UNIVERSITY OF LONDON

GOLDSMITHS COLLEGE

B. Sc. Examination 2012

Computing

IS53024A Artificial Intelligence

Duration: 2 hours and 15 minutes

Date and time:

There are five questions in this paper. You should answer no more than three questions. Full marks will be awarded for complete answers to a total of three questions. Each question carries 25 marks. The marks for each part of a question are indicated at the end of the part in [.] *brackets.*

There are 75 marks available on this paper.

Electronic calculators must not be programmed prior to the examination. Calculators which display graphics, text or algebraic equations are not allowed.

THIS PAPER MUST NOT BE REMOVED FROM THE EXAMINATION ROOM

Question 1

(a) Explain what is meant by terms (i) *search* and (ii) *toy problem* in the context of Artificial Intelligence. Give an example to demonstrate your understanding of these two terms. [4]

(b) Define a *rational agent* in the context of Artificial Intelligence. [3]

(c) Draw a schematic diagram of a *Model-Based Reflex* Agent and highlight the characteristics of such an agent. [7]

(d) What is the main distinguishing concept in the operation of a rule-based system compared to the conventional von Neumann computational processing systems? [3]

(e) Explain briefly the three operational phases of a rule-based system. [3]

(f) Give the forward chaining algorithm used in rule-based systems. [5]

Question 2

Consider the 3-Puzzle problem and the problem instance where the initial state is $\begin{array}{|c|c|}\hline 1 & \\ \hline 2 & 3 \\ \hline \end{array}$ and the goal state is $\begin{array}{|c|c|}\hline 3 & 2 \\ \hline 1 & \\ \hline \end{array}$.

(a) Write down, as specifically as possible, the problem definition for the instance in terms of (i) states, (ii) actions, (iii) transition models, (iv) goal tests and (v) path costs. Provide an example for each of the terms. [10]

(b) Demonstrate the differences between the search tree that is constructed applying the depth-first algorithm using the Tree-Search approach and that using the Graph-Search approach. Show all your work. [10]

[Hint:] You may draw only part of the search trees if the trees are too large. However, you should include (and highlight) at least *one* complete path that leads to the goal state in the search trees.

(c) Explain and demonstrate how the number of misplaced titles can be used as a heuristic for applying the A* algorithm to find an optimal solution to the instance of the problem. [5]

Question 3

Consider a simple game of two players A and B who eat alternately an imagined *bar of* 2×2 *chocolate squares* as shown below including one "poisonous" piece (marked "P"): 

Assume that player A moves first. Each player may choose at least one of the remaining squares of the chocolate. She or he may, however, eat this piece together with the piece below, and/or the piece to the right of the chosen square (but never the one above nor to the left). The player who has to eat the poisonous piece (marked by "P") loses the game.

Answer the questions below and show all your work with a brief explanation of any notation used.

(a) Describe, as specific as possible, the problem instance in terms of states. Draw diagrams to show all its possible states. [5]

(b) Draw a partial (or complete) game tree to demonstrate the characteristics of the game using the Tree-Search Algorithm. [8]

(c) Draw diagrams to demonstrate how Minmax algorithm may be applied to the game tree to find an optimal solution. Explain how the utility and minmax values are computed. [7]

(d) Explain briefly the technique of pruning. Demonstrate how the alpha-beta pruning technique may be applied to the game tree to avoid exploration of part of the search tree. Draw the game tree after pruning and show all your work. [5]

Question 4

(a) Define the notion of a version space in context of symbolic machine learning. [3]

(b) Define and explain the cover predicate in context of symbolic machine learning. [4]

(c) When a generalisation is contained in a version space? [3]

(d) Let a concept description language with 4 attributes be given for symbolic machine learning. Suppose that these attributes can take the following values:

```
     r              q              d              t
 ---------      ------         ---------      -------
|    |    |    |     |        |    |    |    |     |
p    l    m    b     u        a    c    f    h     x
```

Perform training with the candidate elimination algorithm using the following positive and negative training examples:

```
1. ( p b f h ) +)
2. ( l u f x ) -)
3. ( p u a h ) +)
4. ( m b c h ) -)
5. ( p b c x ) -)
```

Demonstrate the changes of the boundary sets after learning each example. [15]

Question 5

Let a neural network with two hidden nodes and one output node be given. All nodes use the sigmoidal activation function. The initial weights on connections from input x1 to the first and second hidden nodes are w11 and w21, and these on connections from input x2 are w12 and w22. The connection from the first hidden node toward the output is weighted by w3, and the connection from the second hidden node to the output is w4. Demonstrate training of this neural network with the backpropagation training algorithm using input vector (x1,x2), desired output t, and learning rate n.

(a) Perform a forward pass and compute the hidden node outputs as well as the network output. [6]

(b) Perform a backward pass and update weights w3 and w4. [5]

(c) Continue the backward pass and update weights w11, w21, w12 and w22. [14]