The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Mechanical Engineering

Study Programme	: Bachelor of Technology Honors in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: DMX5315 – Artificial Intelligence**
Academic Year	: 2020/2021
Date	: 12th February 2022
Time:	: 0930-1230 hrs.
Duration	: **3 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Seven (7)** questions in **three (3) parts.**
3. PART 1, PART 2 and PART 3 of the paper contains 2, 2 and 3 questions respectively.
4. Answer **only 5 questions.**
5. Answer **minimum 1 question** from **PART 1** and **PART 2 each.**
6. Answer **minimum 2 questions** from **PART 3.**
7. All the questions carry **equal marks.** The total mark for the paper is 100.
8. Answer for each question should commence from a new page.
9. This is a CLOSED book test (CBT).
10. The symbols used in this paper have their usual meanings.
11. Clearly state any assumptions that you may make.
12. Answers should be in clear handwriting.
13. Do not use red colour pen.
14. This paper contains 09 pages including the cover page.

PART 1

Question 1.

1. State and explain the 5 types of components in intelligence.

(5 Marks)

2. State and describe three issues of an intelligent system.

(6 Marks)

3. Describe what is artificial intelligence and explain the importance of AI in today's world.

(9 Marks)

Question 2.

1. What is an expert system and explain the structure of an expert system?

(6 Marks)

2. "An AI agent interacts its environment through its sensors and actuators". Elaborate the statement by taking an appropriate example.

(6 Marks)

3. State and explain the three types of virtual environments. What is the most common virtual environment out of them?

(7 Marks)

4. What is the category in taxonomy where the "human agent" falls into?

(1 Marks)

PART 2

Question 3.

Assume you are assigned to design a fuzzy logic-based control system to fill up a water tank using the sensor reading of the water level. The system input is the water level (cm), and the output is the motor speed (1000rpm). The rule base is given in Table Q3 below.

Table Q3: Rule Base

Variable	Water Level	Speed
Rule 1	LOW	FAST
Rule 2	MEDIUM	MODERATE
Rule 3	HIGH	SLOW

Answer the following questions.

1. If the fuzzy set of linguistic variables
   $LOW = \{\frac{1}{1}, \frac{0.8}{2}, \frac{0.6}{3}, \frac{0.4}{4}\}$ and
   $FAST = \{\frac{0.1}{3}, \frac{0.3}{5}, \frac{0.5}{7}, \frac{0.7}{9}, \frac{0.9}{11}\}$,

   Find the Relational matrix (R) using Mamdani Min Operation.

   (6 Marks)

2. If the fuzzy set of linguistic variables
   $MEDIUM = \{\frac{0.3}{1}, \frac{0.6}{2}, \frac{0.6}{3}, \frac{0.3}{4}\}$

   Find linguistic variable $MODERATE$ using Max – MIN fuzzy composition rule.

   (6 Marks)

3. Using Rule 1, Rule 2, and
   $HIGH = \{\frac{0.1}{1}, \frac{0.3}{2}, \frac{0.7}{3}, \frac{0.9}{4}\}$

   Find linguistic variable $SLOW$ using Max – MIN fuzzy composition rule.

   (8 Marks)

Question 4.

Answer the following questions about designing a fuzzy control system for an Air conditioner having 4 linguistic variables for each input and output.

1. Assume the inputs are Temperature and Humidity, and output is the Air conditioner's fan speed. Plot the membership functions which are Triangular equally distributed at the following ranges.

    a. Temperature is from 10°C to 40°C. (VERY LOW, LOW, HIGH, VERY HIGH)
    b. Humidity is from 20% to 80%. (VERY LOW, LOW, HIGH, VERY HIGH)
    c. Fan speed is from 1000 rpm to 4000 rpm. (VERY LOW, LOW, HIGH, VERY HIGH)

    (6 Marks)

2. If only two rules are assigned in the system as shown below, calculate the system output using the Mean of Maximum Height method at Temperature=32.5°C, and Humidity= 55%.

    a. Rule 1: IF Temperature is VERY LOW and Humidity is LOW, THEN Fan speed is LOW
    b. Rule 2: IF Temperature is HIGH and Humidity is HIGH, THEN Fan speed is HIGH

    (14 Marks)

PART 3

Question 5.

1. State the main three types of Deep Learning and explain the difference between each of them.

(6 Marks)

2. Briefly explain the Supervised Learning model.

(4 Marks)

3. A sample data set is given in Table Q5 (a) which consists of the data collected from the Cardiology unit in a hospital. Answer the below questions by assuming that you have to train a Neural Network using the following data set in order to predict the risk of having a heart disease of a patient.

Table Q5 (a): A Sample Data Set

Age (years)	Total cholesterol level (mg/dl)	High density Lipoprotein (mg/dl)	Average blood pressure (mmhg)	Risk of having a heart disease (%)
48	236	66	78.5	5
48	260	51	75.5	15
44	187	49	80.5	10
30	216	57	79.5	0.4
56	156	42	72.5	2.2
44	162	57	74.5	3
50	244	47	78.5	4.2
48	212	30	77.5	17.4
66	202	53	80.5	13.4
63	186	46	72.5	17.3
42	267	28	74.5	19.8
58	234	36	72.5	13.2

(10 Marks)

Answer the following questions.

a. State the type of the problem.
b. What are the inputs and outputs of the Neural Network to be trained?
c. What is the most suitable loss function that can be used for training the neural network?
d. What is the best activation function that can be used for the output layer of the neural network to be trained and explain why you select it?
e. Assume that the following predicted results are shown in Table Q5 (b) were predicted after training the Neural Network for the above problem. Calculate the R^2 score of the trained neural network. Keep the answer to three decimal places.

Table Q5 (b): Predicted and Actual Results

Predicted Risk (%)	Actual Risk (%)
31.0	31.5
12.9	12.4
22.4	23.4
18.8	18.7
2.8	2.9

Question 6.

1. Write forward propagation and error equations for sections a,b and c considering the Neural Network shown in Figure Q6 respectively and find the values for all of them. Use the sigmoid activation function where it is necessary. Y2-Y6 are the outputs of the neurons whereas X is the Input of the Neural Network. The actual values of the trainable parameters, input and outputs are given in Table Q6. Keep the answers to three decimal places.

    a. All the hidden layer neurons
    b. All the output neurons
    c. Error of the 5th neuron

(9 Marks)

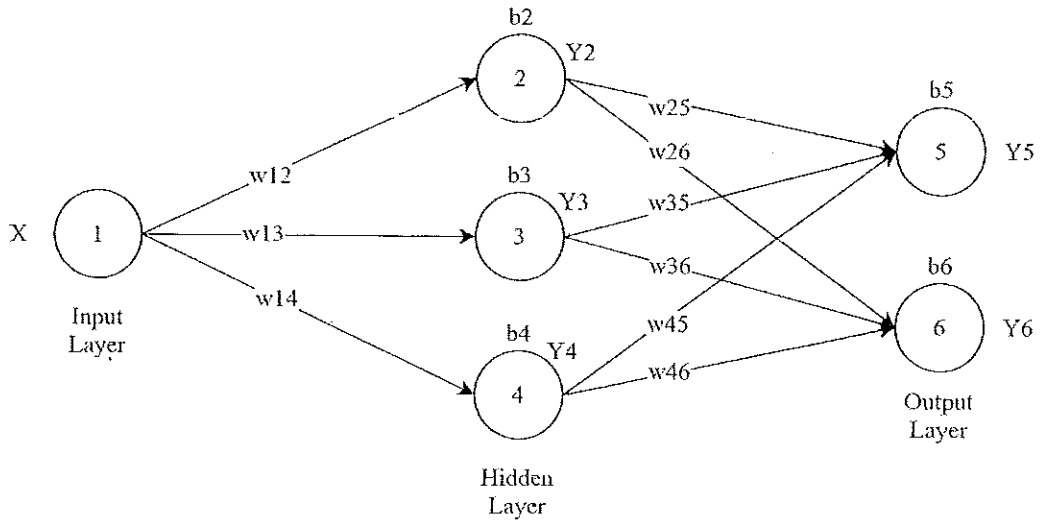

Figure Q6: A Sample Neural Network

Table Q6: Actual Values of the Parameters

	Parameters	Value
Biases	b2	0.05
	b3	0.06
	b4	-0.1
	b5	0.5
	b6	-0.06
Weights	w12	0.03
	w13	0.04
	w14	-0.06
	w25	0.01
	w26	0.05
	w35	0.04
	w36	0.07
	w45	-0.03
	w46	0.02
Input	X	0.6
Outputs	Y2	0.12
	Y3	0.5
	Y4	0.16
	Y5	0.95
	Y6	0.76

2. Briefly explain the role of backpropagation in Neural Networks.

(3 Marks)

3. Briefly explain the impact of Learning Rate on Neural Network performance.

(3 Marks)

4. State three ways that could be used to overcome the problem of overfitting in Neural Networks and briefly explain one out of them.

(5 Marks)

Question 7.

1. Select the most suitable neural network type that could be used for the following applications.
   a. Noise removal
   b. Fake data generation
   c. Pattern recognition
   d. Time series data analysis

(4 Marks)

2. Explain and compare the Mini Batch Gradient Descent, Batch Gradient Descent and Stochastic Gradient Descent methods.

(6 Marks)

3. What is the fastest gradient descent method out of the main three gradient descent methods?

(1 Marks)

4. What is the major difference between fixed learning rates and adaptive learning rates?

(2 Marks)

5. Explain what will happen to the error with respect to the number of epochs in a converging Neural Network?

(4 Marks)

6. Refer to Figure Q7 and apply gradient descent algorithm to calculate the new value of the weight W. Assume that the current value of $W=W_1$ and the Error of the Neural Network is E_1.

   $W_1 = 0.03$
   Learning rate = 0.001
   Derivative of the error with respect to the weight = $\tan\theta$

(3 Marks)

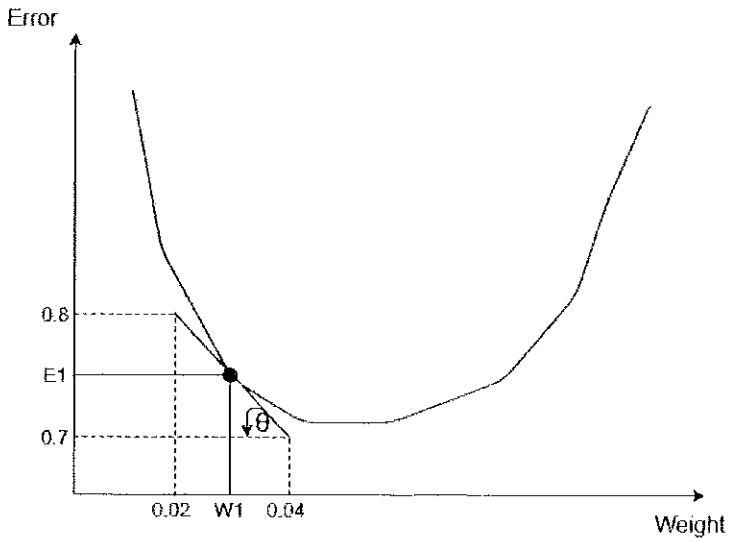

Figure Q7: Weight Vs Error

Hints:

Mamdani Min Operation = $\mu_{Ri}(x, y) = min[\mu_{Ai}(x), \mu_{Bi}(y)]$

MAX-MIN Composition Rule = $\mu_B(y) = max\ [min\ (\mu_A(x),\ \mu_R(x, y))]$

ReLu activation function: $Y = F(Z) = Max(0, Z)$

Tanh activation function: $Y = F(Z) = \frac{1-e^{-2z}}{1+e^{-2z}}$

Sigmoid activation function: $Y = F(Z) = \frac{1}{1+e^{-z}}$

Mean Squared error: $MSE = \frac{1}{n}\sum_{i=1}^{n}(y - \hat{y})^2$

R^2 Score: $R^2 = 1 - \frac{\sum(y-\hat{y})^2}{\sum(y-\bar{y})^2}$

END OF THE PAPER