Student Number:

The University of Melbourne

Semester 1 Assessment 2020

School of Computing and Information Systems

COMP30024 Artificial Intelligence

Writing Time: 3 hours.

This paper has 17 pages including this cover page.

Common Content Papers: None

Authorised Materials: Lecture notes, books, computer, on-line material

Instructions to Students:

- This paper counts for 70% of your final grade.
- There are 7 questions, with marks as indicated. Attempt all questions.
- Answer all the questions on the exam paper if possible, and then upload the completed exam paper containing your solutions. If you are unable to print the exam paper or electronically edit the exam paper, you may write on your own blank paper and then upload images of your written answers.
- You may upload your exam answers multiple times if you need to revise an answer at any time during the exam.
- You must not communicate with other students or seek assistance from anyone else taking whilst taking this exam, e.g. using messaging, chat rooms, email, telephone or face-to-face. Also, you must not assist anyone else taking the exam. You must not post answers to the questions or discussion of the questions online. Failure to comply with these instructions may be considered as academic misconduct.
- You are free to use the course materials and your laptop/PC in this exam but note that there is a 3-hour time window for the exam hence you should be mindful of the time spent using such resources.
- Answer the questions as clearly and precisely as you can.
- Your writing should be clear. Unreadable answers will be deemed wrong. Excessively long answers or irrelevant information may be penalised.
- For numerical methods, marks will be given for applying the correct method. Students will not be heavily penalised for arithmetic errors.

Question 1 (10 marks)

Pick the most appropriate answer to each of the following questions. Please write your answer to each question in the boxes below.

Question	**(a)**	**(b)**	**(c)**	**(d)**	**(e)**
Answer					

(a) Which of the following properties does not apply to the card game Poker:

1. **partially observable**
2. **non-deterministic**
3. **non-episodic (i.e., sequential)**
4. **dynamic**

(b) Breadth first search in a finite search tree is in general:

1. **complete and optimal**
2. **incomplete and optimal**
3. **complete and not optimal**
4. **incomplete and not optimal**

(c) If two heuristics h_1 and h_2 are admissible, which one of the following is *not* guaranteed to be admissible:

1. $\alpha * h_1 + (1 - \alpha) * h_2$**, for** $\alpha \in [0, 1]$
2. $h_1 * h_2$
3. $max(h_1, h_2)$
4. $min(h_1, h_2)$

(d) Which one of the following is true in general:

1. **first-price sealed-bid auctions help overcome the winner's curse**
2. **first-price sealed-bid auctions have more complicated communication than English auctions**
3. **first-price sealed-bid auctions may not be efficient**
4. **first-price sealed-bid auctions have a clear dominant strategy**

Question 1 (continued)

(e) Figure 1-1 shows a robot arm that is made up of two sections Arm_1 and Arm_2. Arm_1 can rotate around the shoulder joint A, while Arm_2 is connected to Arm_1 at the elbow joint B, and can rotate around the joint B. The configuration of the robot arm can be specified by the angle θ_1 between the horizontal axis and Arm_1, and the angle θ_2 between Arm_1 and Arm_2. Both angles are measured in radians. There are also 2 fixed obstacles shown, which restrict the movement of the robot arm.

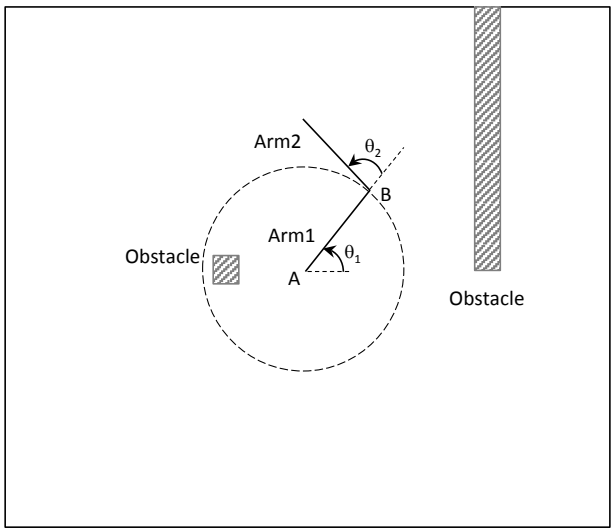


Figure 1-1

Which of the following four figures best represents the *configuration space* for this robot? The figures are labelled (1) to (4).

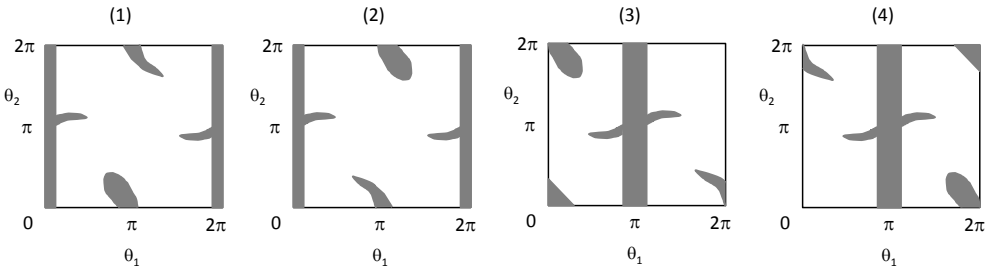


Figure 1-2

Question 2 (10 marks)

For each part of the following question you should write a brief answer in the box provided.

The following is the weight update rule for TDLeaf(λ) learning as described in the lectures

$$w_j \leftarrow w_j + \eta \sum_{i=1}^{N-1} \frac{\partial r(s_i^l, w)}{\partial w_j} [\sum_{m=i}^{N-1} \lambda^{m-i}\, d_m]$$

where η is the learning rate, $d_i = r(s_{i+1}^l, w) - r(s_i^l, w)$ is the temporal difference between successive states, and w is the vector of weights in the evaluation function.

(a) [4 marks] Why do we use the temporal difference d_i between successive states in this rule?

Answer:

Question 2 (continued)

(b) [3 marks] Under what conditions should we use $\lambda = 0$, and why?

Answer:

(c) [3 marks] A rare painting is to be auctioned. Two collectors each attach the same value of $5million to the painting, and the third possible buyer values the painting at $4million. Should the auctioneer use a *first-price, sealed-bid auction* or a *second-price sealed-bid auction*? Briefly justify your answer.

Answer:

Question 3 (10 marks)

Consider the 3-ply game tree shown in Figure 3-1. Each node has an identifier (e.g., the root of the tree is node 1; it has three successor nodes 2, 12 and 22), and each terminal node has an associated value (e.g., the value of node 4 is 7).

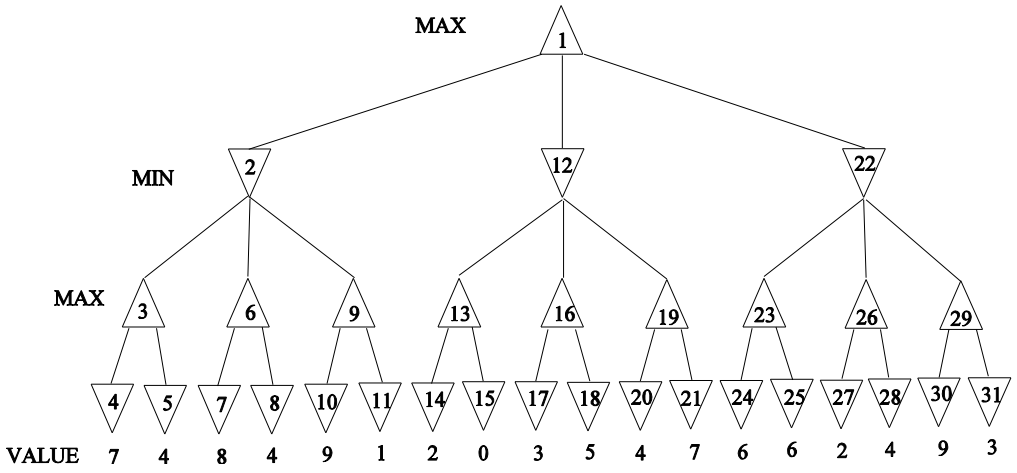


Figure 3-1

In the following questions, you are NOT required to redraw the search tree in your answer.

(a) [2 marks] What is the minimax value at node 1 after applying the minimax algorithm to this search tree?

Answer: ____

(b) [5 marks] If the nodes are examined in the order shown by the identifier in each node in Figure 3-1, which nodes would be pruned if alpha-beta pruning is used? For each node that would be pruned, place a cross in the corresponding box below.

Answer:

Node	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Pruned																

Node	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Pruned															

Question 3 (continued)

(c) [3 marks] Consider the search tree for the *non-deterministic* game shown in Figure 3-2. In this search tree, MAX can choose between two different moves A_1 and A_2. After MAX makes a move, MIN then rolls a pair of dice and makes a move (A_1 or A_2). MIN can choose either action, but the value of the action will depend on the result of rolling the dice. The value of each action depends on whether the sum of the dice is > 3 (indicated by *), or ≤ 3 (indicated by **).

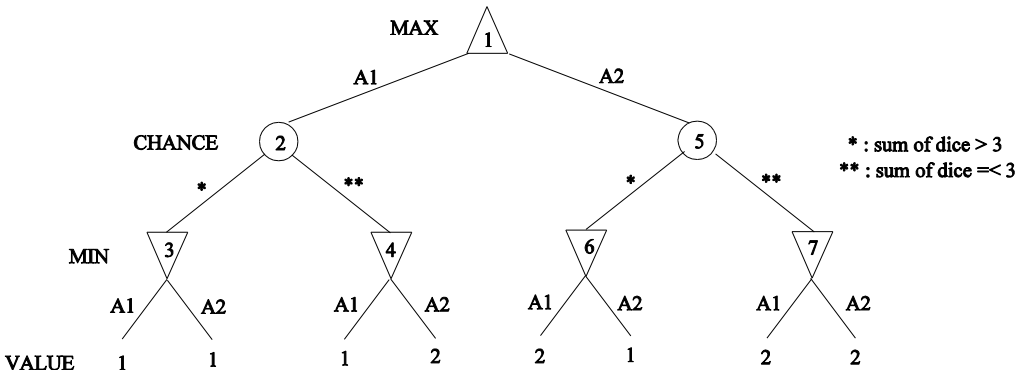


Figure 3-2

What is the *expected minimax value* (also known as the expectiminimax value) at node 1 in this search tree? Write your answer in the space provided below. If you require more space, please use the last page of the exam paper, and clearly indicate on this page that you have used the last page. For full marks you must show how you derived your answer.

Answer:

Question 4 (10 marks)

For parts (a), (b), (c) and (d), consider the problem of searching for paths between nodes in the unbounded two-dimensional grid shown in Figure 4-1. The start state is the node marked S, which has co-ordinates $(0, 0)$. Assume the goal state is the node that has co-ordinates (x, y). Assume that x is the co-ordinate of the column on the grid, and y is the co-ordinate of the row on the grid.

Your answers for parts (a), (b) and (c) should be exact solutions that do not use big-O notation.

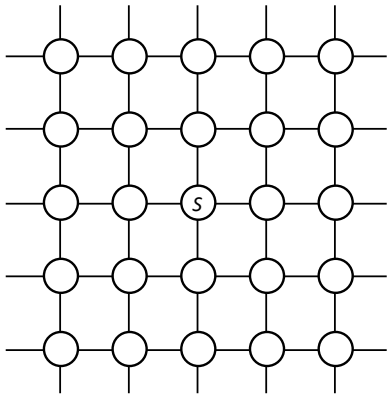


Figure 4-1

(a) [2 marks] What is the *branching factor* for this problem? Briefly justify your answer.

Answer:

Question 4 (continued)

(b) [2 marks] Breadth-first search is used to generate a search tree for this problem, using repeated state checking so that each node in the grid appears *at most once* in the search tree.

In general, what is the maximum number of nodes at depth k in the search tree (for $k > 0$, where the start state has depth 0)? Briefly justify your answer.

Answer:

(c) [3 marks] Using the same breadth-first search strategy with repeated state checking as in part (b), what is the maximum number of nodes that will be *expanded* in the search tree before terminating? Briefly justify your answer.

For full marks, your final answer should not contain summations. Note that a node is expanded when it is removed from the queue of nodes used by the search algorithm, and its successor nodes are generated (if any).

Answer:

Question 4 (continued)

(d) [3 marks] Is $h = |u - x| + |v - y|$ an admissible heuristic for a state at coordinates (u, v)? Briefly justify your answer.

Answer:

Question 5 (10 marks)

Consider the map shown in Figure 5-1(a), which shows five countries A, B, C, D and E. The aim is to assign a colour to each country using the three colours red (r), green (g) and blue (b), such that no two countries have the same colour if they share a border, e.g., A and B cannot have the same colour. The corresponding constraint graph for this problem is shown in Figure 5-1(b).

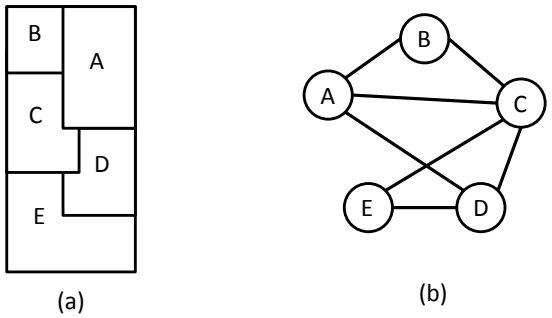


Figure 5-1

(a) [3 marks] If A = r, E = b, and the domains of B, C and D are each r, b, g, show the results of applying *forward checking* to all the variables in this problem, in terms of the reduced domain of values for each variable.

Answer:

Question 5 (continued)

(b) [3 marks] Which variable(s) would you select as the cutset for cutset conditioning on this constraint satisfaction problem? Briefly justify your answer.

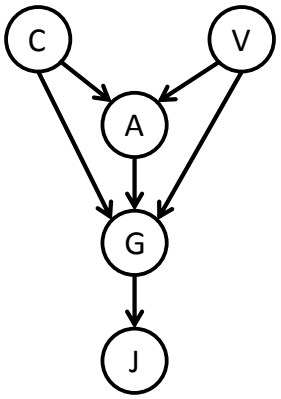
Answer:

(c) [4 marks] In general, if a constraint graph has no loops, what is the runtime complexity of solving the corresponding constraint satisfaction problem? Use big-O notation, and assume the graph has n variables, and the domain of each variables has d possible values. Briefly justify your answer.

Answer:

Question 6 (10 marks)

Consider the Bayes network shown in Figure 6-1, where C = CommitCrime, A = Arrested, G = FoundGuilty, J = SentToJail and V = TelevisedStory are all Boolean random variables, i.e., they take the value either *true (t)* **or** *false (f)*. **Also note that** $P(c)$ **is shorthand for** $P(C = \textbf{true})$ **and** $P(\neg c)$ **is shorthand for** $P(C = \textbf{false})$.



P(C)	P(V)
0.9	0.1

C	V	P(A|C,V)
t	t	0.9
t	f	0.5
f	t	0.5
f	f	0.1

G	P(J|G)
t	0.9
f	0.0

C	A	V	P(G|C,A,V)
t	t	t	0.9
t	t	f	0.8
t	f	t	0.0
t	f	f	0.0
f	t	t	0.2
f	t	f	0.1
f	f	t	0.0
f	f	f	0.0

Figure 6-1

(a) [3 marks] Briefly explain whether or not the following relationship is consistent with the given network structure?

$P(C, A, V) = P(C)P(A)P(V)$

Answer:

Question 6 (continued)

(b) [3 marks] Briefly explain whether or not the following relationship is consistent with the given network structure?

$P(J|G) = P(J|G, A)$

Answer:

(c) [4 marks] Calculate the value of $P(c, a, \neg v, g, j)$. If you cannot easily calculate the final value, try to simplify the expression as best you can. Justify your answer mathematically and show all your calculations.

Answer:

Question 7 (10 marks)

You are given a bag containing n unbiased coins (i.e., either side of a coin can come up with equal probability when tossed). You are told that $n-1$ of these coins are normal (with heads on one side and tails on the other), whereas one coin is a fake that has heads on *both* sides.

(a) [10 marks] Suppose you reach into the bag, and pick out a coin uniformly at random. Suppose you then flip the chosen coin for a total of k times after picking it, and you see k heads. What is the conditional probability that the coin you chose is a fake coin, given these k results?

Justify you answer mathematically and show all your calculations (note: your answer should be an expression in terms of n and k).

Answer:

END OF EXAM QUESTIONS

Extra space if needed to answer any question. If you write part of your answer here, please write the question number, and indicate at the corresponding question that you have used this space.

LAST PAGE OF EXAM