UNIVERSITY OF SOUTHAMPTON COMP2208W1

SEMESTER 1 EXAMINATIONS 2022-2023

INTELLIGENT SYSTEMS

Duration 120 mins (2 hours)

This exam contains FOUR QUESTIONS in TWO Sections

Answer BOTH Questions in Section A and ONE Question in Section B.

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.

9 page examination paper

 Version 1

SECTION A

Answer ALL questions.

Question A1

An agent needs to travel across a country from a city in the east to a city in the west via a network of roads connecting 100 cities. The agent has actions that allow it to follow a road to the next city, but it can ONLY TRAVEL WEST. It has a map that describes the east-west position (longitude) of each city and the westward roads that can be taken from each to connect with other cities. At each city there are at most 5 roads that can be chosen for onward travel. The cost of each action (i.e. going along a road between cities) is the number of miles travelled (this is provided). There is at least one sequence of roads providing a path from the start city to the goal city.

For the following questions, where appropriate show the relevant formula and give a numerical answer (i.e. show that you identify the appropriate formula and can plug in the correct numbers).

Approaching the task as a state-space search problem, aiming to find a sequence of actions that takes the driver to the target city, consider the following strategies for tree search.

One possible strategy is a depth first strategy (DFS).

a) Is this method guaranteed to find a solution for this problem (with unlimited time and space)? Explain briefly.

[2 marks]

b) Give a bound on the number of nodes that this method will generate in the worst case.

[2 marks]

c) Give a bound on the number of nodes that will be stored in memory at any one time.

[2 marks]

d) What can you say about the cost of a solution that it finds (if it finds one)?

[2 marks]

Question continues on following page

Another possible strategy is breadth first strategy (BFS). If the depth of the least cost solution was 20 (=20 actions):

e) Is this method guaranteed to find a solution for this problem (with unlimited time and space)? Explain briefly.

[2 marks]

f) Give a bound on the number of nodes that this method will generate in the worst case.

[2 marks]

g) Give a bound on the number of nodes that will be stored in memory at any one time.

[2 marks]

h) What can you say about the cost of a solution that it finds (if it finds one)?

[2 marks]

i) Describe a tree search strategy for this problem that guarantees optimal solutions. Describe how nodes are ordered for expansion. If the method is heuristic, describe a heuristic using only the information in the question.

[4 marks]

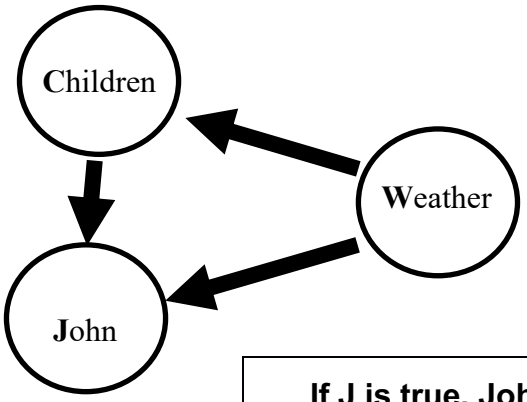
j) Briefly explain why this method is guaranteed optimal.

[5 marks]

Question A2

Consider the Bayesian network below, which describes the relationship between whether the weather is nice (W), John's children want to stay at home (C), and that John will be able to finish writing his annual report (J). The weather being nice does not depend on the other two variables. But, the children are more likely to stay at home if the weather is bad. Whether or not John will be able to finish his report depends on both of the other variables. The conditional probabilities are given in the tables.

If C is true, the children will stay at home.	
p(C = True | W = True)	0.2
p(C = True | W = False)	0.7



If W is true, weather is nice	
p(W = True)	0.8

If J is true, John will finish his report.	
P(J = True | W = True, C = True)	0.5
P(J = True | W = True, C = False)	0.01
P(J = True | W = False, C = True)	0.7
P(J = True | W = False, C = False)	0.95

a) What is the probability that the children will stay at home?

[2 marks]

b) 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]

Question continues on following page

c) Using Bayes' theorem, calculate the following conditional probabilities.

i) What is the probability that the weather was nice given that John finished writing his report?
In other words, what is p(W=True | J=True)?

[5 marks]

ii) What is the probability that the children were staying at home given that John did not finish his report?
In other words, what is p(C=True | J=False)?

[5 marks]

iii) What is the probability that the weather was nice given that the children stayed at home and John did not finish his report?
In other words, what is p(W=True | C=True, J=False)?

[5 marks]

SECTION B
Answer *ONE* out of *TWO* questions

Question B3

a) The following shows a game tree. Player 1 is maximising and it is Player 1's turn to move.

i) If x=6, what is the value of the game to Player 1?

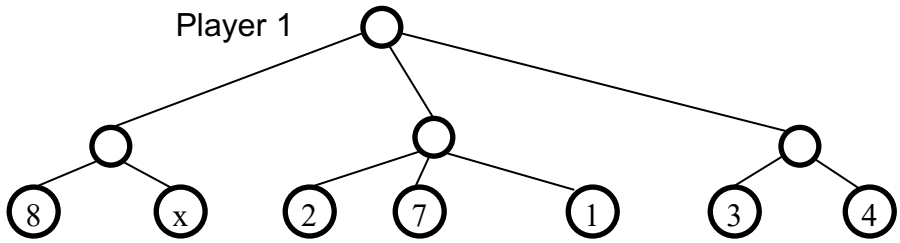
[1 mark]

ii) With x=6, 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.

[3 marks]

iii) With x=1, 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.

[3 marks]



b) The backtracking search algorithm for constraint satisfaction problems has a successor function that generates daughter nodes in the search tree. Does it generate a node for each of the values that can be assigned to:

- one remaining unassigned variable, or
- all remaining unassigned variables?

Explain briefly.

[2 marks]

Question continues on following page

c) A Professor needs to plan a set of actions to achieve the goal ‘Professor at lecture’ ^ ‘Kids at school’.

The initial state is ‘Professor at home’ ^ ’Kids at home’.

The possible actions are given in the table below.

Action	Requires	Effects
home2Uni	Professor at home. Kids at home.	¬ Kids at home, ¬ Professor at home. Professor at lecture. Kids at lecture.
Uni2school	Professor at lecture. Kids at lecture.	¬ Professor at lecture. ¬ Kids at lecture. Professor at school. Kids at school.
school2Uni	Professor at school. Kids at school.	¬ Professor at school. Professor at lecture.
home2school	Professor at home. Kids at home.	¬ Kids at home, ¬ Professor at home. Kids at school, Professor at school.

i) Give a solution to achieve the Professor’s goal.

[3 marks]

ii) Briefly describe the search benefit of searching with partially ordered plans instead of fully-ordered plans.

[3 marks]

d) Briefly describe (a few sentences each) the ways in which these statements are true and/or untrue? (simply writing ‘true’/’false’ answers without justification is insufficient for a mark)

i) A computer must be able to understand the symbols it is manipulating if it is going to pass the Turing Test.

[5 marks]

ii) Anything that good old-fashioned AI can do, modern neural networks can also do, and a lot more besides.

[5 marks]

Question B4

a) In robotics, mention two issues/challenges with "deliberative control architectures".

[2 marks]

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

Beachfront?	Mainland-EU?	Vacation choice
Yes	No	Cornwall (UK)
No	Yes	Rome (Italy)
Yes	Yes	Valencia (Spain)
No	No	Cornwall (UK)

[3 marks]

c) Briefly describe (a few sentences each) the ways in which these statements are true and/or untrue? (simply writing 'true'/'false' answers without justification is insufficient for a mark)

i) The Turing Test is a good test of intelligence because to pass it an AI must be at least as intelligent as a human.

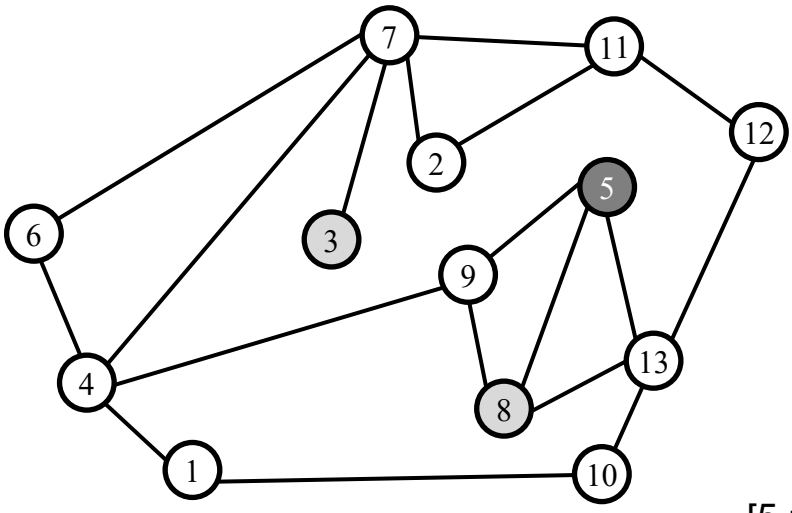
[5 marks]

ii) Rodney Brooks (author of 'Elephants don't play chess') suggests that chess is the right test for intelligence because this kind of intelligence is uniquely human.

[5 marks]

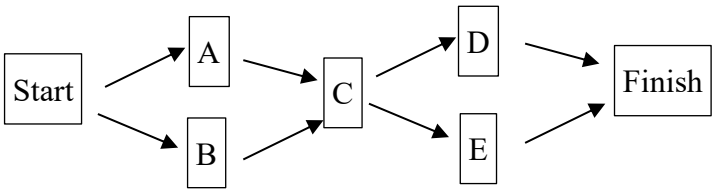
Question continues on following page

d) The following figure shows a partially completed graph-colouring problem using 3 colours. Nodes 3 and 8 have been assigned one colour, and node 5 has been assigned a different 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]

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



[5 marks]

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