UNIVERSITY OF BIRMINGHAM

School of Computer Science

First Year - MSc Computer Science
Fourth Year - MEng Electronic and Software Engineering
Fourth Year - MEng Computer Science/Software Engineering
First Year - M.Res Computational Neuroscience and Cognitive Robotics

06 12412

Introduction to Neural Computation

Summer Examinations 2012

Time allowed: 1 hr 30 min

[Answer ALL Questions]

Answer all questions.

1. (a) Explain why one might want to use *Rate Coding* rather than *Spike Time Coding* when implementing an artificial neural network. [5%]

   (b) Describe what is meant by a *McCulloch-Pitts Neuron* and a *Perceptron*, and explain their relation to biological neural networks. [9%]

   (c) Derive expressions for the weights and thresholds that would be required for a single *McCulloch-Pitts Neuron* to perform the following input-output mapping:

in1	*in2*	*out*
0	0	1
1	0	0
0	1	0
1	1	1

   State in words what can be concluded from those expressions. [6%]

   (d) Discuss the power and limitations of *McCulloch-Pitts Neurons*. [5%]

2. (a) What would be a suitable *Multi-Layer Perceptron* (MLP) neural network architecture for a typical regression problem? Outline how a *gradient descent algorithm* would be used to train it. [9%]

   (b) Explain how and why a *line search* based learning algorithm might work better than simple gradient descent. What is the associated problem that the *conjugate gradient algorithm* aims to avoid? [7%]

   (c) Define what is meant by the terms *generalization* and *regularization*. Describe an example of a particular form of *regularization* for an MLP, and explain how you would optimize any associated parameter values. [9%]

3. (a) An electricity company has provided you with a large collection of data in the form of real valued input vectors, with a subset of them having corresponding output vectors, and wants you to build a system that will predict the outputs for new inputs. Design an appropriate *Radial Basis Function* (RBF) network for them, making it clear what will be computed at each layer of your network. [9%]

   (b) Specify a computationally efficient procedure to use the given training data to determine appropriate weights/parameters for your network that can be expected to result in good generalization performance. [10%]

   (c) Explain the main advantages your *Radial Basis Function* (RBF) network will have over a standard *Multi-Layer Perceptron* (MLP) network designed to perform the same task? [6%]

4. (a) Explain what *dimensional reduction* means and how it is relevant to *data compression*. Outline how it may be performed by a *Multi-Layer Perceptron* (MLP) neural network. [6%]

   b) Describe the architecture of a *Kohonen Network* and the mapping that is performed by such an appropriately trained network. [9%]

   (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 mean, what the equations are used for, and how they are used in practice. Include suggestions for suitable choices of the functions η, σ and S. [10%]