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Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2022/2023

COURSE NAME	:	INTELLIGENT CONTROL SYSTEM
COURSE CODE	:	BEJ44103/BEH41803
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	FEBRUARY 2023
DURATION	:	3 HOURS
INSTRUCTION	:	1. ANSWER ALL QUESTIONS 2.THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK.** 3.STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **SIX (6)** PAGES

Q1 A fully connected Multi-layer Neural Netwoks (MLNN) model in **Figure Q1** will be trained to solve XOR problem using backpropagation optimizer. All neurons in layers i and k have linear activation functions, and all neurons in layer j have tangential activation functions given by:

$$O_j = f(net_j) = \frac{e^{Cnet_j} - e^{-Cnet_j}}{e^{Cnet_j} + e^{-Cnet_j}}$$

(a) With the aid of illustration, explain why XOR samples are categorized as a nonlinear problem.

(2 marks)

(b) If $C=1$, T_k is target, n is learning rate, *net* is the sum of input neuron, and O is firing output of neuron, derive the general weight adaptation equation for ΔW_{kj}, ΔW_{ij}, ΔB_k and ΔB_j using gradient descent algorithm if the MLNN's cost function is given by $E=0.5\ (T_k - O_k)^2$.

(13 marks)

(c) If $n = 1$, sample input and target value is given by $[X_1=1,\ X_2=0,\ T_k=1]$ and initial values as in **Figure Q1**, analyze all new weights adaptation value after single iteration process.

(15 marks)

Q2 By referring to two models of Convolutional Neural Network (CNN) code in **Figure Q2:**

(a) Illustrate both model structure with details of layer labelling.

(4 marks)

(b) Analyze which model produces higher output dimension shape in the final layer of the convolutional stack.

(11 marks)

(c) Identify which model produces lower trainable parameters.

(15 marks)

Q3 An engineer needs to design a fuzzy position control system in which each antecedent and consequent must have only 3 fuzzy sets: Negative (*N*), Zero (*Z*) and Positive (*P*). The membership functions for the two antecedents and one consequent are given in **Figure Q3** and the model use Mamdani rule base and disjunctive aggregator.

(a) With reference to the under-damped transient response, construct the most appropriate fuzzy control rules in matrix form to solve the positioning problem with minimum of overshoot if *error* = *input* - *output*. Give justification for each of the designed rules.

(5 marks)

(b) Based on the rules developed in **Q3(a)**, analyze model of output before defuzzification for E=-15.0 and ΔE = 1.0 case.

(12 marks)

(c) Based on answer from **Q3(b)**, examine the difference of crisp value ΔU when calculated using Bisector of Area (BOA) method and Center of Area (COA) method. For the COA, please use resolution of 1.

(20 marks)

(d) From the answer above, explain why the calculated COA's crisp is different with BOA output and what can be done to improve COA calculation.

(3 marks)

-END OF QUESTIONS –

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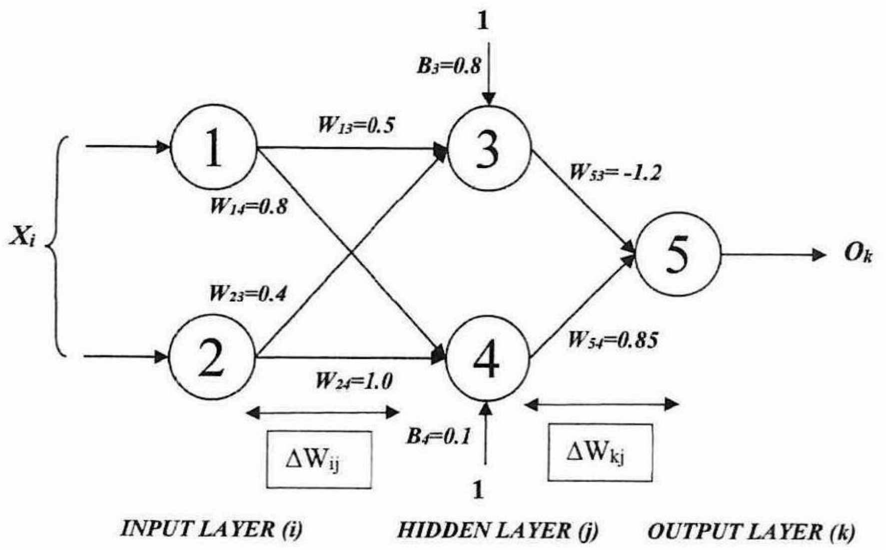

$$\frac{\partial E}{\partial W_{ij}} = \frac{\partial E}{\partial net_k} \cdot \frac{\partial net_k}{\partial O_j} \cdot \frac{\partial O_j}{\partial net_j} \cdot \frac{\partial net_j}{\partial W_{ij}} \qquad \frac{\partial E}{\partial W_{kj}} = \frac{\partial E}{\partial O_k} \cdot \frac{\partial O_k}{\partial net_k} \cdot \frac{\partial net_k}{\partial W_{kj}}$$

Figure Q1

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Model 1

```
model = tf.keras.models.Sequential ([
    tf.keras.layers.Conv2D(32, (3, 3), activation='relu', input_shape=(60, 40, 3)),
    tf.keras.layers.Conv2D(64, (3, 3), activation='relu'),
    tf.keras.layers.Conv2D(128, (3, 3), activation='relu'),
    tf.keras.layers.Conv2D(256, (3, 3), activation='relu'),
    tf.keras.layers.MaxPooling2D(2, 2),
    tf.keras.layers.Conv2D(128, (3, 3), activation='relu'),
    tf.keras.layers.Conv2D(64, (3, 3), activation='relu'),
    tf.keras.layers.MaxPooling2D(2, 2),
    tf.keras.layers.Flatten(),
    tf.keras.layers.Dense(256, activation='relu'),
    tf.keras.layers.Dense(1, activation='sigmoid')
])

model.compile(optimizer='adam', loss='binary_crossentropy', metrics=['acc'])
model.summary()
```

Model 2

```
model = tf.keras.models.Sequential ([
    tf.keras.layers.Conv2D(32, (5, 5), activation='relu', input_shape=(60, 40, 3)),
    tf.keras.layers.Conv2D(64, (5, 5), activation='relu'),
    tf.keras.layers.Conv2D(128, (5, 5), activation='relu'),
    tf.keras.layers.MaxPooling2D(2, 2),
    tf.keras.layers.Conv2D(256, (5, 5), activation='relu'),
    tf.keras.layers.Conv2D(128, (5, 5), activation='relu'),
    tf.keras.layers.Conv2D(64, (5, 5), activation='relu'),
    tf.keras.layers.Flatten(),
    tf.keras.layers.Dense(256, activation='relu'),
    tf.keras.layers.Dense(1, activation='sigmoid')
])

model.compile(optimizer='adam', loss='binary_crossentropy', metrics=['acc'])
model.summary()
```

Figure Q2

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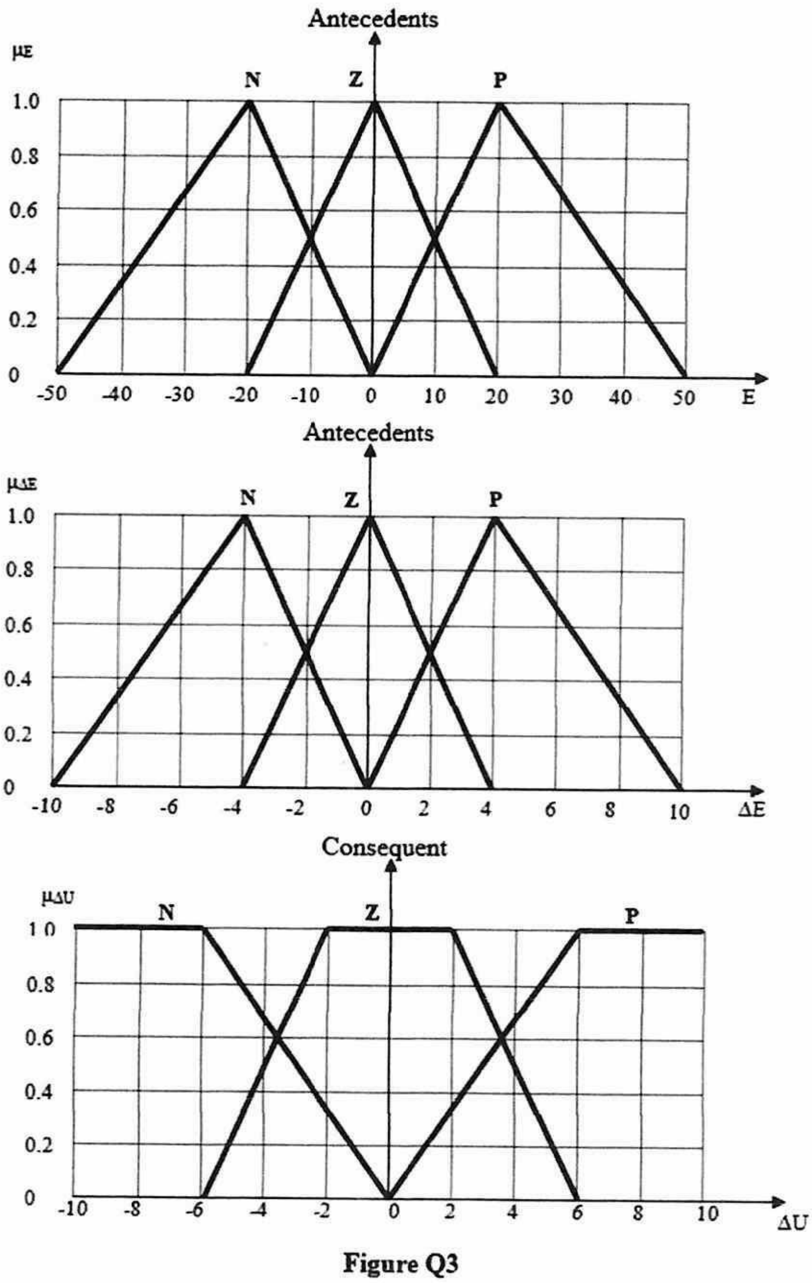

Figure Q3