UNIVERSITY OF LONDON

291 0311 ZA

B.Sc. Examination 2008

COMPUTING AND INFORMATION SYSTEMS

CIS311 Neural Networks [Western]

Duration: 2 hours 15 minutes

Date and time: Wednesday 21 May 2008: 2.30 – 4.45 pm

- *Full marks will be awarded for complete answers to FOUR questions. Do not attempt more than FOUR questions on this paper.*
- A hand held calculator may be used when answering questions on this paper but it must not be pre-programmed or able to display graphics, text or algebraic equations. The make and type of machine must be stated clearly on the front cover of the answer book.

THIS EXAMINATION PAPER MUST NOT BE REMOVED FROM THE EXAMINATION ROOM

Question 1.

a) Which are the three main ingredients of a neural network? Give their alternative names. **[6]**

b) Discuss briefly each of the two main groups of artificial neural networks based on their connectivity pattern. **[6]**

d) A two layer neural network with d inputs, H nodes in the hidden layer, and k outputs is given. Give the expression for calculating the total number of weights and thresholds in this neural network. **[4]**

e) Design a single neuron with three binary inputs and a threshold that implements a function which is one when some of the inputs is one. Suggest integer weights without training the network. Assume the following threshold function: $f(s) = 0$ if $s \leq 0$ and $f(s) = 1$ if $s > 0$. **[9]**

Question 2.

a) Give the Widrow-Hoff rule for batch training sigmoidal neurons and explain each component in it. **[5]**

b) Discuss how the weights of a single discrete neuron are expected to change when non-separable input vectors are given while the neuron is trained . **[4]**

c) Consider a single linear neuron with two inputs without bias. This neuron has to be trained in individual mode with the Widrow-Hoff rule using a training value $\eta = 0.22$ and the following set of examples (where x_1, x_2, x_3 are the inputs and y_T is the output):

x_1	x_2	x_3	y_T
-1	1	1	-1
1	1	-1	1
-1	-1	1	1
1	-1	1	-1

Begin with the following initial weights: $(w_0, w_1, w_2) = (0.1, -0.2, 0.35)$, and show how the weights are updated after each example. **[16]**

Question 3.

a) Construct a single layer neural network with two inputs and two neurons having discrete activation functions that produce two outputs (y_1, y_2).

i) Identify such weights and thresholds with which this network classifies the given point (y_1, y_2) = (0, 0) within the infinite triangle defined by the following equations: $-2x_1 + 4x_2 > -4$ and $-3x_1 + 2x_2 < -1$. **[6]**

ii) Plot on the two-dimensional plane the lines modelled by the 2 neurons and decide whether the point (y_1, y_2) = (0.5, 0.5) will be classified by this network in the same segment as the point (y_1, y_2) = (0, 0). **[5]**

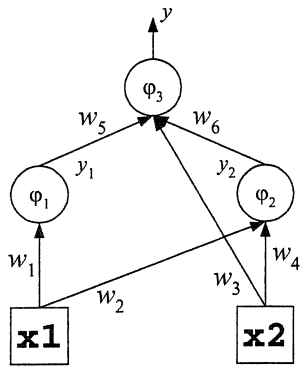
b) Design a two layer neural network with 2 inputs, 4 neurons in the first layer, and 1 neuron in the second layer that generates the final output. Use discrete activation functions.

i) Determine the thresholds and weights of the first layer neurons so that their outputs are 1s: (y_1, y_2, y_3, y_4) = (1, 1, 1, 1) if the input vector $\mathbf{x} = (x_1, x_2)$ is a point within the square defined by the points (0,0), (0,-1), (-1,-1), (-1,0). **[8]**

ii) Determine the thresholds and weights of the second layer neuron so that the final network output is 1 only when its inputs are 1s: (y_1, y_2, y_3, y_4) = (1, 1, 1, 1). **[6]**

Question 4.

Assume the multilayer neural network with irregular topology given in the figure below. This network has two hidden nodes, and one output node, all of which use sigmoidal activations. There are two inputs to the network (x_1, x_2), and six weights as illustrated in the figure. Train this multilayer network with the backpropagation algorithm using training value η=0.3.



Train this neural network starting with the following initial weights:

$w_1 = 0.1$ $w_2 = 0.3$ $w_3 = -0.15$ $w_4 = -0.25$ $w_5 = 0.2$ $w_6 = -0.1$

Consider the following input vector:

x_1	x_2	y
1	1	1

Show the node outputs, the errors at the hidden nodes, and the modified weights. **[25]**

Question 5.

a) Explain how does the energy level in Hopfield networks changes when there is a state change? What is the amount of energy change for a particular neuron? **[3]**

b) Consider a Hopfield network with three neurons and three inputs x_1, x_2, x_3. The neuron N_0 is assumed to have a clamped output x_0=1. Suppose that the initial weight matrix is:

$$\mathbf{W} = \begin{matrix} 0 & -0.1 & -0.4 & 0.2 \\ -0.1 & 0 & 0.2 & -0.3 \\ -0.4 & 0.2 & 0 & 0.3 \\ 0.2 & -0.3 & 0.3 & 0 \end{matrix}$$

i) Give the energy formula, and calculate with it the energy of this network for the two states $[1,0,0]$ and $[1,0,1]$. **[6]**

ii) Draw the state table for this Hopfield net with all network states, which shows the next state when each neuron fires. **[16]**

Question 6.

a) Present the training algorithm for the Kohonen layer of counterpropagation networks. **[6]**

b) Consider a self-organizing neural network with two neurons in the Kohonen layer. Suppose that each of these neurons has three inputs. The initial weight vectors are: $\mathbf{w}_1 = (1.2, -1.4, 1.5)$, $\mathbf{w}_2 = (-1.3, -0.8, 1.6)$.

i) Perform weight normalisation to enable training. **[6]**

ii) Prepare the following input vector: $(x_1, x_2, x_3)=(1.1, -2.1, 1.2)$, in order to enable neural network training. **[3]**

iii) Compute the summation blocks of each of the two neurons in the Kohonen layer when this input vector is presented to the network. **[4]**

iv) Train the Kohonen layer and show the weight change after computing the cluster index assuming a training value $\eta=0.15$. **[6]**

END OF PAPER