A23406 *No calculator permitted in this examination*

UNIVERSITY OF BIRMINGHAM

School of Computer Science

Third Year – BSc Artificial Intelligence and Computer Science
First Year – UG Affiliated Computer Science/Software Engineering
Third Year – BSc Natural Sciences
Third Year – BA English and American Literature with Year in Computer Science
Third Year – BSc Computer Science
Third Year – MSci Computer Science
Third Year - BSc Mathematics and Computer Science
Third Year – BSc Biochemistry with Year in Computer Science
First Year – UG Affiliated Science without Borders Computer Science
Third Year – BSc Computer Science with Industrial Year
Third Year – BSc Artificial Intelligence and Computer Science with Industrial Year
Third Year – BSc Natural Sciences with Year in Computer Science

06 20416

Neural Computation

Summer Examinations 2015

Time allowed: 1 hour 30 minutes

[Answer ALL Questions]

No calculator

[Answer ALL Questions]

1. (a) With the aid of labelled diagrams, describe the crucial components of typical biological neurons and the connections between them. [5%]

   (b) Describe the general process by which information is passed through a network of biological neurons. [5%]

   (c) Explain what is meant by *Rate Coding*, how that relates to the information coding in biological neurons, and why it is useful. [5%]

   (d) Explain how a *McCulloch-Pitts Neuron* relates to a typical biological neuron, and show how one can demonstrate the computational power of networks of such neurons. [10%]

2. (a) A refinery wants to predict various real valued measures of quality of their final product from the real valued properties of their raw ingredients and production processes. Design a suitable *Single Layer Perceptron* neural network (i.e., simple input to output mapping) to do this, and describe in detail a computationally efficient way to determine its weights and thresholds. [9%]

   (b) Suppose the *Single Layer Perceptron* did not produce very good results and the refinery wanted to try a *Multi-Layer Perceptron* neural network instead. Design a suitable neural network architecture, and describe an efficient way to determine its weights and thresholds. [9%]

   (c) Explain how one could try to use a regularization approach to optimize the generalization performance of such a *Multi-Layer Perceptron*. [7%]

3. (a) Describe the architecture of a standard *Radial Basis Function (RBF)* network that can be used to perform exact interpolation of a set of training data. Explain what is computed by each component of the network, and how the various weights and parameters can be determined most efficiently. [9%]

   (b) With reference to the Bias + Variance decomposition, explain why exact interpolation will not usually result in good generalization, and how you could change your exact interpolation *RBF* network architecture so that it generalizes better. [5%]

   (c) Outline an efficient procedure for training your revised *RBF* network. [6%]

   (d) Explain the main advantages your RBF network will have over a Multi-*Layer Perceptron (MLP)* network designed to perform the same task. [5%]

4. (a) Explain what is meant by the term *Topographic Map*. Give an example of where such a map might be found in a human brain, and suggest why it might be useful there. [5%]

   (b) Describe the architecture of the *Self Organising Map (SOM)* known as a *Kohonen Network,* and specify how the output neuron activations are computed for each input pattern. [6%]

   (c) Two equations commonly used in the context of *Kohonen Networks* are:

$$T_{j,I(\mathbf{x})}(t) = \exp(-S_{j,I(\mathbf{x})} / 2\sigma^2(t))$$

$$\Delta w_{ji} = \eta(t) \; . \; T_{j,I(\mathbf{x})}(t) \; . \; (x_i - w_{ji})$$

   Explain what each of the symbols in them represent, what the equations are used for, and how they are used in practice. [7%]

   (d) Explain what is meant by *Learning Vector Quantization (LVQ)*, and how it might result in more useful outputs for a *Kohonen Network*. [7%]