NANYANG TECHNOLOGICAL UNIVERSITY

SEMESTER 2 EXAMINATION 2017-2018

CZ3005 – ARTIFICIAL INTELLIGENCE

Apr/May 2018 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) Explain why the following statement is true or false: "In order to pass the Turing test, a computer would have to behave at least as rationally as a human."

(5 marks)

(b) State the five elements that characterise a search algorithm.

(5 marks)

(c) Consider a complete binary search tree with finite depth d, and with only one goal, which is at depth $k < d$. The search begins at the root node (let's call this node's depth 1). In the best case, how many nodes would be expanded by breadth-first search and depth-first search (including the goal node)?

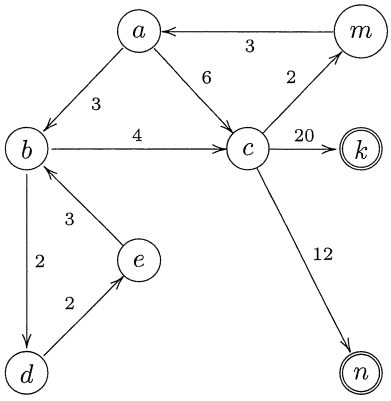
(5 marks)

(d) Give the definition of an admissible heuristic.

(5 marks)

Question Q1 continues on page 2.

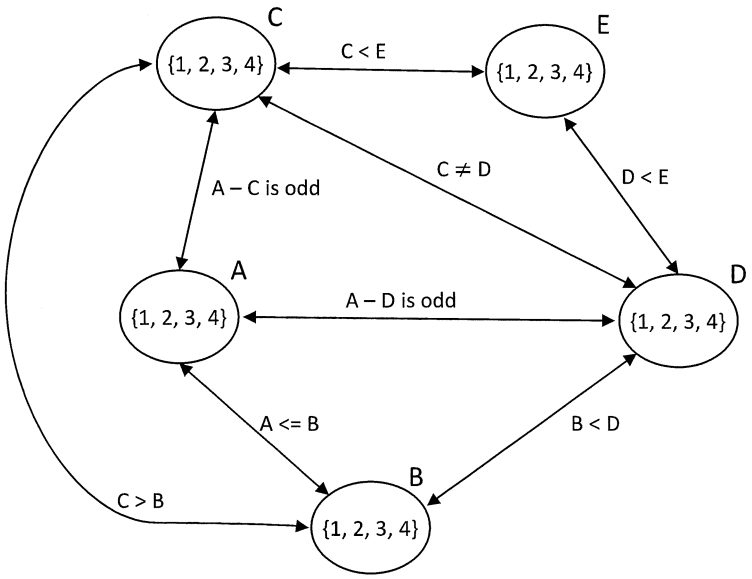
(e) Consider the following directed graph where a is the start node and k and n are both goal nodes, the true cost function is given by the edge labels, and h is an admissible heuristic function. Assuming that ties are broken alphabetically, what paths are returned by A* and branch-and-bound? What are their associated costs?



$node$	$h(node)$
a	16
b	16
c	11
d	20
e	18
k	0
m	2
n	0

(5 marks)

2. (a) Consider a constraint satisfaction problem (CSP) with five variables, A, B, C, D, and E, each with domain {1, 2, 3, 4}. We have eight constraints: A ≤ B; A - C is odd; C > B; A - D is odd; B < D; C ≠ D; C < E; D < E. This CSP is depicted in the following constraint network:



Question Q2 continues on page 3.

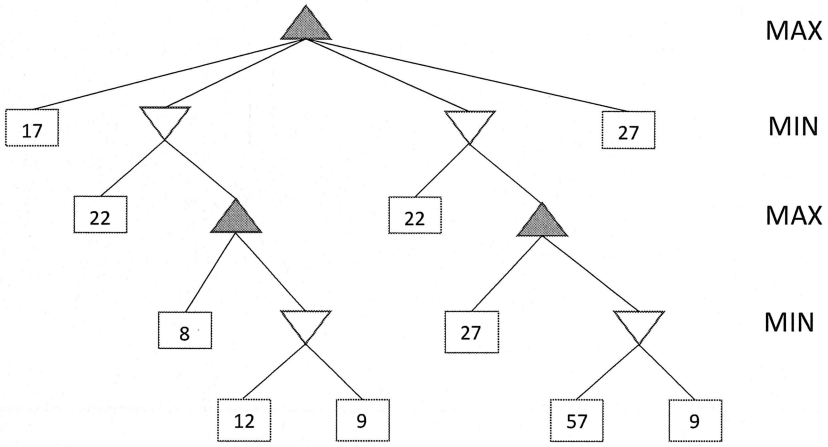
(i) On the constraint network above, cross out those values for each variable that are removed by arc consistency. In the space below, indicate which arc has been used to delete each value. For example, if you have the arc labeled ($X<Y$) and this causes the value *Val1* to be removed from the domain 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.

(8 marks)

(ii) Does this CSP have a solution? Either give a solution or explain why it does not have one.

(5 marks)

(b) Consider the following minimax tree:



(i) 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.

(7 marks)

(ii) Is there another ordering for the children of the root for which more pruning would result? If so, state the order.

(5 marks)

3. Fuzzy rule representation is a useful approach for the description of relationships between a set of variables.

(a) Briefly describe the types of membership function commonly used for fuzzy rules.

(5 marks)

(b) With the aid of a block diagram show the operation of a fuzzy rule system. State how the fuzzy inference process overcomes the rule conflict resolution when multiple fuzzy rules are matched.

(5 marks)

(c) With the help of a block diagram, describe the implementation of a fuzzy rule system using artificial neural networks. Briefly describe the operation of the node in each layer and how they implement a Mamdani type fuzzy rule using the compositional rule of inference. Describe the learning steps needed to construct such a fuzzy rule system from the observation of a set of variables.

(15 marks)

4. (a) Given an empty knowledge base show the necessary proof steps that (A=>B) $\vee$ $\neg$ (A=>B) is a valid sentence using resolution as the inference rule. State your assumption (if any).

(4 marks)

(b) Without using refutation, what other complete proof procedure can be applied to show the validity of the above sentence; namely: (A=>B) $\vee$ $\neg$ (A=>B). Show the steps and state the limitation of the technique.

(4 marks)

(c) In production rule systems, there are possibilities of multiple matching of rules. State the strategies for handling such rule conflict. What is the strategy adopted in Prolog to handle such rule conflict?

(5 marks)

Question Q4 continues on page 5.

(d) Explain what is dependency directed backtracking used in Prolog for the search of an AND-OR tree in a refutation proof. Use the example given below to demonstrate the search for all possible solutions to the refutation of p(X).

```
r(a).
r(c).

s(a).
s(b).

p(c).

q(a).
q(b).
q(c).

p(X):- s(X), r(X).
r(X):- q(X).
```

Show the proof by translating the above example into Conjunctive Normal Form (CNF) and using resolution as the inference procedure for p(b).

(12 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.