



COS711 Assignment 2

Supervised Neural Network Training

Due date: 30 September 2019, at 23h30

1 General instructions

You have to submit a pdf document, containing a technical report wherein you describe what you have done, present and discuss your findings. Guidelines for writing your report are provided in this specification document. The report will be checked for plagiarism using the Turnitin system, and should be submitted through the ClickUp system. You are advised but not required to typeset your report in \LaTeX .

2 Supervised Learning

For this assignment, you will compare 0-order, 1-order, and 2-order methods for training feed-forward neural networks (NNs). NNs will be used to predict whether a star is a pulsar based on astronomical observations.

2.1 Data set

Download the data set from the CS website. The data is also available from the Kaggle page: <https://www.kaggle.com/pavanraj159/predicting-a-pulsar-star/>. Please visit the Kaggle page for a detailed description of the attributes. The data set contains 16,259 non-pulsar examples caused by noise, and 1,639 real pulsar examples.

2.2 Your task

Your task is to train a NN to correctly classify an observation as pulsar or noise. For the purpose of this assignment, you will need to perform the following steps: pre-process the data; optimise NN parameters; compare zero-, first-, and second-order NN training methods of your choice.

2.2.1 Data preparation

The given data contains numeric attributes that lie in various ranges. Analyse the data set, and pre-process it in a way that will make it possible for the NN to effectively discover the

hidden relationships between inputs and outputs. Extra marks can be obtained for performing self-organising map (SOM) analysis of the given data.

Note that the classification task is severely unbalanced, i.e., the majority of the data patterns represent negative examples (non-pulsar). Imbalance is common in real-world datasets. You must decide how to deal with this imbalance, and discuss the chosen approach in the report.

2.2.2 Neural Network Parameter Optimisation

As discussed in class, the performance of your NN model greatly depends on various parameters, such as the number of layers and hidden units, activation functions, error function, optimisation algorithm parameters, etc. You will have to choose the parameter values for your NN model. Your report **must** contain a section justifying all parameter choices. Two justifications are acceptable: (1) theoretical insight; (2) empirical evidence. I.e., if you cannot decide on a value for a certain parameter analytically, you have to run some experiments to see which value performs better than others.

You must empirically compare at least two different parameters of your choice. Additionally, you must also pick at least two regularisation schemes (i.e. weight decay, weight elimination, dropout, etc.), and compare the performance of the above approaches with and without regularisation.

2.2.3 Comparing Zero-, First-, and Second-Order Optimisation

As a final and most important step of the assignment, you will need to perform a comparison of three training approaches: zero-, first-, and second-order training algorithms of your choice. Refer to the lecture slides for a discussion of various training approaches.

Discuss all your results thoroughly. Remember that simply pasting a table with numbers will not yield any marks. If you see that one approach is doing better than the other, give a hypothesis for why it is the case.

3 Notes

- Implementation
 - You may use any programming language and platform
 - You may use a neural network library/framework
- Report
 - You must report on all data preparation steps taken
 - You must report on all algorithm parameters used, and substantiate your choices
 - Training, generalisation, and classification errors have to be reported. When classification error is reported, clearly indicate what part of the dataset was used to generate it. Remember to report means with the corresponding standard deviations.

4 Marking and general guidelines

For this assignment you have to submit a research report where you discuss your findings. Your reports must follow the IEEE conference format (http://www.ieee.org/conferences_events/conferences/publishing/templates.html). You may use the Latex or the Word template, however it will serve as good academic writing practice to utilise L^AT_EX. There is also a strict page limit of **8 pages** for this assignment. Given the imposed two column format it would require a substantial amount of writing to exceed this limit.

This is not a course in technical and report writing; however, you should at least attempt to follow some accepted document writing techniques and make your report as readable as possible. You are more likely to obtain a higher mark if your report generates a good impression with the marker and is void of general errors like spelling and grammar mistakes. You are strongly advised to download some research papers from the CIRG members to get a feel for how to write a report. A quick search on Google Scholar should yield good results.

A typical report would consist of the following sections:

1. **Abstract**

The abstract should briefly summarise the purpose and findings of the report.

2. **Introduction**

The introduction sets the stage for the remainder of your report. You usually have very general statements here. The introduction prepares the reader for what to expect from reading your report. In general, the introduction should either contain or be a summary of your ENTIRE report. Keep the introduction concise, try to limit it to 1 page maximum.

3. **Background**

A very high level discussion on the problem domain and the algorithms and/or approaches that you have used. Do not be too specific on the algorithms and approaches. This section is typically where the “base cases” of concepts that appear throughout the remainder of your report are discussed. It is also an ideal place to refer a reader to other sources containing relevant information on the topic which is outside the scope of your assignment. Remember to discuss very generally. After reading this section the marker should be able to determine whether or not you know what you’re talking about. Try to limit this section to 1 pages maximum.

4. **Experimental Set-Up**

In this section you discuss how you approached, implemented and solved your assignment. Mention the values set for the algorithm’s control parameters, how many simulations you have run and what the characteristics for candidate solutions to your problems are. After reading this section (in addition to the background) the reader should be able to duplicate your experiments to obtain similar results to those obtained by you. This is also the section where your discussion specialises on the concepts mentioned in the background section. Be very specific in your discussions in this section.

5. **Research Results**

This is the section where you report your results obtained from running the experiments as discussed in the experimental set-up section. You have to give, at least, the averages and the standard deviations for all the experiments/simulations. Training, generalisation, and classification errors have to be reported. Thoroughly discuss the results that you’ve obtained and reason about why you obtained the results that you have. Answer questions like “are these results to be expected?” and “why these results occurred?” and “would different circumstances lead to different results?”

6. Conclusion(s)

Very general conclusions about the assignment that you have done. This section “answers” the questions and issues that you’ve raised and investigated. This section is, in general, a summary of what you have done, what the results were and finally what you concluded from these results. This is the final section in your document so be sure that all the issues raised up until now are answered here. This is also the perfect section to discuss what you have learnt in doing this assignment.

Please **do not** include any code or pseudocode in the report. Research reports must focus on the scientific contributions. We just assume that you can code – you do not have to prove it anymore!

4.1 Marking

The following general breakdown will be used during the assessment of this assignment:

Category	Mark Allocation
Report Structure	5 marks
Background	5 marks
Experimental Setup	10 marks
Data Preparation	10 marks
Parameter Optimisation	20 marks
Comparison of 0-, 1-, and 2-order Training	40 marks
Conclusions	5 marks
References	5 marks
TOTAL	100 marks

Submit only the PDF report. No additional files of any sort should be submitted. Upload the PDF file to the appropriate assignment upload on ClickUp. Multiple uploads are allowed, but only the last one will be marked. The deadline is **30 September 2019, at 23h30**.