A23406 No Calculator permitted in this examination

UNIVERSITY OF BIRMINGHAM

School of Computer Science

First Year – Undergraduate Affiliated Computer Science/Software Engineering
Final Year – BSc in Artificial Intelligence and Computer Science
Final Year – BSc Computer Science
Final Year – BEng Computer Science/Software Engineering
Final Year – BSc Computer Science with Study Abroad
Final Year – BSc Artificial Intelligence and Computer Science with an Industrial Year

06 20416

Neural Computation

Summer Examinations 2013

Time allowed: 1 hr 30 min

[Answer ALL Questions]

No Calculator

[Answer all questions]

1. (a) List the main computational factors that are generally considered to make artificial neural networks worth studying. [5%]

   (b) With the help of labelled diagrams, describe how a *McCulloch-Pitts Neuron* is related to a typical *Biological Neuron*. [7%]

   (c) Write down an equation that gives the output of a McCulloch-Pitts neuron in terms of its inputs, weights and threshold. Then, using a simple logical function, derive inequalities for the weights and thresholds which demonstrate that there exists mappings that cannot be performed by a single McCulloch-Pitts neuron. [7%]

   (d) Explain what makes it possible for a Multi-Layer Perceptron (MLP) to perform the kinds of mappings that McCulloch-Pitts neurons and Single Layer Perceptrons cannot. Why is it important that the MLP hidden unit activation functions are non-linear? [6%]

2. (a) Suppose a botanist had collected a large number of measurements of flowers and asked you to supply a neural network that could identify other flowers from their measurements. Design and justify a suitable Multi-Layer Perceptron architecture, including the specification of all activation functions. [6%]

   (b) Explain how you could use a gradient descent based approach to train your neural network on the data supplied. [Detailed mathematical derivations are <u>not</u> required.] [7%]

   (c) One approach to improving generalization is known as *Early Stopping*. Describe in detail how that would work in practice for this problem. [7%]

   (d) Explain how *Ensemble Averaging* could further improve your generalization performance. [5%]

3. (a) A farmer believes it may be possible to predict crop yield and quality for each year from measurements of the average weather conditions earlier that year. Design an appropriate *Radial Basis Function (RBF) Network* that might be able to learn from past data to make such predictions. Explain what will be computed by each component of your network. [7%]

   (b) Explain the operation of the *K-Means Clustering* algorithm, and how it might be helpful for training your RBF Network. [7%]

   (c) Outline the full process required to obtain all weights/parameters of your RBF network. [6%]

   (d) Describe how a regularization approach could be used to improve the generalization performance of your RBF network. [5%]

4. (a) Explain what is meant by the terms *Self Organising Map and Topographic Map*. Give an example of where a *Topographic Map* might be found in the human brain, and suggest why it might be useful there. [7%]

   (b) Describe the architecture of the particular form of *Self Organising Map* known as a *Kohonen Network*. [7%]

   (c) Briefly describe the key steps involved in the standard learning algorithm for a Kohonen network. [7%]

   (d) Provide a simple intuitive justification of why it is normal to decrease the learning rate during the course of training a Kohonen Network. [4%]