CZ3005

NANYANG TECHNOLOGICAL UNIVERSITY

SEMESTER 2 EXAMINATION 2018-2019

CZ3005 – ARTIFICIAL INTELLIGENCE

Apr/May 2019   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)   What is meant by search algorithm optimality?

(5 marks)

(b)   How many states can be represented by eight variables, each of which can take four values?

(5 marks)

(c)   Consider two admissible heuristics h_1 and h_2. Which one of the following options would yield a better heuristic for use with A*? Briefly explain your answer.

(i) $\min(h_1; h_2)$
(ii) $\max(h_1; h_2)$
(iii) $h_1 + h_2$
(iv) A* will have the same performance in all cases.

(5 marks)

(d)   What node(s) is/are in the frontier of a depth-first search? Where b is the maximum branching factor and d is the maximum depth of the search, characterize the maximum size of a DFS frontier.

(5 marks)

(e)   Consider the search problem represented in Figure Q1e below, where a is the start node and f is the goal node. Would you prefer DFS or BFS for this problem? Why?

(5 marks)
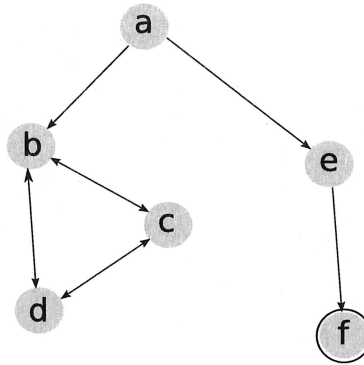
Figure Q1e

2.   (a)   State the condition under which an arc $<X; r(X; Y)>$ is arc consistent.

(3 marks)

(b)   On the constraint network in Figure Q2b, cross out those values for each variable that are removed by running arc consistency. Draw the network on your answer script and indicate which arc has been used to delete each value. For example, if you have the arc labeled $(X<Y)$ and this causes the value *Val1* to be removed from the domain of variable X, you write: Arc $<X, Y>$ removes *Val1* from X. If arc $(Y>X)$ is used to remove *Val2* from the domain of variable Y, you write Arc $<Y, X>$ removes *Val2* from Y. Do not do any domain splitting.

(10 marks)

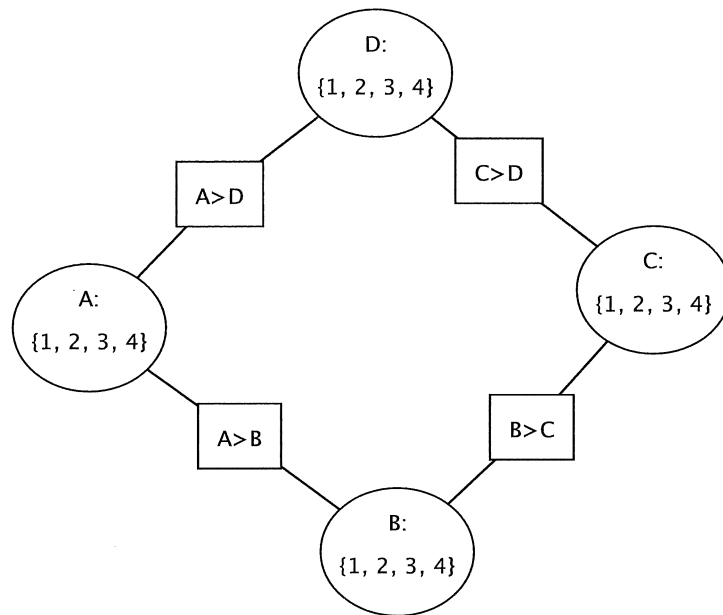Note: Question No. 2 continues on Page 3

Figure Q2b

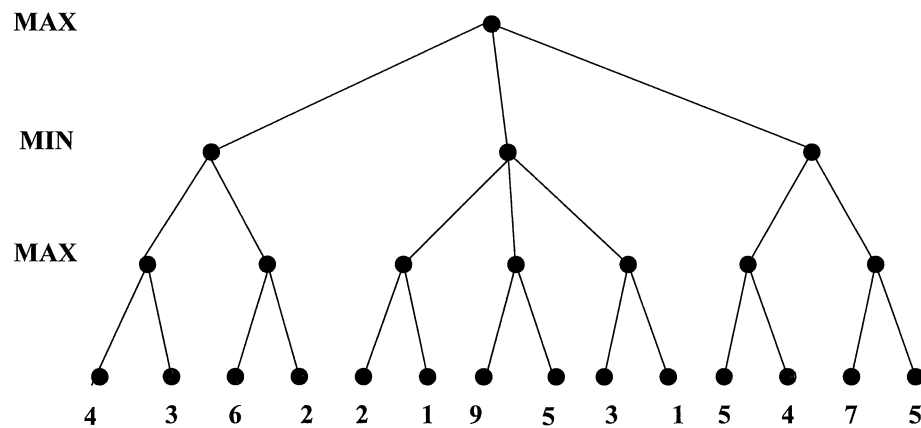(c)   Consider the minimax tree in Figure Q2c:

Figure Q2c

What is the minimax value for the root? Assume children are visited left-to-right. Put a cross mark (X) on the nodes that will be pruned by alpha-beta pruning (please redraw the tree on your answer sheet).

(12 marks)

3. (a) Knowledge are usually expressed as associations using rules, for example, decision trees, rule base system or fuzzy rules. The use of production rule system allows such knowledge to be declared and not hardcoded as in decision trees or procedural algorithms. The design of a Knowledge Based System (KBS) differs from the typical procedural algorithms; whereby the inference engine and the knowledge content are separated.

(i) Briefly explain using a block diagram the organisation of such an implementation. Relate this structure to the cognitive reasoning system in human.

(3 marks)

(ii) Typically, first order logic is used to represent such production rules. Explain the rationale for their use in terms of expressiveness, soundness and completeness.

(4 marks)

(iii) Explain the concept of rule conflict. What sort of meta strategies can be applied to resolve this problem?

(3 marks)

(b) Prolog is a declarative language that allows the expression using first order logic to represent production rules as the formulation of knowledge in an expert system. Explain the working of Prolog and the mechanism used in Prolog to handle the resolution of rule conflicts that ensures the inference procedure is *sound* and *complete*.

(5 marks)

(c) Fuzzy rule based system allows the representation of if-then rules using fuzzy membership to express a degree of belongingness to a concept such as age, height, speed, etc.

(i) Briefly explain the fuzzy rule system in terms of the antecedent and conclusion linguistic labels and their fuzzy operation to derive a fuzzy decision.

(3 Marks)

(ii) A fuzzy system is used to recommend exercise regimes for geriatric rehabilitation. It is described using 2 fuzzy rules as follows:

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R1:   If   Age is OLD and Health is WEAK
       then   Exercise is SIMPLE

R2:   If Age is MODERATE and
              Health is EXCELLENT
       then   Exercise is MODERATE.

Such a fuzzy system can be implemented using a neural network as a fuzzy neural system. Using the information in the 2 rules draw the fuzzy neural network topology needed to implement this fuzzy system.

(4 marks)

(iii)   Briefly explain how the fuzzy inference can address the rule conflict issues in traditional first order logic production rule based system.

(3 Marks)

4.   (a)   The Mosuo people in Yunnan, China is a tribal society. This is the most famous matrilineal society. Lineage is traced through the female side of the family and all agricultural or business holdings are also passed down along the same matriline that is along the first-born female or along the order of females off-springs in the family if the first born is not a female. This line of ownership will be disrupted when there is no female descendent in the current branch and has to be passed down the female line in another branch along the order of birth. Define the landownership rules in the Mosuo 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 landownership along the male and female line of birth.]

(7 marks)

(b)   Translate the landownership rules in Question 4(a) into Conjunctive Normal Form (CNF).
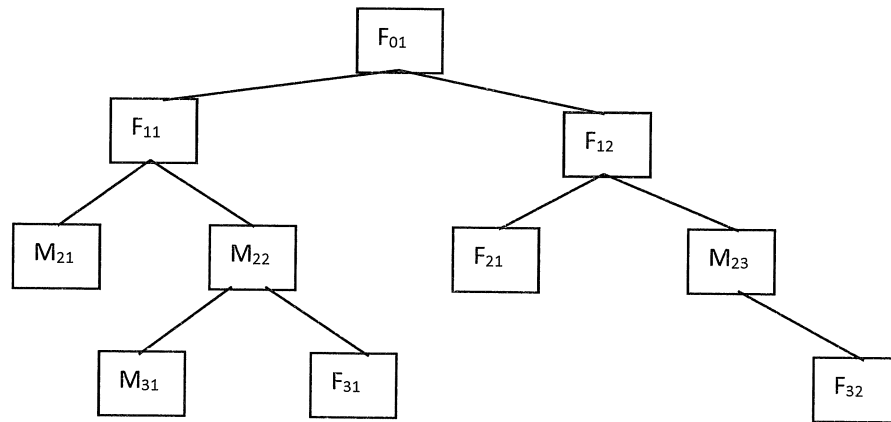
(4 marks)

Figure Q4: Mosuo Family Tree

(c)　　Figure Q4 shows a Mosuo family tree, where M and F are used to represent males and females respectively and the subscripts are used to denote the person. Using the landownership rules and the knowledge embedded in the family tree, write the knowledge base in CNF.

　　　　(i)　　Using refutation proof determine the sequence of landownership from the head of the household, F_{01}. Show the MGU at each level.

(8 marks)

　　　　(ii)　　Given that the female descendant F_{31} is dead as a result of an infection during childhood; determine using refutation proof the new order of landownership in this Mosuo 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.