

**NANYANG TECHNOLOGICAL UNIVERSITY**

**SEMESTER 2 EXAMINATION 2016-2017**

**CZ3005 – ARTIFICIAL INTELLIGENCE**

Apr/May 2017

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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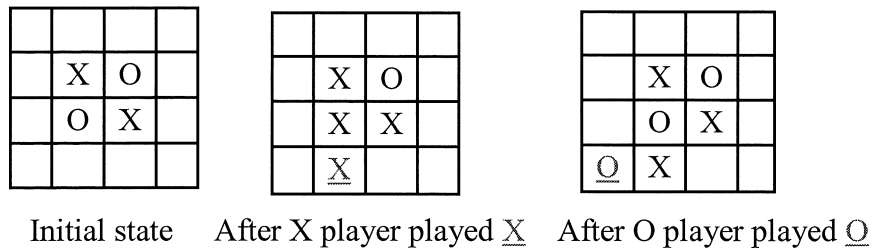
1. (a) A personal assistant agent will be designed to act as a companion to the elderly, reminding them of events and conversing with them like a human. The agent will run on smart phones or other mobile devices that have equipped with microphones and speakers. A knowledge base contains the scheduled events, collected questions and answers. The agent will remind the elder of an event in advance by talking to him/her; answer his/her questions; and ask him/her questions after a long period of silence.
  - (i) Describe the personal assistant agent in terms of its goals, environment, actions, and sensors (or percepts).  
(5 marks)
  - (ii) Briefly explain whether or not the environment is accessible, deterministic, episodic, static, and discrete.  
(5 marks)

Note: clearly state your assumptions when answering the above questions, if any.

Note: Question No. 1 continues on Page 2

- (b) Othello 4 is a two-player game. A player can place a new piece in a position if there exists at least one straight (horizontal, vertical, or diagonal) occupied line between the new piece and another piece of the same kind, with one or more contiguous pieces from the opponent player between them. After placing the new piece, the pieces from the opponent player will be captured and become the pieces from the same player. The player with the most pieces on the board wins.

Assuming X player plays first, Figure Q1b1 shows the play after the first move from each player.



**Figure Q1b1**

A heuristics for X player is proposed as follows:

For any non-terminal game state, the evaluation function is computed as

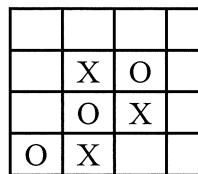
$$3(-O_C) + 2(X_b - O_b) + (X_m - O_m)$$

where  $X_C$  is the number of X's at corners,

$X_b$  is the number of X's at the border (excluding corners),

$X_m$  is the number of X's in the middle of the grid, and

$O_C$ ,  $O_b$  and  $O_m$  are the number of O's at the corners, the border and the middle of the board respectively.



**Figure Q1b2**

- (i) Figure Q1b2 shows the state where X player considers to play. Show the game tree up to depth 2 starting from this state. Indicate on the game tree the evaluation values of all the nodes at depth 2.

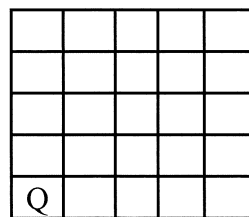
(5 marks)

Note: Question No. 1 continues on Page 3

- (ii) Let X player be the MAX, O player be the MIN. Use the MiniMax algorithm to derive the backed-up values for the nodes at depth 1 and 0 respectively. Determine the best move for the X player.

(4 marks)

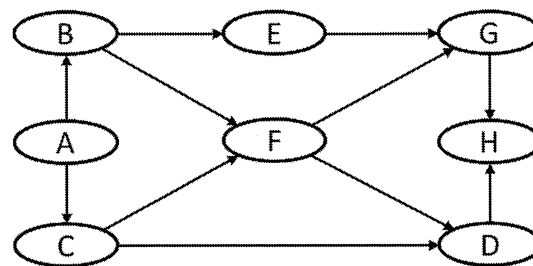
- (c) The Five Queen Puzzle is the problem of placing five chess queens on a 5 x 5 chess board so that no two queens attack each other. A solution requires that no two queens share the same row, column, or diagonal. Based on the initial state given in Figure Q1c, show the entire search tree with the constraint propagation heuristics to find all the solutions.



**Figure Q1c**

(6 marks)

2. (a) Figure Q2a shows the state space of a search problem. The directed arcs from a node represent successors of the node. The initial state is A and the goal state is H.



**Figure Q2a**

- (i) Perform breadth-first search to find a solution path. State clearly the search steps. (1) List the nodes in the order they would be expanded in each step; (2) list the nodes that lie along the final path to the goal state; (3) state the number of nodes generated and the number of nodes expanded. If there are ties, expand nodes in alphabetical order.

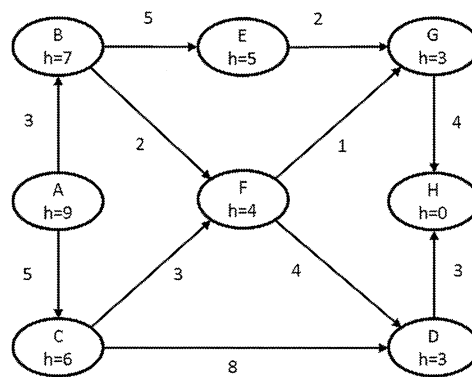
(4 marks)

Note: Question No. 2 continues on Page 4

- (ii) Perform depth-first search to find a solution path. State clearly the search steps. (1) List the nodes in the order they would be expanded in each step; (2) list the nodes that lie along the final path to the goal state; (3) state the number of nodes generated and the number of nodes expanded. If there are ties, expand nodes in alphabetical order.

(4 marks)

- (b) Figure Q2b shows the state space of a search problem. The directed arcs from a node represent successors of the node. The initial state is A and the goal state is H. The number on an arc is the cost moving from the start node to the end node. The value of the heuristic function  $h$  is given inside each node.



**Figure Q2b**

- (i) Perform uniform-cost search to find a solution path. State clearly the search steps with the  $g$ -cost values. (1) List the nodes in the order they would be expanded in each step; (2) list the nodes that lie along the final path to the goal state; (3) state the number of nodes generated and the number of nodes expanded.

(6 marks)

- (ii) Perform greedy search to find a solution path. State clearly the search steps. (1) List the nodes in the order they would be expanded in each step; (2) list the nodes that lie along the final path to the goal state; (3) state the number of nodes generated and the number of nodes expanded.

(5 marks)

- (iii) Perform A\* search to find a solution path. State clearly the search steps with the  $f$ -cost values. (1) List the nodes in the order they would be expanded in each step; (2) list the nodes that lie along the final path to the goal state; (3) state the number of nodes generated and the number of nodes expanded.

(6 marks)

3. (a) A rule based system employs an inference procedure to extract new knowledge in the form of facts or production from the rule base. Briefly describe the organizational structure and operation of the rule based system and map this to the cognitive structure of human cognition.

(7 marks)

- (b) When more than one production rule is matched for firing, describe the strategies to de-conflict these rules. State the rationale supporting each of these strategies.

(7 marks)

- (c) An inference procedure possesses the soundness and completeness properties.

- (i) Briefly describe these 2 concepts and state 2 inference procedures that are both sound and complete.

(4 marks)

- (ii) State the proof procedure that is used in Prolog rule based system such that it is sound and complete.

(3 marks)

- (d) Use a sound and complete inference procedure stated in your answer to Q3c(i) to show if the following logical statement is TRUE.

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

(4 marks)

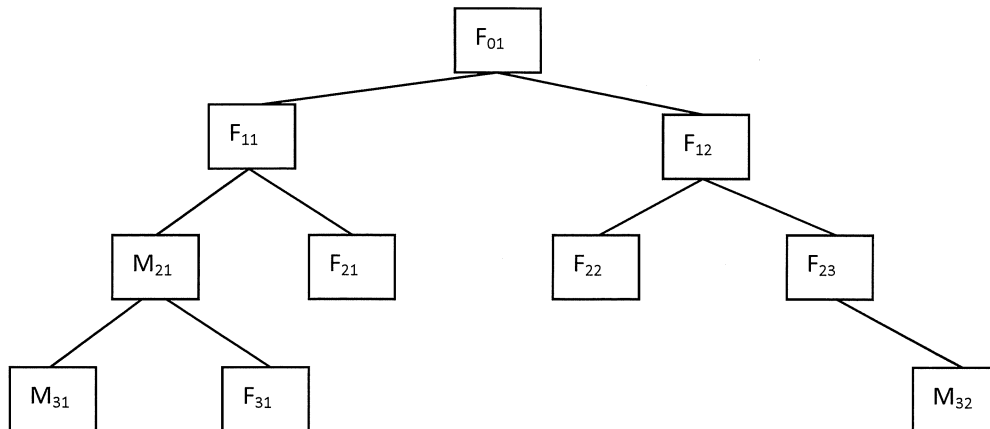
4. (a) The Minangkabau ethnic group in the Western Highlands of Sumatra is a Matrilineal society where the properties, family name and land are passed down from mother to the eldest surviving daughter in the family. This is passed down the male line only if there is no surviving female along that line of succession. Define the predicates needed to describe the family relationship and hence using this to define the inheritance rule for such a society.

(7 marks)

Note: Question No. 4 continues on Page 6

- (b) Translate these rules stated in your answer to Q4a into Conjunctive Normal Form (CNF).

(4 marks)



**Figure Q4c A typical Minangkabau family tree**

- (c) Figure Q4c shows a Minangkabau family tree, where M and F are used to represent males and females respectively and the subscripts are used to denote the person. The order of birth is from left to right of each branch of the family; for example:  $F_{11}$  is older than  $F_{12}$ .

- (i) Using the land ownership rules and the knowledge embedded in the Minangkabau family tree, write the knowledge base in CNF. Hence, by refutation proof, determine the sequence of land ownership from the head of the household,  $F_{01}$ .

(8 marks)

- (ii) Given that the female descendants  $F_{21}$  and  $F_{22}$  are dead as a result of an infection during childhood, determine using refutation proof the new order of land ownership in this Minangkabau family.

(6 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.