NANYANG TECHNOLOGICAL UNIVERSITY

SEMESTER 1 EXAMINATION 2018-2019

CZ3005 – ARTIFICIAL INTELLIGENCE

Nov/Dec 2018 Time Allowed: 2 hours

INSTRUCTIONS

1. This paper contains 4 questions and comprises 6 pages.
2. Answer **ALL** questions.
3. This is a closed-book examination.
4. All questions carry equal marks.

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1. (a) State whether each statement is TRUE or FALSE.

   (i) Depth-first search (DFS) is complete if there is no loop and the depth of the search tree is finite.

   (ii) For any search problem, there is always an admissible A* heuristic function.

   (iii) A* search always expands fewer nodes than Depth First Search (DFS) does.

   (iv) Each uninformed search algorithm can be applied to solve a constraint satisfaction problem.

   (v) The environment of autonomous cars is observable.

   (5 marks)

Note: Question No. 1 continues on Page 2

(b) You have a list of the top 10 places of interest in Singapore, located at different places. You just want to visit 6 of them in the shortest time. You will start your trip from your hotel and would like to go back to the hotel after you visit 6 places. Express your situation as a search problem. That is, define the states, operators, and goal test you will use.

(6 marks)

(c) Games (e.g., chess, GO, and poker) have been widely used as benchmark problems for AI research. AlphaGo has been recognized as one of the biggest success of AI over the last few years. Please explain why the game GO is difficult to solve if we simply apply tree search algorithms studied in our course.

(7 marks)

(d) Perform Minimax on the tree in Figure Q1. The MAX player moves first to choose the best move and then the MIN player moves. All the values are from the perspectives of the MAX player.

Find the best initial move for player MAX by using Minimax search. List the value of each node on the search tree.

(7 marks)

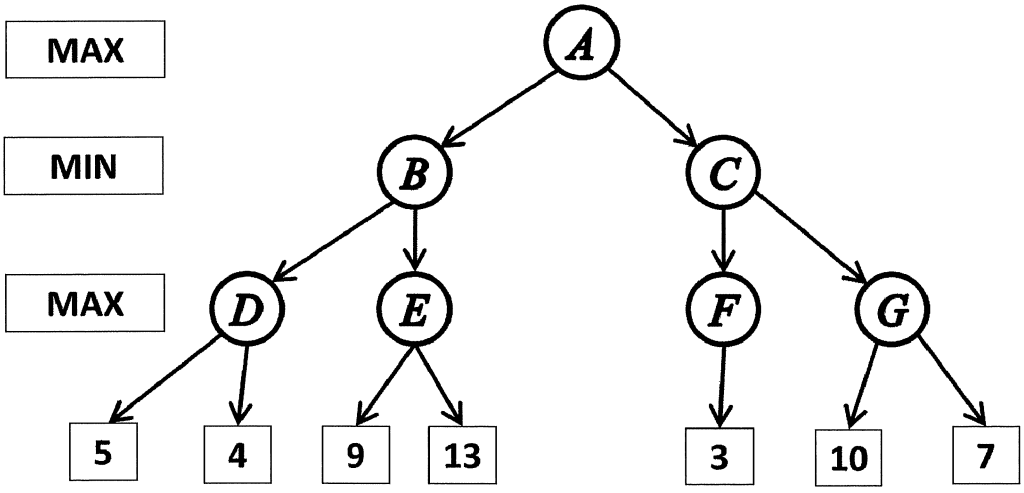

Figure Q1

2. Figure Q2 shows the graph of a search problem, where the directed arcs represent the successors of a node. The cost of moving to a node is given by the number on the arc. The value of the heuristic function *h* is shown inside each node. The start state is S and the goal is G.

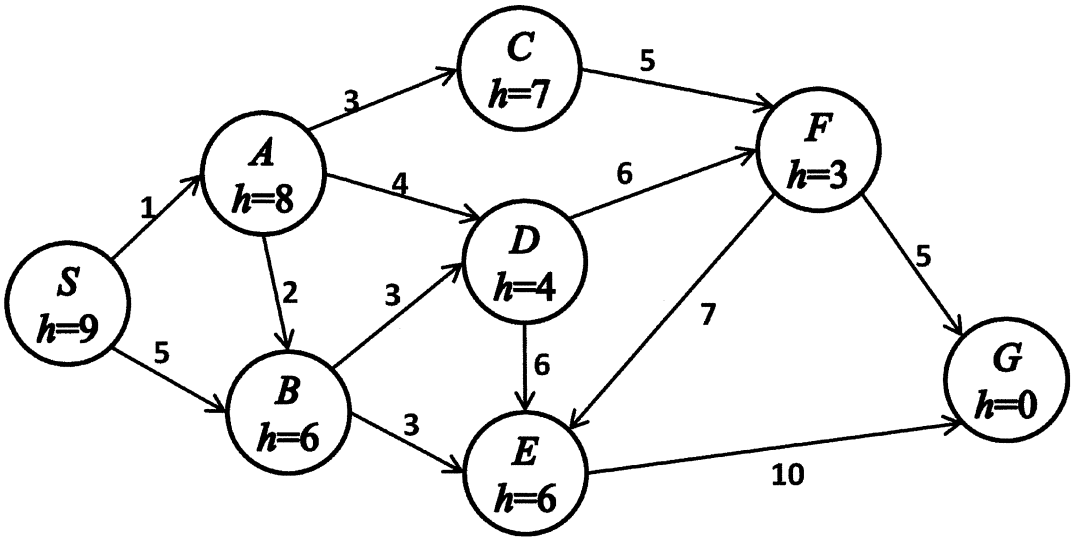

Figure Q2

For each of the following search strategies, state the order in which states are expanded (i.e., when they are removed from the frontier), as well as the final path returned when the search is finished. Assume that all ties are resolved in alphabetical order (i.e., the A state is expanded before the B state which is expanded before the C state, etc.). If a node has been expanded, do not expand it again.

(a) Apply **breadth-first search** to the graph in Figure Q2: (1) list the nodes in the order they would be expanded; (2) list the nodes that lie along the final path to the goal state.

(4 marks)

(b) Apply **depth-first search** to the graph in Figure Q2: (1) list the nodes in the order they would be expanded; (2) list the nodes that lie along the final path to the goal state.

(4 marks)

Note: Question No. 2 continues on Page 4

(c) Apply **uniform cost search** to the graph in Figure Q2: (1) list the nodes and their g(n) values in the order they would be expanded; (2) list the nodes that lie along the final path to the goal state.

(5 marks)

(d) Apply **greedy search** to the graph in Figure Q2: (1) list the nodes and their h(n) values in the order they would be expanded; (2) list the nodes that lie along the final path to the goal state.

(5 marks)

(e) Apply **A* search** to the graph in Figure Q2: (1) list the nodes and their f(n) values in the order they would be expanded; (2) list the nodes that lie along the final path to the goal state.

(7 marks)

3. (a) Describe three types of logic: propositional logic, first order logic and fuzzy logic. Your answer must discuss the difference of the three logics in terms of their ontological commitment and epistemological commitments.

(5 marks)

(b) You are given the following proposition.

- $A \Rightarrow B \Rightarrow C \Leftrightarrow (A \wedge \neg B) \vee C$
- $\neg(A \wedge B) \Leftrightarrow A \Rightarrow \neg B$

(i) Using logical laws, determine the equivalence between left hand side and right hand side propositions.

(3 marks)

(ii) Constructing their truth table, determine whether the two propositions are equivalent.

(4 marks)

(iii) Using the truth table that you have derived in Question (ii), determine whether the two propositions are valid, satisfiable or unsatisfiable.

(3 marks)

Note: Question No. 3 continues on Page 5

(c) You are presented with the following sentences.

- If Jose Mourinho works hard then Manchester United wins
- If Manchester United wins, the fans are happy
- If the fans are happy, Manchester United is rich
- Jose Mourinho works hard

(i) Using modus ponens, prove that **Manchester United is rich.**

(5 marks)

(ii) Using resolution by refutation, prove that **Manchester United is rich.**

(5 marks)

4. (a) Provide a correct and concise translation in plain English for each of sentences below.

(i) $\forall x, y, Teacher(x) \wedge Student(y, x) \Rightarrow Teach(x, y)$

(1 mark)

(ii) $\forall y, x, Workhard(y) \wedge Smart(y) \wedge Teach(x, y) \Rightarrow Pass(y)$

(1 mark)

(iii) $\forall y, x, Pass(y) \Rightarrow Happy(x)$

(1 mark)

(iv) $Workhard(PaulPogba)$

(1 mark)

(v) $Smart(PaulPogba)$

(1 mark)

(vi) $Teacher(JoseMourinho)$

(1 mark)

(vii) $Student(PaulPogba, JoseMourinho)$

(1 mark)

Note: Question No. 4 continues on Page 6

(b) Using resolution by refutation concept and First Order Logic (FOL) sentences in question 4(a), prove that "**Jose Mourinho is happy**".

(8 marks)

(c) You are given four fuzzy rules describing automatic braking system of autonomous car as follows:

(i) If speed is fast and Distance is near then brake is hard.
(ii) If speed is fast and Distance is far then brake is moderate.
(iii) If speed is slow and Distance is far then brake is gentle.
(iv) If speed is slow and Distance is near then brake is gentle.

Draw Fuzzy Neural Network (FNNs) structure to construct the four fuzzy rules.

(5 marks)

(d) Design Neural Networks (NNs) that function as AND operator under binary inputs. Your answer must include NN's structures, its weights and must show truth tables that support the functionality of your NN.

(5 marks)

END OF PAPER

CZ3005 ARTIFICIAL INTELLIGENCE

Please read the following instructions carefully:

1. **Please do not turn over the question paper until you are told to do so. Disciplinary action may be taken against you if you do so.**

2. You are not allowed to leave the examination hall unless accompanied by an invigilator. You may raise your hand if you need to communicate with the invigilator.

3. Please write your Matriculation Number on the front of the answer book.

4. Please indicate clearly in the answer book (at the appropriate place) if you are continuing the answer to a question elsewhere in the book.