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 90 MINUTES.**
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.

QUESTION 0 [DECLARATION]

(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.

QUESTION 1 [20 MARKS]

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:

$$d_i(I_{test}, I_{train,i}) = \sum_p |I^p_{test} - I^p_{train,i}|$$

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	–	–	53 20 85 50	–
Training images	0	chair	84 91 99 74	$\boldsymbol{d_0}$
	1	couch	220 189 203 157	$\boldsymbol{d_1}$
	2	couch	217 188 146 133	476
	3	chair	33 56 28 28	135

(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:

$$d_i(I_{test}, I_{train,i}) = \sqrt{\sum_p (I^p_{test} - I^p_{train,i})^2}$$

[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 *kangaroo* 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.

$$Score = \begin{bmatrix} \text{chimpanzee} \\ \text{elephant} \\ \text{kangaroo} \end{bmatrix} = \begin{bmatrix} -1.3 \\ 3.1 \\ 5.0 \end{bmatrix} \qquad Correct\_Score = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$$

(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:

$$Score = \begin{bmatrix} \text{chimpanzee} \\ \text{elephant} \\ \text{kangaroo} \end{bmatrix} = \begin{bmatrix} -2.6 \\ 6.2 \\ 10 \end{bmatrix}$$

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

[2 marks]

QUESTION 5 [10 MARKS]

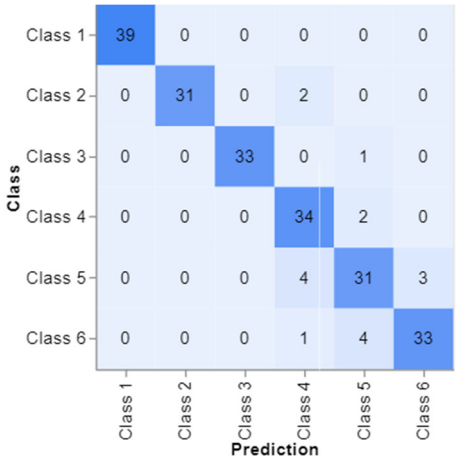
Answer the following questions based on your experience in Group Project 1.

(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	Loss with small change, h	Gradient
i	$(f(W+h))$	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-