UNIVERSITY of York

BEng/BSc, MEng, MMath Examinations, 2016-2017

Introduction to Neural Computing and Applications (INCA)
Open Examination

Issued at:
Wednesday 1st March 2017

Submission due:
Wednesday 26th April 2017

Feedback and marks due:
Wednesday 24th May 2017

All students should submit their answers through the electronic submission system: http://www.cs.york.ac.uk/student/assessment/submit/ by 12 noon, **Wednesday 26th April 2017**. An assessment (or part of an assessment) submitted after this deadline will be marked initially as if it had been handed in on time, but the Board of Examiners will normally apply a lateness penalty to the whole assessment.

The feedback and marks date is guided by departmental policy but, in exceptional cases, there may be a delay. In these cases, all students expecting feedback will be emailed by the module owner with a revised feedback date. The date that students can expect to see their feedback is published on the module descriptor: http://www.cs.york.ac.uk/modules/

Your attention is drawn to the section about Academic Misconduct in the Departmental Statement on Assessment:
http://www.cs.york.ac.uk/student/assessment/policies/.

All queries on this assessment should be addressed to
Simon O'Keefe, simon.okeefe@york.ac.uk.

Your examination number must be written on the front of your submission.
You must not identify yourself in any other way.

Answers must not exceed 12 A4 pages in total; this limit includes any title page, diagrams, references, and so on. Excess pages will not be marked.

Section A - [60 marks]

This part of the assessment requires you to create a neural network. You may use any appropriate software to create the neural network, including but not limited to MATLAB and/or its toolboxes. A full justification for your choice of network and evaluation of its performance are more important than the ability of the network to produce "correct" results.

The data for this assessment are available from the Assessment page of the VLE. They are taken from the UCI Machine Learning Repository:

`http://http://archive.ics.uci.edu/ml/datasets/Occupancy+Detection+`

The data is experimental data used for automatically determining whether a room is occupied, as part of a building management system. The binary classification (room occupancy) is determined from measurements of temperature, humidity, light and CO2. The ground-truth occupancy data was obtained from time stamped pictures that were taken every minute.

The dataset comprises 20,560 samples and 5 features, with the aim of predicting occupancy. The data are effectively a time series. You do not necessarily need to use this fact in designing your network – you may treat each datapoint as an independent observation.

The data is provided in three CSV files called `datatraining.txt`, `datatest.txt` and `datatest2.txt`. You may use these files as they are for training, validation and test data, or merge them into a single dataset.

[This data was first used in:

Luis M. Candanedo, Véronique Feldheim. "Accurate occupancy detection of an office room from light, temperature, humidity and CO2 measurements using statistical learning models". Energy and Buildings. Volume 112, 15 January 2016, Pages 28-39.]

Your report should cover all the following points:

1. [10 marks] Discussion of architectures.

   This should

   - identify the type of problem
   - identify which feed-forward architectures would be suitable
   - give a brief discussion of the technical features of the architectures
   - give the advantages and disadvantages of each

   You should then state which class of architecture you are going to use and justify your choice, relating the characteristics of the problem to the advantages/disadvantages of each architecture.

   To do this you might need to

   - do some preliminary experiments with simple versions of the architecture to get a feel for what will work
   - do some exploratory data analysis to see what the characteristics of the data are
   - consider the principles involved and relate them to the problem

2. [50 marks] Creation and application of a neural network with your chosen architecture.

   - Data [10 marks]

     Describe (briefly) the data you have, and how much there is of it.

     Describe the inputs to (and outputs from) the network. You need to describe how the data you started with have been preprocessed. Explain how you investigated the data, including any assumptions you have made. Again, this may include some testing of networks to see what the effects are of different preprocessing choices. Give a step by step process for transforming the data into the network inputs, sufficient for someone else to process a new batch of data for use with the trained network. If you have transformed inputs using PCA, give the transformation matrix as an appendix to the report.

   - Network [10 marks]

     You should describe the network architecture that you have found to be the best for solving the problem. The description of the structure of

the architecture should be sufficient for someone else to implement your network exactly, and not necessarily using MATLAB, so you should include all the structural information and parameters necessary. Include a diagram.

You should also indicate how you implemented it. This could be brief if you have used MATLAB defaults, for example.

- Training [10 marks]

  Explain how you selected the best training algorithm for this problem. This could include testing different networks and training algorithms to see what might work well.

  For the training algorithm you used with the final version of the network, give sufficient detail for someone to implement the training algorithm. This does NOT mean (for example) describe gradient descent in great detail. It DOES mean give any parameters, initialisation, etc, even if they are the toolbox defaults.

- Evaluations [10 marks]

  In selecting the final network you will have to make choices about, for example, the number of neurons or the number of layers to use.

  - Explain what metric or metrics you used for comparison between networks.
  - Explain the process you went through in making the selection of the final architecture. If you evaluated a number of networks, give details of what their structures were and how they performed. You may summarise repeated tests of the same structure, but remember to give mean and variance of summary statistics.
  - Explain how you used the data in this selection process. For example, was it split into training, validation and test sets? How big were they?

- Results [10 marks]

  Give a synopsis of the results obtained from the final selected network. Relate these results back to the problem as stated – a MSE on its own is not helpful in judging how well something works.

  Identify anything of interest in the results, such as areas of particularly good or poor performance, or variation between different training runs.

Section B - [40 marks]

Buildings worldwide account for a significant portion of world energy consumption. Thus, increasing building energy efficiency can result in substantial financial savings. Building Management Systems (BMSs) are responsible for maintaining the indoor environment by controlling heating, ventilation, air conditioning, and lighting systems in buildings. Buildings are constantly affected by changing temperature, humidity and occupancy. To increase efficiency and maintain comfort, the BMS relys on an array of sensors inside the building that provide detailed data about the building state. The diagram in figure 1 suggests some elements of such a system.

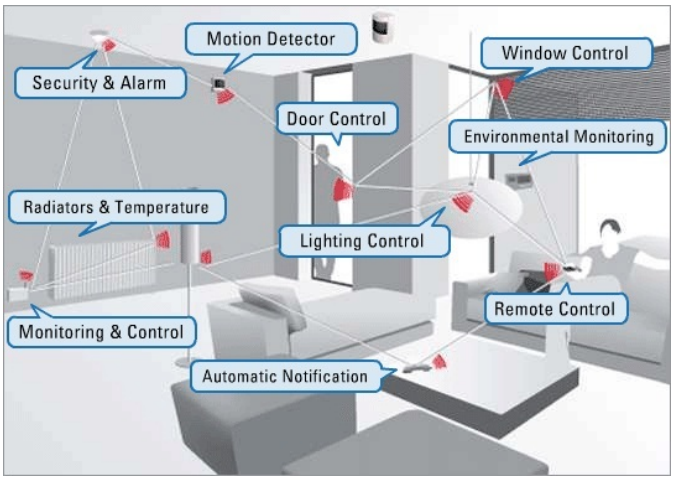

Figure 1: Building Management System that uses real time data to monitor and control services such as heating, ventilation and air-conditioning [source: http:www.nairaland.com].

Discuss *two* possible applications of neural networks to parts of the operation of the BMS. Each application should use a different architecture, both of which differ from your chosen architecture in Section A.

For each application, discuss:

- The technical features of the architecture [5 marks]
- The suitability of the architecture for your application [5 marks]
- The source of data, and how the network might be trained [5 marks]
- How the network would handle significant changes to building or environment [5 marks]