IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

EXAMINATIONS 2019

BEng Honours Degree in Computing Part III
BEng Honours Degree in Electronic and Information Engineering Part III
MEng Honours Degree in Electronic and Information Engineering Part III
MEng Honours Degree in Electronic and Information Engineering Part IV
MEng Honours Degree in Mathematics and Computer Science Part IV
BEng Honours Degree in Mathematics and Computer Science Part III
MEng Honours Degree in Mathematics and Computer Science Part III
MEng Honours Degrees in Computing Part III
MSc in Computing Science
MSc in Computing Science (Specialist)
for Internal Students of the Imperial College of Science, Technology and Medicine

This paper is also taken for the relevant examinations for the Associateship of the City and Guilds of London Institute

PAPER C395

INTRODUCTION TO MACHINE LEARNING

Wednesday 20th March 2019, 10:00
Duration: 90 minutes

Answer TWO questions

Paper contains 3 questions
Calculators required

1 Consider the following set of training examples regarding a decision process to know whether or not to purchase an item:

	Quality	Brand	Price	Review	Buy?
1	High	Famous	Normal	Bad	Yes
2	Poor	Famous	Normal	Bad	No
3	High	Mainstream	Expensive	Good	No
4	Poor	Mainstream	Normal	Good	No
5	Standard	Mainstream	Normal	Good	Yes
6	Standard	Unknown	Expensive	Good	Yes
7	Standard	Mainstream	Normal	Bad	No
8	High	Mainstream	Normal	Good	Yes
9	Poor	Famous	Expensive	Bad	No
10	Standard	Mainstream	Normal	Good	Yes

a Apply the algorithm seen in class (ID3) to create a decision tree. Write out the intermediate and the final results. Draw the produced decision tree.

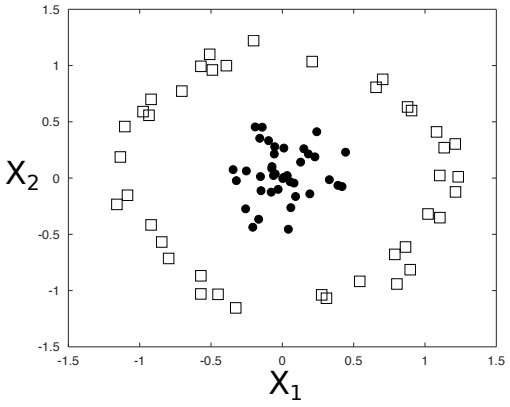
b Apply the distance-weighted k-Nearest Neighbour algorithm , k=3, to classify the instance <High, Unknown, Normal, Good>, assuming that the above listed examples are already known. Write out the algorithm, the distance function, the weight function, and the intermediate results.

c Compute the classification rate for the given confusion matrix. Compute the unweighted average recall and F1 measure for each class. Which performance measure is suitable in this case? Explain why and what the issue is with the given test set. Explain one alternative to mitigate this issue.

	Class 1 Predicted	Class 2 Predicted	Class 3 Predicted
Class 1 - Actual	100	0	0
Class 2 - Actual	80	0	20
Class 3 - Actual	20	10	970

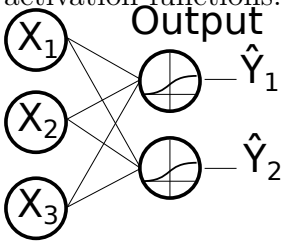
The three parts carry, respectively, 40%, 30%, and 30% of the marks.

2a We want to use a neural network to learn a classifier to distinguish two classes: circles and squares. We have the following training dataset:



Draw a network that can solve this classification problem. Justify your choice of number of layers, number of nodes, and activation function. Draw the decision boundary that your network can find on the diagram (for this, you can approximately reproduce the diagram on your answer book).

b Consider now the following neural network (not related to the previous part), with no hidden layers, 2 outputs and 3 inputs, and using sigmoid activation functions:



The training dataset is composed of 2 samples: $X = \begin{bmatrix} x_{1,1} & x_{1,2} & x_{1,3} \\ x_{2,1} & x_{2,2} & x_{2,3} \end{bmatrix}$ with the following target values (labels): $Y = \begin{bmatrix} Y_{1,1} & Y_{1,2} \\ Y_{2,1} & Y_{2,2} \end{bmatrix}$

Derive the update rule for the weights of the given neural network using a gradient descent rule. You can assume that a quadratic loss is used for the error function.

c You have a dataset with 200 samples. Explain how you will manage this dataset to train, evaluate and find the parameters (numbers of layers, number of neurons,...) of a neural network. Describe in details all the necessary steps. How would you train a final model just before moving in production?

The three parts carry, respectively, 25%, 50%, and 25% of the marks.

3 You want to control a robot with three motors (like the one used in the coursework) by using a genetic algorithm. For the purpose of this question, we assume that the possible angular positions are discrete and can have 11 different values: -50; -40; -30; -20; -10; 0; 10; 20; 30; 40; 50 (degrees).

The goal is to find the angular positions of the three motors so that the gripper (tip) of the robot reaches a pre-defined target (a 3D position). The (3D) position of the gripper can be measured after executing one potential solution.

a Give a suitable genotype, phenotype, and function used to develop a genotype into a phenotype, that you would use to solve the problem described above. Provide a short explanation of your choice.

b Choose the genetic operators that can be used to solve this problem (given the genotype you defined in the previous part) and explain how they work.

c Define the fitness function that can be used to solve this problem. Explain your answer in a clear and compact manner.

d Give the pseudo code of the genetic algorithm, using the operators and elements you defined above. Detail the parameter values that need to be defined, and explain their role. For each of the parameters that you will describe, give a potential value and explain your choice.

The four parts carry, respectively, 20%, 20%, 20%, and 40% of the marks.