The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Electrical and Computer Engineering

033

Study Programme	: Bachelor of Science Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: EEX7241-Neural Networks and Fuzzy Logic**
Academic Year	: 2022/23
Date	: 31sh January 2024
Time	: 1330-1630hrs
Duration	: **3 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Five (5)** questions in **four (4)** pages.
3. Answer **all questions.**
4. Answer for each question should commence from a new page.
6. This is a Closed Book Test **(CBT).**
7. Answers should be in clear handwriting and do not use red colour pens.

Question 1

(a) Explain what is meant by following pieces of code (3 marks)

```
import tensorflow as tf
import numpy as np
from tensorflow import keras
```

(b) What is the role of a "loss" function in an ANN? (2 marks)

(c) Given the following piece of code for a CNN, explain what is meant by each of the terms; (5 marks)

i) Sequential
ii) Dense
iii) Relu
iv) Softmax
v) Flatten

(d)

```
model = tf.keras.models.Sequential([
  tf.keras.layers.Flatten(input_shape=(28, 28)),
  tf.keras.layers.Dense(512, activation=tf.nn.relu),
  tf.keras.layers.Dense(10, activation=tf.nn.softmax)
])
```

(e) Briefly explain what is achieved by the above code (in part (c)). (3 marks)

(f) A neural network that you have just finished training performs poorly on the validation set. List 2 possible causes why this would happen and suggest solutions to overcome the problem. (4 marks)

(g) Provide an example where RNN is the best-suited model to solve a given problem with justification. (3 marks)

Question 2

(a) Not all problems are suited to model with a Neural Network. If there are certain features in the program, we can say it is not a problem suitable for NN. Explain what kind of problems are not suited to model with an ANN. (6 marks)

(b) What are the equations to describe the Perceptron Learning Rule? (2 marks)

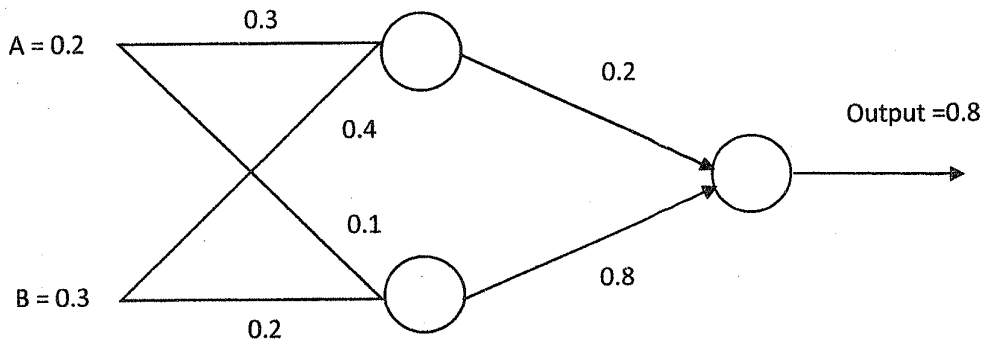
(c) Assume that the neurons of the below ANN have Sigmoid activation function and that $\alpha = 1$ and $\eta = 1$. Assume that the expected output is also set to 0.8 and the bias given for hidden nodes is set to 1.

i. Use the Backpropagation training algorithm to find the error of the network after one forward traversal. (show the calculations to 3 decimal points) (6 marks)

ii. Calculate the new weights for hidden neurons in the first backward pass. (6 marks)

Use the following equation to calculate the error when updating weights in backward pass;

Error = Output(1-output)(Target-output)



Question 3

The following gives details related to the design of a fuzzy-controlled Washing Machine. During the design process, the following fuzzy quantities and corresponding states were identified.

Greasy Level (Low, Medium, High)
Amount of Dirt (Small, Medium, High)
Washing Time (Very short, Short, Medium, Long, Very Long)

The relationship between the 2 inputs **Greasy**, **Amount of Dirt**, and the output Washing Time is as follows.

If ***Greasy Level*** *is Low* AND ***Amount of Dirt is Small,*** *THEN* ***Washing Time*** *is Very Short.*

If ***Greasy Level*** *is Medium* AND ***Amount of Dirt is Medium,*** *THEN* ***Washing Time*** *is Medium.*

If ***Greasy Level*** *is Medium* AND ***Amount of Dirt is Small,*** *THEN* ***Washing Time*** *is Medium.*

If ***Greasy Level*** *is High* AND ***Amount of Dirt is Large,*** *THEN* ***Washing Time*** *is Very Long.*

Greasy Level, Amount of Dirt and **Washing Time** have the following membership functions.

Consider the following fuzzy membership functions and answer the below questions: -

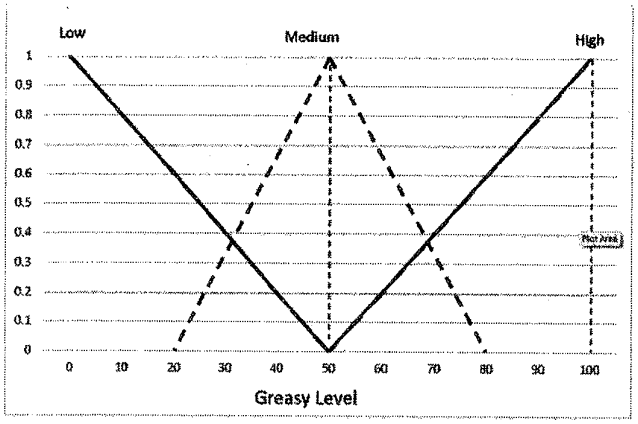


Figure 1 Greasy Level

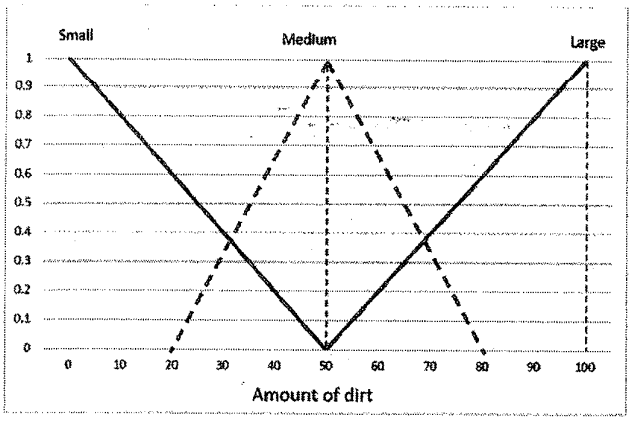


Figure 2 Amount of dirt

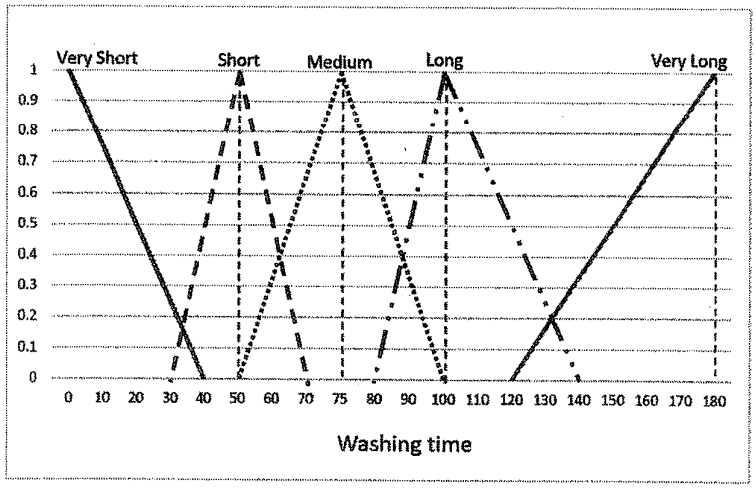


Figure 3 Washing Time

a) List all the linguistic variables and linguistic values associated with the above system. (5 Marks)

To answer b) and c) use the following crisp measurements of the process, at a given instance:
Greasy Level – 65 Amount of Dirt – 40

Use the following techniques as applicable.

- Min – Max inference method; Centroid method

b) Determine the corresponding inference membership function for the **Washing Time (min)** (12 Marks).

c) Determine the crisp value for the control action (3 Marks).

Question 4

(a) Given 2 fuzzy sets as,

$$A = \left\{\frac{0.1}{1}, \frac{0.3}{2}, \frac{0.2}{3}, \frac{0.1}{4}, \frac{0}{5}\right\}, \quad B = \left\{\frac{0.3}{1}, \frac{0.5}{2}, \frac{0.3}{3}, \frac{0.2}{4}, \frac{0.1}{5}\right\}$$

What is $A \cup B$ and $A \cap B$? (8 marks)

(b) The shape of the fuzzy membership function is important in building fuzzy systems. Draw the fuzzy membership functions for the following scenarios. (4*2 = 8 marks)

i. Modelling how you can choose to tip at a restaurant when food is served.
When tipping, you must consider the quality of the service and the taste of the food and rate them between 0 and 10. You may use this information to leave a tip between 0 and Rs. 500.

ii. Modelling whether to take an umbrella based on weather prediction.
When predicting weather, assume that only the amount of rainfall and the wind speed are considered.

(c) What is the key difference between a Mamdani controller and a Takagi-Sugeno-Kang Controller? (4 marks)

Question 5

"Predicting undergraduate students' success is a widely researched area. There are many reasons for an undergraduate to drop out from a Study programme. Based on the number of reasons, number of parameters will increase. If these reasons can be identified, preventive measures can be taken from the educational institute concerned."
Assuming that you are to devise an ANN to predict the undergraduate dropout/graduate possibility, answer the following questions.

(a) Suggest 10 input parameters for any ANN model. (5 marks)

(b) Identify a suitable Artificial Neural Network model to solve this problem and explain why you chose it? (4 marks)

(c) State the following for the neural network: (6 marks)

- No of nodes for input layer
- Number of nodes for output layer
- Number of Hidden layers

(d) What is the main difference between a Rule-Based Fuzzy Logic System and an Artificial Neural Network and how can they combine to make a hybrid system? (5 marks)