Q1:

a) In the PEAS model discussed in lectures, define what is meant by the environment of an agent. Give an example to illustrate your answer. [3 marks]

b) Define each of the following properties of agent environments, and give an example of each:

(i) Fully observable

(ii) Static

(iii) Stochastic

(iv) Continuous [8 marks]

c) A two-legged robot agent is standing at the foot of a mountain without a map. It has the goal of reaching the summit. Using height above sea level as the utility function, explain the hill-climbing algorithm discussed in lectures. What limitations does this algorithm have? [4 marks]

d) Explain the local beam search algorithm. What is the relationship between local beam search and hill-climbing? Would beam search be a suitable algorithm for the agent in part (c)? Why or why not? [6 marks]

e) Explain the role of selection in genetic algorithms. How would you choose a selection function for a genetic algorithm for the task of composing music? [4 marks]

Q2:

The 8-puzzle has 9 squares, each of which contains a numbered tile, except one square which is vacant. A tile adjacent to the vacant square may be moved by sliding it into the vacant square (up, down, left or right respectively). There are no other legal moves. Given an initial configuration of tiles shown on the left, the aim is to reach the goal configuration shown on the right. The cost of a solution is the number of moves performed.

|  |  |  |
| --- | --- | --- |
| 7 | 1 | 3 |
|  | 2 | 8 |
| 4 | 6 | 5 |

Initial configuration

|  |  |  |
| --- | --- | --- |
| 7 | 1 | 3 |
|  | 2 | 8 |
| 4 | 6 | 5 |

Goal configuration

a) Using depth-first search, give the first three node expansions in a search for a solution. At each step show the node expanded and the resulting agenda. [6 marks]

b) What problem occurs with depth-first search for this problem? [2 marks]

c) Would uniform-cost search be a suitable approach for this problem? Explain your answer carefully. [4 marks]

d) Now using the heuristic of the number of tiles in incorrect positions, execute the first two steps (node expansions) of a greedy search with agenda length of 1. Show your working (the agenda, the states considered and their costs). [4 marks]

e) What problem occurs with greedy search for this problem? [2 marks]

f) Using the same heuristic, execute the first three node expansions of the A\* search algorithm. Show your working, including the nodes expanded, the agenda and the utility values for each node. [7 marks]

Q3:

a) What assumption is the minimax algorithm based on? Does this limit the quality of its output? Why? [4 marks]

b) Minimax search is based on depth-first search of the game tree. Name and describe three approaches that are used (separately or together) to address the problem of having insufficient computational resources for exploring the complete search space due to the depth of the tree. [9 marks]

c) Using the training data in the table below, execute the ID3 algorithm to build a decision tree classifier to shed light on the relationship between sales (represented by the variable Sale) and the attributes Price, Change (of price), Quality and Ads. Show all of your working and represent the final solution by drawing the decision tree. [12 marks]

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Price** | **Change** | **Quality** | **Ads** | **Sale** |
| Low | None | Poor | Radio | No |
| Low | None | Good | Radio | No |
| Low | Positive | Good | Radio | No |
| High | Negative | Poor | Web | No |
| High | Positive | Poor | Radio | No |
| Low | Negative | Good | Web | Yes |
| Low | Positive | Poor | Web | Yes |
| Medium | Negative | Poor | Web | Yes |
| Medium | None | Good | Radio | Yes |
| Medium | None | Good | Web | Yes |
| Medium | Positive | Poor | Radio | Yes |
| High | Negative | Good | Radio | Yes |
| High | Negative | Good | Web | Yes |
| High | Positive | Good | Web | Yes |

Q4:

a) What is the advantage of having one or more hidden layers in an artificial neural network? Illustrate your answer with an example. [3 marks]

b) How do you choose the number of units in each layer of an artificial neural network? Is there an algorithm for determining the number of units needed? What is the danger of having too many units? [4 marks]

c) Write (in pseudocode) the backpropagation algorithm for training a multilayer neural network. You do not need to include the formulae. [7 marks]

d) Convert the following two formulae into clausal form:   
  
∀x S(A, x, x)   
∀x∀y∀z S(f(x), y, z) ≡ S(x, f(y), z)   
  
and use resolution to prove the sentence: S(f(f(A)), f(f(A)), f(f(f(f(A))))). Show all working. [10 marks]

e) In part (d), if A represents the number 0, and f(x) represents the successor of x (i.e. x + 1), then predicate S defines addition for non-negative integers. What is the meaning of the sentence you were asked to prove? [1 mark]