UNIVERSITY OF SOUTHAMPTON COMP2208W1

SEMESTER 1 EXAMINATIONS 2023-2024

INTELLIGENT SYSTEMS

Duration 120 mins (2 hours)

This paper contains FOUR questions.

Answer THREE questions only.
(**BOTH** questions in SECTION A and **ONE** in SECTION B**)**

An outline marking scheme is shown in square brackets to the right of each question.

Only University approved calculators may be used.

A foreign language dictionary is permitted ONLY IF it is a paper version of a direct 'Word to Word' translation dictionary AND it contains no notes, additions or annotations.

11 page examination paper

SECTION A

Answer ALL questions.

A1

An agent moves on a square 4x4 grid, labelled as shown:

D1	D2	D3	D4
C1	C2	C3	C4
B1	B2	B3	B4
A1	A2	A3	A4

The agent starts from the bottom left corner (A1). The agent can move one square at a time in one of two directions (where the dimensions of the board allow):

- up one square (e.g. from A1 to B1),
- right one square (e.g. from A1 to A2).

Assume that moves are generated in this order when a node is expanded. (Downwards, leftward and diagonal moves are not permitted). Each move has a cost of 1. The goal is to reach a particular square (goal state).

First, consider the following TREE search methods (assume the goal state is not found in the first 8 states).

a) What are the first 8 states EXPANDED (in order) under BREADTH FIRST search? [4 marks]

b) What are the first 8 states EXPANDED (in order) under DEPTH FIRST search? [4 marks]

c) What are the first 8 states EXPANDED (in order) under ITERATIVE DEEPENING search? [4 marks]

Question continues on following page

TURN OVER

d) If we now switch to GRAPH SEARCH, what are the first 8 states EXPANDED (in order) under GRAPH search? (use breadth-first graph search) [4 marks]

If the board is extended in size to an NxN board (finite N), and the goal state is at square (E7), answer the following questions (you can assume the branching factor is constant):

e) Which of the four strategies in questions a-d is optimal? [1 mark]

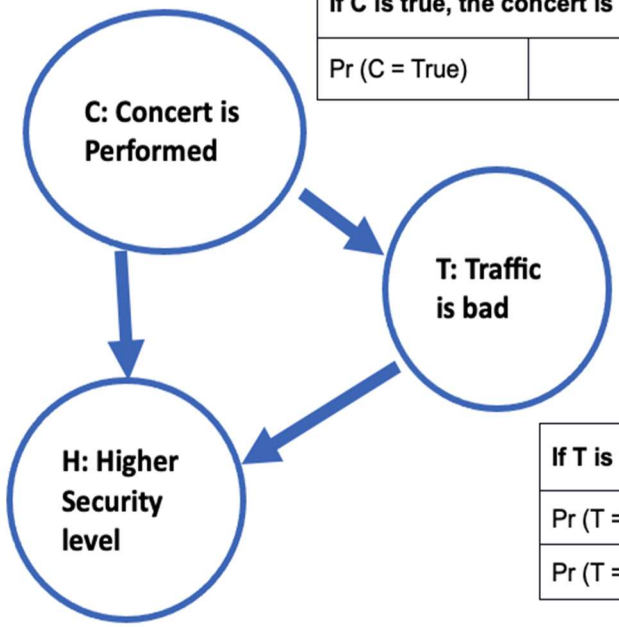
f) Give an upper bound on both the number of nodes GENERATED and the number of nodes that need to be STORED in memory at one time for BREADTH FIRST search? Provide both general formula and numerical instantiations. [4 marks]

g) Give an upper bound on both the number of nodes GENERATED and the number of nodes that need to be STORED in memory at one time for DEPTH FIRST search? Provide formula in general terms and as a function of N. [4 marks]

TURN OVER

A2

Consider the Bayesian network below, which describes the relationship between a concert is performed (C), traffic is bad (T), and a higher security level (H). The “concert is performed” does not depend on the other two variables. But, the traffic is more likely to be bad when there is a concert. Whether or not a higher-level security guard is needed depends on both of the other variables. The conditional probabilities are given in the tables.



If C is true, the concert is performed	
Pr (C = True)	0.9

If T is true, the traffic is bad	
Pr (T = True | C = True)	0.8
Pr (T = True | C = False)	0.4

If H is true, a higher-level security guard is needed	
Pr (H = True | C = True, T = True)	0.8
Pr (H = True | C = True, T = False)	0.5
Pr (H = True | C = False, T = True)	0.2
Pr (H = True | C = False, T = False)	0.1

Question continues on following page

a) What is the probability that the traffic will be bad? [3 marks]

b) We can use Monte Carlo simulation to study the behaviour of a Bayesian network. Assume that we generate random states by taking a random value from zero to one inclusive, and set a given state to True if the random value is less than or equal to the relevant probability of that state being True. We need three such random values to generate one set of state values for the network. Take these three random values

[0.3, 0.9, 0.6]

and use them in sequence for the variables C, T and H, respectively, to generate a single random state of the network. [4 marks]

c) In the form of a truth table, with an additional column showing the relevant probability, use the Bayesian network diagram to reconstruct the full joint probability distribution across the three Boolean state variables. [8 marks]

Using Bayes' theorem, calculate the following conditional probabilities:

d) What is the probability that the concert was performed given that a higher-level security guard was needed? In other words, Pr(C=True | H=True)? [5 marks]

e) What is the probability that the traffic was bad given that a higher-level security was not needed?
That is, Pr(T=True | H=False)? [5 marks]

TURN OVER

SECTION B

Answer *ONE* out of *TWO* questions

B1

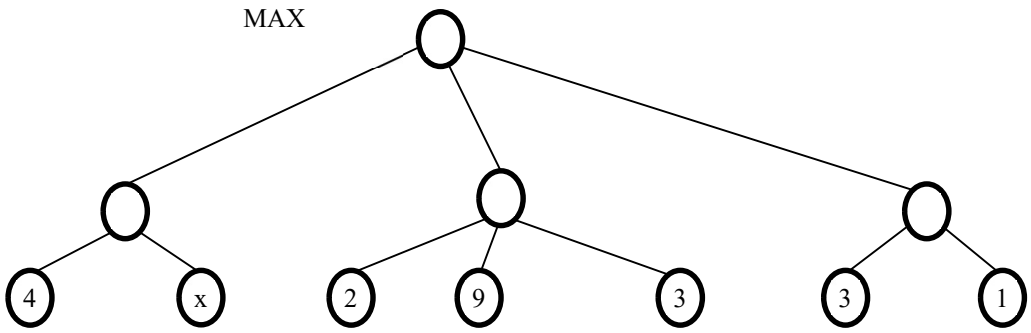
a) In robotics, mention two issues/challenges with "deliberative control architectures" and one of its advantages. [2 marks]

b) Draw a decision tree, using as few nodes as possible, to classify the food choice described by the following data.

Favourite?	Spicy?	Food Choice
Yes	No	Pizza
No	Yes	Hot Curry
Yes	Yes	Tacos
No	No	Pizza

[3 marks]

c) The following shows a game tree. MAX is maximising and it is MAX's turn to move.



i) If x=5, what is the value of the game to the MAX player? [1 mark]

Question continues on following page

ii) With x=7, using the minimax algorithm with alpha-beta pruning, and assuming conventional left-to-right traversal of the tree, indicate the branches that can be pruned.
[2 marks]

iii) With x=3, using the minimax algorithm with alpha-beta pruning, and assuming conventional left-to-right traversal of the tree, indicate the branches that can be pruned.
[2 marks]

d) A delivery agent needs to plan a set of actions to achieve the goal ‘parcel at customer’. The initial state is ‘parcel at factory’ ^ ’van at depot’ ^ ’van empty’ ^ ‘factory isa location’ ^ ‘customer isa location’ ^ ‘depot isa location’. Available actions include:

Action	Requires	Effects
Load(p)	Parcel at p. Van at p. p isa location,	¬ Parcel at p, ¬ Van empty. Van loaded.
Unload(p)	Van at p. Van loaded. p isa location.	¬ Van loaded. Van empty. Parcel at p.
Carry(p,q)	Van at p. p isa location. q isa location. Van loaded.	¬ Van at p. Van at q.
Drive(p,q)	Van empty. p isa location. q isa location.	¬ Van at p, Van at q.

i) Give a solution to achieve the delivery agent’s goal.
[4 marks]

Question continues on following page

ii) Briefly describe the potential search benefit of searching backwards from the goal state instead of forwards from the initial state. [1 mark]

e) Give a few discussion points (bullet-point sentences, not an essay) for each of the following statements (simply writing 'true'/'false' answers without justification is insufficient for a mark).

i) Supposing we are only interested in how a machine behaves (not what's on the inside), then the Turing test is sufficient to assess whether the behaviour of a machine is intelligent. [4 marks]

ii) A machine that behaves intelligently is actually intelligent. [3 marks]

iii) If people don't want to use AI they don't have to. Therefore it is ethical to produce and deploy any and all AI, and people can choose for themselves. [3 marks]

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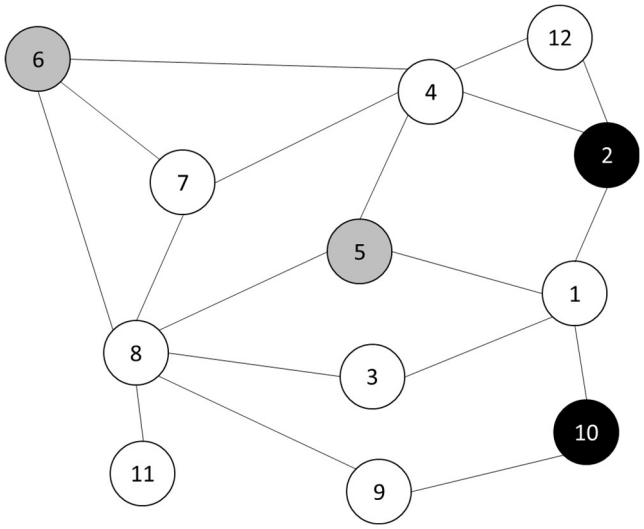
B2

a) The following figure shows a partially completed graph-colouring problem using 3 colours. Nodes 5 and 6 have already been assigned one colour, and nodes 2 and 10 have already been assigned another colour. Other nodes do not yet have a colour assigned. Using the common heuristics we discussed for this task, which node do you assign a colour to next? Why are these heuristics useful?



[5 marks]

b) An agent must find a sequence of actions that moves blocks of ice and heaters on a square grid. The goal is to find a sequence of discrete actions that moves all items to a particular configuration, with all the items in specific target locations. All actions move one item and have the same cost. It is easy to calculate a sequence of moves that relocates each of the items individually (as if it was the only item on the grid). However, there is a restriction on the moves allowed; A block of ice cannot occupy the same position as a heater.

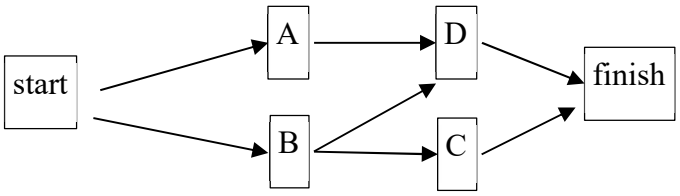
A student considers using A* (A-star) tree search with a heuristic. The first heuristic they consider is the number of items that are not in the correct position.

Question continues on following page

i) Prove that A* tree search with this heuristic is optimal.
[7 marks]

ii) Describe a heuristic which dominates the heuristic suggested, explain what dominating means and its significance for the time complexity and optimality of A*.
[3 marks]

c) Consider the partially ordered plan shown below.
Write out all the fully ordered plans that it describes.



[5 marks]

d) Briefly describe (a few bullet-point sentences) some of the ways in which Classical or GOFAI (good old-fashioned AI) and modern (machine learning) AI differ in approaches and capability. [5 marks]

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END OF PAPER

This page contains no examination material