Student Number:

The University of Melbourne

Practice Exam – Solution

School of Computing and Information Systems

COMP30024 Artificial Intelligence

Reading Time: 15 minutes.

Writing Time: 3 hours.

This paper has 13 pages including this cover page.

Common Content Papers: None

Authorised Materials: None.

Instructions to Invigilators:
Each student should initially receive one standard script book.
Students must hand in **both** their **exam paper** and their **script book(s)**.
Students may **not** remove any part of the examination paper from the exam room.

Instructions to Students:

- This paper counts for 70% of your final grade.
- There are 7 questions, with marks as indicated. Attempt all questions.
- Answer questions 1, 2 and 3 **on the exam paper**, and answer questions 4, 5, 6, and 7 on the lined pages in your **script book**. If you need more space for questions 1, 2, or 3, then use the spare page at the end of the exam paper.
- You must hand in **both** your **exam paper** and your **script book(s)**.
- Start your answer to each question in the script book on a new page.
- 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.

Library: This paper is a practice exam.

Question 1 (10 marks) [Write your answers on this page]

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	3	1	2	4	1

(a) The environment for a lecture timetabling system is:

1. observable, stochastic, discrete
2. partially-observable, stochastic, continuous
3. observable, deterministic, discrete
4. partially-observable, stochastic, continuous

(b) What is the time complexity of iterative deepening search:

1. $O(b^d)$
2. $O(bd)$
3. $O(b^{d/2})$
4. none of the above

(c) Which of the following problems is *not* suited to using constraint satisfaction search:

1. staff roster in a cafe
2. poker
3. exam scheduling
4. office layout design

(d) An auction has a *dominant strategy* if:

1. the goods go to the agent who values them the most
2. the auction mechanism discourages agreements between bidders to manipulate prices
3. the strategy results in bidders revealing their true value for a good
4. none of the above

Question 1 (continued) [Write your answers on the previous page]

(e) Given $P(a) = 0.5$ and $P(b) = 0.4$ for two Boolean random variables A and B, in which of the following joint probability tables are A and B *absolutely independent*:

1.

	a	$\neg a$
b	0.2	0.2
$\neg b$	0.3	0.3

2.

	a	$\neg a$
b	0.9	0
$\neg b$	0	0.1

3.

	a	$\neg a$
b	0.25	0.25
$\neg b$	0.25	0.25

4.

	a	$\neg a$
b	0.2	0.3
$\neg b$	0.2	0.3

Question 2 (10 marks) [Write your answers on this page]

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

(a) [2 marks] Briefly explain what is the difference between a *goal-based* agent and a *utility-based* agent.

While goal-based agents can identify action sequences that achieve a given goal, utility-based agents can choose between alternative action sequences that satify a goal, by using a utility measure on the sequence of states in the solution.

(b) [2 marks] Briefly explain what is the main difficulty in using Voronoi diagrams for skeletonisation in robot path planning.

It can be computationally difficult to compute Voronoi diagrams in high-dimensional configuration spaces.

(c) [2 marks] Briefly exaplain in what way can a sealed-bid auction help prevent collusion.

Bidders cannot see each others' bids. Hence, they cannot use their bids to send a price signal to the other bidders.

Question 2 (continued) [Write your answer on this page]

(d) [2 marks] Briefly give two reasons why supervised learning with gradient descent search is not a good approach for learning in game playing search.

Delayed reinforcement – the reward from an action is not known until several time steps later, which slows down learning.

Credit assignment – difficult to know which action was responsible for the outcome.

(e) [2 marks] Briefly describe the operation of the *most-constrained-variable* heuristic for the forward checking search algorithm.

When backtracking, choose the variable with the most constraints with respect to the other unassigned variables.

Question 3 (10 marks) [Write your answers on this page]

Consider the game tree shown in Figure 3-1.

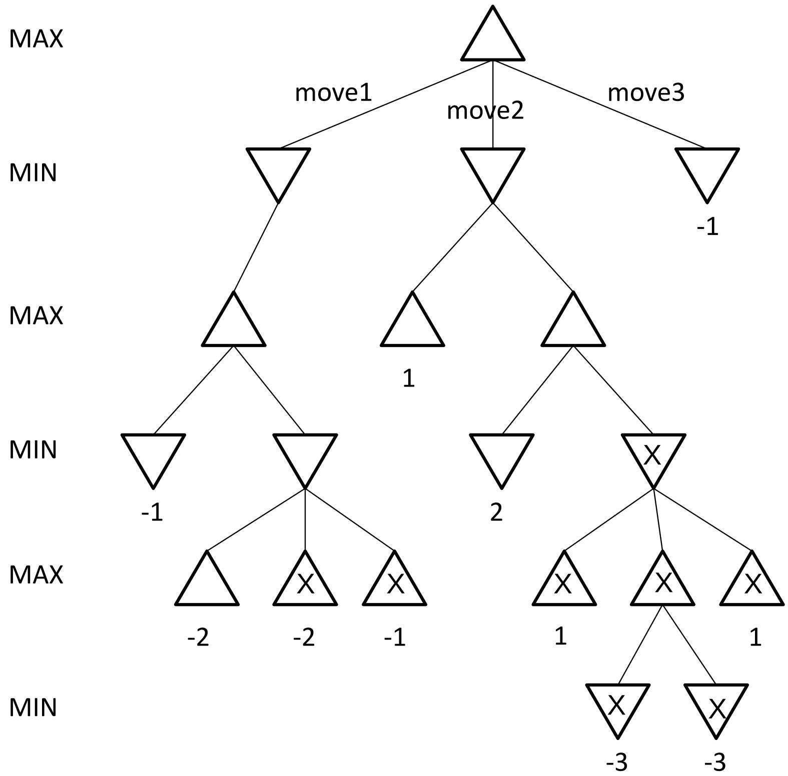


Figure 3-1

(a) [2 marks] What would be the next move if the minimax procedure is applied at the root of the tree to select your next move?

Answer: Move 2

(b) [5 marks] Which nodes do not need to be evaluated if alpah-beta pruning is used? Mark with an "X" on Figure 3-1 the nodes that do not need to be evaluated (i.e., are pruned). Assume that nodes are explored in the order they are shown from left to right.

(c) [3 marks] Briefly describe two methods for setting the *cut-off depth* in minimax search.

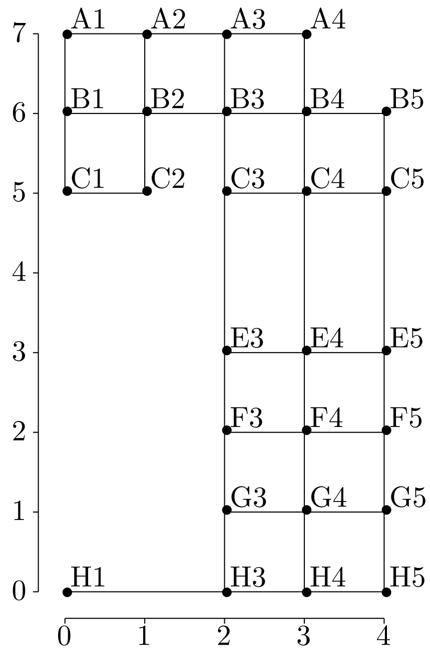
– *Predefined depth limit on search*

– *Use quiescence search to detect a state that is unlikely to exhibit substantial changes in value in the near future.*

Question 4 (10 marks) [Write your answers in the answer book]

The following questions relate to a trip-planner to be equipped in cars. The planner is equipped with a road map of the city and a Global Positioning System that allows it to accurately estimate the position of the car at any time. The map of the central city is shown below, the position of intersection nodes corresponds with the corners of the regular square grid, and are labelled. The system will suggest a path that the car might take from its current position to any specified goal location.

In the following the start point is A1, and the goal is G3. A table of straight-line distances from each node to the goal is also shown (e.g., the distance from B2 to G3 is 5.10).



	1	2	3	4	5
A	6.32	6.08	6.00	6.08	
B	5.39	5.10	5.00	5.10	5.39
C	4.47	4.12	4.00	4.12	4.47
D					
E			2.00	2.23	2.83
F			1.00	1.41	2.23
G			0.00	1.00	2.00
H	2.23		1.00	1.41	2.23

(a) [2 marks] If the system used **breadth-first search**, which path would be chosen from A1 to G3? Assume that nodes with the same depth are explored in increasing order of their node label.

A1, A2, A3, B3, C3, E3, F3, G3

(b) [2 marks] If the system used **greedy search** with the heuristic $h(x)$ = straight-line distance from node x to the goal state G, which path would be chosen from A1 to G3?

A1, B1, C1, C2, B2, B3, C3, E3, F3, G3 or

A1, B1, B2, B3, C3, E3, F3, G3 depending on which instance of B2 in the search tree is chosen

(c) [3 marks] If the system used **A* search** with the heuristic $h(x)$ defined as above and $g(x)$ = distance travelled from the start state S to node x, which path would be chosen from A1 to G3?

A1, A2, A3, B3, C3, E3, F3, G3

(d) [3 marks] Suggest another heuristic function for A* search that may lead to more efficient searching for this problem. Briefly justify your answer, and explain why the heuristic is admissible.

Use manhattan distance from G3 to node at $(x, y) = |x - 2| + |y - 1|$

This is admissible because the manhattan distance is less than or equal to the actual distance of a grid of streets such as this.

The manhattand distance dominates the straight line distance because it is always greater than or equal to straight line distance.

Question 5 (10 marks) [Write your answers in your script book]

You are designing a menu for a special dinner. There are several choices, each represented as a variable: (E)ntre, (B)everage, main (C)ourse, and (D)essert. The domains of the variables are as follows:

E: (v)eggies, (es)scargot
B: (w)ater, (j)uice, (m)ilk
C: (f)ish, (b)eef, (p)asta
D: (a)pple strudel, (i)ce cream, (ch)eese

Because all guests get the same menu, it must obey the following dietary constraints:
(i) Total budget: If you serve the escargot, your only beverage is water.
(ii) Calcium requirement: You must serve at least one of milk, ice cream, or cheese.
(iii) Vegetarian options: The entre must be veggies or the main course must be pasta or fish.

(a) [3 marks] Draw the constraint graph over the variables E, B, C, and D.

$C - E - B - D$

(b) [3 marks] Imagine we first assign E=es. Cross out eliminated values to show the domains of the variables after forward checking.

As the variable E has been assigned, we need to check the domains of it's neighbours in the constraint graph, namely C and B. From C, b is eliminated by forward checking. From B, j and m are eliminated.

(c) [4 marks] Again imagine we first assign E=es. Cross out eliminated values to show the domains of the variables after arc consistency has been enforced.

As before, from C, b is eliminated, and from B, j and m are eliminated. However, since the domain of B has been updated, arc consistency requires that its neighbours E and D be checked. E has been assigned a value. From D, a is eliminated as there is now no value in B that is compatible with D=a

Question 6 (10 marks) [Write your answers in your script book]

(a) [5 marks] Consider the floor plan shown in Figure 6-1, which shows a circular robot that can move around the room. For the purposes of this question, you can assume that the robot has two degrees of freedom: the x and y coordinates of the centre of the robot. You do not need to consider the orientation of the robot.

The room contains a wall with a corner near the middle of the room. The robot cannot move through this wall, and must find a path around the wall. Note that the room is 10m wide and deep, and the robot has a diameter of 1m.

Draw the configuration diagram for the robot in this environment, where the horizontal axis of your diagram is the x coordinate of the robot, and the veritical axis is the y coordinate. Clearly shade in black the regions of the configuration space that are not feasible for the robot.

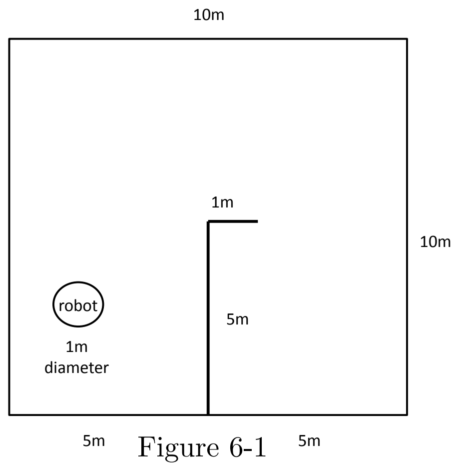
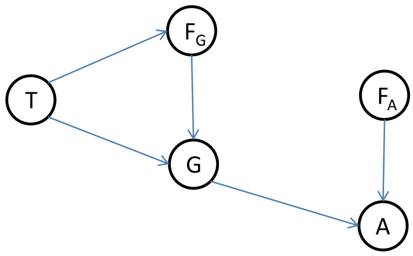


Figure 6-1

(b) [5 marks] Consider a car engine, which has a temperature alarm light that is activated when a temperature gauge exceeds a given threshold. The gauge measures the temperature in the engine of the car. We can model this system in terms of the following Boolean random variables: A (alarm light active), F_A (alarm light faulty), F_G (temperature gauge faulty), G (gauge reading high) and T (actual engine temperature high). Ideally, if the temperature in the engine is high, the gauge will give a high reading, and the alarm light will be active.

Draw a Bayesian network for this system, given that the gauge is more likely to fail when the engine temperature is high.



Question 7 (10 marks) [Write your answers in your script book]

A mobile robot has to decide whether to move forward or not, based on whether there is an obstacle in front of it. It is equipped with a laser range finder that will register that there is an obstacle, if one is actually present, 80% of the time. It is also known that the laser range finder will register that there is an obstacle when there is none present 20% of the time. The robot has information about the density of obstacles in the environment that indicates that the prior probability of an obstacle being in front of it in the current situation is 20%. The robot algorithm is such that it will take a fixed large number of readings, and update its confidence of there being an obstacle using the Bayesian update rule with each reading. If at any time its confidence that the path in front of it is clear drops below 40% it will immediately stop taking readings and turn and scan in another direction.

(a) [4 marks] Given that there is an obstacle in front of the robot and that, on this particular occasion, the sensor returns positive every time, how many readings will the robot take before it turns.

Given $P(d|o) = 0.8, P(o) = 0.2, P(d|\neg o) = 0.2$

Incremental Bayes rule for first detection:
$P(o|d) = \frac{P(d|o)P(o)}{P(d|o)P(o)+P(d|\neg o)P(\neg o)}$
$P(o|d) = \frac{0.8x0.2}{0.8x0.2+0.2x0.8} = 0.5$
Incremental Bayes rule for second detection:
$P(o|d_2, d_1) = \frac{P(d|o)P(o|d)}{P(d|o)P(o|d)+P(d|\neg o)P(\neg o|d)}$
$P(o|d_2, d_1) = \frac{0.8x0.5}{0.8x0.5+0.2x0.5} = \frac{0.8}{0.8+0.2} = 0.8 > 0.5$

Therefore, the robot turns after two detections.

(b) [3 marks] What is the robot's confidence (probability) that there is no obstacle in front of it when it decides to turn?

$P(\neg o|d_2, d_1) = 1 - P(o|d_2, d_1) = 1 - 0.8 = 0.2$

(c) [3 marks] When debugging this system, it was found that the robot was taking readings from the sensor too frequently. The robot was checking the sensor every second, while the sensor was only scanning every two seconds. Thus, pairs of readings would always be identical. Is the use of Bayesian reasoning in the algorithm described above still appropriate in this case? Explain your answer in one or two sentences.

No. The incremental Bayes formulation requires the observations to be independent (see derivation in lecture slides). If the sensor is taking pairs of identical readings, then they are not independent.

END OF EXAM QUESTIONS

Extra space if needed to answer questions 1, 2 or 3. 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