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Divya - B

HA - 1

1) Apply hill climbing search to solve the 4- Queens problem. Describe the steps of the algorithm, possible outcomes and limitations when used for this problem?

A) Hill climbing search - 4 Queens problem:-

Hill climbing is a local search algorithm that starts from a random state and repeatedly moves to a better neighbour state. Until no better move exists.

Steps of the algorithm

1) Start with a random arrangement of queens (1 per column).

2) Evaluate using heuristic h. no. of pairs of queens attacking each other.

3) Generate neighbours by moving one queen in its column to a different row.

4) Select the best neighbour with the lowest h value.

5) Move to that neighbour.

6) Repeat until :→ h=0 → Solution found

→ no better neighbour → stop.

[illegible] 3

Initial State :-

. Q . .

. . . Q

Q . . .

. . Q .

h = 3

Step 1 :- Move queen (Q) in column 2 → row 3 → h = 1

Step 2 :- Move queen (Q) in column 1 → row 1 → h = 0

Final board :

Q . . .

. . Q .

. Q . .

. . . Q

No queens attack each other

Possible Outcomes :-

• Solution found : h = 0

• Local minimum : No better move, but no solution

• Plateau : [illegible] same h

[illegible]

Example :

Intial State :-

. Q . .

. . . Q

Q . . .

. . Q .

h = 3

Step 1 :- Move queen (Q) in column 2 →

row 3 → h = 1

Step 2 :- Move queen (Q) in column 1 →

row 1 → h = 0

Final board :

Q . . .

. . Q .

. Q . .

. . . Q

No queens attack each other

Possible Outcomes :-

* Solution found : h = 0
* Local maximum : No better move, but no a Solution.
* plateau : All neighbours have same h, no progress.

* Ridge : Needs multiple side ways moves before improvements

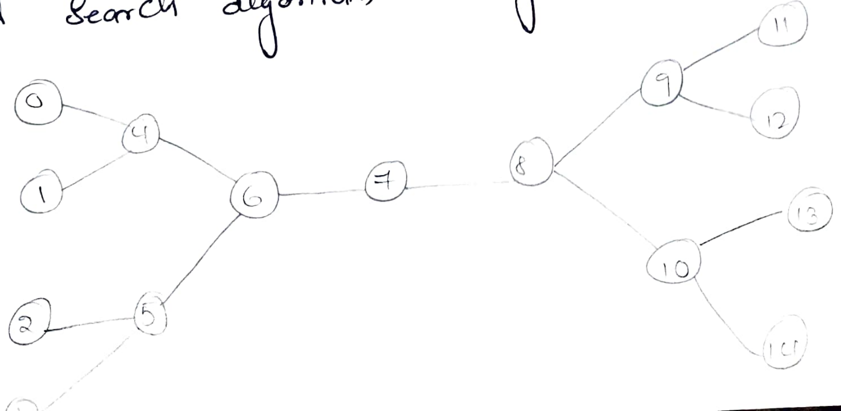
Limitations :-

* Can get stuck in local maxima (or) plateaus.
* No back tracking - one stuck, its stops.
* Starting position affects success.
* Works better with random restarts of simulated annealing.

Summary :-

Hill climbing for 4-queens moves queens step by step to reduce attacks. It's fast and simple, but may fail without restarts because it only looks for immediate improvement.

② Solve the following problem using Bidirectional search algorithm with goal state 7?



Bidirectional Search :-

It is graph search algorithm that runs two simultaneous searches - one forward and backward from the goal node and stops when the two searches meet.

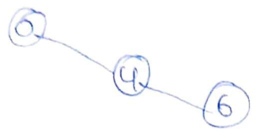
Algorithm :-

1) Start a BFS from start and BFS from goal.
2) keep track of visited nodes for each search.
3) Expanding one level from each side.
4) If a node is visited by both searches stop - that meeting point.
5) Combine the paths from start → meeting → goal to from the shortest path.

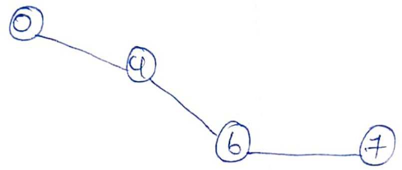
Start at '0' node and forward Explanation is '4'.

Goal node at '7' and back Expansion is '6'

and after '4' we have to take forward expansion to '6'.



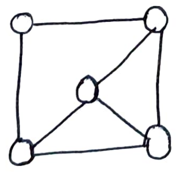
Then the both forward and backward expansi-ons are meeting node '6'. So, we have to stop the expansion and we get a shortest path.



They meet at node '6' giving the shortest path 0 → 4 → 6 → 7

Unvisited nods = { 2, 3, 5, 9, 10, 11, 12, 13, 14 }.

(3) Solve map colouring through back tracking algorithm where no. of colours available are { Red, green, blue, yellow }.



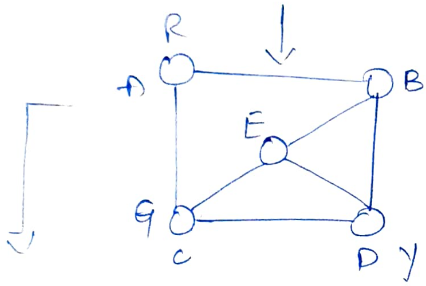
A) Steps to solve :-

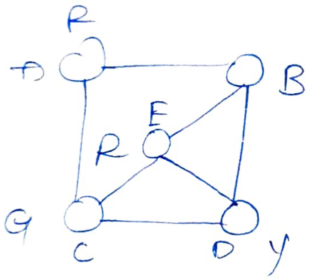
1) Assign a colour to the first node.

2) Move to the next node and assign the first available colour that doesn't conflict with it's neighbours.

5) If no colour is possible, backtrack to the previous node and try a different colour

6) Continue untill all nodes are coloured





Node A = Red

Node B = Blue

Node C = Green

Node D = Yellow

Node E = (Entry) = Red

4) Using the Constraint Satisfaction Problem (CSP) approach, solve the cryptarithmetic Puzzle SEND + MORE "MONEY."

Constraint Satisfaction problem (CSP) :-

It involves finding values for set of variables from their respective finite domains such that given constraints are satisfied.

Give puzzle,

$$SEND + MORE = MONEY$$

Variables :-

$S, E, N, D, M, O, R, Y \Rightarrow$ digit $0-9$, different

$S \,\&\, M \neq 0$

Carries : $C_1, C_2, C_3, C_4 \Rightarrow 0$ (or) 1

Column Equations :-

1) Units : $D + E = Y + 10 \cdot C_2$

2) Tens : $N + R + C_1 = E + 10 \cdot C_2$

3) Hundreds : $E + O + C_2 = N + 10 \cdot C_3$

4) Thousands : $S + M + C_3 = O + 10 \cdot C_4$

5) Since answer has 5 digits : $M = C_4 = 1$.

Steps :

From (4) : $S + 1 + C_3 = O + 10$

Only possible if

$S = 9, \quad O = 0, \quad C_3 = 0$

$N = E + 1$

From ②: $(E+1) + R + C_1 = E + 10 \Rightarrow$

$R + C_1 = 9 \Rightarrow C_1 = 1$

$R = 8$

From ①: $D + E = Y + 10 \Rightarrow Y = D + E - 10$

Try possible E & N

$E = 5 \Rightarrow N = 6$

$Y = D + 5 - 10$

$Y = D - 5$

Works with D

$D = 7$

$Y = 7 - 5$

$= 2.$

Final digits:-

$S = 9$, $E = 5$, $N = 6$, $D = 7$, $M = 1$, $O = 0$,

$R = 8$, $Y = 2$.

Now check,

SEND + MORE

$9567 + \cancel{1058}\ 1085 = 10652.$

(5) Using the CSP, solve the Cryptarithmetic puzzle CROSS + ROADS = Danger.

Given Puzzle,

CROSS + ROADS = DANGER

Variables :-

C, R, O, S, A, D, N, G, E → digits (0→9)

all different C, R, D $\neq 0$.

Carries : $C_1 \ldots C_5 = 0$ (or) 1.

Column Equations

1) Units : $S + S = R + 10 \cdot C_1$

2) Tens : $S + D + C_1 = E + 10 \cdot C_2$

3) Hundreds : $O + A + C_2 = G + 10 \cdot C_3$

4) Thousands : $R + O + C_3 = N + 10 \cdot C_4$

5) Ten-thousands : $C + R + C_4 = A + 10 \cdot C_5$

6) $C_5 = D \Rightarrow D = 1, \; C_5 = 1$.

Deduction :-

From (1) ⇒ $C_1 = 0 \rightarrow S + S = R + 0$

$R = 2S$

Choose $S = 3$

$R = 2(3)$

$R = 6$.

From (2) $\Rightarrow$ $S + D + C_1 = E + 10 \cdot C_2$

$3 + 1 + 0 = E + 10(0)$

$4 = E$

From (5) $\Rightarrow$ $C + R + C_4 = A + 10 C_5$

$C + 6 + C_4 = A + 10$

$C + 6 + 0 = A + 10$

Choose $C = 9$, $\therefore C_4 = 0$

$9 + 6 = A + 10 \Rightarrow A = 5$

From (3) $\Rightarrow$ $O + A + C_2 = G + 10 \cdot C_3$

$O + 5 + 0 = G + 0$

$G = 5$

From (4) $\Rightarrow$ $R + O + C_3 = N + 10 \cdot C_4$

$6 + 0 + 0 \neq N$

$N = 6 \neq 0$

then from (3) $\Rightarrow$ $O + A + C_2 = G + 10 \cdot C_3$

$A = 5$, $C_2 = 0$, C_3

$O + 5 = G$

Now, Try $O = 2$

G = 2 + 5 = 7

N = 6 + 2 = 8

G = 7, N = 8

Final digits :-

C = 9, R = 6, O = 2, S = 3, A = 5, D = 1,

N = 8, G = 7, E = 4.

Now,

CROSS + ROADS

96233 + 62513

= 158746.

6) Using the CSP, solve the Cryptarithmetic puzzle TWO + TWO = FOUR

A) Given puzzle,

TWO + TWO = FOUR

Variables :

T, W, O, F, U, R ⇒ Digits (0-9) all different

T, F ≠ 0 (leading letters)

Carries, C_1, C_2, C_3 = 0 (or) 1

Column Equations :-

1) Units : O + O = R + 10 · C_1

2) Tens : W + W + C_1 = U + 10 · C_2

3) Hundreds : T + T + C_2 = O + 10 · C_3

4) $C_3 = F \to 1$ (Since Sum is 4 digits)

Deduction :—

From ① Try $O = 5$

$$O + O = 10\,(C_1) + R$$

$$5 + 5 = 10 + R$$

$$R = 10 - 10 \qquad [C_1 = 1]$$

$$R = 0$$

From ② $C_1 = 1$

$$W + W + 1 = U + 10 \cdot C_2$$

$$2W + 1 = U + 10 \cdot C_2$$

Then $W = 6$

$$2(6) + 1 = 13$$

Then $U + 10 \cdot C_2 = 13$

$$C_2 = 1$$

$$U + 10 - 13$$

$$U = 3.$$

From ③ : $T + T + C_2 = O + 10 \cdot C_3$

$$2T + 1 = O + 10 \cdot C_3$$

$$T = 7$$

$$2(7) + 1 = 15$$

So, $O + 10 \cdot C_3 = 15$

$O + 10 = 15$ [$C_3 = 1$]

$O = 15 - 10$

$O = 5$

Final digits

$T = 7$, $W = 6$, $O = 5$, $F = 1$, $U = 3$, $R = 0$

Check, TWO + TWO

$\Rightarrow 765 + 765$

$\Rightarrow 1530.$