UNIVERSITY OF LONDON

291 0311W

B.Sc. Examination 2006

For External Students

COMPUTING AND INFORMATION SYSTEMS

CIS311 Neural Networks [Western]

Duration: 2 hours 15 minutes

Date and time: Monday 22 May 2006: 2.30 - 4.45pm

- *Full marks will be awarded for complete answers to FOUR questions. Do not attempt more than FOUR questions on this paper.*
- *Electronic calculators may be used. The make and model should be specified on the script. The calculator must not be programmed prior to the examination. Calculators which display graphics, text or algebraic equations are not allowed.*

THIS EXAMINATION PAPER MUST NOT BE REMOVED FROM THE EXAMINATION ROOM

UL06/701

Question 1.

a) Explain what the design of an artificial neural network involves. What are the most common activation functions used in the design of neurons? **[7]**

b) What are the two potential applications of artificial neural networks? Describe briefly how neural networks are realized to make such applications possible. **[5]**

c) Which are the two main architectures of artificial neural networks with respect to their connectivity pattern? **[4]**

d) Explain whether the behaviour of a single neuron with a discrete activation function and two inputs will change, and if so how exactly, if its weights and threshold are multiplied by a given constant z. **[9]**

Question 2.

a) Describe the training rule (formula) for modification of the weights in single discrete neurons. Explain every term in this training rule. **[5]**

b) Consider a single discrete neuron with seven inputs and a threshold x_0. This neuron may learn to recognize the digits from 0,9,8,7,6,5,4,3,2,1 represented by seven segments each associated with an input. When the neuron is trained to learn a digit the output should be greater than one only for this digit $F(s) = 1$ if $s > 1$. Assume that the learning rate is one. Training can be performed using the following example vectors, provided sequentially:

x_0	x_1	x_2	x_3	x_4	x_5	x_6	x_7	y	digit
1	0	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	0	0	9
1	1	1	1	1	1	1	1	0	8
1	0	0	1	1	1	0	0	0	7
1	1	1	1	0	1	1	1	0	6
1	1	1	1	0	1	1	0	0	5
1	1	1	0	1	1	0	0	0	4
1	1	0	1	1	1	1	0	0	3
1	1	0	1	1	0	1	1	0	2
1	0	0	0	1	1	0	0	0	1

How many weight updates are necessary to learn the digit 0 starting with weights that are all zero: (w_0, w_1, w_2, w_3, w_4, w_5, w_6, w_7)=(0,0,0,0,0,0,0,0)? Demonstrate the training step by step. What is the neuron output after each example and what should happen to the weights after this example? **[20]**

Question 3.

a) Develop and draw a single-layer neural network that classifies the examples of the boolean AND function. Assume that there are four inputs: x_i is either 1 or -1, $1 <= i <= 4$. The boolean AND function produces signal one when all of its inputs are plus one. Use the following activation function $F(s) = 1$ if $s > 0$ and 0 otherwise. **[8]**

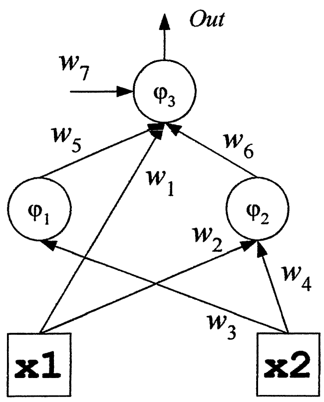
b) i) Give the probability formula for accepting the weight changes in the Boltzmann training algorithm for multilayer neural networks. Explain each component in it. **[5]**

ii) Explain how the computation of the probability affects the training process. **[6]**

iii) Explain what convergence technique the Boltzmann training algorithm implements and what solutions it produces. **[6]**

Question 4.

Let a multilayer neural network with two hidden and one output node be given. All network nodes use the sigmoidal activation function, and only the output node has a bias connection. There are two inputs to the network: (x_1, x_2), and seven weights as shown in the picture below. This network has an irregular architecture because: the input x_1 feeds directly the output node, the first hidden node is fed only by the second input x_2, while the second hidden node is fed by both inputs.



Develop backpropagation training rules for training this neural network as follows:

i) Give expressions for computing the error and weight updates w'_1, w'_5, w'_6 and w'_7 for the connections to the output node. Explain the meanings of all terms. **[13]**

ii) Give expressions for computing the errors and weight updates w'_2, w'_3, and w'_4 for the connections entering the hidden nodes. Explain the meanings of all terms. **[10]**

iii) Give the formula for computing the momentum term for improving the convergence of the backpropagation algorithm. **[2]**

Question 5.

a) The Kohonen layer of counterpropagation neural networks for unsupervised learning is trained using the following formula: $\mathbf{w}_r' = \mathbf{w}_r + \eta\ (\mathbf{x} - \mathbf{w}_r)$. Give the alternative way of writing this formula and explain each component in it. **[4]**

b) Describe the algorithm for training the Kohonen layer of counterpropagation neural networks using the alternative weight update formula. **[5]**

c) Consider a simple self-organizing neural network with two neurons in the Kohonen layer, There are given two input vectors: $(x_{11}, x_{12}, x_{13}, x_{14})=(0.2, 0.3, 0.4, 0.5)$ and $(x_{21}, x_{22}, x_{23}, x_{24})=(0.4, 0.5, 0.3, 0.2)$. The initial weight vectors are: $\mathbf{w}_1 =(0.3, -0.2, -0.1, 0.6)$, and $\mathbf{w}_2 =(-0.8, 0.1, -0.4, -0.5)$.
The training value is $\eta=0.3$.

i) Train the Kohonen layer with the first input vector $(x_{11}, x_{12}, x_{13}, x_{14})$, and show the updated weight vector of the chosen neuron. **[8]**

ii) Continue training the Kohonen layer with the second input vector $(x_{21}, x_{22}, x_{23}, x_{24})$, and show the updated weight vector of the chosen neuron. **[8]**

Question 6.

a) Explain what is the most distinguishing characteristic of Hopfield neural networks with respect to the connectivity pattern. **[3]**

b) Define the Widrow-Hoff rule for learning in Hopfield neural networks, and explain each component in it. **[6]**

c) Let a Hopfield neural network be initialised with the following weight matrix:

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

Determine the stable state for this network by drawing a state table with all network states, which shows what will be the next state when each neuron fires, using the formula: $s_i = w_{i0} + w_{i1}\, x_1 + w_{i2}\, x_2 + w_{i3}\, x_3$. **[16]**

END OF EXAMINATION