Module Code
COM00029H

BEng, BSc, MEng and MMath Degree Examinations 2019–20

DEPARTMENT OF COMPUTER SCIENCE

Introduction to Neural Networks (INNS)

Open Individual Assessment

Issued: 26th February 2020, 12:00 noon
Submission due: 22nd April 2020, 12:00 noon
Feedback and marks due: 20th May 2020, 12:00 noon

All students should submit their answers through the electronic submission system: http://www.cs.york.ac.uk/student/assessment/submit/ by 22nd April 2020, 12:00 noon. An assessment that has been 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.

Your attention is drawn to the section about Academic Misconduct in your Departmental Handbook: https://www.cs.york.ac.uk/student/handbook/.

Any queries on this assessment should be addressed by email to Simon O'Keefe at simon.okeefe@york.ac.uk. Answers that apply to all students will be posted on the VLE.

Rubric:

Answers must not exceed 8 A4 pages in total, with a minimum 11pt font and minimum 2cm margins either side. This limit includes any title page, diagrams, references, and so on. Excess pages will not be marked.

Your answer must address all of the questions outlined in the 'Report' section to gain full marks. Each question must be answered in its own dedicated section of the report, in the order given. Material outside the four prescribed sections will not be marked.

Your exam number should be on the front cover of your assessment. You should not be otherwise identified anywhere on your submission.

1 Scenario

The scenario for this assessment is the detection and classification of fetal cardiac anomalies using cardiotocography (CTG). CTG is used during pregnancy to monitor the fetal heart and contractions of the uterus. Its purpose is to monitor fetal well-being and allow early detection of fetal distress.

The data for this assessment are taken from the UCI Machine Learning Repository, and may be found on the Assessment page of the VLE site.

The data relate to fetal cardiac abnormalities. 2126 fetal cardiotocograms (CTGs) were automatically processed and the diagnostic features measured. The CTGs were also classified by three expert obstetricians and a consensus classification label assigned to each of them. Classification was both with respect to a morphologic pattern (A, B, C. ...) and to a fetal state (N, S, P).

This assessment requires you to construct two neural network classifiers, one to map from diagnostic features to the morphologic class, and one to map from the diagnostic features to the fetal state class.

After any experimentation and testing, your report must present a final network for each classification task, such as might be used by others to classify new data.

2 Data

For this assessment, you will use the data in the file `CTG.xls`, an Excel file that contains:

- 'Description' sheet: The metadata (data description)
- 'Data' sheet: The data to use
- 'Raw Data': The raw data. You do not need to use this.

The features that you may use as input are listed in column J on the 'Description' sheet, and appear in columns K-AE on the 'Data' sheet. The target classes are in columns AR and AT on the 'Data' sheet.

[This data was first used in:

Ayres de Campos et al. (2000) SisPorto 2.0 A Program for Automated Analysis of Cardiotocograms. J Matern Fetal Med 5:311-318]

Note: for consistency, the spellings "fetal" and "fetus" have been used instead of "foetal" and "foetus".

3 Report

You may use any appropriate software to create a 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.

It is not necessary to submit code for the neural network, but you must evaluate thoroughly the performance of the network (in terms of accuracy). You must provide justification for the choices you make. If your network does not perform perfectly you will still get credit for attempting to explain the performance.

Credit will be given for reference to the appropriate literature. Your answer should show that you have understood the literature you have selected, are able to explain the material, and can critically compare material from different sources.

Your report must be **no more than 8 A4 pages in length**, including any title page, diagrams, or references. It must contain the following sections, in the order given below, and material outside the four prescribed sections will not be marked.

1. [20 marks] Discussion of architectures.

   This section should

   - describe (briefly) the data you have, and how much there is of it.
   - identify the type of problem
   - identify which classes of architectures would be suitable
   - give a brief discussion of the technical features of the architectures, and the advantages and disadvantages of each
   - 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 the 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. [40 marks] Creation and application of neural networks.

   This section should

   - Describe the chosen inputs to (and outputs from) the networks.
   - Describe how the data you started with have been preprocessed.
   - Give sufficient detail for someone else to process a new batch of data for use with the final trained network.
   - State which training algorithm you selected, and explain how you selected that training algorithm. For this training algorithm, give sufficient detail to enable someone to use the same training algorithm in exactly the same way. This does NOT mean (for example) describing gradient descent in great detail. It DOES mean giving any parameters, initialisation, etc, even if they are the toolbox defaults.
   - Explain the process you went through in making the selection of the final architecture, for example, the number of neurons or the number of layers to use.

   To do this you might need to:

   - Test of one or more networks to demonstrate the effect of different preprocessing choices on the performance of the network.
   - Try different training algorithms on one or more networks to compare performance.
   - Evaluate a number of networks, and record details of their structures and how they performed. You may summarise repeated tests of the same structure.

3. [20 marks] Results and evaluation

   This section should

   - Explain the metric or metrics you have used for comparison between networks.
   - Give a synopsis of the results obtained from the *final* selected network.
   - Evaluate the results, in relation to the problem posed in the scenario.

   To do this you might need to:

   - Consider different metrics for performance, appropriate to the problem. Remember that a Mean Squared Error (MSE) on its own is not always 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.

- Reflect on the conclusions that you may draw from the results, and whether they are showing that the neural network is useful in this case.

4. [20 marks] Further application

   In the previous sections you used a neural network to convert cardiotocogram features into a diagnosis.

   Another tool for detection and diagnosis of fetal abnormalities is the ultrasound scan, that produces an image of the a section through the fetus. Interpreting fetal scans is a highly complex task which require years of training.

   Assume the availability of a large number of fetal scan images, both normal and with some abnormality, and labelled to indicate different types of abnormalities.

   The task is for a neural network to process new ultrasound images, and to indicate which images needed further investigation. This section should discuss the issues you would need to consider in relation to:

   - selection of an architecture
   - construction of the network
   - use of data for training
   - evaluation of the network

End of examination paper