A23406 No Calculator permitted in this examination

UNIVERSITY OF BIRMINGHAM

School of Computer Science

Third Year – Artificial Intelligence and Computer Science
Fourth Year – Artificial Intelligence and Computer Science with Industrial Year
First Year – UG Aff Computer Science/Software Engineering
Third Year – BSc Computer Science
Final Year – BSc Computer Science with Industrial Year
Third Year – MSci Computer Science
Third Year - BA African Studies and Ancient History with Year in Computer Science
Third Year - MSci Physics with Year in Computer Science
Third Year - BSc Physics with Year in Computer Science
Third Year - BA Philosophy with Year in Computer Science
Third Year - BSc Psychology with Year in Computer Science
Third Year - BSc Biochemistry with Year in Computer Science
Third Year - BSc Mathematics with Year in Computer Science
Third Year - BSc Biological Sciences with Year in Computer Science
Third Year - MSci Psychology and Psychological Research with Year in Computer Science
Third Year - BSc Mathematics and Sports Science with Year in Computer Science
Third Year - BSc Economics with Year in Computer Science
Third Year - MSci Physics with Particle Physics Cosmology with Year in Computer Science
Fourth Year - MEng Mechanical Engineering with Year in Computer Science
Fourth Year – MSci Chemistry with Year in Computer Science
Third Year – BSc Human Biology with Year in Computer Science

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Neural Computation

Summer Examinations 2014

Time allowed: 1 hr 30 min

[Answer ALL Questions]

No Calculator

[Answer ALL Questions].

1. (a) Explain what is meant by *Spike Time Coding* and *Rate Coding* when building artificial neural networks. Describe the advantages and disadvantages of the two approaches. [6%]

   (b) Using labelled diagrams of each, describe how the *McCulloch-Pitts Neuron* represents the key features of *Biological Neurons*. [7%]

   (c) Using a simple example, show that there are some logical functions that a single McCulloch-Pitts neuron cannot represent. [7%]

   (d) Explain how it is possible to avoid the limitations of single McCulloch-Pitts neurons. [5%]

2. (a) A large-scale bread producer has collected a large amount of data relating properties of their raw ingredients to the properties of their final product. Design and justify a Multi-Layer Perceptron (MLP) neural network that could predict future final product properties from their raw ingredient properties. [7%]

   (b) Describe in detail how a gradient descent based approach could be used to train your network. [Detailed mathematical derivations are <u>not</u> required.] [9%]

   (c) Explain in detail the approach you would follow to optimize the generalization ability of your trained network. [9%]

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3. (a) Explain what the various symbols in following equation mean, and how it is relevant to understanding the performance of trained neural networks.

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

[10%]

(b) Describe the architecture of a standard *Radial Basis Function (RBF)* network, and explain what is computed by each component of the network. [5%]

(c) Outline an efficient procedure for training RBF networks. [6%]

(d) Explain how the RBF network can be used to perform *exact interpolation* and what the equation in (a) says about the consequences of doing that. [4%]

4. (a) Explain what *dimensionaity reduction* and *vector quantization* mean and how they are relevant to *data compression*. [6%]

(b) Suppose you had a large amount of data concerning factors such as nutrition, health, education, productivity for each country of the world. Design a Kohonen Network that will allow you to position the countries on a two dimensional grid in such a way that similar countries appear close together. Outline the data pre-processing and learning algorithm you would use to achieve your objective. [10%]

(c) Describe how an evolutionary computation approach might be used to optimize the learning parameters of your network. [9%]