Q1:

a) The Turing Test has been proposed as a test for computational intelligence. Explain what the test is, and describe what capabilities an AI system would need in order to pass the test. [9 marks]

b) The PEAS description (Performance measure, Environment, Actuators, Sensors) can be used to describe the task environment of an agent. Define each of the four terms and illustrate them with reference to a chess-playing agent. [8 marks]

c) Consider the following 8-bit chromosomes, to be used as the initial state of a very small genetic algorithm

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Bit number | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Chromosome C0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 |
| Chromosome C1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 |
| Chromosome C2 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 |
| Chromosome C3 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 |

What would be result of applying crossover to C0 and C2 between bits 4 and 5? [2 marks]

d) Given the initial state in Part (c) above, explain why crossover is not enough to explore the entire search space described by this representation. Give a detailed explanation of how this problem is solved in genetic algorithms. [6 marks]

Q2:

a) Write out the Minimax algorithm for adversarial search in pseudocode. Explain all of the symbols and terms you define. [12 marks]

b) Does alpha-beta pruning result in a better game-playing agent? Explain your answer carefully. [4 marks]

c) Given a neural network with 3 inputs (1 of which is bias), 2 hidden units, and 1 output unit, where all units use the sigmoid activation function.  
  
The initial weights are shown below:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| w\_{1,4} | w\_{1,5} | w\_{2,4} | w\_{2,5} | w\_{3,4} | w\_{3,5} | w\_{4,7} | w\_{5,7} | w\_{6,7} |
| 0.4 | 0.8 | 0.3 | -0.2 | 0.9 | 0.5 | -0.3 | 0.1 | 0.8 |

Given a training example with Input1 = Input2 = 1 and Output = 0:

(i) Calculate the activations of nodes 4, 5 and 7.

(ii) Calculate the delta values for backpropagation.

(iii) Using a learning rate of α = 2 and the delta values from part (ii), calculate the updated values of the weights.

Useful formulae Sigmoid and derivative:

g(x) = 1 / (1 + e^{-x})

g(x) = g(x)\*(1 – g(x))

Update function for individual weights:

w\_{i,j} = w\_{i,j} + alpha \* a\_i \* delta\_j

where:

delta\_j = (y\_i – h\_j) \* g’(sum of(w\_{k,j}\*a\_k)) for output layers

delta\_j = g’(sum of(w\_{k,j}\*a\_k)) \* sum of(w\_{i,j}\*delta\_i) for other layers

Q3:

a) Use a truth table to verify that ((A intersect B) → C) ≡ (¬A ∨ ¬B ∨ C). [4 marks]

b) Using the following predicates and their natural language meanings:

cat(x), x is a cat

dog(x), x is a dog

owns(x, y), x owns y

grey(x), x is grey

Express the following sentences in first order logic:

(i) John has a cat.

(ii) Dogs are never grey.

(iii) All of John’s cats are grey.

(iv) No dog owner owns any cats. [8 marks]

c) Express the following first order formula in clausal form:

isNumber(0) ∧ ∀x number(x) → ∃y greater(y, x) [3 marks]

d) Using the predicate S(x, y) meaning “x shaves y”, express the following sentence in first order logic:

There is a person who shaves only every person who does not shave themselves.

Then convert the logical expression into clausal form and use resolution and factoring to show that the sentence is inconsistent. (Note: factoring reduces two identical literals within a clause to one; if two literals in a clause are unifiable, their most general unifier is applied to the whole clause and then the duplicate literal is deleted.) [10 marks]

Q4:

a) Give the formula for Bayes’ theorem. [2 marks]

b) The computer company Picoflop screens applicants for jobs using an intelligence test that they have devised to identify ‘genius’ applicants. The test has a false positive rate of 1.5%, i.e. an applicant who is not a true genius still has a probability of 0.015 to pass the test. It also has a false negative rate of 0.2%, i.e. it fails to recognise 1 in 500 geniuses. From previous experience, Picoflop estimates that 1 in 50000 of their applicants are geniuses. Every time an applicant passes this intelligence test, Picoflop immediately offers them an attractive salary package, believing that the applicant has a 98.5% chance of being a genius. Is this rational? Explain using Bayes’ rule. [11 marks]

c) In a game show the contestant and the host are standing in front of 3 closed chests. Two of them are empty and the third one contains a cash prize. The winning chest is chosen randomly (i.e. uniformly) but only the host knows its location. The game follows this sequence:

1) The contestant chooses one of the chests.

2) The host opens one of the chests that the contestant did not choose, always choosing an empty one.

3) The contestant is given one last opportunity to change his mind: either keeping the chest already chosen or switching to the other unopened one.

4) All the chests are opened and the contestant wins the prize if he picked the right chest. Should the contestant keep his chest or switch? Does it matter? Justify your answer by computing the probability of winning in each case. [12 marks]