

Artificial Intelligence

Assignment II

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PROBLEM-I

MIN-MAX ALGORITHM.

Given game tree:

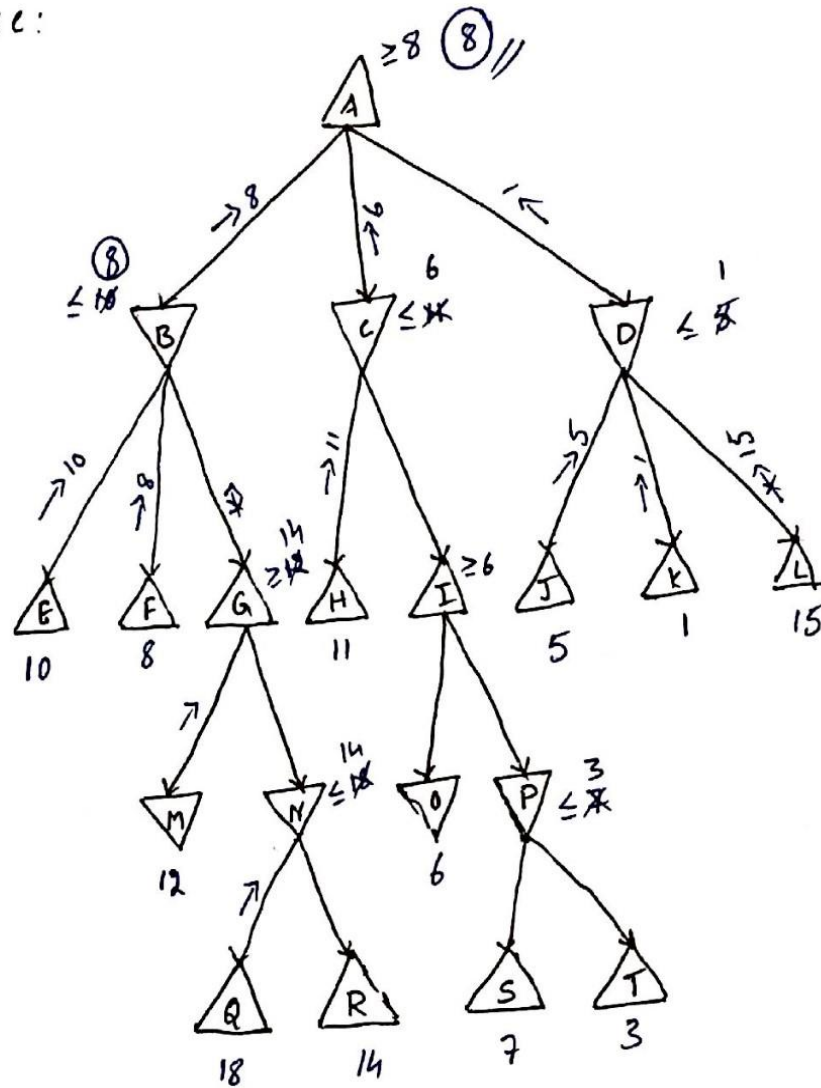
MAX:

MIN:

MAX:

MIN:

MAX:



* Min-Max algorithm is implemented using Depth-First Search.

OBSERVATIONS/IMPLEMENTATION:

→ Every MAX node tries to maximize its value from the nodes below it.

→ Every MIN node tries to minimize its value from the child nodes below it.

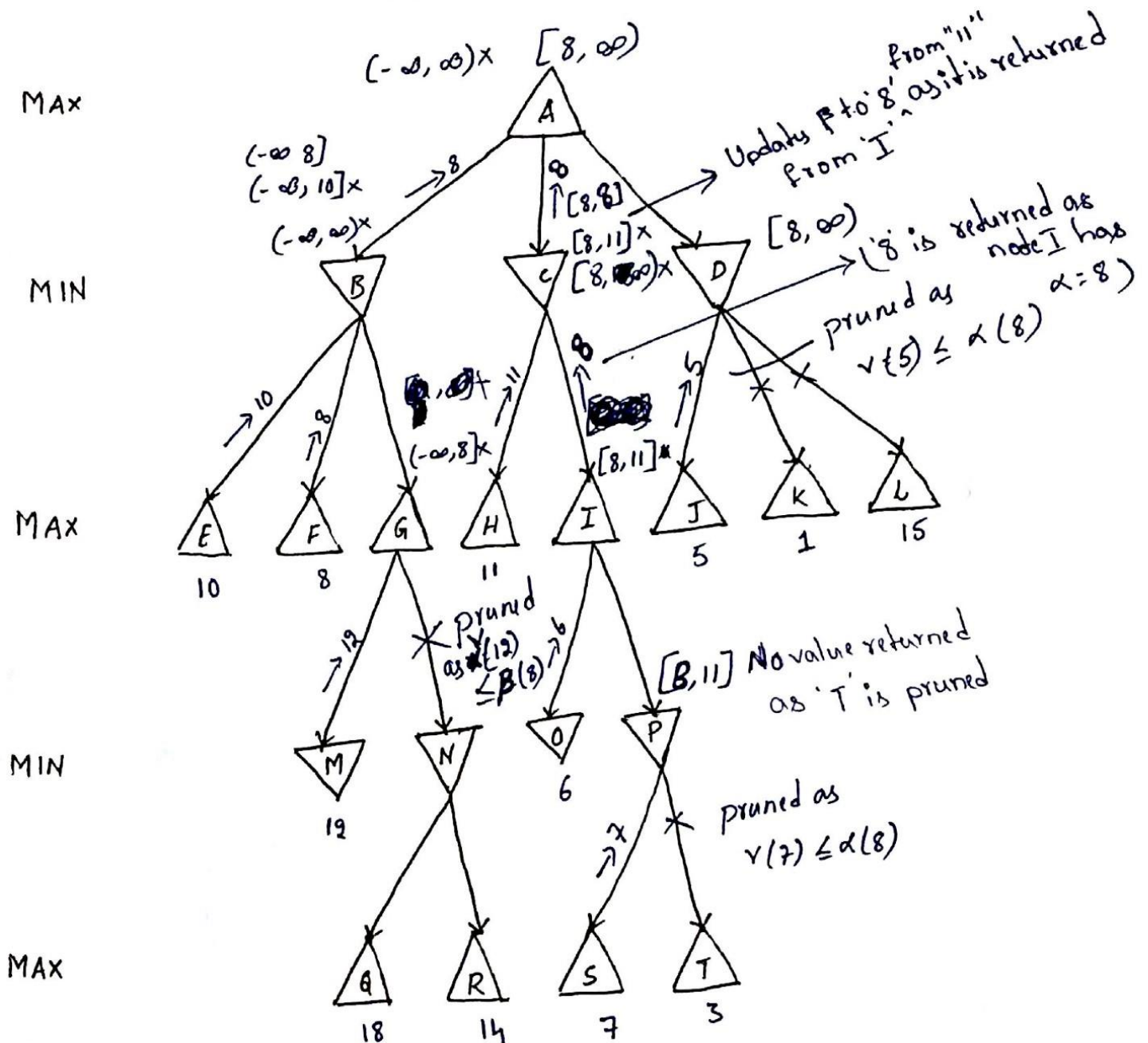
By implementing this the maximum utility that MAX can achieve

is "8"

Path: $A \rightarrow B \rightarrow F$
MAX MIN MAX

PROBLEM-II

ALPHA - BETA PRUNING.



OBSERVATIONS/IMPLEMENTATION:

- * Alpha-Beta Pruning algorithm is implemented using Depth-First Search.
- * Bounds on nodes are specified in the above graph.
- * The following nodes are pruned N, Q, R, T, K, L
- * The maximum utility that MAX can achieve is "8".

Hence Alpha-Beta Pruning//

PROBLEM-III

BACKTRACKING SEARCH ①

Given Variables:

$$A: \{4, 5, 6, 7, 8\}$$

$$B: \{10, 20, 30, 40\}$$

$$C: \{2, 3, 4\}$$

$$D: \{32, 43, 56, 75, 92, 113\}$$

Var: MRV, DEG, ALPH.

Val: LCV, Increasing Value.

Infer: Forward Checking

Given Constraints:

* $A+C$ is odd.

* $A+D$ is a square of an Integer

* $B+D < 60$.

→ The Minimum Remaining Value among A, B, C, D has '3' which is for 'C' Hence $C: \{2, 3, 4\} \Rightarrow$ We have to calculate LCV (C) which is shown below.

C: 2

$$A: \{4, 5, 6, 7, 8\} - 3$$

$$B: \{10, 20, 30, 40\}$$

$$C: 2$$

$$D: \{32, 43, 56, 75, 92, 113\}$$

C: 3

$$A: \{4, 5, 6, 7, 8\} - 2$$

$$B: \{10, 20, 30, 40\}$$

$$C: 3$$

$$D: \{32, 43, 56, 75, 92, 113\}$$

C: 4

$$A: \{4, 5, 6, 7, 8\} - 3$$

$$B: \{10, 20, 30, 40\}$$

$$C: 4$$

$$D: \{32, 43, 56, 75, 92, 113\}$$

Hence $C: 3$ is considered as per least Constraint Value.

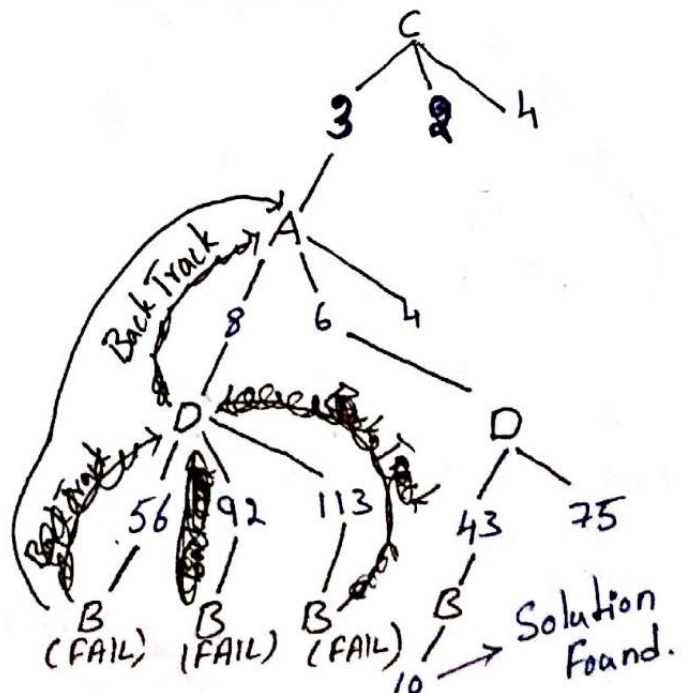
①
C: 3

$$A: \{4, 6, 8\}$$

$$B: \{10, 20, 30, 40\}$$

$$C: 3$$

$$D: \{32, 43, 56, 75, 92, 113\}$$



BACKTRACKING SEARCH ③

* Now We have to calculate $LCV(A)$ as A has minimum Remaining Values

$LCV(A)$: $A: \{4, 6, 8\}$

$A = 4$

$A: 4$

$B: \{10, 20, 30, 40\}$

$C: 3$

$D: \{32, 43, 56, 75, 92, 113\}$ ⑤

$A = 6$

$A: 6$

$B: \{10, 20, 30, 40\}$

$C: 3$

$D: \{32, 43, 56, 75, 92, 113\}$ ④

$A = 8$

$A: 8$

$B: \{10, 20, 30, 40\}$

$C: 3$

$D: \{32, 43, 56, 75, 92, 113\}$ ③

Hence the $LCV(A) = 8, 6, 4$ in order. So we have to consider $A: 8$.

$A: 8$

$A: 8$

$B: \{10, 20, 30, 40\}$

$C: 3$

$D: \{56, 92, 113\}$

* Now We have to calculate $LCV(D)$ as D has Minimum Remaining Values.

$LCV(D)$: $D: \{56, 92, 113\}$

$D = 56$

$A: 4$

$B: \{10, 20, 30, 40\}$ ④

$C: 3$

$D: \{56\}$

$D: 92$

$A: 4$

$B: \{10, 20, 30, 40\}$ ④

$C: 3$

$D: 92$

$D: 113$

$A: 4$

$B: \{10, 20, 30, 40\}$ ④

$C: 3$

$D: 113$

As $LCV(D)$ is same We have to go by Increasing Values

$D: 56$

$A: 4$

$B: \{\} \emptyset$

$C: 3$

$D: 56$

$D: 92$

$A: 4$

$B: \{\} \emptyset$

$C: 3$

$D: 92$

$D: 113$

$A: 4$

$B: \{\} \emptyset$

$C: 3$

$D: 92$

As there are Empty or (\emptyset) Null

Values for variable 'B' When

$D: \{56, 92, 113\}$ We have to back

track now to variable A which has possibilities $\{6, 4\}$ remained.

BACK-TRACKING SEARCH ③

Now $A: \{6, 8\}$ $LCV(A\{6\}) < LCV(A\{4\})$

\Rightarrow $A: 6$

$A: 6$
 $B: \{10\}$
 $C: 3$
 $D: \{43, 75\}$

We have to
 Consider variable
 'B' as MRV of B is '1'

$B: 10$

$A: 6$ left out
 $B: 10$ Variable with MRV
 $C: 3$ '1' is 'D'
 $D: \{43\}$

Hence. $D: 43$

$A: 6$
 $B: 10$
 $C: 3$
 $D: 43$

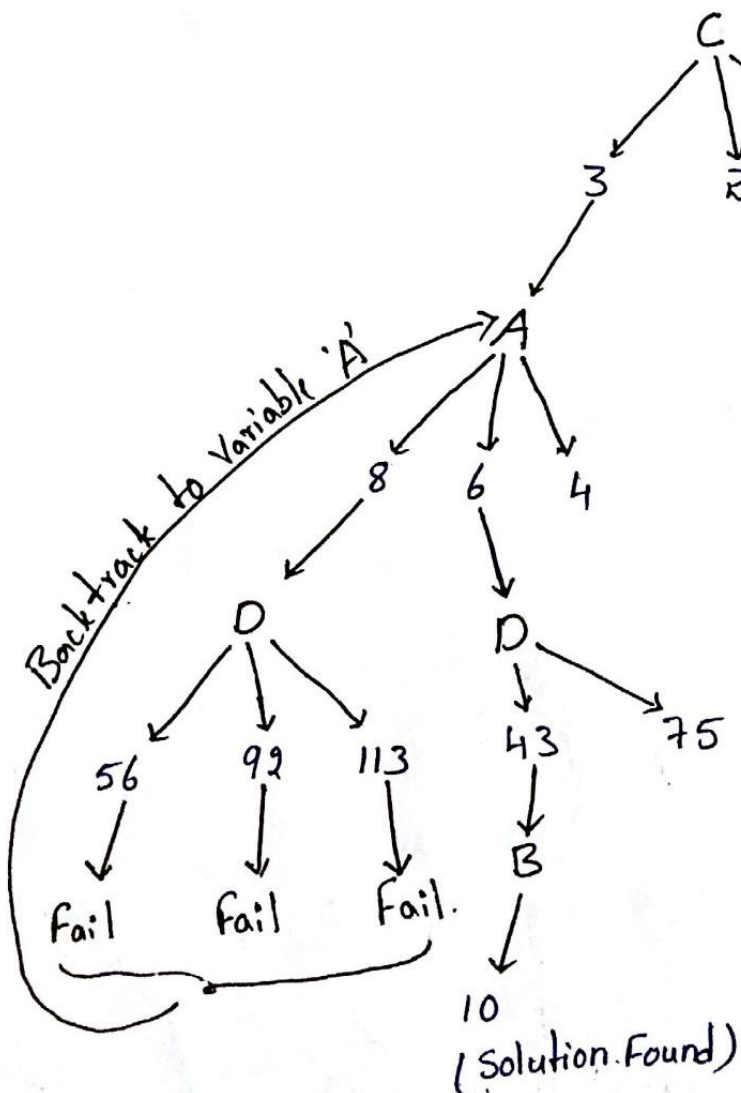
Hence, Solution Reached. The graph for this approach is plotted below.

Solution $A: 6, B: 10, C: 3, D: 43$

Given Conditions

1. $A+C$ is odd
 $6+3=9$ is odd
2. $A+D$ is a square of an Integer
 $6+43=49 \Rightarrow 7 \times 7$ Square(7)
3. $B+D < 60$
 $10+43=53 < 60$.

Satisfying all the conditions.



PROBLEM - IV CRYPTARITHMETIC PROBLEM - BACKTRACKING SEARCH. ①

Given Variables:

O: {7, 8, 9}

R: {0, 2, 3, 4, 5, 6, 7, 8, 9}

W: {5, 6, 7, 8, 9}

U: {0, 2, 3, 4, 5, 6, 7, 8, 9}

T: {5, 6, 7, 8, 9}

Given Conditions

$F = 1$

$O + O = 10 + R$

$W + W + 1 = 10 + U$

$T + T + 1 = 10 + O$

TWO
+ TWO
FOUR

Var: MRV, {O, R, W, U, T}

Val: Increasing Order

Inference: Forward Checking

→ From the given variables the MRV is least for variable 'O'. & by Increasing Order Values.

O: {7, 8, 9} ⇒ O: 7 is considered first

O: 7
R: {0, 2, 3, 4, 5, 6, 7, 8, 9}

W: {5, 6, 7, 8, 9}

U: {0, 2, 3, 4, 5, 6, 7, 8, 9}

T: {5, 6, 7, 8, 9}

⇓

O: 7

O: 7

R: {4}

W: {5, 6, 8, 9}

U: {0, 2, 3, 4, 5, 6, 8, 9}

T: {8}

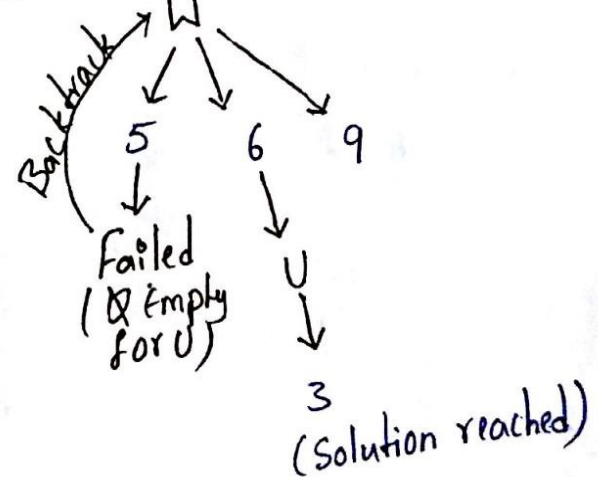
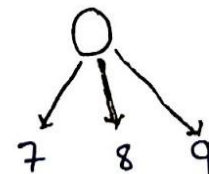
* Minimum Remaining Value

for variables R & T is '1'

Hence we go by variable ordering {O, R, W, U, T}

⇒ R appears first.

Hence R: 4 is considered



R:4

O: 7

R: 4

W: {5, 6, 8, 9}

U: {0, 2, 3, 5, 6, 8, 9}

T: {8}

MRV for variable

'T' is 1

T:8

O: 7

R: 4

W: {5, 6, 8, 9}

U: {0, 2, 3, 5, 6, 8, 9}

T: 8

②

By MRV variable selected

is W \Rightarrow Increasing values in W is considered.

\Rightarrow W = 5 is considered

W:5

O: 7

R: 4

W: {5}

U: { } \emptyset Empty

T: 8

Failed

So Back

Track to

T: 8 node

as search for

other value of

W i.e; W = 6 is considered.

W:6

O: 7

R: 4

W: 6

U: {3}

T: 8

MRV of

U = 1

U:3

O: 7

R: 4

W: 6

U: 3

T: 8

Hence Solution Reached. Path: O{7} \rightarrow R{4} \rightarrow T{8} \rightarrow W{6}

Given Conditions & Substituting the Solution values

\downarrow
U{3}

1. $O+O = 10+R \Rightarrow 7+7 = 10+4 \rightarrow \text{true}$

2. $W+W+1 = 10+U \Rightarrow 6+6+1 = 10+3 \rightarrow \text{true}$

3. $T+T+1 = 10+O \Rightarrow 8+8+1 = 10+7 \rightarrow \text{true}$

TWO
 + TWO

 FOUR

Given
F=1
 \Rightarrow

8 6 7
 8 6 7

 1 7 3 4

Hence, Solution