The University of Nottingham

SCHOOL OF COMPUTER SCIENCE

A LEVEL 3 MODULE, SPRING SEMESTER 2011-2012

MACHINE LEARNING

Time allowed: **Two Hours**

Candidates may complete the front cover of their answer book and sign their desk card but must NOT write anything else until the start of the examination period is announced

Answer All Questions

Only silent, self contained calculators with a Single-Line Display or Dual-Line Display are permitted in this examination

Dictionaries are not allowed with one exception. Those whose first language is not English may use a standard translation dictionary to translate between that language and English provided that neither language is the subject of this examination. Subject specific translation dictionaries are not permitted.

No electronic devices capable of storing and retrieving text, including electronic dictionaries, may be used.

DO NOT turn your examination paper over until instructed to do so

Question 1

Briefly sketch the respective procedure of building a handwritten digit recognition system using each of the following four machine learning techniques

(a) Multilayer Perceptron Neural Network (5 marks)
(b) K-Nearest Neighbours (5 marks)
(c) Support Vector Machines (7 marks)
(d) Naïve Bayesian (8 marks)

You can assume training and testing data have already been collected and appropriately processed. Using diagrams and drawings as appropriate.

Question 2

Although a single Perceptron can only classify two classes, it is possible to combine several Perceptrons together to classify more than two classes. For example, combining the outputs of two Perceptrons can distinguish four classes, and combining the outputs of three Perceptrons can distinguish eight classes, and so on.

An experiment has generated 2-dimensional feature vectors belonging to four classes as shown in the following table

2 Dimensional Feature Vector	Class
(-4, 6)	A
(6, 6)	B
(4, -6)	D
(-4, -4)	C
(-6, 4)	A
(4, 4)	B
(-6, -6)	C
(6, -4)	D

Using as many Perceptrons as appropriate, design a system that will be able to distinguish the four classes. Your answer should include

(a) A diagrams of each Perceptron. (5 marks)
(b) The values of all connection weights of each Perceptron. (5 marks)
(c) The equation of each Perceptron's decision boundary. (5 marks)
(d) An explanation of how your design has achieved the goal. (10 marks)

Question 3

In an object recognition task, it is known that the objects come from one of two classes, C_1 or C_2. Each instance of an object X has four features, $X = (x_1, x_2, x_3, x_4)$. An experiment has collected 14 instances and their feature values and classification are shown in the following table

$X = (x_1, x_2, x_3, x_4)$.				Classification
x_1	x_2	x_3	x_4	C
1	1	1	1	C_1
1	1	1	2	C_1
2	1	1	1	C_2
3	2	1	1	C_2
3	3	2	1	C_2
3	3	2	2	C_1
2	3	2	2	C_2
1	2	1	1	C_1
1	3	2	1	C_2
3	2	2	1	C_2
1	2	2	2	C_2
2	2	1	2	C_2
2	1	2	1	C_2
3	2	1	2	C_1
1	3	1	2	= ?
2	2	2	2	=?
3	1	1	1	=?

Design a decision tree classifier to class unknown feature vectors X1 = (1, 3, 1, 2), X2 = (2, 2, 2, 2) and X3 = (3, 1, 1, 1). You must show the detail of the working process. An answer without the working process will not receive any marks.

(25 marks)

Question 4

(a) Compare and contrast how Multilayer Perceptron (MLP) and Support Vector Machine tackle linearly non-separable classes.

(10 marks)

(b) Discuss the similarity and difference of K-means and K-nearest neighbours (KNN)

(8 marks)

(c) Discuss what causes over-fitting in machine learning and why it should be avoided.

(7 marks)