AI Assignment 3

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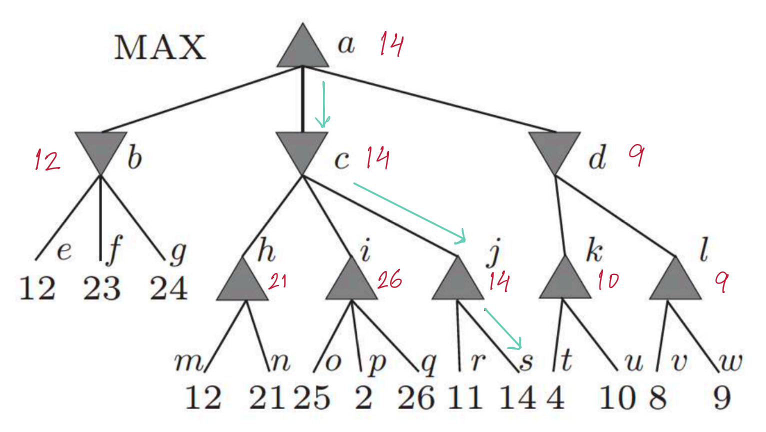
Ans 1) MinMax Algorithm



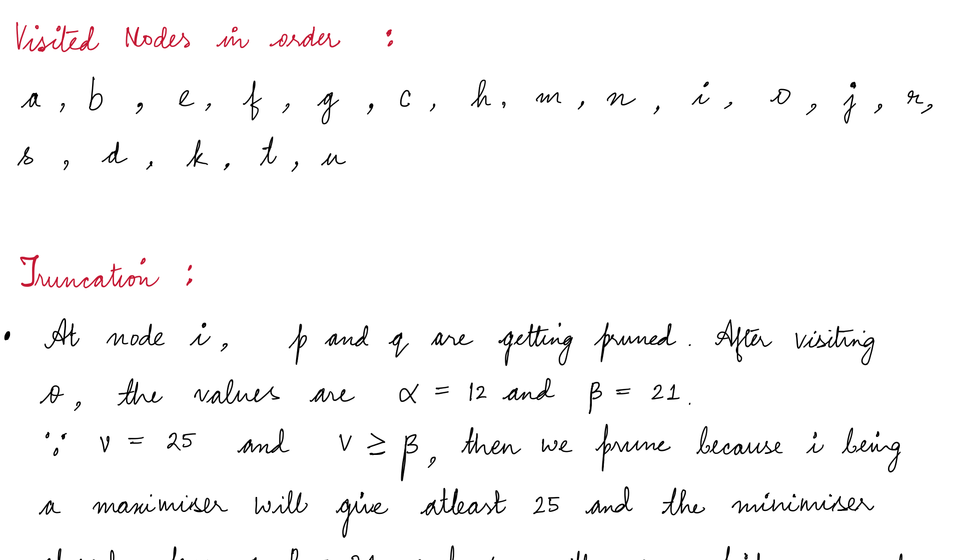
$h = \max(m, n) = 21$
$i = \max(o, p, q) = 26$
$j = \max(r, s) = 14$
$k = \max(t, u) = 10$
$l = \max(v, w) = 9$
$b = \min(e, f, g) = 12$
$c = \min(h, i, j) = 14$
$d = \min(k, l) = 9$
$a = \max(b, c, d) = 14$

Best sequence of moves :

$a \to c \to j \to s$

The utility for this best sequence of moves is 14.

MinMax with Alpha Beta Pruning



Visited Nodes in order :

a, b, e, f, g, c, h, m, n, i, o, j, r, s, d, k, t, u

Truncation :

- At node i, p and q are getting pruned. After visiting o, the values are $\alpha = 12$ and $\beta = 21$.
  $\because v = 25$ and $v \geq \beta$, then we prune because i being a maximiser will give atleast 25 and the minimiser already has a $\beta = 21$ and so will never pick any value generated at i.
- At node d, we are truncating l. After visiting k, the values are $\alpha = 14$ and $\beta = \infty$.
  $\because v = 10$ and $v \leq \alpha$, then l and its leaves v and w are pruned. d being a minimiser will pick at most 10 but a already has an $\alpha = 14$ so it will never pick any value given by d (which will be 10 or less) so we prune l.

Ans 2)

		P1		
		1	2	3
P2	a	1,2	6,3	6,3
	b	4,4	3,1	4,7

(a) A strategy that always yields better outcome for a player regardless of the choice made by other players is called dominant strategy.

P1 has dominant strategy 3. Regardless of whether P2 picks a or b, P1 always gets highest outcome at 3.

P2 has no dominant strategy.

(b) A strategy with which no player has anything to gain by changing his/her strategy alone is called Nash Equilibrium.

The Nash equilibriums are
(a, 2), (b, 1) & (b, 3)

- (a, 2)
  P1 cannot gain anything by moving from 2 (=6) to 1 (=1) or 3 (=6) while P2 is at a.
  P2 cannot gain anything by moving from a (=3) to b (=1) while P1 is at 2.
- (b, 1)
  P1 cannot gain anything by moving from 1 (=4) to 2 (=3) or 3 (=4) while P2 is at b.
  P2 cannot gain anything by moving from b (=4) to a (=2) while P1 is at 1.
- (b, 3)
  P1 cannot gain anything by moving from 3 (=4) to 2 (=3) or 1 (=4) while P2 is at b.
  P2 cannot gain anything by moving from b (=7) to a (=3) while P1 is at 3.

Ans 3) (a) Knowledge base

P: System is armed
Q: Fire
R: Alarm sounds
S: Motion is detected

If system is armed and motion is detected, the alarm will sound.
(i) $P \wedge S \Rightarrow R$
If alarm sounds, then system has been armed or there has been a fire.
(ii) $R \Rightarrow P \vee Q$
Alarm should go off when there is a fire.
(iii) $Q \Rightarrow R$

(b) Theorem : The alarm will sound if and only if the system is armed or there is a fire
i.e. $P \vee Q \Leftrightarrow R$

We need to derive -:
$$((P \vee Q) \Rightarrow R) \wedge \underbrace{(R \Rightarrow (P \vee Q))}_{\text{Given (ii)}}$$

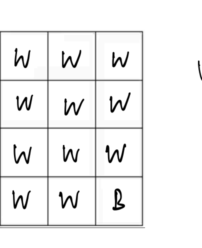
- $P \wedge S \Rightarrow R$ (from i)
  Given that S is always true,
  $P \wedge T \Rightarrow R$
  which means $P \Rightarrow R$ — (iv)
- $Q \Rightarrow R$ (from iii)
  From (iii) and (iv)
  $P \vee Q \Rightarrow R$ — (v)
  From (ii) and (v), we have
  $R \Rightarrow (P \vee Q)$ and $(P \vee Q) \Rightarrow R$
  i.e. $(P \vee Q) \Leftrightarrow R$

Thus we can derive that $(P \vee Q) \Leftrightarrow R$.
This theorem can be validated using the truth table.

P	Q	R	$P \vee Q \Leftrightarrow R$
F	F	F	T
F	F	T	F
F	T	F	F
F	T	T	T
T	F	F	F
T	F	T	T
T	T	F	F
T	T	T	T

Ans 4)

(c)



MinMax Optimal path

B : (0, 2) → W : (0, 3) → B : (1, 3) → W : (0, 1) → B : (3, 0) → W : (2, 3) → B : (0, 0) → W : (3, 2) → B : (3, 3) → W : (3, 1)

Terminal state for optimal game play

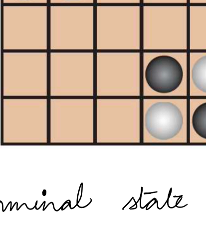
B	W	W	W
	W	W	W
	W	W	W
B	W	W	B

Value = blackpieces − whitepieces
= 3 − 11
= −8

Number of terminal states encountered = 60060

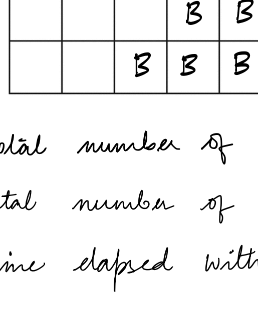
We are optimizing for 'B' but 'W' ends up winning. Therefore, the second player ('W' in this case) is guaranteed to win given this initial state.

(e)



For optimal game play –

- Time elapsed for full minimax = 8.913 seconds
- Time elapsed for full minimax with alpha beta pruning = 0.526 seconds
- Total terminal states with alpha beta pruning = 2506
- Total number of truncated nodes = 3902



Optimal path with $\alpha\beta$ pruning –

B : (2, 4) → W : (0, 2) → B : (4, 2) → W : (2, 0)

Terminal state for optimal game play

W	W	W		
W	W			
W				B
			B	B
		B	B	B

Value = 0

Total number of terminal nodes = 65469
Total number of truncated nodes = 101775
Time elapsed with alpha beta pruning = 13.9012 seconds

We are optimizing for 'B' and the game ends in a draw. Therefore, we can say that this game will always end in a draw for this initial state.