

COS30019 – Mid-Semester Test

Answering Instructions:

Please do not use a red pen/type in red.

There are 4 problems.

Total marks on paper: 70 marks + 5 bonus marks

The maximum mark you can get for the Mid-Semester Test is 70 (100%). However, if you lose marks in some questions and you get the bonus marks, the bonus marks will be added to your total of the Mid-Semester Test.

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Problem 1 – State True or False (5x2 = 10 marks)

1. A simple-reflex agent will maximise the expected performance measure in a partially observable environment.

False

Since simple-reflex agent do not record what it has experienced before, only implement actions based on its current percept, maximise outcome cannot always be made.

2. In a deterministic environment, if you are in state S_0 and you perform action A, the probability of reaching the next state S_1 is 1.

True

Deterministic environment is where every action has the specific outcome, regardless of unpredictable factors. So, you can still surely move from state S_0 to state S_1 by implementing action A.

3. A program implementing breadth-first search can be easily converted to depth-first search just by changing the frontier implementation from a FIFO queue to a LIFO queue.

True

Since the difference between breath-first search (BFS) and depth-first search (DFS) is how the explored nodes are arranged in the Frontier, in FIFO queue (BFS) or LIFO queue (DFS). Therefore, changing the frontier implantation will lead to changing searching algorithm.

4. Depth-first search with repeated state check can guarantee to find the optimal solution.

False

Depth-first search will explore as far as possible before backtracking, even with repeated state check. As a result, it can seek for redundant solution as it goes deep into the search tree, which is not regarded as the optimal solution.

5. Alpha-beta pruning with a heuristic evaluation function yields an optimal playing strategy against an optimal opponent.

False

Although alpha-beta pruning is used to reduce the number of nodes evaluated in the search tree of minimax algorithm, it does not improve the optimality of the result, since it might still yield the same result as minimax would without pruning.

Moreover, the optimality of the playing strategy also relies on the heuristic evaluation function used, as it only occurs when the heuristic evaluates the minimax value accurately & perfectly.

Therefore, alpha-beta pruning with a heuristic evaluation function might yield a good playing strategy, but sometimes maybe not the optimal one.

Problem 2 – Multiple-choice questions (12 marks)

(You can choose more than one option.)

1. Consider the maze below for the robot navigation problem, where being at either G1 or G2 satisfies the goal test. Shaded cells represent the wall. The robot can only travel north, south, east or west.

	1	2	3	4	5	6
1						
2						G2
3						
4	G1					

Assume that $MD(S1, S2)$ is the Manhattan Distance between two squares $S1$ and $S2$, and $\max[x, y]$ returns the biggest value of x and y , and $\min[x, y]$ returns the smallest value of x and y . Which of the following heuristic function for a square S is admissible?

- A. $h(S) = MD(S, G1)$
- B. $h(S) = MD(S, G1) + MD(S, G2)$
- C. $h(S) = \max[MD(S, G1), MD(S, G2)]$
- D. $h(S) = \min[MD(S, G1), MD(S, G2)]$

Answer: D

The admissible heuristic function for square S is the shortest Manhattan Distance from the initial state S to the goal state (G1 or G2). Based on the formula given, the Manhattan Distance from S to G1 and G2 are $MD(S, G1)$ and $MD(S, G2)$, the smaller value can be regarded as the admissible heuristic function.

$$\Rightarrow h(S) = \min[MD(S, G1), MD(S, G2)].$$

(4 marks)

2. Consider the Vacuum Cleaner World discussed in the lecture. If the agent does not know the geography of the environment and a room may become dirty again after being cleaned, then what type of agent would best be used?

- A. Simple reflex agent
- B. Goal-based agent
- C. Utility-based agent with learning
- D. Rule-based agent with internal states.

Answer: C

Since the agent does now know the geography of the environment, the room can be cleaned at some locations repeatedly, by virtue of the implementation of the agent, missing some spots making the room become dirty again. On this condition, an adaptable agent that can learn from the experience from the past, from the mistakes made will be the most appropriate option.

Therefore, **utility-based agent with learning** will be the best option.

(4 marks)

3. Which of the following statements can be used to define various paradigms of Artificial Intelligence (AI)?
- A. AI as a system that acts rationally aims to pass the Turing test.
 - B. AI as a system that thinks rationally aims to maximise the value of the performance measure.
 - C. AI as a system that thinks like a human always follows logical reasoning.
 - D. AI as a system that acts like a human aims to create machines that perform functions that require intelligence when performed by people.

Answer: B; D

A: Incorrect; Passing the Turing test only demonstrates human-like behaviour, which is not the target of AI.

B: Correct; Rational thinking is deciding which options, actions to be made based on logic, probability to maximise the value of the performance measure. Therefore, this statement is correct.

C: Incorrect; Human can also be affected by unpredictable factors, lead to making unreasonable decisions. Therefore, thinking like a human is not the same as constantly following logical reasoning.

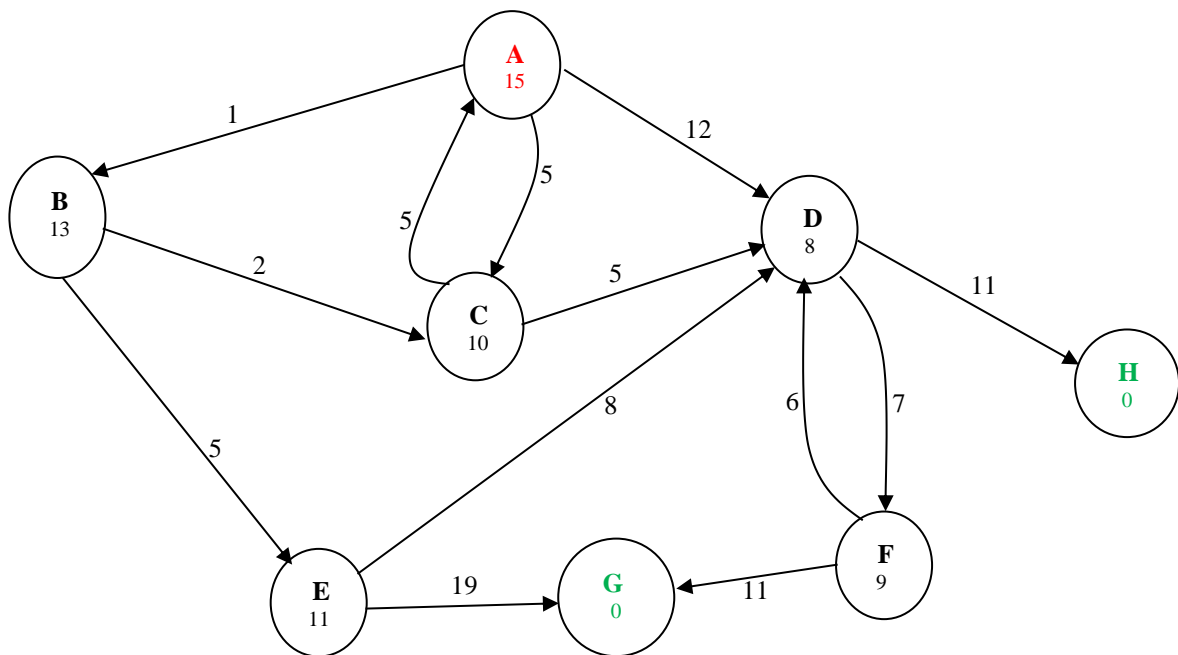
D: Correct; The main target of AI research is to create something that can simulate the actions like human human-like behaviour, which is what the statement indicates. Therefore, this statement is correct.

(4 marks)

Problem 3 – Search (30 marks+ 5 bonus marks)

Consider the search space below, where **A** is the initial state and **both states G and H satisfy the goal test**. Arcs are labelled with the cost of traversing them; for instance, traversing from **B** to **C** costs 2. And the estimated (heuristic) cost to the nearest goal is reported inside nodes. That is, the following heuristic function $h()$ is used: $h(\mathbf{A}) = 15$; $h(\mathbf{B}) = 13$; $h(\mathbf{C}) = 10$; $h(\mathbf{D}) = 8$; $h(\mathbf{E}) = 11$; $h(\mathbf{F}) = 9$; $h(\mathbf{G}) = h(\mathbf{H}) = 0$.

(6x5 = 30 marks) + 5 bonus marks



For each of the following **tree-based search strategies**, you are given a list of options. Each option describes, using that search strategy, the solution found (if any) and the sequence of all the states associated with the expanded nodes on the search tree. **When all else is equal**, the agent should try to expand the successor state of a state according to the **alphabetical order**.

Please select one option that correctly describes the search strategy.

Hints: (i) The sequence of expanded nodes is NOT the same as the solution. It is the nodes on your search tree that are expanded, in order, according to the search strategy.

(ii) You may not always traverse directly from one node to another. For instance, you can directly traverse from **A** to **B**, but you cannot directly traverse from **B** to **A**.

(iii) If you want to insert extra information to explain your answer (such as the search tree you draw), please feel free to do so.

1. Which of the following options correctly describes Breadth First Search (BFS) without repeated state check?

B

- (a) Solution found: **A-B-E-G**; expanded nodes: **A, B, C, D, E, G**
- (b) Solution found: **A-D-H**; expanded nodes: **A, B, C, D, C, E, A, D, F, H**
- (c) Solution found: **A-D-H**; expanded nodes: **A, B, C, D, C, E, D, F, H**
- (d) Solution found: **A-D-H**; expanded nodes: **A, B, C, D, E, F, H**
- (e) Solution found: **A-B-E-G**; expanded nodes: **A, B, C, D, C, E, D, G**

Without repeated state check, BFS expands the nodes in an order. The agent will start from A, then expand B, C, D. From B it will expand E, while from D it will expand F. After all, it reaches H as goal state and stop. So the expanded nodes will be A, B, C, D, C (repeated), E, A (repeated), D (repeated), F, H.

(5 marks)

2. Which of the following options correctly describes Breadth First Search (BFS) with repeated state check?

D

- (a) Solution found: **A-B-E-G**; expanded nodes: **A, B, C, D, E, G**
- (b) Solution found: **A-D-H**; expanded nodes: **A, B, C, D, C, E, A, D, F, H**
- (c) Solution found: **A-D-H**; expanded nodes: **A, B, C, D, C, E, D, F, H**
- (d) Solution found: **A-D-H**; expanded nodes: **A, B, C, D, E, F, H**
- (e) Solution found: **A-B-E-G**; expanded nodes: **A, B, C, D, C, E, D, G**

Same to question 1, but with additional repeated state check; the agent will start from A, then expand B, C, D. From B it will expand E, while from D it will expand F. Finally, it still reaches H as goal state and stop. The expanded nodes will be A, B, C, D, E, F, H.

(5 marks)

3. Which of the following options correctly describes Depth First Search (DFS) without repeated state check?

D

- (a) Solution found: **A- D-H**; expanded nodes: **A, B, C, D, C, E, A, D, F, H**
- (b) Solution found: **A-B-C-D-F-G**; expanded nodes: **A, B, C, D, F, G**
- (c) Solution found: **A-B-C-D-H**; expanded nodes: **A, B, C, D, F, H**
- (d) Solution found: **No**; expanded nodes: **A, B, C, A, B, C, ... Infinite loop**
- (e) Solution found: **No**; expanded nodes: **A, B, C, A, C, A, C, Infinite loop**

Without repeated state check, by implementing DFS, the agent will move from A then expand B, from B it expands C, then come back to A. Therefore, no solutions are found, and the agent will be stuck in an infinite loop A-B-C.

(5 marks)

4. Which of the following options correctly describes Depth First Search (DFS) with repeated state check?

C

- (a) Solution found: **A-B-C-D-H**; expanded nodes: **A, B, C, D, H**
- (b) Solution found: **A- D-H**; expanded nodes: **A, B, C, D, C, E, A, D, F, H**
- (c) Solution found: **A-B-C-D-F-G**; expanded nodes: **A, B, C, D, F, G**
- (d) Solution found: **A-B-C-D-H**; expanded nodes: **A, B, C, D, F, H**
- (e) Solution found: **No**; expanded nodes: **A, B, C, A, B, C, ... Infinite loop**

With repeated state check, by implementing DFS, the agent can confidently explore a path as deep as possible, before tracking the passed destinations. The agent will start from A and expand B, from B it expands C, from C it expands D, from D it expands F, then finally from F it reaches G as a goal state.

(5 marks)

5. Which of the following options correctly describes Greedy Best First Search (GBFS) with repeated state check?

D

- (a) Solution found: **A-B-E-G**; expanded nodes: **A, B, E, G**
- (b) Solution found: **A-D-H**; expanded nodes: **A, D, B, C, H**
- (c) Solution found: **A-D-H**; expanded nodes: **A, B, C, D, F, H**
- (d) Solution found: **A-D-H**; expanded nodes: **A, D, H**
- (e) Solution found: **A-B-C-D-H**; expanded nodes: **A, B, C, D, H**

GBFS expands the “closest-to-the-goal” nodes, based on the heuristic, which means choosing the path with lowest value of h . By implementing GBFS, the agent will move from A then expand D ($h = 8$), from D it expands H ($h = 0$), reaching goal state.

(5 marks)

E

6. Which of the following options correctly describes A* with repeated state check?

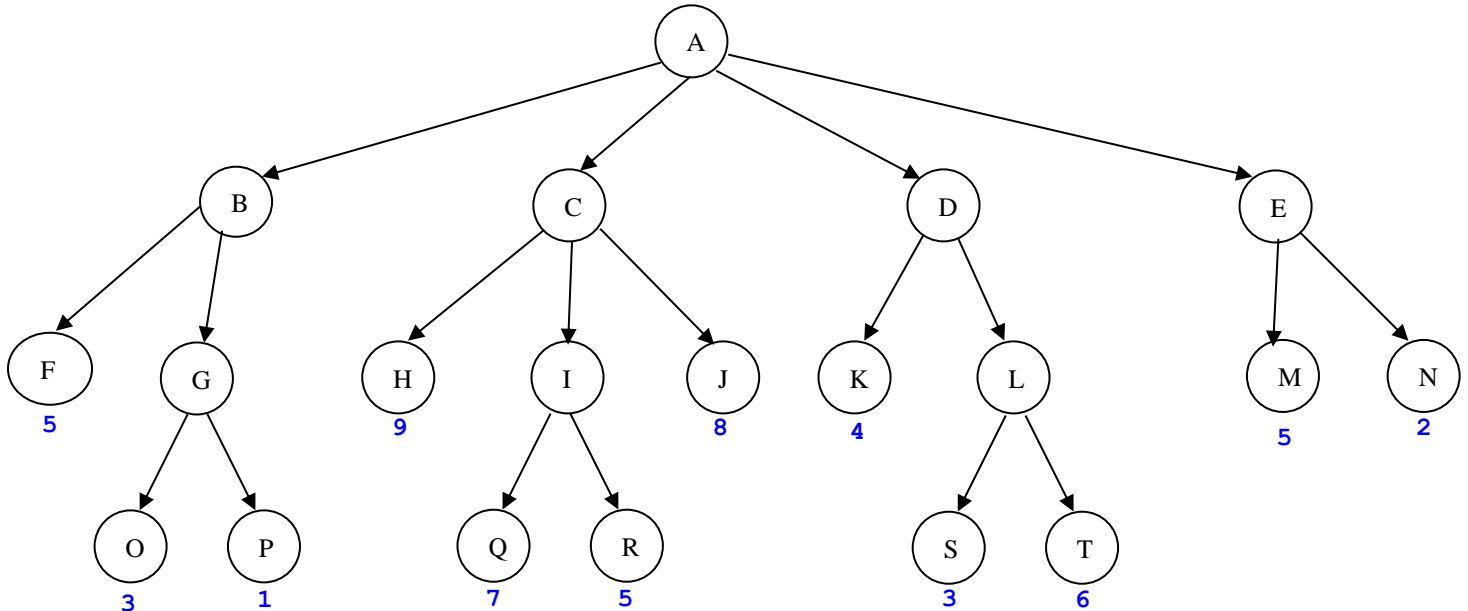
- (a) Solution found: **A-B-E-G**; expanded nodes: **A, B, C, D, E, G**
- (b) Solution found: **A-B-C-D-H**; expanded nodes: **A, B, C, E, D, H**
- (c) Solution found: **A-B-C-D-H**; expanded nodes: **A, B, C, C, D, E, D, H**
- (d) Solution found: **A-D-H**; expanded nodes: **A, D, H**
- (e) Solution found: **A-B-C-D-H**; expanded nodes: **A, B, C, D, H**

A* decides the next path based on the calculated cost from initial states to the goal. By implementing A*, the cost of path A-B-C-D-H will be $1+2+5+11 = 19$, making it the path with the smallest cost. So, the agent will move from A then expand B, from B it expands C, from C it expands D, then from D it expands H.

(5 marks + 5 bonus marks)

Problem 4 – Game Playing and Expected Values (18 marks)

Consider the following game tree in which the utility values are shown below each leaf node.



Assume that the root node corresponds to the maximising player. That is, **the first player (MAX)** is trying to maximise the final score. Assume that **the search always visits children left-to-right**.

Hints: If you want to insert extra information to explain your answer (such as game tree with details of alpha and beta), please feel free to do so.

For each of the following questions, choose one option:

1. According to **minimax**, the best first move for player MAX at node A is:

2

- 1) MAX moves from node A to node B with the expected final score being 5
- 2) MAX moves from node A to node C with the expected final score being 7
- 3) MAX moves from node A to node D with the expected final score being 6
- 4) MAX moves from node A to node E with the expected final score being 2

(6 marks)

2. Using **alpha-beta pruning**, the following nodes will be pruned from the search tree during the search process:

3

- 1) R, T, N will be pruned.
- 2) J, L, S, T, N will be pruned.
- 3) L, S, T, N will be pruned.
- 4) R, J, L, S, T, N will be pruned.
- 5) P, J, L, S, T, N will be pruned.
- 6) P, R, J, T, N will be pruned.

(12 marks)

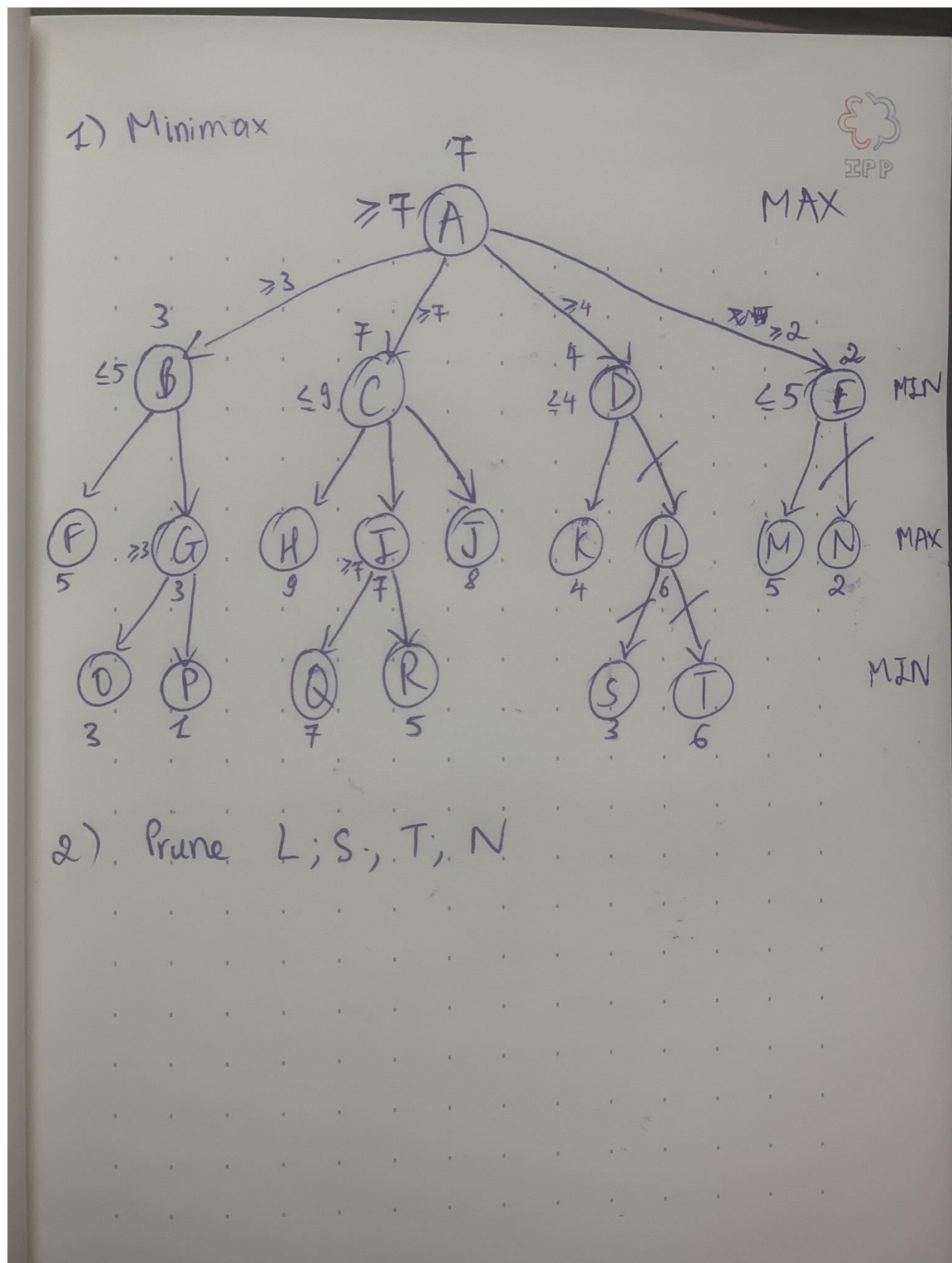


Image: Comprehensive game tree

- 1) Maximising player will move from A to C, as the anticipated maximised value = 7
- 2) Alpha-beta prune applies the depth-first search algorithm. Therefore, after experiencing the paths of node C and realizing 7 is the most appropriate value for A, the node D and E will not be chosen finally. Therefore, after experiencing the first path of these nodes, the second path of the nodes D and E will be pruned, which are the nodes L; S; T; N.