UNIVERSITY OF LONDON

IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

EXAMINATIONS 1998

BEng Honours Degree in Computing Part III
BEng Honours Degree in Information Systems Engineering Part III
MEng Honours Degree in Information Systems Engineering Part III
BSc Honours Degree in Mathematics and Computer Science Part III
MSci Honours Degree in Mathematics and Computer Science Part III
MSc Degree in Advanced Computing
MSc Degree in Computing Science
for Internal Students of the Imperial College of Science, Technology and Medicine

This paper is also taken for the relevant examinations for the
Diploma of Membership of Imperial College
Associateship of the City and Guilds of London Institute
Associateship of the Royal College of Science

PAPER 3.89 / I3.24

NEURAL NETS

Wednesday, May 6th 1998, 10.00 - 12.00

Answer THREE questions

For admin. only: paper contains 4 questions

1a i Describe the Hopfield model of an asynchronous fully connected network.

ii Define the energy function for a Hopfield network and show that single unit state changes will always lead to a decrease in the energy.

b i It is required to use a Hopfield network to reconstruct an unclassified noisy sample from one of P random prototypes. Given prototypes $\mathbf{x}^{(1)},\ldots, \mathbf{x}^{(P)} \in \{0,1\}^n$ show how to assign the weights to accomplish this task.

c A Hopfield network is required to classify black and white images of size 128x128 pixels.

i How many prototype images would you predict that the network could recall accurately?

ii Briefly state why the recall of patterns is expected to decreases as the number of prototypes increases from number calculated in 1c part (i).

The three parts carry, respectively, 50%, 25%, 25% of the marks.

2. Suggest reasons for using the paradigms stated for Each of the tasks (i)-(iii) below:

i Using Bi-directional Associative Memory to associate photographs from a database with a name for each photograph. (The photograph is 128 pixels long and 200 pixels high)

ii Using Sequence Component Ration Coding (SCRC) and the Short-Term Memory (STM) Network to recognise a person's speech by sampling speech at 10KHz using a microphone and A/D converter card on a personal computer.

iii Using the Kohonen Self-Organising Feature Map to classify students by age, sex, height, weight and grades to find any groupings.

Your responses should include neural network input/output architecture diagram for each suggested solution, an explanation of what information you plan to present as input vector to the network and a description of network output layer.

The three parts i, ii and iii carry, respectively, 35%, 35%, 30% of the marks

3a Describe the architecture of a multi-layer perceptron (MLP) feed-forward network.

b Commonly, error back propagation is used to train MLP feed-forward networks. The error for pattern n being trained into the network is

$$E^n = \frac{1}{2}\sum_{k=1}^{c}(y_k - t_k)^2$$

where y_k is the output of the output layer node k and t_k is the target value for output layer node k. There are c nodes in the output layer.

The activation function g(a) used for hidden layer neurons is the sigmoid function

$$g(a) = \frac{1}{1+e^{-a}}$$

Assume that we have a three layer network with *a* neurons in the input layer, *b* neurons in the hidden layer and *c* neurons in the output layer.

Derive the expressions for weight adaptations (Δw) between

i the input and the hidden layer

ii the hidden and output layer.

Show clearly how you arrive at your result.

c i Suggest what a *single* Perceptron unit , with up to 10 inputs, could be used for. Your answer should include both a description of the mathematical activation function and a list of two possible applications.

ii How does the functionality change mathematically, when more layers are introduced creating a multi-layered Perceptron network ?

The three parts carry, respectively, 20%, 45%, 35% of the marks

Turn over

4a Describe the basic principles behind the WISARD (Wilkie, Stonham, Aleksander recognition device) system. In your account, give an explanation of the RAM neuron and what is meant by content addressable memory in this context.

b Describe the training and running processes of the WISARD.

c In an experiment we are trying to use the WISARD to recognise where the eyes are located in a database of 80 different photographs of people's faces. Suggest what architecture, training and running of the system is required for such a task. You may assume that the images are 128 pixels wise and 200 pixels high and that each pixel is either black or white.

Hint: The WISARD can be programmed to inspect any part of any image (any size) while analysing each photograph.

The three parts carry, respectively, 30%, 30%, 40% of the marks.

End of paper