A23406 **No calculator permitted in this examination**

UNIVERSITY OF BIRMINGHAM

School of Computer Science

Third Year Degree of BSc

Artificial Intelligence and Computer Science
Computer Science

Undergraduate Occasional

Computer Science/Software Engineering

06 20416

Neural Computation

Summer Examinations 2011

Time allowed: 1 ½ hours

[Answer ALL Questions]

No calculator

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1. (a) With the aid of labelled diagrams, describe the relationship between a *Biological Neuron* and a *McCulloch-Pitts Neuron.* [7%]

   (b) Outline what is meant by the terms *Spike Time Coding* and *Rate Coding* for neural networks, and discuss their relative advantages and disadvantages. [7%]

   (c) Give an example of a binary mapping with two inputs and one output that a single McCulloch-Pitts neuron cannot perform. By deriving inequalities for the weights and thresholds that would be required for a McCulloch-Pitts neuron to perform that mapping, prove that the mapping cannot be performed. [8%]

   (d) Given that some simple mappings cannot be performed by a McCulloch-Pitts neuron, what can one do to allow such mappings to be performed by artificial neural networks? [3%]

2. (a) Describe how a gradient descent approach can be used to derive a neural network learning algorithm for regression (function approximation) problems. [Detailed mathematical derivations are <u>not</u> required.] [7%]

   (b) The following equation represents the bias-variance decomposition:

$$\mathcal{E}_D\left[\left(\mathcal{E}[y \mid x_i] - net(x_i, W, D)\right)^2\right]$$

$$= \left(\mathcal{E}_D\left[net(x_i, W, D)\right] - \mathcal{E}[y \mid x_i]\right)^2 + \mathcal{E}_D\left[\left(net(x_i, W, D) - \mathcal{E}_D\left[net(x_i, W, D)\right]\right)^2\right]$$

$$= \quad (\text{bias})^2 \quad + \quad (\text{variance})$$

   Explain what the various symbols in it mean, and what it tells us about the performance of a trained neural network. [12%]

   (c) Describe how *early stopping* can improve generalization performance, and how the stopping point can be determined. [6%]

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3. (a) Suppose you wish to approximate the underlying function from a set of noisy training data. Design a *Radial Basis Function (RBF)* network that you could use to do this. Explain what will be computed by each part of your network. [10%]

   (b) It is possible to use an RBF network to perform exact interpolation. Why is that generally not a good idea? [5%]

   (c) Outline a computationally efficient procedure for determining appropriate values for *all* the parameters and weights involved in your network. [10%]

4. (a) Explain what is meant by the term *Topographic Map*. Give an example of where such a map can be found in the human brain, and outline why it might be useful there. [7%]

   (b) Describe the key components of the architecture and self-organizing process that can be used to generate topographic maps in a *Kohonen Network*. [10%]

   (c) Describe the nature of the mapping performed by such a network, and explain how it relates to the concept of *Voronoi Tessellation*. [8%]