NANYANG TECHNOLOGICAL UNIVERSITY

SEMESTER 2 EXAMINATION 2015-2016

CZ3005 – ARTIFICIAL INTELLIGENCE

CSC304 – AI AND INTELLIGENT SYSTEMS

Apr/May 2016 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 of the statements is TRUE or FALSE.

(i) When the environment is such that the agent can obtain new information from its sensors before acting, the agent faces a contingency problem.

(1 mark)

(ii) Backward checking can reduce the branching factor of the search by propagating the consequences of the partial assignments that it constructs.

(1 mark)

(iii) The least constraining-value heuristic helps the search algorithm to decide on the order in which to examine the possible values of a variable. It prefers the value that rules out the fewest choices for the neighbouring variable in a constraint graph.

(1 mark)

(iv) An autonomous agent does not rely entirely on built-in knowledge about the environment.

(1 mark)

Note: Question No. 1 continues on Page 2

(b) You are given the task to develop an intelligent house that is aware of a person entering and exiting the house. It reacts to the person's need based on built-in sensor that can measure his/her body temperature, outside temperature, his/her location, and light intensity in the house. The intelligent house has full control of the lights, fans, and air-conditioner.

Describe the agent's environment. Briefly explain whether or not the environment is *(fully) observable*, *deterministic*, *episodic*, *static*, and *discrete*. (Hint: Clearly state your assumptions when answering the question)

(11 marks)

(c) In the jealous husbands problem, three married couples must cross a river using a boat that carries at most two people, under the constraint that no woman can be in the presence of another man unless her husband is also present. Moreover, for both river banks, there cannot be both women and men present with women outnumbering men. The boat cannot cross the river by itself with no one on board. There can be at most two persons on the boat.

Provide a suitable definition of states and operators for the jealous husbands problem. Show a sequence of operators yielding a possible solution (i.e., the solution does not need to be optimal).

(10 marks)

2. (a) For a cryptarithmetic problem, each letter stands for a distinct digit. The objective is to find a substitution of digits for letters such that the resulting sum is arithmetically correct, with the added restriction that no leading zeros are allowed (e.g., for the problem below, O and T cannot be substituted with zeros).

Solve the cryptarithmetic problem:

ONE + ONE = TWO

using **backtracking**, **forward checking**, and the **minimum remaining values** and **least-constraining-value** heuristics. State all the constraints and variables used. **Only one solution is needed.** (Hint: There are 16 solutions for this problem.)

(13 marks)

Note: Question No. 2 continues on Page 3

(b)

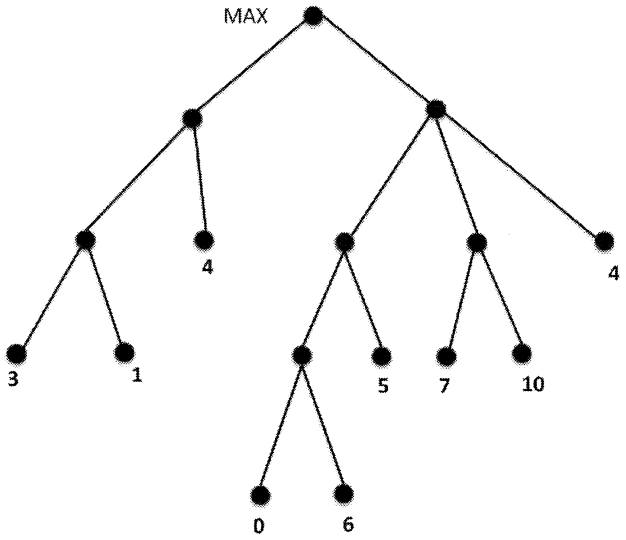

Figure Q2

(i) Apply **Minimax algorithm** on the game tree shown in Figure Q2.

(2 marks)

(ii) Apply **Alpha-Beta pruning algorithm** on the game tree in Figure Q2 from left to right.

(3 marks)

(iii) Apply **Alpha-Beta pruning algorithm** on the game tree in Figure Q2 from right to left. Compare your solution to the solution in Q2(b)(ii). Is there any difference in the pruning? Explain your answer briefly.

(7 marks)

3. (a) The design of a Knowledge Based System (KBS) differs from the typical procedural algorithms. The inference engine and the knowledge content are separated. The knowledge is declared and new knowledge is deduced using the inference system in the KBS. Briefly explain using a block diagram the organisation of such a declarative structure. Relate this structure to the cognitive reasoning system in human. How can such a structure address the rule conflict resolution problem found in declarative knowledge?

(10 marks)

Note: Question No. 3 continues on Page 4

(b) Prolog is a non-procedural language commonly associated with the formulation of knowledge in an expert system. Explain the working of Prolog and the mechanism used in the resolution of rule conflicts.

(8 marks)

(c) Given the following assertions in a prolog knowledge base; show the detailed trace of the inference in the entire solution space to prove the goal "p". Explain the mechanism in prolog that ensures the inference procedure is *sound* and *complete*.

```
p:- q.
q:- r.
r:- s.
s:- j.
s:- h.
j.
h.
```

(7 marks)

4. (a) The Maori people in New Zealand is a tribal society. The land ownership is usually passed down along the first born male or along the order of male off-springs in the family if the first born is not a male. This line of ownership will be disrupted when there is no male descendent and has to be passed down the female line in the order of birth. Define the land ownership rules in the Maori family using first order logic expressed in terms of HORN clauses. State the predicates needed to describe the knowledge base. (Hint: Need to recursively discover the land ownership along the male and female lines of birth.)

(7 marks)

(b) Translate the rules defined in Q4(a) into Conjunctive Normal Form (CNF).

(4 marks)

Note: Question No. 4 continues on Page 5

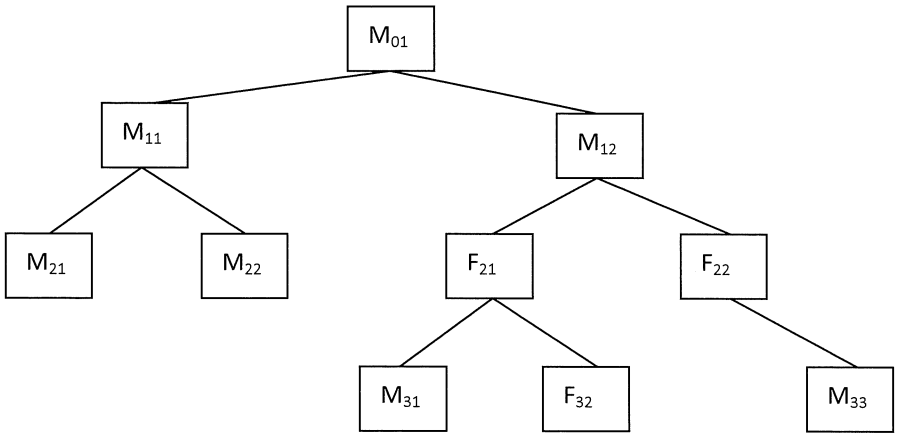

Figure Q4 Maori Family Tree

(c) Figure Q4 shows a Maori family tree, where M and F are used to represent males and females respectively and the subscripts are used to denote the person.

(i) Using refutation proof on the rules defined in Q4(b) and the knowledge embedded in the family tree, determine the sequence of land ownership from the head of the household, M_{01}. Show the MGU at each level.

(8 marks)

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

(6 marks)

END OF PAPER

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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.