291 0311 ZB

UNIVERSITY OF LONDON

B.Sc. Examination 2008

COMPUTING AND INFORMATION SYSTEMS

CIS311 Neural Networks [Eastern]

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

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Question 1.

a) Define the three most commonly used activation functions in artificial neural networks. **[6]**

b) Explain how we can perform classification into 3 classes using single neurons each of which generates its own decision line using a binary output using a thresholded activation functions *Threshold* (s) = 1 if $s > 0$ and -1 otherwise. How many single neurons do we need to accomplish such kind of classification into 3 classes? **[6]**

c) Explain how we can train a neural network with two layers to recognise multiple classes simultaneously. **[4]**

e) Develop a single neuron with three binary inputs and a threshold that implements a function which is one when all inputs are 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) Design a single layer neural network with 2 inputs $\mathbf{x} = (x_1, x_2)$, and 2 neurons with discrete activation functions producing outputs (y_1, y_2).

i) Determine the weights and thresholds so that this network classifies the point $(y_1, y_2) = (0, 0)$ within the infinite triangle defined by the equations: $3x_1 - 2x_2 > -1$ and $2x_1 + x_2 < 2$. **[6]**

ii) Draw 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) Develop a two layer neural network with 2 inputs, 4 neurons in the first layer, and 1 neuron in the second layer that produces the final output. All activation functions are discrete.

i) Derive the weights and thresholds 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) Derive the weights and thresholds of the second layer neuron so that the final network output is 0 only when its inputs are 1s: $(y_1, y_2, y_3, y_4) = (1, 1, 1, 1)$. **[6]**

Question 3.

a) Define the training rule for single-layer networks having a single discrete neuron, and explain the meaning of every term in the training rule. **[5]**

b) Explain what happens to the weights of a single discrete neuron when non-separable input vectors are provided, while the neuron is trained with this rule. **[4]**

c) A single discrete neuron with two inputs and a bias input is given. Train this neuron with the Widrow-Hoff rule in individual mode using a training value $\eta = 0.15$ 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

Start with the following initial weights: $(w_0, w_1, w_2) = (-0.1, 0.3, 0.25)$, and demonstrate how the weights are updated after each example. **[16]**

Question 4.

a) Give the algorithm for training the Kohonen layer of counterpropagation networks using the alternative weight update formula. **[6]**

b) Suppose that a self-organizing Kohonen neural network with two neurons is given. Each of these neurons has three inputs. Consider the following two initial weight vectors: $\mathbf{w}_1 = (-1.3, -1.2, 1.4)$, $\mathbf{w}_2 = (1.2, -1.8, 1.5)$.

i) Normalise the initial weights to prepare them for training. **[6]**

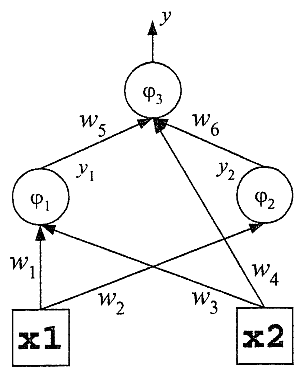
ii) Normalise the following input vector: $(x_1, x_2, x_3)=(1.5, -1.4, 2.2)$ to make it suitable for neural network training. **[3]**

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

iv) Perform training of the Kohonen layer and show the weight change after computing the cluster index, assuming a training value η=0.22. **[6]**

Question 5.

Consider the multilayer neural network with irregular topology illustrated 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=0.2.



Perform neural network training starting with the following initial weights:

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

Use the following input vector:

x_1	x_2	y
1	1	0

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

Question 6.

a) Which state in Hopfield networks is called energy well? Explain whether the process of training a Hopfield network starting from any initial state will reach an energy well. **[3]**

b) Consider a Hopfield network with three neurons and three inputs x_1, x_2, x_3, where the neuron N_0 has a clamped output x_0=1. Assume that the initial weight matrix is:

$$\mathbf{W} = \begin{matrix} 0 & 0.15 & -0.3 & 0.2 \\ 0.15 & 0 & 0.4 & -0.1 \\ -0.3 & 0.4 & 0 & 0.2 \\ 0.2 & -0.1 & 0.2 & 0 \end{matrix}$$

i) Define the energy formula, and use it to compute the energy of this network for the two states $[0,1,1]$ and $[1,0,1]$. **[6]**

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

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