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

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Neural Computation
Summer Examinations 2015

Time allowed: 1 hour 30 minutes

[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:

\[
T_{j,l(x)}(t) = \exp(-S_{j,l(x)}/2\sigma^2(t))
\]

\[
\Delta w_{ji} = \eta(t) \cdot T_{j,l(x)}(t) \cdot (x_i - w_{ji})
\]

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%]