

**MASINDE MULIRO UNIVERSITY OF  
SCIENCE AND TECHNOLOGY  
(MMUST)**

**MAIN CAMPUS**

**UNIVERSITY MAIN EXAMINATIONS  
2021/2022 ACADEMIC YEAR**

**FOURTH YEAR 2<sup>ND</sup> SEMESTER EXAMINATIONS**

**BACHELOR OF SCIENCE IN  
COMPUTER SCIENCE**

**COURSE CODE: BCS 465  
COURSE TITLE: NEURAL NETWORKS**

**DATE: THURSDAY 28<sup>TH</sup> APRIL, 2022      TIME: 8:00 - 10:00**

**INSTRUCTIONS TO CANDIDATES**

Answer Question **ONE (1)** and Any **OTHER 2** questions

Ensure your answers/ideas are clearly expressed

All your answers must be clearly numbered

Write in ink. Rough work can be done (in answer booklet) in pencil and will not be marked. Cross out any rough work.

Calculators, phones, tablets, computers not allowed

**TIME: 2 Hours 20 Minutes (20 minutes for reading and choosing questions)**

**MMUST observes ZERO tolerance to examination cheating**

This Paper Consists of 04 Printed Pages. Please Turn Over. ▲

**QUESTION ONE: COMPULSORY QUESTION [30 MARKS]**

Figure 1 shows a neural network that uses back-propagation learning algorithm

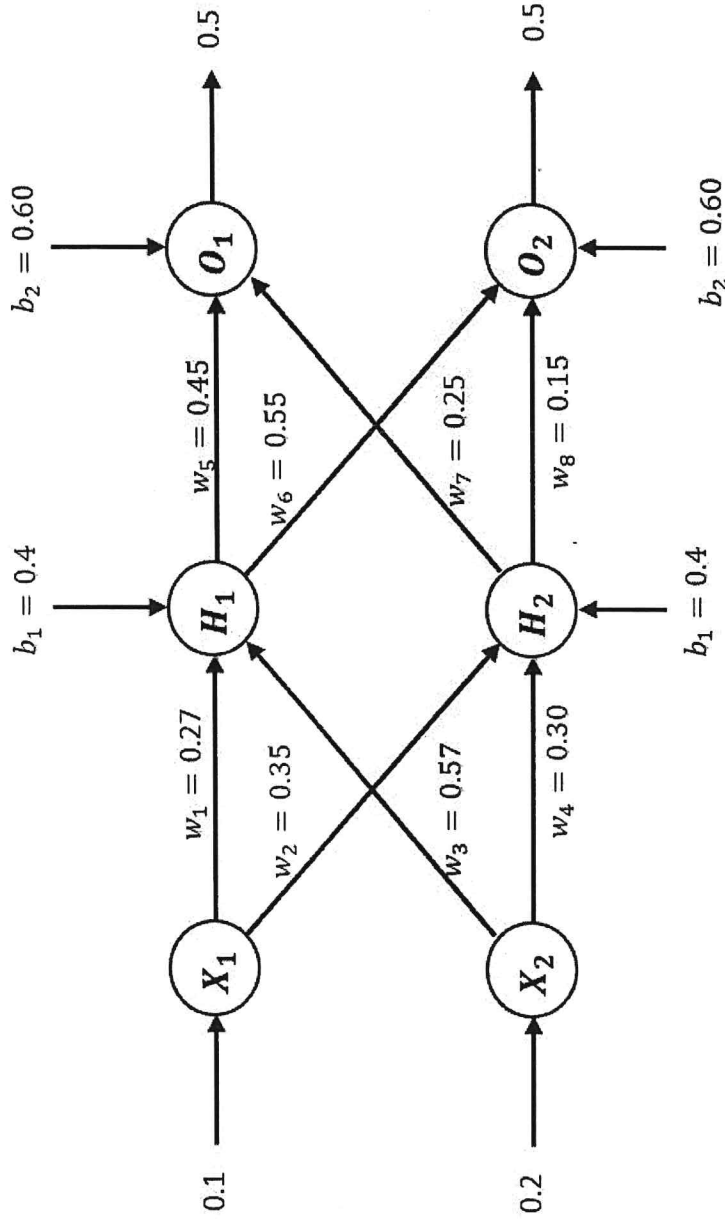


Figure 1: Neural Network

Neurons in the hidden layer and output layer use logistic sigmoid activation function.

- Calculate the output for  $O_1$  and  $O_2$  neurons. [4 Marks]
- Using Mean Squared Error (MSE), calculate the error  $E_{O_1}$  for  $O_1$  and  $E_{O_2}$  for  $O_2$  neurons given that the target output were 0.6 and 0.4 for  $O_1$  and  $O_2$  respectively. [4 Marks]
- Calculate the total error  $E_{Total}$  of the network. [2 Marks]
- Show that derivative of logistic sigmoid function

$$f(x) = \frac{1}{1 + e^{-x}}$$

- is  $f'(x) = f(x)(1 - f(x))$  [4 Marks]
- Calculate the ratio of change in  $E_{Total}$  to changes in  $w_6$ . Calculate the new  $w_6$ . Use learning rate of 0.5. Show your working. [7 Marks]
- Calculate the ratio of change in  $E_{Total}$  to changes in  $w_3$ . Calculate the new  $w_3$ . Use learning rate of 0.5. Show your working. [9 Marks]

## QUESTION TWO

[15 MARKS]

The following 4 input vectors are to be clustered into two clusters using Kohonen Self-Organizing Maps (SOM)

$$\mathbf{s}^{(1)} = [0 \ 0 \ 1 \ 0] \quad \mathbf{s}^{(2)} = [1 \ 0 \ 1 \ 0]$$

$$\mathbf{s}^{(3)} = [1 \ 0 \ 0 \ 1] \quad \mathbf{s}^{(4)} = [1 \ 1 \ 0 \ 1]$$

Assume that the initial weight matrix is

$$\text{Unit 1} \quad [0.2 \ 0.6 \ 0.5 \ 0.9]$$

$$\text{Unit 2} \quad [0.8 \ 0.4 \ 0.7 \ 0.3]$$

$$\text{Unit 3} \quad [0.3 \ 0.5 \ 0.8 \ 0.6]$$

A learning rate of 0.3 is used to update the weights for each iteration (for each training sample) with a topological radius  $r = 0$ . During training, the input vectors are presented to the neural network one at a time in the order  $\mathbf{s}^{(1)}$ ,  $\mathbf{s}^{(2)}$ ,  $\mathbf{s}^{(3)}$  and then  $\mathbf{s}^{(4)}$

(i) For each training input vector  $\mathbf{s}^{(i)}$  for  $i = 1, 2 \dots 4$ , calculate the weight matrix  $\mathbf{w}^{(i)}$ . [10 Marks]

(ii) Assuming that after 100 epochs (iterations), the weight vector becomes

$$\mathbf{W} = \begin{bmatrix} 0.0 & 0.5 & 1.0 \\ 0.0 & 1.0 & 0.5 \\ 1.0 & 0.0 & 0.0 \\ 0.5 & 0.0 & 0.0 \end{bmatrix}$$

Determine the clusters to which the input vectors belong to. Assume unit 1 represent cluster 1, unit 2 represent cluster 2 and unit 3 represent cluster 3. [5 Marks]

## QUESTION THREE

[15 MARKS]

(a) Briefly explain how a neural network can be used to fight Covid-19 pandemic.

[5 Marks]

(b) Figure 2 shows a perceptron. The threshold function at the output node is defined as

$$f(x) = \begin{cases} 1 & \text{if } x \geq 1.2 \\ 0 & \text{otherwise} \end{cases}$$

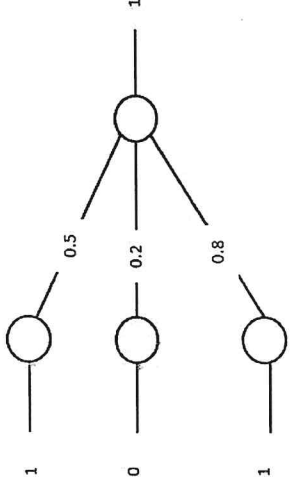


Figure 2: A Perceptron

- (i) Show how the output **1** was arrived at by the perceptron. [2 Marks]
- (ii) Assume the output was supposed to be **0**, calculate the new weights of this perceptron. [3 Marks]
- (iii) Write a C++ function that can be used to update the weights. The function receives a vector of old weights, vector of inputs and calculates and returns a vector of new weights. [3 Marks]
- (c) Briefly explain what is under-fitting as used in a Neural Network. [2 Marks]

#### QUESTION FOUR [15 MARKS]

- (a) What is capacity as used in neural network learning. [2 Marks]
- (b) Calculate the derivative of swish sigmoid function defined as

$$f(x) = \frac{x}{1 + e^{-x}}$$

- [5 Marks]
- (c) Briefly explain the effect of a smaller learning rate in a neural network. [3 Marks]
- (d) Briefly explain what is under-fitting as used in a Neural Network. [3 Marks]
- (e) Logistic sigmoid and tanh activations functions are mostly similar. Why would one prefer logistic sigmoid to tanh. [2 Marks]