NANYANG TECHNOLOGICAL UNIVERSITY

SEMESTER 1 EXAMINATION 2017-2018

CZ3005 – ARTIFICIAL INTELLIGENCE

Nov/Dec 2017 Time Allowed: 2 hours

INSTRUCTIONS

1. This paper contains 4 questions and comprises 5 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 (T) or false (F).

   (i) Uniform cost search will expand no more nodes than breadth-first search.

   (ii) If h value of every state is 0, A* search is equivalent to uniform cost search.

   (iii) We will test whether a state is a goal state when we add the state to the frontier.

   (iv) Iterative deepening search is complete.

   (v) The environment of game Poker is partially observable.

   (5 marks)

Note: Question No. 1 continues on Page 2

(b) A hungry mouse wants to eat all 4 fruits in a maze with b x h squares (Figure Q1), in as few moves as possible. At each turn the mouse can move any number of squares in one of the following directions: up, down, left or right. However, the mouse is not allowed to enter (or jump over) any walls (i.e., the black squares). To eat a fruit, the mouse has to stop at that square.

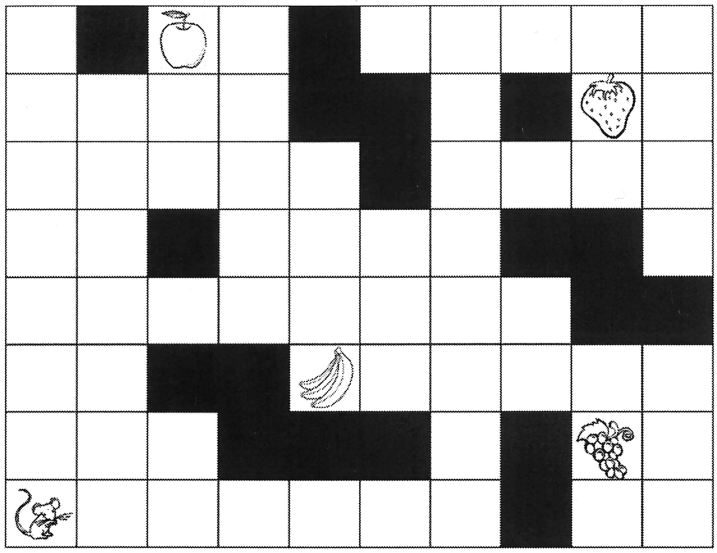

Figure Q1

Give a suitable representation of the states in this searching problem.

(5 marks)

(c) A constraint satisfaction problem can be formulated as a search problem and then different search algorithms can be applied to find a solution. Explain the idea of constraint propagation and how it can reduce the number of nodes to be expanded.

(6 marks)

(d) Consider the flag-removing game played in turns by two players **A** and **B**. There are 7 flags. **A** plays first and **A** can remove 2 or 3 flags for his/her first move. At each later turn, the current player can remove 1, 2, or 3 flags with the constraint that the current player must remove at least F flags where F is the number of flags removed by the other player at the previous turn. This constraint holds only if the number of remaining flags is at least F; otherwise there is no constraint. The loser is the player who removes the last flag. The winner receives utility 1 and the loser receives utility -1.

Find the best initial move for player **A** by using minimax search. List the value of each node on the search tree.

(9 marks)

2. Figure Q2 shows a 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 A and the goal is G.

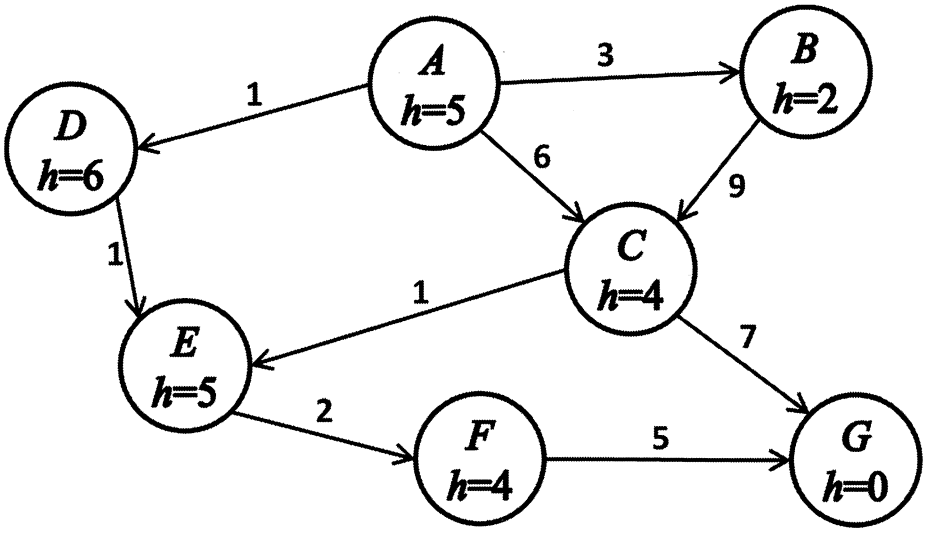

Figure Q2

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 add the node to the frontier 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. If a node is already in the frontier, do not add the node to the frontier again.

(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. If a node is already in the frontier, do not add the node to the frontier again.

(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. If you find a path to a node already on the frontier, update its cost (using the lower value) instead of adding another copy of that node to the frontier.

(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. If you find a path to a node already on the frontier, update its cost (using the lower value) instead of adding another copy of that node to the frontier.

(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. If you find a path to a node already on the frontier, update its cost (using the lower value) instead of adding another copy of that node to the frontier.

(7 marks)

3. (a) Decide, using truth table, whether the following sentences are valid, satisfiable or unsatisfiable:

(i) $\neg(A \wedge B) \Rightarrow C$

(3 marks)

(ii) $A \Rightarrow B \Rightarrow C$

(3 marks)

(b) Decide, using the equivalence rule, whether the following logical equivalences hold:

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

(2 marks)

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

(2 marks)

Note: Question No. 3 continues on Page 5

(c) A room is shared by Leo Messi and Christiano Ronaldo. Christiano works in the morning shift and Leo works in the night shift, so they never occupy the room at the same time. The room consists of TV, Aircon, Light and CCTV. Aircon and TV are only on when somebody is in the room regardless of who he is. It is assumed that there is always a person in the room. CCTV and Light are on at night only or when Messi is in the room.

(i) Translate the above knowledge into Propositional Logic.

(8 marks)

(ii) Prove that CCTV and Light cannot be on if Ronaldo is in the room.

(7 marks)

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

(i) $\neg(\forall x, Student(x) \Rightarrow Takes(x, AI))$

(2 marks)

(ii) $\neg(\forall x, Student(x) \wedge takes(x, AI) \Rightarrow pass(x, AI)$

(2 marks)

(iii) $\forall x, y, student(x) \wedge pass(x, y) \wedge subjet\_hard(y) \Rightarrow diligent(x)$

(2 marks)

(iv) $Subject\_hard(AI)$

(2 marks)

(v) $Pass(PaulPogba, AI)$

(2 marks)

(b) Convert the First Order Logic (FOL) sentences (i) to (vi) to canonical Conjunctive Normal Form (CNF).

(7 marks)

(c) Using your CNF sentences and resolution by refutation, show the steps that prove $diligent(PaulPogba)$.

(8 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.