UNIVERSITY OF BIRMINGHAM

School of Computer Science

MSc Computer Science
MSc Advanced Computer Science
Fourth Year - MSci Computer Science
Fourth Year - MEng Comp Science/Software Engineering
MSc Cyber Security
Fourth Year - MSci Mathematics + Computer Science
MRes Natural Computation
MSc Human-Computer Interaction
Fifth Year - MEng Comp Science/Software Engineering w Industrial Year
Fifth Year - MSci Computer Science w Industrial Year
MSc Computational Neuroscience + Cognitive Robotics
MSc Robotics

06 12412

Introduction to Neural Computation

Main Summer Examinations 2018

Time allowed: 01:30

[Answer ALL Questions]

Each question will be marked out of 24. Up to 20 marks will be awarded for content, with up to 4 additional marks for the quality, coherence, and clarity of your answer. The examination will be marked out of 72, which will be rescaled to a mark out of 100

NOTE: Answer ALL questions (3 in total). Each question will be marked out of 24. Up to 20 marks will be awarded for content, with up to 4 additional marks for the quality, coherence, and clarity of your answer. The examination will be marked out of 72, which will be rescaled to a mark out of 100.

1. (a) Categorise each of the four machine learning tasks below as either unsupervised learning, supervised learning, or reinforcement learning.
    1. Assume a collection of images of skin samples, each labelled with a skin disease. Diagnose skin diseases from images of skin samples.
    2. Given a collection of Renessaince paintings, generate pictures resemblant of Renessaince paintings.
    3. Given the layout of a warehouse, a description of its inventory, and camera and other robot sensory input, control a robot such that it moves a box from location A to location B in the warehouse.
    4. Given recordings of bird songs, each labelled with bird species, classify new recordings of birds according to species.

    Copy the table below in your answer sheet, and mark your answers with tick marks.

	Unsupervised L.	Supervised L.	Reinforcement L.
1			
2			
3			
4			

[8 marks]

(b) State the mathematical definitions of the terms *local minimum* and *global minimum*, and explain why they are important in machine learning.

[6 marks]

(c) Consider a dataset of n data points

$$(x^{(1)}, y^{(1)}), \ldots, (x^{(n)}, y^{(n)}) \in \mathbb{R} \times \mathbb{R},$$

and the linear regression model

$$f_{w,b}(x) = wx + b$$

with two parameters $w, b \in \mathbb{R}$. Find the values of these parameters which minimise the following loss function

$$J(w, b) = \frac{1}{2} \sum_{i=1}^{n} \left(y^{(i)} - f_{w,b}(x^{(i)}) \right)^2 .$$

[6 marks]

2. (a) State the pseudo-code for the gradient descent algorithm.

[8 marks]

(b) Consider the point $a = (1, -1)$ and the function

$$f(x, y) := 4x^2 - y^2 + xy + 1.$$

Find a vector $b \in \mathbb{R}^2$ which describes the direction from point a in which the function f decreases the most steeply. Show all the steps in your derivation.

[6 marks]

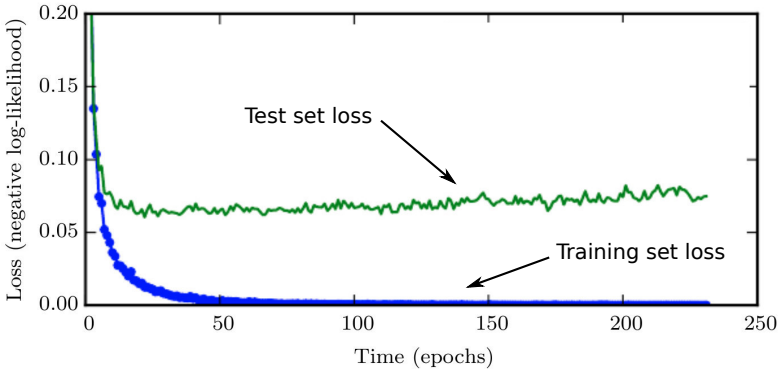
(c) Suggest how to combine evolutionary computation and neural computation.

[6 marks]

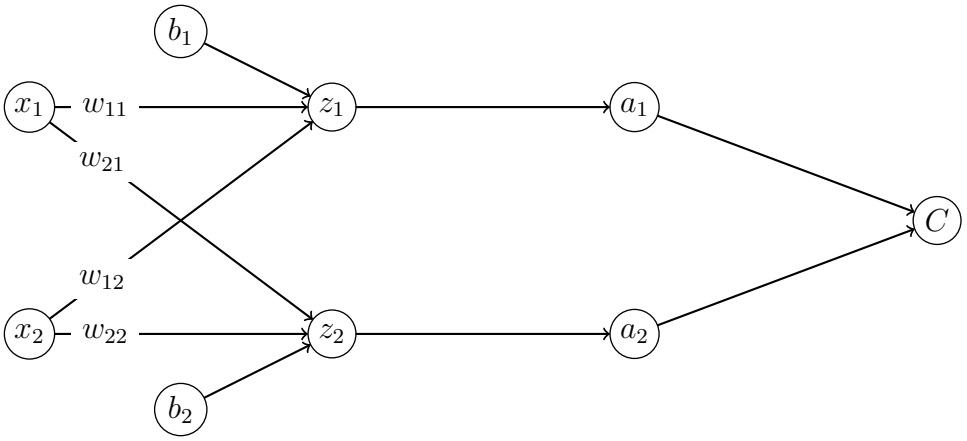
3. (a) Explain the difference between mini-batch gradient descent and batch gradient descent. Why is one of these methods usually preferred over the other?

[8 marks]

(b) Assume that after training a neural network for 250 epochs, the test set error remains high, despite a low training set loss, as in the figure below. Explain what may cause this behaviour, and suggest two methods for alleviating the problem.



[6 marks]



(c) Consider the feed forward neural network depicted above which has input units x_1 and x_2, output units a_1 and a_2, and C is a cost function. The relationship between the units are given below, where ϕ is some differentiable activation function.

$$z_j = \sum_{k=1}^{2} w_{jk} x_k + b_j \quad \text{for } j \in \{1, 2\}$$

$$a_j = \phi(z_j) \quad \text{for } j \in \{1, 2\}$$

$$C = \frac{1}{2} \sum_{k=1}^{2} (y_k - a_k)^2.$$

Compute the partial derivative $\frac{\partial C}{\partial w_{11}}$ given the information above, and explain how the gradient descent algorithm can use this quantity to train the network.

[6 marks]

A10894 Introduction to Neural Computation

Do not complete the attendance slip, fill in the front of the answer book or turn over the question paper until you are told to do so

Important Reminders

- Coats/outwear should be placed in the designated area.
- Unauthorised materials (e.g. notes or Tippex) must be placed in the designated area.
- Check that you do not have any unauthorised materials with you (e.g. in your pockets, pencil case).
- Mobile phones and smart watches **must** be switched off and placed in the designated area or under your desk. They must not be left on your person or in your pockets.
- You are not permitted to use a mobile phone as a clock. If you have difficulty seeing a clock, please alert an Invigilator.
- You are not permitted to have writing on your hand, arm or other body part.
- Check that you do not have writing on your hand, arm or other body part – if you do, you must inform an Invigilator immediately
- Alert an Invigilator immediately if you find any unauthorised item upon you during the examination.

Any students found with non-permitted items upon their person during the examination, or who fail to comply with Examination rules may be subject to Student Conduct procedures.