm returns a solution

to the problem, the solution is then executed by the agent.

⇒ Eg: A* search.

Well defined Problem:

⇒ A problem can be defined by

- Initial state
- Actions
- Goal test
- Path cost
- Solutions

Solutions
⇒ It is a path from the initial state to a goal state.

⇒ A problem ~~may be~~ when defined with these components is called well defined problem

Ans

Defining problem as a state space search:

⇒ A set of all possible state for the given problem is known as state space for the problem.

⇒ A state space is the set of all states reachable from the initial state.

⇒ The major component of state space representation are :

1) Initial state

2. Goal state
3. Operator / legal moves

Examples:

Initial State:

1		2
4	5	3
7	8	6

Final State:

1	2	3
4	5	6
7	8	

Operators:
UP
DOWN
LEFT
RIGHT

Explanation:

⇒ To explain the state space representation let us consider a problem of 8 puzzle game as an example.

⇒ The puzzle consist of 8 square frames & an empty slot.

⇒ The tiles are number from 1-8. It is possible to move the tiles in the square field by moving tile into empty slot

2002 | K | Y | CN

⇒ Objective is to get square in numeric order.

Q. Explain problem as a state space with an example.

Problem formulation & problem types.

⇒ The process of deciding the initial state to consider for the particular problems so that the operator perform the specified operation to reach the given goal is called problem formulation.

Types of problem

1. Single state problem
   ⇒ Deterministic, accessible
   ⇒ Eg:- Chess
   ⇒ Agent know everything about world (environment)
   ⇒ Calculate optimum action sequence to reach goal state.

2. Multiple state problem.
   ⇒ Deterministic
   ⇒ Inaccessible
   ⇒ Agent doesnot know the exact state.
   ⇒ Assume states while walking forward to goal state.
   ⇒ Eg:- walking in dark room to switch on the light, PUBG

3. Contingency Problem:

⇒ Non-deterministic, Inaccessible

⇒ Must use sensor during ~~an~~ execution.

⇒ Solution is a tree or policy

⇒ Often interleave search & execution

Eg:- a new ~~staker~~ skater in an arena
- sliding problem.

4. Exploration problem:

⇒ Unknown state space

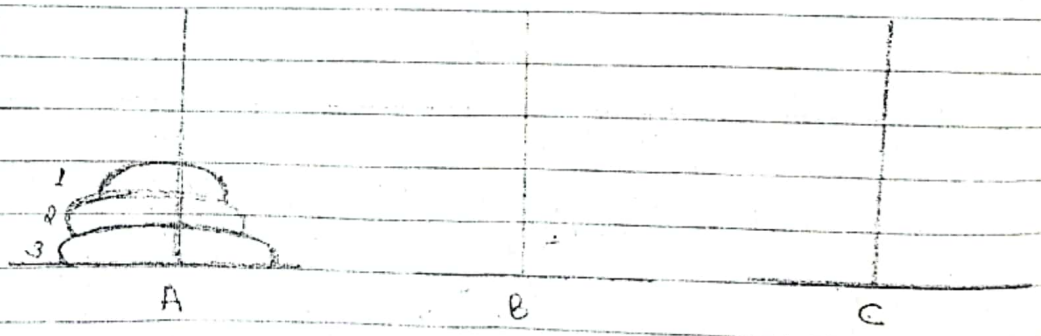
⇒ Discover and learn about environment while taking action

⇒ Example:- Maze

Q. Define problem formulation. What are different types of problem? Encounter in problem solving.

Q. ~~Pegs~~ & Disks Problem.

Tower of Hanoi Problem.



Goal: All disks in B

Mov 1 to B
Mov 2 to C
Mov 1 to C
Mov 3 to B
Mov 1 to A
Mov 2 to B
Mov 1 to B

Mov 1 to B
Mov 2 to C
Mov

(B)

8 puzzle problem

1		2
4	5	3
7	8	6

initial state

1	2	3
4	5	6
7	8	

Final state

Mov 2 to left
Mov 3 to up
Mov 6 to up

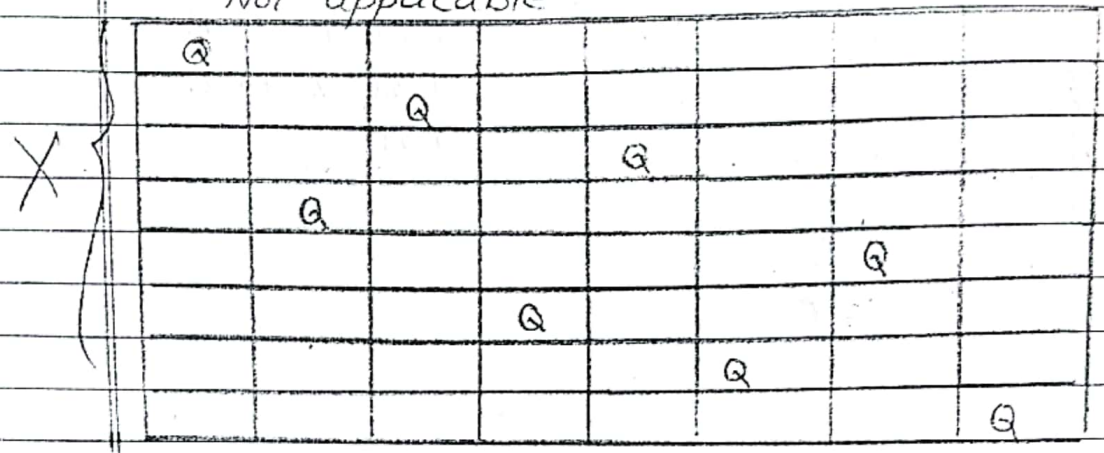
left up up
Mov 2 left
" 3 up
" 6 "

8 queen Problem:

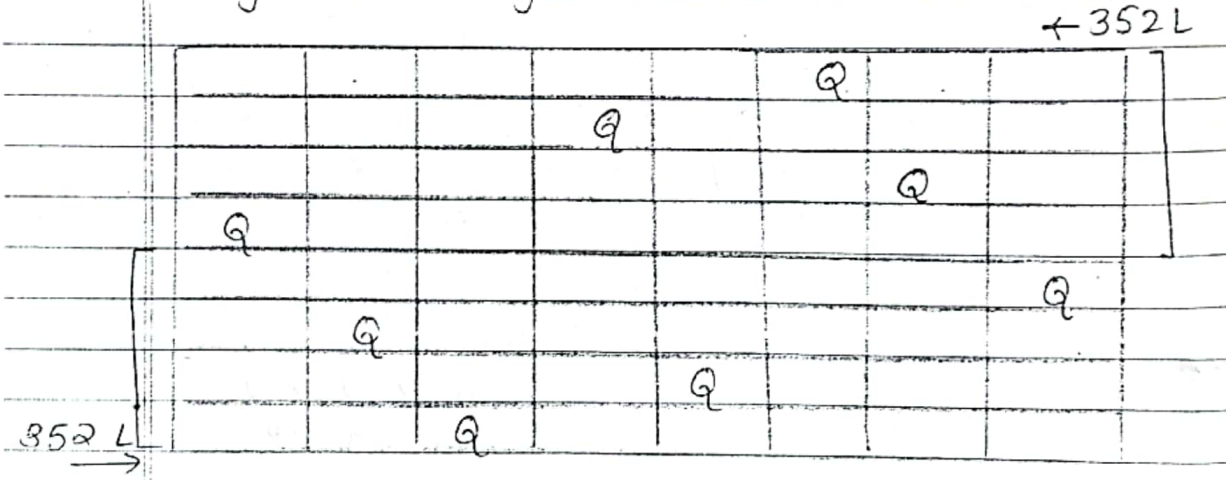
» The problem is to place 8 queens on a chess board so that no two queens are in the same row, column or diagonal.

trick. 352 L

Not applicable



Using trick (only solution)



Water Jug problem

Q You are given two jugs one 4 liter & another 3 litre. Neither of them have measuring mark on them. There is a tap that is used to fill the jug with water. Your goal is to fill 2 litre water in 4 litre jug

4 3 2

4 3 3

4, 3

(4) → Fill → 3

(0,0) — (0,0)

(4,0) (0,4)

(1,3) (3,1)

(1,0)

Here:

Initial state (0,0)

Operator:

⇒ Fill 3 litre jug from tap, fill 4 litre jug from tap.

⇒ Fill 3 litre jug from 4 litre jug. ~~fill~~

⇒ Fill 4 litre jug from 3 litre jug

⇒ Empty 3 litre into 4 litre,

⇒ Empty 4 litre into 3 litre

⇒ Dump 3 litre jug down drain.

⇒ Dump 4 litre jug down drain.

Final state (0,2)

Litres of water in 3L		Litres of water in 4L	
	0	0	
operator (1)	3	3	
	0	3	(2)
(1)	3	4	(2)
	2	0	(4)
	0	2	(3)

River crossing problem

A farmer has a goat, wolf and cabbage. On the west side of the river. He wants to get all of his animals and cabbage (abbage across the river on east side. The farmer has single goat. But he only has enough room for himself & one other thing. The wolf will eat the goat. If they are left together alone. The goat will eat cabbage

if they are left alone. How can the farmer get everything on the east side.

West	river	East
goat, wolf, cabbage	farmer+goat	goat
wolf, cabbage	farmer (←)	goat
cabbage	farmer+wolf	goat
cabbage	farmer+goat(←)	wolf
goat	farmer+cabbage	wolf
goat	farmer (←)	wolf, cabbage
C	farmer	wolf, goat, cabbag

Here,
Initial state
West {farmer, cabbage, wolf, goal} &
East {ϕ}

Operators
More farmer and one of the cabbage, wolf & goal from west to East & vice versa.

Final state:
West {ϕ} & {F, G, W, C}

Sol^n

SN	West	River	East
1	{F, C, W, G}		{ϕ}
2.	W, C	(F, G) →	(F, G)
3	W, C, F	F ←	G
4.	W	F, C →	F, C, G
5	W, F, G	F, G ←	C
6.	G	F, W →	W, C
7	F, G	F ←	W, C
8	{ϕ}	F, G →	F, W, C, G

Q. In a distinct land bigamy is common, there are 6 people who want to crass a river in this land. These group consists of two men, each two wives. No men can tolerate any of his wife being in company of another man unless atleast he or his wife is present in boat or in next land. There is a boat that holds two people to be used for crossing the river. How is the trip possible.

Here,

Initial state

West {H_1, W_1, W_1'}
{H_2, W_2, W_2'}

East {ϕ}

Operator

No men can tolerate any of his wife being in company of another.

Final state

west {ϕ} & east {H_1, W_1, W_1'}

~~we~~ {H_2, W_2, W_2'}

Solution,

SN	West	River	East
1.	(H_1, W_1, W_1') (H_2, W_2, W_2')	—	ϕ
2.	H_1, H_2, W_2, W_2'	$(W_1, W_1') \rightarrow$	(W_1, W_1')
3.	H_1, H_2, W_2, W_2', W	$(W_1) \leftarrow$	(W_1')
4.	H_2, W_2, W_2'	$(H_1, W_1) \rightarrow$	(H_1, W_1, W_1^2)
5.	H_1, H_2, W_2, W_2'	$H_1 \leftarrow$	(W_1, W_1')
6.	W_2, W_2'	$(H_1, H_2) \rightarrow$	$(H_1, H_2, W_1, W_1'$
7.	H_2, W_2, W_2'	$H_2 \leftarrow$	H_1, W_1, W_1'
8.	W_2'	$H_2, W_2 \rightarrow$	H_1, H_2, W_1, W_1',
9.	W_2, W_2'	$W_2 \leftarrow$	H_1, H_2, W_1, W_1'
10.	{ϕ}	$W_2, W_2' \rightarrow$	$H_1, H_2, W_1, W_2,$ W_1', W_2'.

Q You are given two jars of 6L and 8L respectively. There is no marking in the jar. There is a water tap which can be used to fill the jar. Your goal is to have 4l of water in 8 litre of jar without taking any other jar or measuring device. solve by production rule system.

Here,

Initial state (0,0)

Operators

1. Fill 6l jar from tap, fill 8l jar from tap.
2. Fill 6l jar from 8l jar, fill 8l jar from 4l jar.
3. Empty 6l jar from 8l jar, empty 8l jar into 6l jar.
4. Dump 6l jar down drain, dump 8l jar down drain.

final (0,4)

	6L	8L	
Inital	0	0	
	6	0	
	0	6	
	6	6	
	4	8	
	4	0	(Dump)
	0	4	

Production System.

=> Production System are among the earliest forward chaining system in use.
=> It is based on the if and then condition.
=> If a pre condition matches, the correct state of the world, then the ~~pre condition~~ production is said to be triggered.
=> If the production action is executed. It is said to have fired.
=> It consist of 4 basic component

(1) A set of production rules based on IF-THEN contruct.
(2) A database (working memory) of current facts
(3) A control strategy which specifies the order in which the rules are selected.
(4) Rule firing module which is computational system that implements the control strategy and applys the rule.

=> A production system is ~~based~~ best implemented AI technique to solve the state space problem. Like water jug and crossing river problem.

=> This problem consist of initial state, state space & goal state.

- Advantage

1) It provide an excellent tool for structuring AI programming.
2) They are highly modular because the individual rules can be added, can be moved, or modified independently.
3) The production rules are expressed in natural form so the statement contain in knowledge based seems to be opinion of an expert.

- Disadvantages:

1) It may be very difficult to analyze flow of control within a production system because individual rules don't call each other.
2) Some problem may be difficult to implement as code. Thus, advante IT & computer expertise are needed.

Q. What is production system? Write down the component of production along with its advantages & disadvantages.

Q. Explain production system with the help of an example.

Q. Explain production system along with its types.

Types

1. Monotonic Production System (Defn / Eg)
2. A non-monotonic " "
3. A partially commutative " "
4. A commutative " "

1. Monotonic productive system.

=> They are useful for problems in which changes occur but can be reversed and in which the order of operation is not critical.

=> Example: 8 puzzle problem.

2. A partially Production system

=> It is one in which the application of a particular sequence of rules transforms state x into state y, then any permutation of those rules that is allowable also transforms state x into state y.

3. A non-monotonic Commutative productive System.

=> A production system in which the application of part

=> Without the property of monotonic production system.

4. A commutative Production System

⇒ It is a production system that is both monotonic & partially commutative.

- Constraint satisfaction Problem (CSP)
  or
  Crypto arithmetic Problem

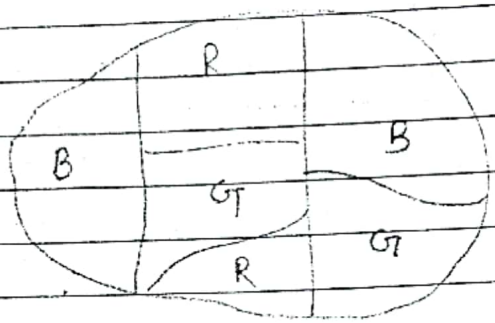
⇒ In AI constraint satisfaction is the process of finding a solution to a set of variables $V_i (V_1, V_2, V_3 \ldots V_n)$ and a set of constraint $C_i (C_1, C_2, \ldots C_m)$, where each variable has a domain of allowed value.

⇒ There is no specified rule to defined the procedure to solve the CSP.

⇒ The main features of CSP are

i) It is high level description of a problem.
ii) A model for the problem is represented by a set of variables & their domain.
iii) The problem is stated as constraint specifying relationship between the variable
iv) The constraint only specifying the relationship with specifying a computational procedure to enforce the relationship.
v) The computer has to find the solution of the specified problem.

Eg:- map colouring



⇒ The CSP consist of two steps
i) Constraints are discovered.
ii) Propagate the constraints throughout the system.

If no solution are found a new guess is made about some values, added as constraints and then propagated.

Advantages of CSP:

1) Standard representation pattern.
2) Generic Goal and successor function
3) Generic heuristics (no domain experts reqd)

Crypto Arithmetic Problem

Problem 1:

A B C	SEND	9 5 6 7
+ D E F	MORE	⇐ 1 0 8 5
G H I	MONEY	1 0 6 5 2

TOW

Instruction for solving

i) Alphabet can take only one distinct value.
ii) Alphabet can only take up values between 0 to 9.
iii) Decoded number cannot begin with zero.
iv) Problem are uni°-solutional.
v) 19 is the maximum value with the carry over 4 to 1 digit number in the same column.
vi) Carry over can only be 1

Rules.

1. $A \neq B \neq C \neq D \neq E \neq F \neq G \neq H \neq I$
2. $C + F = I$
   $C + F = 10 + I$
3. $B + E = H$
   $B + E + 1 = H$
   $B + E + 1 = 10 + H$
   $B + E = 10 + H$
4. $A + D = G$
   $A + D + 1 = G$

Step 1 : Domain of C = {0, 1, 2, 3, 4, 5, 6, 7, 8, 9}
Domain of F = {0, 1 ..... 9}
So, Domain of I = {0, 1, 2 ..... 9}
select C = 2
F = 4

```
  A B 2
+ D E 4
-------
  G H G
```

{0, 1, 3, 5, 7, 8, 9}

Step 2: select B = 7
E = 5

A	7	2
D	5	4
G	2	6

{0, 1, 7, 9}

Step 3:
select A : 0
D : 1

0	7	2
1	5	4
2		6

or

select C = 4
F = 9

A	B	4
D	E	9
G	H	3

{0, 1, 2, 5, 6, 7, 8}

Step 2:
select B = 2
E = 8

A	2	4
D	8	9
G	1	3

{0, 5, 6, 7}

Step 3:

Select A = 0

D = 5

```
  0  8  4
  5  0  9
-------
  6  1  3
```

Imp

Q. SEND
MORE
1 ← (M)ONEY

always

A ≠ B ≠ C ≠ D ≠ E ≠ F ≠ G ≠ H ≠ I

Step 1:

Domain of D = {0, 1, 2, 3 ... 9}

E = {0 ..... 9}

Y = {0 ..... 9}

So, Step 1:

Select D = 7

E = 5

```
  S E N 7
  M O R 5
-------
  M O N E 2
```

Step 2:

Select N → 6

R → 8

```
  S E 6 7
  M O 8 5
-------
  M O N 5 2
```

SEND
MORE
MONEY

S → 9
E →
N →
D →
M → 1
O → 0
R →
E →
Y →

Step 3:

Select E → 5

O → 0

```
  S 5 6 7
  M 0 8 5
M 0 6 5 2
```

Step 4:

Select : S → 9

M → 1

```
  9 5 6 7
  1 0 8 5
1 0 6 5 2
```

Q.2. TRUE

```
  TRUE
FALSE
```

select E = 0

```
  TRUO
  TRUO
FALSO
```

Select U = 2

```
  TR2O
  TR2O
FAL4O
```

Step 3 :- select R = 3

```
  T 3 2 0
  T 3 2 0
-------
1 6 4 0
```

Select 4 T = 9

```
  9 3 2 0
  9 3 2 0
---------
1 8 6 4 0
```

Q. 3.

```
  B A S E
  B A L L
---------
G A M E S
```

Step 1 : select E → 3
L → 5

```
  B A S 3
  B A 5 5
---------
G A M E 8
```

Step 2 : A = 4 , S = 8

```
  B 4 8 3
  B 4 5 5
---------
G A 9 3 8
```

Step 3 B → 7

```
  7 4 8 3
  7 4 5 5
---------
1 4 9 3 8
```

(4) EAT
THAT
APPLE

(5) LETS
WAVE
LATER

(4) EAT
THAT
APPLE

Step 1:

Select T → 9

8 1 9

A → 1 9 H 1 9

1 P P 3 8

Select E H → 2

8 1 9

9 2 1 9

1 P P 3 8

8 1 9

9 2 1 9

1 0 0 3 8

Missionary & cannibal Problem

Q Three missionary & 3 cannibal find themself & on oneside on the river.

=> The missionary wants to manage the trip across the river in such a way that the no. of missionaries on either side of the river is never less than no. of cannibals who are on the same side.

=> There is a single boat that holds two people at a time. How can you get all of them across the river.

Left	River	Right
MMMCCC	—	000000
MMCC	MC →	MC
MMMCC	M ←	C
MMM	CC →	CCC
MMMC	C ←	CC
MC	MM →	MMCC
MMCC	CM ←	MC
CC	MM →	MMMC
CCC	C ←	MMM
C	CC →	MMMCC
CC	C ←	MMMC
000000	CC →	MMMCCC

Here, in this way we can get all of them across

the river and solve the missionary and cannibal problem.

Q. Consider a person having certain number of flowers and he has to visit three temples to equally present equal number of flowers to each temple. When he enters in any temple with flowers the no. of flower just become double after visiting each temple he return with the empty hand. How many flowers were there with him initially & how many flowers did he offer to each temple.

Let the initial flowers be x & y be the flowers he offered to each temple.

At 1st temple,
The flowers is doubled $2x$
He offered : $(2x - y)$ flowers.

At 2nd temple,
Flowers doubled $2 * (2x - y) = 4x - 2y$
He offered : $(4x - 2y) - y = 4x - 3y$

At 3rd temple,
Flowers doubled : $2x(4x - 3y) = 8x - 6y$
He offered $(8x - 6y) - y = 8x - 7y$

He returns empty handed. So,

$$8x - 7y = 0$$

$$\therefore \frac{x}{y} = \frac{7}{8}$$