

ARTIFICIAL INTELLIGENCE

M T W T F S S

Constraint Satisfaction Problem

Roll no
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Q1

$$\begin{array}{r} A \ B \ C \ D \\ + \ E \ B \ C \ B \\ \hline A \ F \ G \ A \ G \end{array}$$

Solution

data:

digits 0-9

$$\begin{array}{r} 1 \\ 1657 \\ + 8656 \\ \hline 10313 \end{array}$$

$$\begin{aligned} 1 + E &= 10 + F \\ 1 + 1 + E &= 10 + F \\ E - F &= 9 \\ 9 \ 0 &\rightarrow \textcircled{1} \\ E - F &= 8 \\ \underline{9 \ 1} & \\ 8 \ 0 & \end{aligned}$$

$$A = 1$$

$$B = 6$$

$$C = 5$$

$$D = 7$$

$$E = 8$$

$$F = 0$$

$$G = 3$$

(b) W T R E 0-9
 + M O R E

M O N E Y

		1	1		
1	9	3	7	6	
+	5	4	7	6	
3	4	8	5	2	

M = 1

W = 9 I = 3 R = 7 E = 6 M = 5
 O = 4 N = 8 Y = 2

~~ii~~ (ii) Original condition state

	0	1	2	3
0	Q ₁	 	x	x
1	x	x	 	
2	x		x	
3	x			x

Step 1: put Queen 2 to (1,2)

Q ₁				
		Q ₂		

Step 2: No place to Q₃ because of row violation with Q₁ diagonal and column violation with Q₂

~~Step~~ So, backtrack and remove Q₂

Step 3: put Q₂ on (1,3) cell

Q ₁				
			Q ₂	

Step 4: put Q₃ on (2,1)

Q ₁				
	Q ₂		Q ₃	

no violations detected

Step 5: No valid position for Q₄
Row, column, diagonal violations

Backtrack Q_3 row 2

Backtrack Q_2 from row 1

As Q_1 is not in a good position change its position to $(0,1)$

Step 6: Place Q_1 at $(0,1)$

	0	1	2	3
0		Q_1		
1				
2				
3				

Step 7: Place Q_2 to $(1,3)$

Step 8: Place Q_3 to $(2,0)$

		Q_1		
			Q_2	
Q_3				

Step 9:

x	Q_1	x	x
x	x	x	Q_2
Q_3	x	x	x
x	x	Q_4	x

Solution #1

Second valid solution:

	0	1	2	3
0	Q ₁	x	x	x
1	x	x		
2	x		x	
3	x			x

(Initial state)

Step 1: Remove Q₁ and place it in (0,2)

			Q ₁	

Step 2: Place Q₂ to (1,0)

0			Q ₁	
1	Q ₂			
2				
3				

Step 3: Place Q₃ to (2,3)

0			Q ₁	
1	Q ₂			
2				Q ₃
3				

Step 4 Place Q_4 to 3,1

	0	1	2	3
0	*		Q_1	
1	Q_2	*		
2			*	Q_3
3		Q_4		*

2nd valid solution

(Local & Adversarial Search)

Q1

(a)

$$f(x_1) = (6+5) - (4+1) + (3+5) - (3+2) = 9$$

$$f(x_2) = (8+7) - (1+2) + (6+6) - (0+1) = 23$$

$$f(x_3) = (2+3) - (9+2) + (1+2) - (8+5) = -16$$

$$f(x_4) = (4+1) - (8+5) + (2+0) - (9+4) = -19$$

Order = $x_2 \rightarrow x_1 \rightarrow x_3 \rightarrow x_4$

(b) One point crossover on x_2 and x_1

$$\begin{array}{l|l} \text{(i)} & x_2 = 8712 \quad 6601 \\ & x_1 = 6541 \quad 3532 \end{array} \Rightarrow \begin{array}{l|l} 8712 & 3532 \\ 6541 & 6601 \end{array}$$

(ii) Two point crossover on x_1 and x_3

$$\begin{array}{l|l|l} x_1 = 65 & 4135 & 32 \\ x_2 = 23 & 9212 & 85 \end{array} \Rightarrow \begin{array}{l|l|l} 65 & 9212 & 32 \\ 23 & 4135 & 85 \end{array}$$

$$(iii) x_2 = \begin{array}{cccccc} 8 & 7 & 1 & 2 & 6 & 6 & 0 & 1 \\ \hline & & & & & & & \end{array}$$

$$x_3 = \begin{array}{cccccc} 2 & 3 & 9 & 2 & 1 & 2 & 8 & 5 \\ \hline & & & & & & & \end{array}$$

$$\text{answer} = \begin{array}{cccccc} 2 & 7 & 1 & 2 & 6 & 2 & 0 & 1 \\ 8 & 3 & 9 & 2 & 1 & 6 & 8 & 5 \end{array}$$

(c) New population

$$A_1 = 8 \ 7 \ 1 \ 2 \ 3 \ 5 \ 3 \ 2$$

$$A_2 = 6 \ 5 \ 4 \ 1 \ 6 \ 6 \ 0 \ 1$$

$$A_3 = 6 \ 5 \ 9 \ 2 \ 1 \ 2 \ 3 \ 2$$

$$\underline{2 \ 3 \ 4 \ 1 \ 3 \ 5 \ 8 \ 5}$$

$$A_4 = 2 \ 3 \ 4 \ 1 \ 3 \ 5 \ 8 \ 5$$

$$A_5 = 2 \ 7 \ 1 \ 2 \ 6 \ 2 \ 0 \ 1$$

$$A_6 = 8 \ 3 \ 9 \ 2 \ 1 \ 6 \ 8 \ 5$$

Apply function

$$f(A_1) = (8+7) - (1+2) + (3+5) - (3+2) = 15$$

$$f(A_2) = (6+5) - (4+1) + (6+6) - (0+1) = 17$$

$$f(A_3) = (6+5) - (9+2) + (1+2) - (3+2) = -2$$

$$f(A_4) = (2+3) - (4+1) + (3+5) - (8+5) = -5$$

$$f(A_5) = (2+7) - (1+2) + (6+2) - (0+1) = 13$$

$$f(A_6) = (8+3) - (9+2) + (1+6) - (8+5) = -6$$

We can see fitness has improved

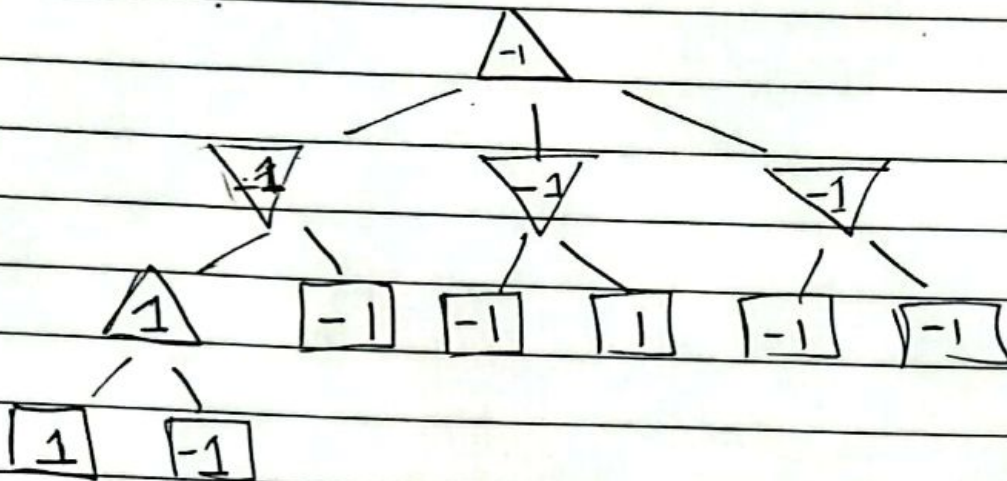
(d) Max fitness

$$= 9 \ 9 \ 0 \ 0 \ 9 \ 9 \ 0 \ 0$$

$$f(\text{max}) = 9+9 - 0+0 + 9+9 - 0+0 = 36$$

Q₂

* Minimax Solution



max player will loose the game

* minimax with alpha beta

