Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2022/2023

COURSE NAME	:	INTELLIGENT CONTROL SYSTEMS
COURSE CODE	:	BEJ44103/BEH41803
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	JULY/AUGUST 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 **SEVEN (7)** PAGES

Q1 This section contains six objective questions regarding Neural Neetwork (NN). Answer all questions by providing the correct answer in the answer sheet.

(a) For a *NN* sigmoid activation function with *C* firing angle, select the false statement effect of *C* to the training process.

(2 marks)

i) When C is higher than 1, learning is fast, but less information is retained
ii) When C is lower than 1, learning is slow, but much information is retained
iii) When C equal to 1, learning and information is well balance since the activation function become straight line
iv) When C equal to 0, *NN* model cannot learn since output is always 1

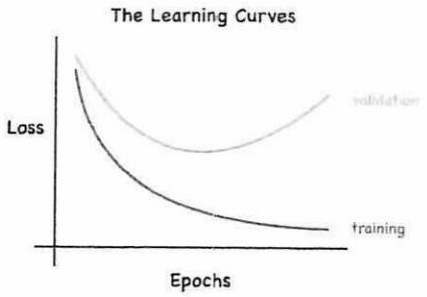
(b) Explain the difference between training data and validation data for the NN training process.

(2 marks)

i) *NN* use training data to memorize and validation data to generalize
ii) *NN* use training data to generalize and validation data to memorize
iii) *NN* use training data and validation data to memorize
iv) *NN* use training data and validation data to generalize
v) No correct answer

(c) The error rate obtained after the full cycle of NN model training is shown below. Examine the result performance.

(2 marks)



i) The model performance is well balance between training and validation
ii) The model performance is overfitting
iii) The model performance is underfitting
iv) No correct answer

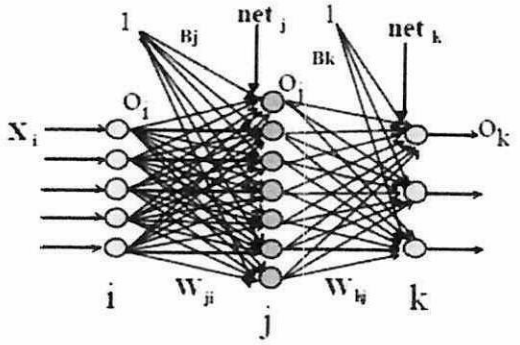
(d) Select the correct statement regarding XOR problem.

(2 marks)

i) Sample in XOR cluster can be separated using a single line
ii) Sample in XOR cluster cannot be separated using a single line
iii) XOR is define a linear problem
iv) XOR problem can be solve using Hebbian training algorithm

(e) For the multilayer NN model shown below with linear-sigmoid-linear activation function and C=1 for the sigmoid firing angle. Analyze five true statements regarding the model equation if $E = 0.5(T_k - O_k)$

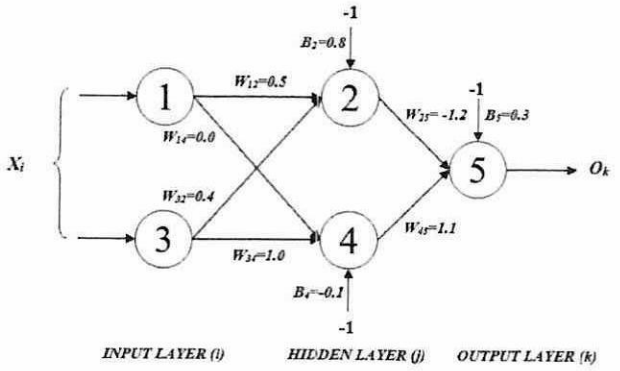
(10 marks)



i) $O_j = netj$
ii) $O_j = netj + B_j$
iii) $O_j = 1/(1+e^{-netj})$
iv) $O_k = netk$
v) $O_k = netk + B_k$
vi) $O_k = 1/(1+e^{-netk})$
vii) $net_j = \Sigma W_{ji} * O_i + B_j$
viii) $net_j = \Sigma W_{ji} * O_j + B_j$
ix) $net_j = \Sigma W_{ji} * O_j$
x) $net_j = \Sigma W_{ji} * O_i$
xi) $net_k = \Sigma W_{kj} * O_j + B_k$
xii) $net_k = \Sigma W_{kj} * O_k + B_k$
xiii) $net_k = \Sigma W_{kj} * O_j$
xiv) $\Delta W_{kj} = n*(T_k-O_k) *Ok(1-O_k) *O_j$
xv) $\Delta W_{kj} = n*(T_k-O_k) *(1-O_k) *O_j$
xvi) $\Delta W_{kj} = n*(T_k-O_k) *O_j$
xvii) $\Delta W_{kj} = n*(T_k-O_k) *O_i$

(f) The Multi-layer NN model which will be trained using backpropagation algorithm is shown below. All neurons in layer *i* have liner activation function and all neurons in layer *j* and *k* have sigmoid activation function with $f(net) = 1/(1 + e^{-net})$. If X_1=1 and X_2=1, analyze four six correct values from the set below.

(12 marks)



i) $net_2 = -0.8$
ii) $net_2 = 0.1$
iii) $net_2 = 0.9$
iv) $net_4 = 1.0$
v) $net_4 = 1.1$
vi) $net_4 = 0.1$
vii) $net_5 = -0.10467$
viii) $net_5 = 0.2145$
ix) $net_5 = -0.3267$
x) $O_2 = 0.475$
xi) $O_2 = 0.515$
xii) $O_2 = 0.525$
xiii) $O_4 = 0.2997$
xiv) $O_4 = 0.7503$
xv) $O_4 = 0.3625$
xvi) $O_5 = 0.526$
xvii) $O_5 = 0.474$
xviii) $O_5 = 0.362$

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) Analyze 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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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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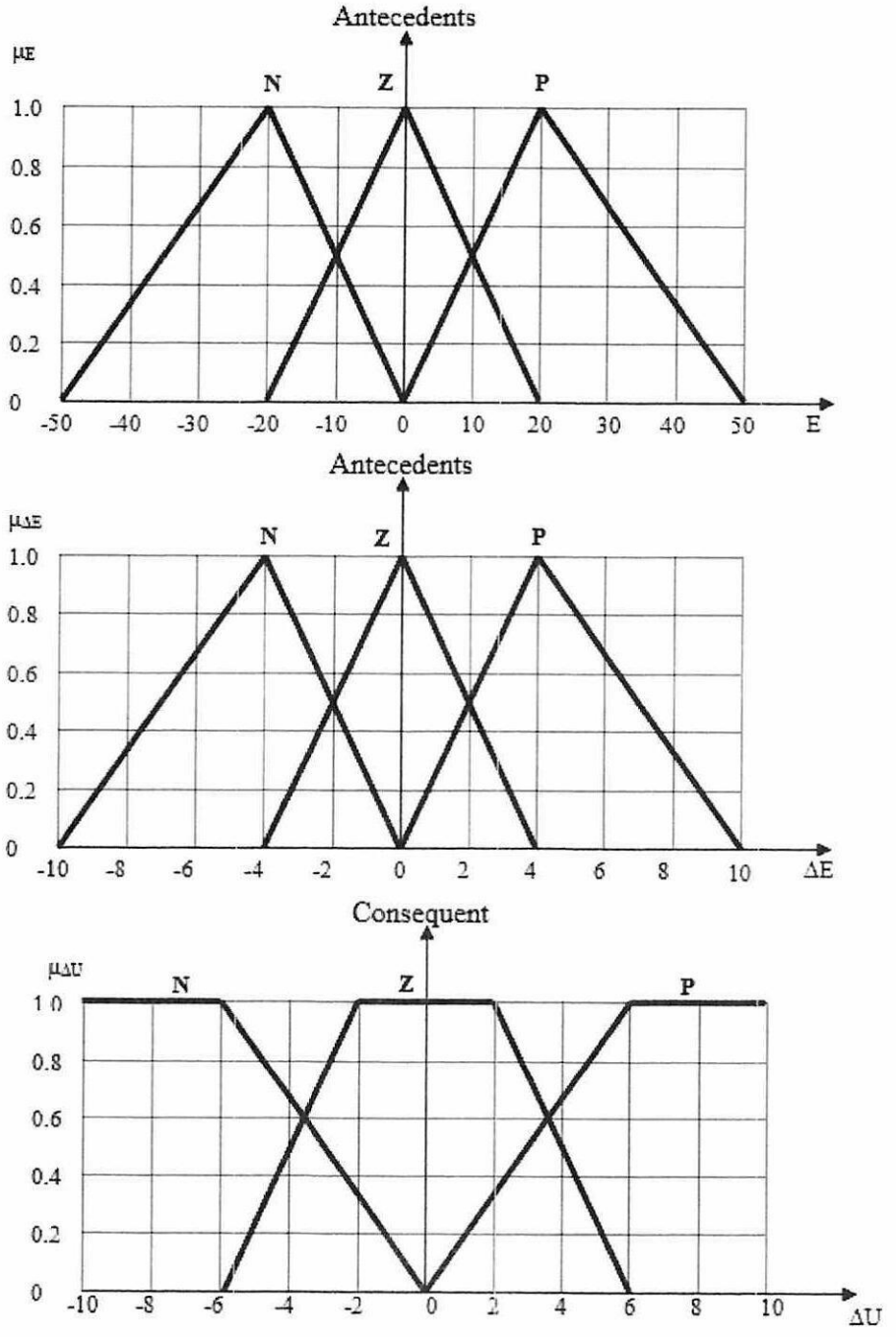

Figure Q3