EE3-16

IMPERIAL COLLEGE LONDON

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING
EXAMINATIONS 2016

EEE/EIE PART III/IV: MEng, BEng and ACGI

ARTIFICIAL INTELLIGENCE

Corrected copy

Friday, 9 December 9:00 am

Time allowed: 3:00 hours

There are FIVE questions on this paper.

Answer FOUR questions.

All questions carry equal marks

Any special instructions for invigilators and information for candidates are on page 1.

Examiners responsible	First Marker(s) :	P. Petruzzi
	Second Marker(s) :	T-K. Kim

1. a) Briefly describe the operation of the depth-first, depth-limited depth-first and iterative deepening depth-first search algorithms.

[3]

b) Compare and contrast the performance of the three algorithms with respect to appropriate criteria.

[3]

c) The Fibonacci sequence are the numbers in the following integer sequence: 0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144... By definition, the first two numbers in the Fibonacci sequence are 0 and 1, and each subsequent number is the sum of the previous two. In mathematical terms, the sequence F_n of Fibonacci numbers is defined by the recurrence relation:

$$F_n = F_{n-1} + F_{n-2}$$

and

$$F_0 = 0,\ F_1 = 1.$$

Write a Prolog program which, given an integer computes all the Fibonacci numbers until zero, i.e.:

```
?- fibonacciN(5,X).
X = [5, 3, 2, 1, 1, 0]
```

[4]

d) An Uber driver wants to ride John, Anna, and James from A to C, stopping at B. They all want to stop together at B before going to C.
If left unsupervised at A or C, John will argue with Anna and Anna will argue with James. They all behave when the driver is present.
When they are at B they behave differently. If left unsupervised there, John will argue with James and Anna will argue with John. Again, they all behave nicely to each other when the driver is present. There is only room for one passenger in the car.

Formulate the problem so that the General Graph Search Engine (GGSE) can be used to find a plan where all the people can go from A to C and have a pleasant trip.

i) The state representation.

ii) The start state.

iii) The goal state.

iv) The state-change rules.

A solution to the problem is not required.

[10]

2. a) Briefly describe the operation of the uniform-cost, best-first and A* search algorithms.

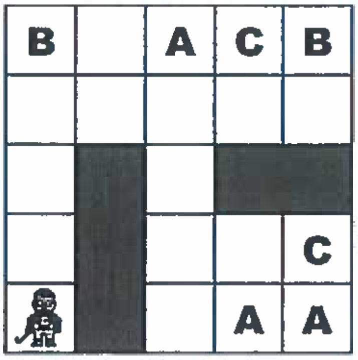
[4]

b) Compare and contrast the performance of the three algorithms with respect to appropriate criteria.

[4]

c) Capture the aliens. There are three kinds of aliens, each one defined by a, b and c. The position of the aliens is fixed (do not move). Gordon Freeman is trying to capture at least one alien of each type by moving onto the positions where the aliens sit: the game ends when he has captured at least one a, one b and one c alien (though Gordon may capture more than one alien of the same kind). Gordon has four actions: move up, down, left or right. The number of aliens are specified by A, B and C respectively, and the dimensions of the board are N by M.

Questions:



A = 3, B = 2, C = 2, N = 5, M = 5

i) Give a state representation. Specify the domain of each variable in your state space.

ii) Approximate the size of the state space.

iii) Analyse the branching factor of the search problem.

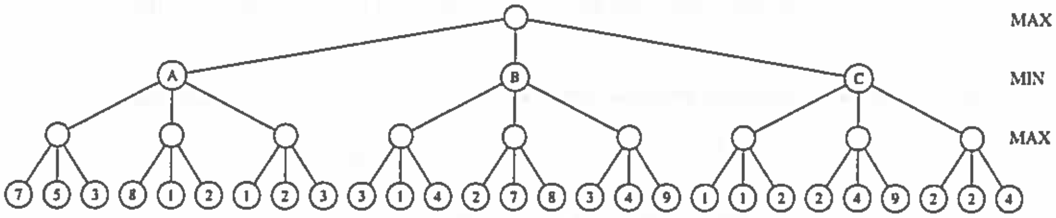
iv) Assuming that Gordon Freeman starts in the position (x,y), what is the initial state?

v) Define a goal state for the problem.

vi) Give one admissible heuristic and one not admissible heuristic.

[12]

3. The figure below is the game tree of a two-player game. The first player is the maximiser and the second player is the minimiser. Apply the AlphaBeta algorithm to the tree to answer the following questions:



a) What is the final value of this game? [4]

b) Is the final value of β at the root node $+\infty$?
(After all children nodes have been visited) [4]

c) What is the final value of β at the node labeled A?
(After all of A's children nodes have been visited) [4]

d) Will any nodes under B be pruned? [2]

e) Will any nodes under C be pruned? [2]

f) What value will B return to its parent? [2]

g) What value will C return to its parent? [2]

4. a) In the context of automated reasoning, define the term resolution, specify the resolution rule, and explain its relevance to logic programming.

[4]

b) In the context of automated reasoning, define the term unification, specify a unification algorithm, and explain its relevance to logic programming.

[4]

c) Consider the following statements:

If he flies like Superman and he looks like Superman, then he is Superman.

If he levitates, then he flies like Superman.

If he wears a cape, then he looks like Superman.

If one person wears a cape, and a second person wears something similar, then the second person wears a cape.

Express these four statements as formulas of First Order Predicate Logic, and translate them into clausal form.

[4]

d) Consider the following facts:

Batman wears a cape.

Clark Kent levitates.

Clark Kent wears something similar to Batman.

Express these facts in clausal form.

[2]

e) Prove, using resolution and showing the unifiers, that *Clark Kent is Superman.*

[6]

5. a) Specify a syntax for well-formed formulas of propositional modal logic. Define a model which can be used to give a semantics for well-formed formulas of modal logic.

[5]

b) Consider the following axiom schema. State the frame condition for the corresponding class of models:

i) $\Box p \rightarrow p$

ii) $p \rightarrow \Box\Diamond p$

iii) $\Box p \rightarrow \Box\Box p$

iv) $\Box p \rightarrow \Diamond p$

[4]

c) Using the KE calculus for propositional modal logic, prove that the following formulas are all theorems of modal logic S5:

i) $\Diamond\Box p \rightarrow \Box p$

ii) $\Diamond\Diamond p \rightarrow \Diamond p$

[4]

d) Describe the Beliefs-Desires-Intentions (BDI) Agent architecture. Include a description of each of the BDI modules and how it is related to planning and reasoning.

[7]