ECS629U   **Artificial Intelligence**   Duration: $2\frac{1}{2}$ hours

YOU ARE NOT PERMITTED TO READ THE CONTENTS OF THIS QUESTION PAPER UNTIL INSTRUCTED TO DO SO BY AN INVIGILATOR.

Instructions: This paper contains FOUR questions. **Answer ALL questions**.
Cross out any answers that you do not wish to be marked.

Calculators are permitted in this examination. Please state on your answer book the name and type of machine used.

Complete all rough workings in the answer book and cross through any work that is not to be assessed.

Possession of unauthorised material at any time when under examination conditions is an assessment offence and can lead to expulsion from QMUL. Check now to ensure you do not have any notes, mobile phones, smartwatches or unauthorised electronic devices on your person. If you do, raise your hand and give them to an invigilator immediately.

It is also an offence to have any writing of any kind on your person, including on your body. If you are found to have hidden unauthorised material elsewhere, including toilets and cloakrooms it will be treated as being found in your possession. Unauthorised material found on your mobile phone or other electronic device will be considered the same as being in possession of paper notes. A mobile phone that causes a disruption in the exam is also an assessment offence.

Exam papers must not be removed from the exam room.

Examiners: Prof. S. Dixon and Dr S. Reis

Question 1

(a) Explain the difference between the views of "strong AI" and "weak AI".

[2 marks]

(b) In the context of artificial intelligence, what is the difference between "human" and "rational" actions? For each case, give an example of a situation where it would be advantageous for a system to be able to act this way.

[3 marks]

(c) What is a reflex agent? What is its major limitation?

[2 marks]

(d) Define the terms "goal-based agent" and "utility-based agent". List two advantages of utility-based agents over goal-based agents.

[4 marks]

(e) For search problems, a node is removed from the agenda, expanded, and its children are added to the agenda. What type of data structure (or queuing function) is associated with each of the following search algorithms:

  (i) Depth-first search

 (ii) Breadth-first search

(iii) Uniform cost search

[3 marks]

(f) Given the road map in Figure 1, use uniform cost search to find a route from Fagaras to Craiova. Show all working, including the agenda and node which is expanded at each step. You may abbreviate names of towns to their initial letter (e.g. F for Fagaras).
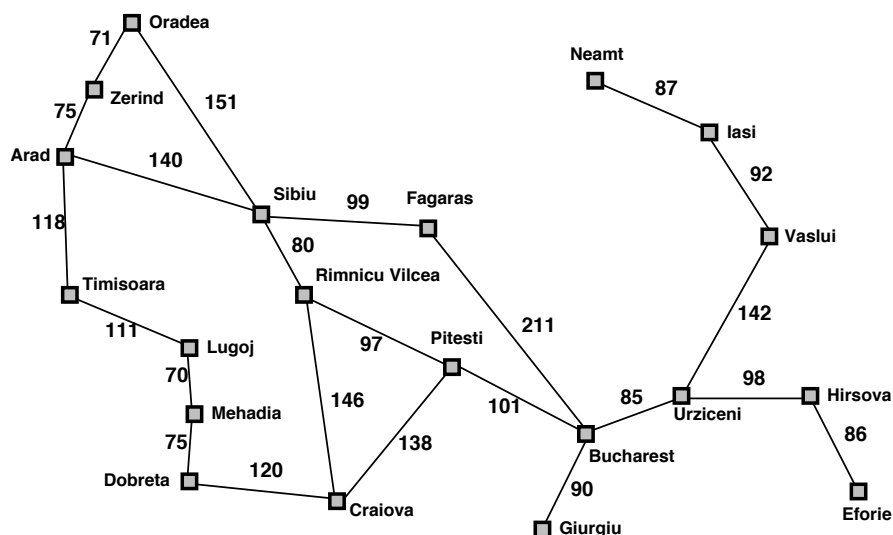

Figure 1: Road map showing roads and distances between towns.

[11 marks]

Question 2

(a) Consider the n-queens problem discussed in lectures: you are required to place *n* queens on an $n \times n$ chess board so that no pair of queens attack each other (i.e. no two queens share the same row, column or diagonal). Give a detailed description of:

  (i) your formulation of the problem

 (ii) the hill-climbing search algorithm applied to the problem.

[9 marks]

(b) How would you modify the algorithm from Part (a) above to use local beam search instead? How would you choose a suitable beam width?

[3 marks]

(c) What limitation of hill climbing does local beam search address? Name another approach aimed at solving this problem.

[2 marks]

(d) A two-player game has the following game tree for the last four moves. MAX tries to score the largest value and MIN the smallest one. It is MAX's turn to play.
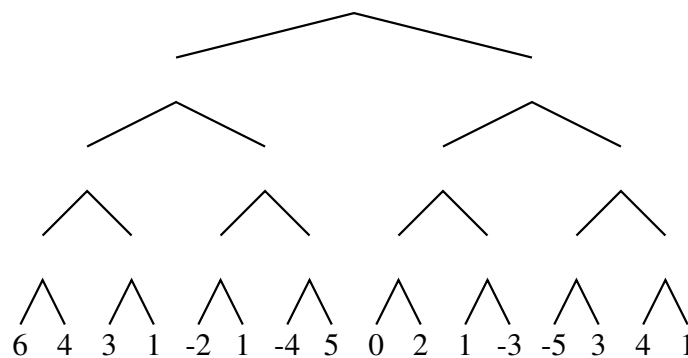
Use the minimax algorithm to calculate the value at each node of the tree. (You will need to copy the whole tree into your answer book.) What sequence of moves (left or right branch) is selected by each player at each level?

[5 marks]

(e) Simulate the execution of α-β pruning on the tree from Part (d), searching from left to right. Which branches are pruned and why? Refer to nodes by (*depth, position*), where *depth* is counted from the root (depth 1) and *position* from the left (also starting at 1). E.g. the second leaf, value 4, is at node (5,2).

[6 marks]

Question 3

(a) The table below contains some observations of the weather conditions on particular days and whether or not Mary rode her bike to university on that day. Using the ID3 algorithm, build a decision tree classifier which can predict whether or not Mary rides her bike given the weather conditions, based on the training data in the table. Make sure that you show and explain all working. Draw the resulting decision tree, and use it to determine whether Mary rides her bike when there is rain and snow but no wind.

Rain	Wind	Snow	RideBike
yes	yes	no	no
no	yes	no	yes
no	no	yes	yes
no	yes	yes	no
yes	yes	yes	no
yes	no	no	no
no	no	no	yes

[13 marks]

(b) Draw a diagram of a basic perceptron, and give the equation(s) relating its inputs, parameters and outputs.

[5 marks]

(c) Show how a single perceptron can implement each of the following:

(i) And gate

(ii) Or gate

[4 marks]

(d) Perceptron networks usually have a hidden layer of neurons. What is the main advantage and main disadvantage of using hidden layers?

[3 marks]

Question 4

(a) Using the two predicates *Parent*(x, y) (x is a parent of y) and *Female*(x) (x is female), for each of the following predicates, write a first order predicate calculus formula defining it:

   (i) *Brothers*(x, y), where x and y are full biological brothers

   (ii) *Ancestor*(x, y), where x is an ancestor of y (parent or parent's parent, etc.)

[9 marks]

(b) Consider the following logical statements:

$$\forall x \, Greater(Inc(x), Zero)$$
$$\forall x \forall y ((Greater(Inc(x), Inc(y)) \rightarrow Greater(x, y)) \wedge$$
$$(Greater(x, y) \rightarrow Greater(Inc(x), Inc(y))))$$

   (i) Convert the formulae into conjunctive normal form, showing all working.

   (ii) Use resolution to prove that $Greater(Inc(Inc(Inc(Zero))), Inc(Zero))$

[9 marks]

(c) A company wants to drill for oil in a region where they believe the chance of success is one in twenty thousand. After performing preliminary tests which gave a positive result, they want to make a press release to tell investors the news. The preliminary tests are nearly always correct: they have a false negative rate of 0.5% and a false positive rate of 2%. Given the evidence of the tests, what is the new probability of finding oil in the region? What would you advise the company to tell investors based on the test results?

[7 marks]

End of questions