EEEB4023/ECEB463
Artificial Intelligence and Neural-fuzzy Systems

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Midterm Test, Sem 2 2021/2022

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100 marks in this Test contribute to 20% of the final grade. Instructions:

1. This is an **OPEN BOOK** test.
2. Prepare your own pieces of paper, A4 or foolscap.
3. Redraw any required diagrams on your own paper.
4. **You have <u>90 MINUTES</u>.**
5. **There are SIX (6) QUESTIONS. Answer all questions.**
6. Convert your answers to PDF using Adobe Scan, CamScanner or similar app or scanner.
7. Submit your PDF file to the Teams assignment page.

<u>QUESTION 0 [DECLARATION]</u>

(a) Rewrite the following on the first page of your submission:

"I promise that I have not given or received aid in this test, and that I have done my part in ensuring that others as well as I uphold the UNITEN Student Rules and Regulations."

(b) Below the declaration, write your full name, student ID and signature.

<u>QUESTION 1 [20 MARKS]</u>

For each of the following, provide an answer with justifications.

(a) Explain the use of training dataset and test dataset in machine learning. **[5 marks]**

(b) Does the *k*-nearest neighbour algorithm require more computation during training time or test time? **[5 marks]**

(c) Explain the pros and cons of the linear classifier for image classification algorithms. **[5 marks]**

(d) In a neural network, is "activation function" a hyperparameter? **[5 marks]**

QUESTION 2 [30 MARKS]

A training dataset consisting of four 2×2 images with its class labels is shown in the table below. A new test image is to be evaluated using the L1 Manhattan distance metric and listed in column d_i. The L1 distance equation is provided as:

$$d_i(I_{test}, I_{train,i}) = \sum_p \left| I_{test}^p - I_{train,i}^p \right|$$

where i is the data number in the training dataset, and p is the pixels of each image.

	i	**class**	**image**	d_i
Test image	–	–	$\begin{array}{\|c\|c\|}\hline 98 & 20 \\ \hline 33 & 60 \\ \hline\end{array}$	–
Training images	0	computer	$\begin{array}{\|c\|c\|}\hline 84 & 91 \\ \hline 99 & 74 \\ \hline\end{array}$	d_0
	1	lamp	$\begin{array}{\|c\|c\|}\hline 220 & 189 \\ \hline 203 & 157 \\ \hline\end{array}$	d_1
	2	lamp	$\begin{array}{\|c\|c\|}\hline 217 & 188 \\ \hline 146 & 133 \\ \hline\end{array}$	473
	3	computer	$\begin{array}{\|c\|c\|}\hline 33 & 56 \\ \hline 28 & 28 \\ \hline\end{array}$	138

(a) Determine the distance values for d_0 **AND** d_1. **[10 marks]**

(b) Using k-nearest neighbour, what is the output class when $k = 3$? **[4 marks]**

(c) What is the output class when $k = 2$? **[3 marks]**

(d) What is the output class when $k = 1$? **[3 marks]**

(e) Using the Euclidean distance metric, determine the distance value for d_0. The Euclidean distance equation is:

$$d_i(I_{test}, I_{train,i}) = \sqrt{\sum_p \left(I_{test}^p - I_{train,i}^p \right)^2}$$

[10 marks]

QUESTION 3 [10 MARKS]

A linear classifier has the function $f(x, W) = Wx + b$, with pre-trained weights and biases values as below:

$$W = \begin{bmatrix} 0.5 & 0.8 & -0.1 & 0.9 \\ 0.8 & -0.3 & 0.7 & 0.2 \\ 0.2 & -0.7 & 0.9 & 0.2 \\ 0.6 & 0.2 & -0.2 & 0.7 \end{bmatrix} \qquad b = \begin{bmatrix} 0.3 \\ 0.4 \\ 0.6 \\ 0.5 \end{bmatrix} \qquad classes = \begin{bmatrix} phenomenal \\ awesome \\ successful \\ generous \end{bmatrix}$$

Using the last four digits of your Student ID number as the input column vector, *x*, determine the output scores of the linear classifier above. Lastly, state the class that was categorised by the model.

[10 marks]

QUESTION 4 [20 MARKS]

A *tiger* image is input to a 3-class classification model. The raw scores of the classifier, and the correct 1-hot encoding scores are given below.

$$Score = \begin{bmatrix} \text{leopard} \\ \text{lion} \\ \text{tiger} \end{bmatrix} = \begin{bmatrix} -2.9 \\ 3.1 \\ 6.3 \end{bmatrix} \qquad Correct\_Score = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$$

(a) Determine the SVM loss. **[8 marks]**

(b) Determine the cross-entropy loss. **[8 marks]**

(c) Is this a good or bad classifier? Why? **[2 marks]**

(d) If all the scores were doubled, such that:

$$Score = \begin{bmatrix} \text{leopard} \\ \text{lion} \\ \text{tiger} \end{bmatrix} = \begin{bmatrix} -5.8 \\ 6.2 \\ 12.6 \end{bmatrix}$$

Explain what would happen to the SVM and cross-entropy losses? Calculations not required.

[2 marks]

QUESTION 5 [10 MARKS]

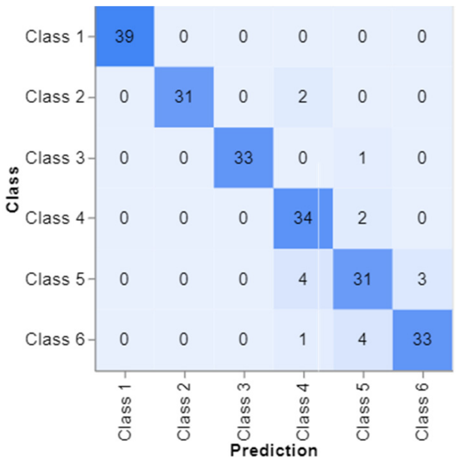
Answer the following questions based on your experience in Group Project 1.

(a) List down the classes of your dataset. **[1 marks]**

(b) Briefly explain the application your group submitted for Group Project 1. **[2 marks]**

(c) In your opinion, which single hyperparameter was the most important to be modified before training? Why is that so? **[3 marks]**

(d) A model was trained on the Teachable Machine, and its confusion matrix and accuracy per class is shown below. Comment on this model's performance based on these output results. **[4 marks]**



CLASS	ACCURACY	# SAMPLES
Class 1	1.00	39
Class 2	0.94	33
Class 3	0.97	34
Class 4	0.94	36
Class 5	0.82	38
Class 6	0.87	38

QUESTION 6 [10 MARKS]

Weight values, W, in a neural network model need to be optimized by minimizing the loss at every iteration. When a small change, h, is introduced to a weight value, the Loss rate of change can be calculated using the numerical gradient function below.

$$\frac{df(W)}{dW} = \lim_{h \to 0} \frac{f(W+h) - f(W)}{h}$$

where loss, $L = f(W)$. With the initial loss $f(W) = 1.7918$ and learning rate, $h = 0.001$, some gradients for a single step were calculated as below.

Weight number, W_i i	Loss with small change, h $(f(W+h))$	Gradient dL/dW
0	1.7925	0.74
1	1.7953	3.54
2	1.802	10.24
3	1.7846	dL_3/dW
4	1.7914	-0.36
5	1.795	3.24

(a) Determine the missing gradient, dL_3/dW in the table above. **[6 marks]**

(b) Among the gradients in the table above, which weight number, i, should be changed to quickly reduce the loss? Please explain your chosen answer. **[4 marks]**

-END OF QUESTION PAPER-