THIS IS NOT AN OPEN-BOOK EXAMINATION - CANDIDATES MAY NOT CONSULT ANY REFERENCE MATERIAL DURING THE SITTING

Calculators may be used in this examination but must not be used to store text. Calculators with the ability to store text should have their memories deleted prior to the start of the examination.

THE UNIVERSITY OF BIRMINGHAM

Degree of B.Sc. with Honours

Artificial Intelligence and Computer Science. Second Examination
Computer Science/Software Engineering. Second Examination

Joint Honours Degree of B.Sc. with Honours

Mathematics and Artificial Intelligence. Second Examination
Psychology and Artificial Intelligence. Second Examination

M.Sc. in Computer Science

06 02360

(SEM 2A2)
Introduction to Neural Networks

January 2000 2 hours

[Answer ALL Questions]

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Any Calculator

1. Answer the following questions:

   (a) Give the mathematical expression that defines the logistic function. [5%]

   (b) Explain what the gain parameter in the logistic function is and what it is used for. [5%]

   (c) Explain why we prefer to use the logistic function as the activation function in backpropagation networks. [5%]

   (d) What does the learning rate do in backpropagation training? What may happen when we use a very large learning rate and when we use a very small learning rate? [5%]

   (e) Can a backpropagation training algorithm always find a set of weights which minimise the training error for a given feedforward neural network? Explain your answer. [5%]

   (f) What roles does momentum play in backpropagation training? [5%]

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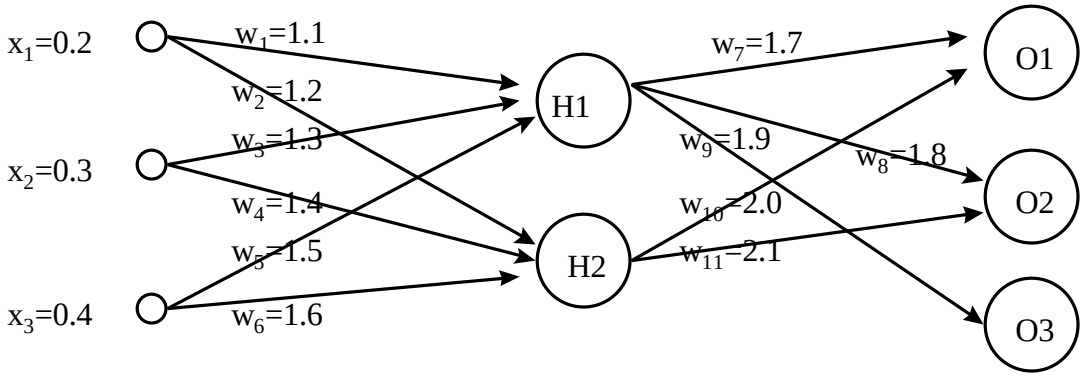
2. The following figure shows a backpropagation network with all weights given. There are no biases (thresholds) in this network. Suppose the network is given a training pattern with input (0.2, 0.3, 0.4). Assume that the logistic function with gain parameter 1 is used for all hidden and output nodes.

(a) What are the outputs from hidden units H1 and H2? [5%]

(b) What are the outputs from the three output units O1, O2, and O3? [5%]

(c) Assume that the outputs from O1 and O2 are the same as the target outputs, but the output from O3 is different from the target output. List all the weights which will be unchanged after the presentation of the training pattern. [10%]

(Note: You only need to give correct expressions for questions (a) and (b). Calculation of the values of exponential functions is not required.)



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Any Calculator

3. Discuss how a backpropagation network with Gaussian activation functions compares with a radial basis function network. [10%]

4. Describe the Kohonen learning algorithm in pseudo-code. [15%]

5. The post code problem can be described as follows.

   (a) Each post code consists of six or seven hand-written letters/digits. The letters are 26 upper-case English letters, i.e., 'A' .. 'Z'. The digits are '0' .. '9'.

   (b) Each letter/digit is represented by a 32x32 binary image.

   (c) The total available data consist of 10000 images. They are in the format of

   0111011 ... 0100000 B
   0100000 ... 1111110 H
   1100111 ... 0011010 7
   ... ...

   where the first 1024 bits represent 32x32 pixel values and the last column indicates the class.

   You are required to design a feedforward artificial neural network (or several networks) to recognise letters/digits. Your answer should include

   (i) Input representation, output representation, and network (or networks) architecture (including the number of hidden layers, hidden nodes and connectivity pattern).
   (ii) Any pre-processing of the input data and/or post-processing of the output data that should be carried out.
   (iii) The training algorithm that should be used.

   You must justify all your design choices.

   [25%]