UNIVERSITY OF SOUTHAMPTON COMP2208W1

SEMESTER 1 EXAMINATIONS 2017/18

INTELLIGENT SYSTEMS

Duration 120 mins (2 hours)

This paper contains 4 questions

Answer **THREE** questions**.**

**Please start a new page for each question.**

Each question carries 1/3 of the total marks for the exam paper and you should aim to spend about 40 minutes on each.

An outline marking scheme is shown in 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.

**7 page examination paper**

***QUESTION 1*.**

a) Explain in detail the important trade-offs in choosing between breadth-first and depth-first search strategies, and explain what difference it makes whether the search tree has finite maximum depth or not? [10 marks]

b) What is the difference between the evaluation functions of A-Star ("A*") search and greedy best-first search? [5 marks]

c) Describe two admissible heuristics for A-star search on the 8 puzzle, and explain what it means for one heuristic to dominate the other using these examples. [6 marks]

d) Explain why A-Star is guaranteed to return optimal solutions when using an admissible heuristic. [12 marks]

***QUESTION 2.***

For each part below, show your understanding by briefly summarizing the relevant concepts.

a) Briefly describe the following terms:

   i) Activity function of an artificial neuron; [2 marks]

   ii) Hidden layer (in artificial neural nets); [2 marks]

   iii) Feedforward architecture (of artificial neural nets). [2 marks]

b) What are the main differences between:

   i) Top down and bottom up architectures; [2 marks]

   ii) Temporal difference learning and Q-learning; [2 marks]

   iii) Lazy learning and eager learning. [2 marks]

c) Explain the key concepts of reinforcement learning. [6 marks]

d) What are decision trees? Describe the key components of a decision tree process [6 marks]

e) In sequential decision making:

   i) Briefly explain why it is necessary to balance exploration with exploitation. [3 marks]

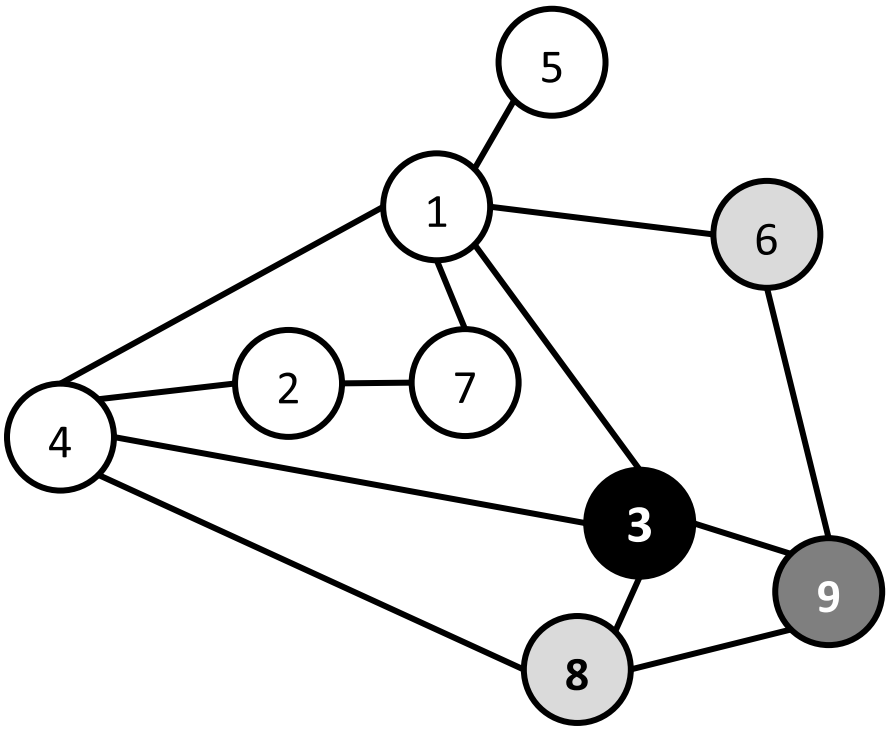
   ii) Briefly explain what is the Markov property and how it can be utilised in MDPs. [3 marks]

   iii) Briefly explain the concept of multi-armed bandits. [3 marks]

**TURN OVER**

***QUESTION 3.***

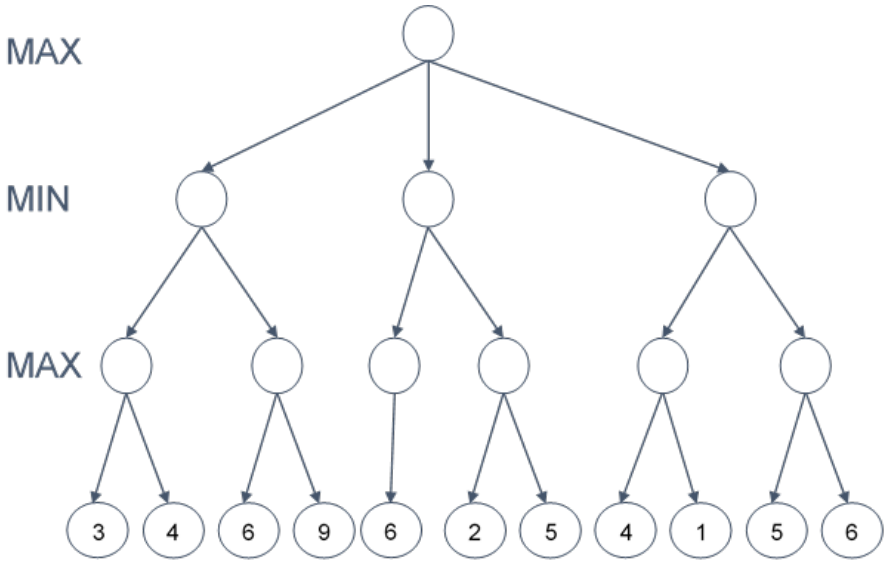
a) Consider the following graph representing the constraints of a graph-colouring problem. The four shaded nodes (3, 6, 8 and 9) have already been assigned colours. Which node should we choose to assign a colour to next? Explain. [9 marks]




b) What approaches can be used to find admissible heuristics in planning problems? [7 marks]

**QUESTION CONTINUES**

c) Consider the game tree shown below. Assume the top node is a max node as shown. The numbers in the bottom layer are the values of the different outcomes of the game to the max player. What is the value of the game to the max player?




[6 marks]

d) Consider the alpha-beta pruning algorithm applied to the game tree shown in part (iii). Assume the tree is traversed in the usual depth-first left-to-right order. Which nodes will not be evaluated (will be pruned)?

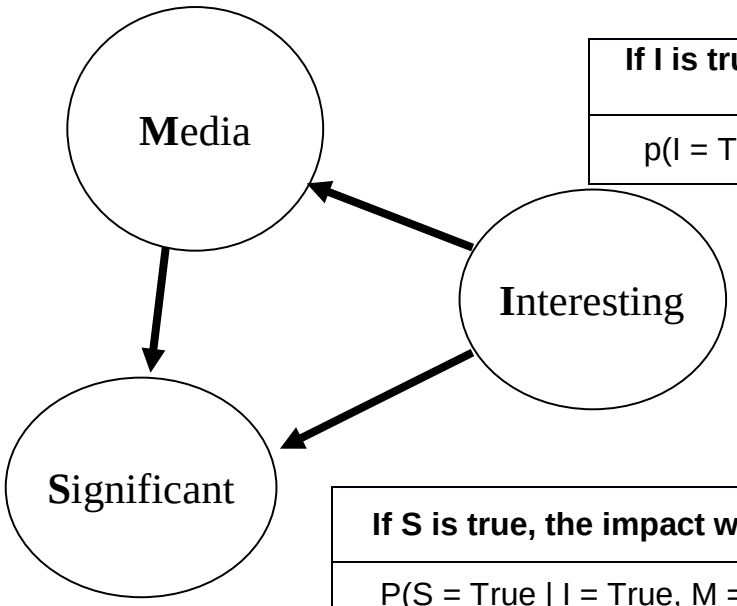
[11 marks]

**TURN OVER**

***QUESTION 4.***

We aim to predict whether a research project will generate large impact on the society, based on the importance of the research, and whether it has news media coverage. Consider the Bayesian network below, which describes the relationship between whether the research results will be potentially important to the society (I), it will be covered by news media (M), and its impact will be significant in the next 5 years (S). The topic being interesting does not depend on the other two variables. But the news media will cover it with higher probability if the topic is more interesting. Whether or not the impact will be high depends on both of the other variables. The conditional probabilities are given in the tables.

| **If M is true, the news media will mention the research project** | |
|---|---|
| p(M = True \| I = True) | 0.6 |
| p(M = True \| I = False) | 0.1 |




| **If I is true, the research is important** | |
|---|---|
| p(I = True) | 0.4 |

| **If S is true, the impact will be significant.** | |
|---|---|
| P(S = True \| I = True, M = True) | 0.7 |
| P(S = True \| I = True, M = False) | 0.4 |
| P(S = True \| I = False, M = True) | 0.3 |
| P(S = True \| I = False, M = False) | 0.05 |

**QUESTION CONTINUES**

a) What is the probability that news media will talk about the project? [4 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 the following random values and use them in sequence for the variables I, M and S, respectively, to generate a single random state of the network: [0.1, 0.8, 0.2] [6 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]

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

i) What is the probability that a particular research's topic was important news media covers it? In other words, p(I=True | M=True)? [5 marks]

ii) What is the probability that despite the media coverage the project will not have significant impact? That is, p(S=False | M=True)? [5 marks]

iii) What is the probability that the topic was in fact important despite it was not covered in news media, neither had large impact in the subsequent 5 years after the publication of the results? In other words, what is p(I=True | M=False, S=False)? [5 marks]

**END OF PAPER**