Introduction to Neural Networks : Exercise Sheet 1

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The syllabus and terminology for the Introduction to Neural Networks module have changed considerably over the years. The following questions are typical of what might come up in the exam this year. The percentages indicate what fraction of the two hour exam they correspond to.

Question 1 (Based on Question 1 in Jan 1999 Exam)

(a) Biological neurons have a cell body, axons, dendrites and synapses. Draw a diagram and label these terms on it. **[4%]**

(b) Draw the computational equivalent and label it. **[4%]**

(c) List the main differences between the computational model and the biological equivalent. **[6%]**

(d) The human brain has 10^{10} neurons, whereas a large computational model may have only 10,000. Give reasons why the difference in number may matter, and reasons why it may not. **[4%]**

(e) The human brain can generalise. Can neural network models? Explain why the question of whether they can or cannot is, or is not, important. **[5%]**

Question 2 (Based on Question 2 in Jan 1997 Exam)

(a) Derive expressions for the weights and threshold of a Perceptron that computes the logical function OR. **[4%]**

(b) Single layer Perceptrons are limited in the class of input-output mappings they can perform. Identify that class, and give one simple example of a problem within that class, and one simple example from outside that class. **[6%]**

Question 3 (Based on Question 1 in May 2002 Exam)

(a) Outline the basic structure and components of a simple biological neuron. **[5%]**

(b) Describe how this is related to a McCulloch-Pitts neuron. **[5%]**

(c) Design networks of McCulloch-Pitts neurons that implement logical NOT, AND and OR gates. Draw each network and label all the weight and threshold values. **[6%]**

(d) In what way is XOR more difficult? **[4%]**

Question 4 (Based on Question 1 in May 2003 Exam)

(a) Draw labelled diagrams of a *Biological Neuron* and a *McCulloch-Pitts Neuron*. Discuss their relationship. **[7%]**

(b) Write down the equation for the output of a McCulloch-Pitts neuron in terms of its two inputs, its connection weights and its threshold. Derive inequalities that specify the weights and threshold for the logic gates NOT, AND, OR, and XOR. **[9%]**

(c) What do those inequalities tell us about the computational power of networks of McCulloch-Pitts neurons? **[4%]**

Question 5 (Based on Question 1 in August 2003 Resit Exam)

(a) Describe what a McCulloch-Pitts neuron is. **[5%]**

(b) Explain its relation to biological neurons. **[5%]**

(c) Derive expressions for the weights and thresholds of a McCulloch-Pitts neuron that can compute the following input-output mappings:

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

State in words what values the weights and thresholds can take. **[5%]**

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

Question 6 (Based on Question 1 in May 2004 Exam)

(a) Write down the equation for the output of a McCulloch-Pitts neuron in terms of its two inputs, its connection weights and its threshold. Derive expressions for the weights and thresholds of a McCulloch-Pitts neuron that can compute the following input-output mappings:

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

State in words what values the weights and thresholds can take, and provide an example of particular values. **[8%]**