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

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	: 2023/2024
Date	: 1st February 2025
Time	: 0930-1230hrs
Duration	: **3 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Four (4)** questions in **four (4)** pages.
3. Answer **all questions.**
4. Answer for each question should commence from a new page. You will need **a graph paper** to draw diagrams for Question 3.
5. You may **use a calculator** for answering questions
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 piece of code (5 marks)

```
import tensorflow as tf
import numpy as np
import matplotlib as mpl
import pandas as pd
from tensorflow import keras
```

(b) Briefly explain what is achieved by the piece of code given below. (9 marks)

```
model.compile(optimizer = 'adam', loss = 'mse', metrics = 'mae')

history = model.fit (
   X_train_lstm, y_train,
   Validation_data = (X_test_lstm, y_test),
   Epochs =50,
   Batch_size = 32,
   Verbose = 1 )
```

(c) Assume that the training data set you have received contains many missing values for some attributes. What can you do to pre-process the data to overcome the problem of missing values in a data set? (4 marks)

(d) When is it necessary to normalize a data set? Briefly explain one method to normalize data. (4 marks)

(e) What is the purpose of calculating the error during the training of a neural network? How does it help to improve the performance of the network? (3 marks)

Question 2

Assume the following parameters for a small ANN and answer the questions asked below.

- *Inputs to the ANN*: x_1=0.2, x_2=0.1
- *Hidden Layer*: 3 neurons
  - The weights for the hidden layer neurons are provided as:
    - w_{11h}=0.4, w_{12h}=0.1; w_{21h} =0.3, w_{22h} =0.2 and w_{31h}=0.5, w_{32h}=0.1 (weights for hidden neuron 1, 2, and 3, respectively).
  - Bias for each hidden neuron is $bias_h$=1
- *Output Layer*: 1 output neuron
  - The output weights from hidden neurons to the output neuron are assumed as:
    - w_{1O}=0.6 , w_{2O}=0.4, w_{3O} =0.7
  - The bias at the output layer is $bias_O$ =1.
- *Desired Output*: $y_{expected}$=0.99
- *Learning Rate*: α=1
- *Activation Function*: Sigmoid $\sigma(x) = 1/\{1 + e^{-x}\}$

a) Use the Backpropagation training algorithm to find the error of the network after one forward traversal (show the calculations to 3 decimal points). (7 marks)
Use the Mean Square Error formula given below to calculate the error.

$$\frac{1}{2} * (y_{expected} - o)^2$$

b) Calculate the new weights for hidden neurons in the first backward pass. (8 marks)
Use the equation for weight update - $w_{ijnew}=w_{ijold}+\alpha \cdot \delta_{hi} \cdot x_j$

c) What will the error be if the ReLU activation function is used? (4 marks)
hint: *ReLU(x)=max(0,x)*

d) List 2 other activation functions (except Sigmoid and ReLU) that are used with ANNs. (2 marks)

e) The activation function used in hidden layers is typically chosen based on the type of neural network architecture. What is the generally used activation function in CNN? (2 marks)

f) What is the significance of Softmax function? (2 marks)

Question 3

In the design of a fuzzy-controlled traffic light system, the following fuzzy quantities and corresponding states were identified:

Traffic Density (Low, Medium, High)

Time of Day (Morning, Afternoon, Evening)

Traffic Light Duration (Short, Medium, Long)

The relationship between the two inputs (Traffic Density, Time of Day) and the output (Traffic Light Duration) is described by the following fuzzy rules:

1. If **Traffic Density** is Low AND **Time of Day** is Morning, THEN **Traffic Light Duration** is Short.
2. If **Traffic Density** is Medium AND **Time of Day** is Afternoon, THEN **Traffic Light Duration** is Medium.
3. If **Traffic Density** is High AND **Time of Day** is Evening, THEN **Traffic Light Duration** is Long.
4. If **Traffic Density** is High AND **Time of Day** is Morning, THEN **Traffic Light Duration** is Medium.
5. If **Traffic Density** is Low AND **Time of Day** is Evening, THEN **Traffic Light Duration** is Medium.

Traffic Density, **Time of Day**, and **Traffic Light Duration** have the following membership functions:

Traffic Density: Low (0 to 5 vehicles per minute), Medium (2 to 8 vehicles per minute), High (5 to 10 vehicles per minute)

Time of Day: Morning (6 AM to 12 PM), Afternoon (9AM to 5 PM), Evening (2 PM to 8 PM)

Traffic Light Duration: Short (30 to 70 seconds), Medium (50 to 130 seconds), Long (110 to 180 seconds)

a) Draw the membership functions for **Traffic Density**, **Time of Day**, and **Traffic Light Duration**. (select a membership function type that will help find the answers to the questions given below.) (12 Marks)

b) If the **Traffic Density** is **3 cars per minute** and the t**ime of Day** is **3 PM**, compute the degree of membership for each fuzzy set (Low, Medium, High for Traffic Density and Morning, Afternoon, and Evening for Time of Day) using the given membership functions. (5 Marks)

c) Based on the fuzzified input values, apply the fuzzy rules to determine the corresponding **Traffic Light Duration** (4 marks)

d) Briefly describe 2 defuzzification methods. (4 Marks).

Question 4

(a) Given 2 fuzzy sets as,

$$A = \left\{\frac{0.2}{1}, \frac{0.4}{2}, \frac{0.3}{3}, \frac{0.2}{4}, \frac{0}{5}\right\},\ B = \left\{\frac{0.4}{1}, \frac{0.6}{2}, \frac{0.2}{3}, \frac{0.1}{4}, \frac{0.7}{5}\right\}$$

What is A∪B and A/B? (8 marks)

(b) Indicate whether the Mamdani Inference system or Takagi-Sugeno inference system is best suited for given applications (with reasoning). (2*4 = 8 marks)

i. *A system requiring precise mathematical modeling and control*
ii. *A system where the control logic is based on human expertise and decision-making*
iii. *Washing machines that adjust washing cycles based on load and dirt level*
iv. *Microcontroller-based control systems.*

(c) Give an example not suited to model with Fuzzy Logic and explain why (4 marks)

(d) Name 2 other AI techniques that can be used with Fuzzy systems to make them more efficient. Explain with applications. (5 marks)