FACULTY OF ELECTRICAL & ELECTRONICS ENGINEERING

FINAL EXAMINATION

COURSE	**:**	**INTELLIGENT CONTROL**
COURSE CODE	**:**	**BEE4333**
LECTURER	**:**	**DR. DWI PEBRIANTI**
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DATE	**:**	**2015**
DURATION	**:**	**3 HOURS**
SESSION/SEMESTER	**:**	**SESSION 2015/2016 SEMESTER II**
PROGRAM CODE	**:**	**BEE**

INSTRUCTIONS TO CANDIDATES:

1. This question paper consists of **FOUR (4)** Questions. Answer **ALL** questions.
2. All answers to a new question should start on new page.
3. All the calculations and assumptions must be clearly stated.
4. Candidates are not allowed to bring any material other than those allowed by the invigilator into the examination room.

EXAMINATION REQUIREMENTS:

1. Graph paper

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO

This examination paper consists of **NINE (9)** printed pages including front page

QUESTION 1

(a) Expert system is most widely used and applied successfully in Artificial Intelligence, AI technology. It can either support decision makers or completely replace them.

(i) Define the term ‘expert system’.

[2 Marks]

(ii) State why industries need AI technology. Name **TWO (2)** examples of the industry.

[4 Marks]

(iii) Rule-based expert system is represented as a series of rules or type of knowledge representation, can be defined as an IF-THEN structure which are relatively easy to understand. Draw the basic structure of a rule-based expert system.

[8 Marks]

(b) An automated sorting machine can sort any combination of common domestic plastic bottles. A conveyer is used to move the bottles to specified location depending on the color. An infrared sensor is used to detect the color of each bottle. There are main conveyers connected with other three conveyers to move the bottles into specified box. Detail operations follow these conditions:

Green bottles must be placed into **green box**.
Red bottles must be placed into **red box**.
Yellow bottles must be placed into **yellow box**.

Condition 1

Conveyer A goes to **green box**.
Conveyer B goes to **red box**.
Conveyer C goes to **yellow box**.

Condition 2

Summary of the operations can be simplified as follows:

(Green bottles → conveyer A →green box)
(Red bottles → conveyer B → red box)
(Yellow bottles → conveyer C → yellow box)

(i) Construct **TWO (2)** strategy rules to ensure the specified bottles goes to the correct box.

(ii) In each rule in (i), list **THREE (3)** conditions/antecedents, and **ONE (1)** consequence.

[11 Marks]
[CO1, PO1, C3]

QUESTION 2

(a) Consider two fuzzy sets, Error, e and Change of Error, Δe :

Error, e={e1/0.1, e2/0.2, e3/0.4, e4/0.6, e5/0.8, e6/1}

Change of Error, Δe={ Δe1/1, Δe2/0.6, Δe3/0.4, Δe4/0.3, Δe5/0.1}

Determine the results of following combinations for these two sets:

(i) $e \cup \Delta e$

(ii) $e \cap \Delta e$

[6 Marks]

(b) A dynamic control system has two input variables, 'x' and 'y' while the control output is 'z'. The 'x' update of this equation in discrete form is:

$$x_{k+1} = k_1 x_k + [1 - k_2]\begin{bmatrix} y_k \\ z_k \end{bmatrix}$$

where k_1, k_2 are constants. The membership functions for x, y and z are shown in **Figure 2.1**:

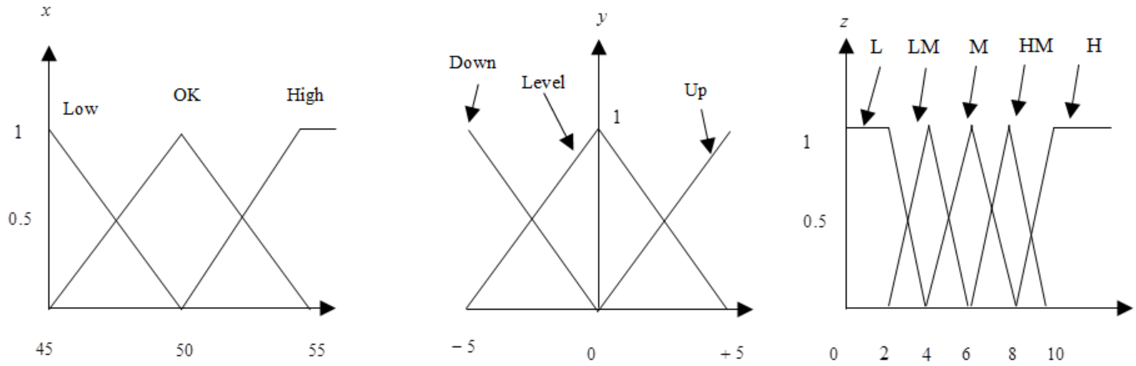

Figure 2.1

The rule-base for the fuzzy controller is given in **Table 2.1**.

Table 2.1

Inclination / Road Speed	UP	LEVEL	DOWN
HIGH	Low Medium	Low Medium	Low
OK	High Medium	Medium	Low Medium
LOW	High	High Medium	High Medium

Taking initial conditions, $x_0 = 52.5$ and $y_0 = -5$, **demonstrate graphically how you would simulate one cycle of this closed loop fuzzy control system using Mamdani-style inference. Use only estimates in COG defuzzification method.**

Detach graph paper together with the answer script.

[19 Marks]

[CO2, P10, C4]

QUESTION 3

(a) Artificial Neural Network (ANN) is an intelligence technique that is adapted from the working principle of human brain. Draw the model of the human brain. Give explanation on the working principle of this system.

[5 Marks]

(b) Artificial Neural network can be used for the classification process of pure honey. The odor profile of the pure honey is obtained by using a **FOUR (4)** array of gas sensors. This profile will be pre-processed to obtain the normalization data of the resistance values obtained from each sensor. The pre-processed data will be the input for a backpropagation neural network that has **ONE (1)** neuron in the hidden layer. **Table 3.1** shows the training data set used in the classification process. Target value 1 shows that the odor is coming from pure honey.

Table 3.1 Training data set for classification of pure honey

Sensor 1	Sensor 2	Sensor 3	Sensor 4	Target
0.51	0.29	0.47	0.47	1
1	1	1	1	1
0.37	0.36	0.34	0.34	0
0.23	0.23	0.20	0.20	0

Assume that the weight between input layer and hidden layer has a format of w_{ij}. For the initial condition, when *i* is an odd number, the associated weight value is 0.3. And when *i* is an even number, the associated weight value is - 0.1. Additionally, weight between hidden layer and output layer is 0.5.

(i) Draw the model of the system. Give the details of each weight value in the network.

[2 Marks]

(ii) Calculate the output of the system, by using the **FIRST (1^{st})** data pattern. [**NOTED : use number with THREE (3) decimal places**]

[2 Marks]

(iii) Calculate the new weight of network by using result in (ii).

[**NOTED : use number with THREE (3) decimal places**]

[14 Marks]

(iv) Draw the new network of the system.

[2 Marks]

[CO2, PO3, C4]

The information for the Neural Networks configurations is as follows.

1. Sigmoid function; $f(x) = (1+e^{-x})^{-1}$
2. Learning rate, η is 0.5 and momentum term is, α is 0.4.
3. The formula for updating the weight values between input and hidden layer is
$$\Delta w_{ij}(t+1) = \eta \delta_j O_i + \alpha \Delta w_{ij}(t)$$
$$w_{ij}(t+1) = w_{ij}(t) + \Delta w_{ij}(t+1)$$
4. The formula for updating the weight values between hidden and output layer is
$$\Delta w_{jk}(t+1) = \eta \delta_k O_j + \alpha \Delta w_{jk}(t)$$
$$w_{jk}(t+1) = w_{jk}(t) + \Delta w_{jk}(t+1)$$
5. O_i and O_j are output of the neuron after we apply the sigmoid function.
6. δ_j is error signal equations between hidden (j) and input (i) layer
$$\delta_j = O_j(1-O_j)\sum \delta_k w_{jk}$$
7. δ_k is error signal equations between output (k) and hidden (j) layer
$$\delta_k = O_k(1-O_k)(t_k - O_k)$$

QUESTION 4

(a) M. Negnevitsky defines Genetic Algorithm (GA) as a class of stochastic search algorithms based on biological evolution. There are **THREE (3)** simplest operators in GA; selection, crossover and mutation. Define those **THREE (3)** operators.

[2 Marks]

(b) Genetic Algorithm (GA) is used for optimizing the appropriate values of weight in a Neural Network for solving an OR problem with **THREE (3)** inputs. The network is shown in **Figure 4.1**. A sigmoid function is applied at the output layer. The training data set is shown in **Table 4.1**.

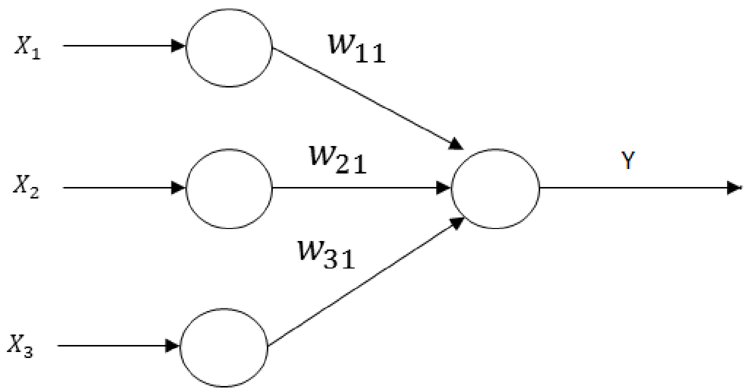

Figure 4.1 : Neural Network for OR Problem

Table 4.1 : Data set for training process

Data No.	INPUT			OUTPUT
	X1	X2	X3	Yd
#1	1	1	0	1
#2	1	1	1	1
#3	0	0	1	1
#4	0	0	0	0
#5	0	1	0	1
#6	0	1	1	1
#7	1	0	0	1
#8	1	0	1	1

The population in this problem is a collection of binary set that represents the values of weight from input to output layer. The format of the population is shown in **Figure 4.2**. The weight between all layers has range between -1 and 1. The initial population is listed in **Table 4.2**.

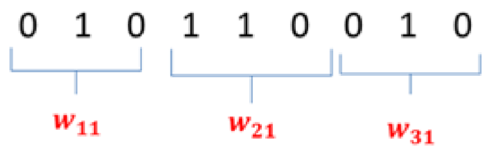

Figure 4.2 Format of GA Population to Solve OR Problem

Table 4.2 Initial Population / Individuals

Population	Chromosome
p_1	1 0 0 0 1 0 1 1 0
p_2	1 1 0 0 0 1 0 1 1
p_3	1 1 1 1 1 0 1 1 0
p_4	1 0 1 0 1 0 1 1 0

(i) Calculate the output value of L_k for all population using the **FIRST (1st) data** pattern. (**NOTE** : Sigmoid function is represented as $f(x) = (1+e^{-x})^{-1}$)

(ii) Calculate the absolute error for each population. Arrange the population from the minimum error (***NOTE : called the fittest individual***) to the maximum error (***NOTE : called the less fit individual***).

(iii) For the 1st generation do the following :

a) Cross the fittest two individuals using one-point crossover at the **FIFTH (5th)** gene.

b) Cross the **SECOND (2nd)** and **THIRD (3rd)** fit individuals using a two-point crossover (***point 'c' and 'f'***).

(iv) Find the error of the new population obtained in (iii).

(v) Evaluate the performance after the **FIRST (1st)** generation by considering the average of mean error.

[23 Marks]
[CO3, PO2, C4]

END OF QUESTION PAPER