University of South Wales Prifysgol De Cymru

Faculty of Computing, Engineering and Science

Assessment Cover Sheet 2021-22

Module Code:	Module Title:	Module Team:
MS4S16	Applied Machine Learning and Deep Learning	Ieuan Griffiths Sam Jobbins
Assessment Title and Tasks: Assessment 2		Assessment No. 2
Date Set: **20-Jan-23**	Submission Date: **21-Mar-23**	Return Date: **16-May-23**

IT IS YOUR RESPONSIBILITY TO KEEP RECORDS OF ALL WORK SUBMITTED

Marking and Assessment

This assignment will be marked out of 100%

This assignment contributes to 50% of the total module marks.

Learning Outcomes to be assessed (as specified in the validated module descriptor https://icis.southwales.ac.uk/):

Learning Outcomes	
Learning Outcome 1:	To understand the concepts of machine learning and deep learning for Data Science, and compare and test a range of techniques.
Learning Outcome 2:	To classify features of data sources, analysing and interpreting the outputs of machine learning and deep learning techniques in the context of practical situations in the area of Data Science.

Marking Criteria/Marking Scheme

Marking Guidelines for this assessment are provided at the end of this brief.

Feedback Method

Feedback will be provided via BlackBoard Assessment.

Provisional mark only: subject to change and / or confirmation by the Assessment Board

Assessment 2

Deadline: 21st March 2023

This assessment is worth 50% of your overall mark for this module. You must use Python and PyTorch to perform your analyses and produce a Juypter Notebook summarising your output and results. Your findings should be interpretated with valid conclusions drawn within the notebook.

Produce and submit one Juypter Notebook per task with the contents converted to a PDF Format. Any written parts, include as images and submit these as separate files (or use markdown in your Juypter Notebook if possible). Written sections will be made apparent within the assessment outline below.

Note:

1. Upload your three Juypter Notebook (.ipynb) files to the blackboard assessment before the deadline. Only in situations where this is not possible, you should email a copy of your notebooks to the lecturer (ieuan.griffiths@southwales.ac.uk).
2. Any Questions regarding the coursework, please don't hesitate to ask. The subject email of your query should be: "MS4S16 Assignment Query". Doing this, will allow me to ensure I can filter my emails for queries and not miss any emails.

Task 1 – Gradient Descent using NumPy (20%)

Part 1 (13 marks):

Using the rules of differentiation, differentiate the following (showing your workings, by-hand):

Q1) $f(u) = (2u - 14)^3$
Q2) $f(v) = (4v - 16)^2 + (v^2 - 16)^2$
Q3) $f(w) = \left(5\frac{w^2}{w} - 15\right)^2$

Part 2 (12 marks):

Using your answers, create a NumPy Program which applies the gradient descent algorithm to minimise the given error function. Initialise the algorithm with the following values: $u = 8, v = 1, w = 4$.

$$y = f(u, v, w) = (2u - 14)^3 + (4v - 16)^2 + (v^2 - 16)^2 + \left(5\frac{w^2}{w} - 15\right)^2$$

Hence find the values of u, v & w where the function (and thus the Error) is equal to zero.

Part 2b (2 marks):

Determine the true (non-approximated) values of u, v & w such that $E = y = 0$, verifying your answers mathematically (show your workings, by-hand).

Please Check all Pages

Task 2 – Regression using PyTorch (35%)

Part 1 (13 marks):

Using PyTorch and its Autograd feature, calculate dy/dx for each of the following questions, initalising two variables $(x \ \& \ c)$ as scaler tensor of a single value = 1, where c is a constant.

Q1) $y = 4(u^2 + 3)^2 + u, where\ u = 3x^2 + c$

Q2) $y = 3(2v^2 + 2) + 2c^4, where\ v = 2x$

Q3) y = 2u, *where* $u = (l + l^2)^2, l = \frac{1}{2}s^3, s = v^2, v = 10r, r = x$

Q4) Draw (by-hand) two separate diagrams/ computational maps for the functions shown in Q1 & Q2 of this Task. That is, the diagram/ computational map should highlight the significant sub-components, demonstrating how inputs $x \ \& \ c$ are converted to the final function y.

Part 2 (22 marks):

Using PyTorch without helper functions (without using torch.nn or torch.optim), calculate the values of $a, b \ \& \ c$ that best fit the model $f(x)$ using the gradient descent algorithms with the following:

$$f(x) = e^{-ax} + bx + c$$

$$X = [-2, -1.6, -1.2, -0.8, -0.4, 0, 0.4, 0.8\ , 1.2, 1.6, 2]$$

$$y_0 = [1.71828183, 2.02554093, 2.4221188, 2.8918247, 3.42140276, 4,$$

$$4.61873075, 5.27032005\ 5.94881164, 6.64932896, 7.36787944]$$

Task 3 – Neural Networks (35%)

Part 1 (25 marks):

Using the datasets provided on Blackboard:

1. Create two basic* Neural Networks. The first should be a Simple Neural Network. The second, a Convolutional Neural Network.
2. Create two improved* Neural Networks. The first should be a Simple Neural Network. The second, a Convolutional Neural Network.

You should then conduct a comparative analysis of the two improved models, discussing the changes you made and how they've improved on the basic models.

- A "basic" neural network is "A functional neural network, that contains the necessary features to constitute as that type of neural network, however may not produce the best results.".
- An "improved" neural network is "A neural network where changes/adaptations have been made to the model structure, or training algorithm, to improve the results delivered by the model.".

Part 2 (10 marks):

1. Using only your optimized Convolutional Neural Network you've created. Test a learning rate of 0.00000001 vs a learning rate of 10 (using the SGD optimizer from the learning material & keeping all other parameters in your model the same). Discuss what happens when these values are used and why. Furthermore, discuss in detail, the advantages and disadvantages of a higher & lower learning rate, and its impact.
2. Secondly, discuss in detail, the advantages and disadvantages of a higher & lower batch size.

Jupyter Notebook (10%)

1. Your code should be clear, efficient, and well commented. The notebook must be well structured, well written and comments should be grammatically correct. Titles, headings and figures should be correct and labelled in a meaningful way and referenced accordingly.

Note: If you decide to use a different IDE to Jupyter Notebook (such as Jupyter Lab or VSCode), this won't effect your results.

END OF ASSESSMENT