Universiti Tun Hussein Onn Malaysia

# UNIVERSITI TUN HUSSEIN ONN MALAYSIA

## FINAL EXAMINATION
## SEMESTER I
## SESSION 2015/2016

| | | |
|---|---|---|
| COURSE NAME | : | INTELLIGENT CONTROL SYSTEM |
| COURSE CODE | : | BEH 41803 |
| PROGRAMME | : | BACHELOR OF ELECTRONIC ENGINEERING WITH HONOURS |
| EXAMINATION DATE | : | DECEMBER 2015 / JANUARY 2015 |
| DURATION | : | 3 HOURS |
| INSTRUCTION | : | ANSWER **ALL** QUESTIONS. |

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

**Q1** Sugeno fuzzy control system is applied to control robot manipulator in the presence of fixed obstacle as shown in **Figure Q1(a)**. The controller has two inputs and one output. There are two inputs, first is the observation angle ($\theta_{obs}$) and the second is the distance ($d_{obs}$) toward the obstacle. The output is the repulsive angle ($\theta_{rep}$). Suppose that the arm can perceive an obstacle in a direction inside the interval $of\ [-90^o \quad 90^o]$. The membership function is represented by seven fuzzy subsets: Zero (Z), Positive Small (PS), Positive Medium (PM), Positive Big (PM), Negative Small (NS), Negative Medium (NM), and Negative Big (NB) as shown in **Figure Q1(b)**. The arm can detect an obstacle from a distance of 30 cm. The membership function is expressed by three fuzzy subsets: Small (S), Medium (M), and Large (L) as shown in **Figure Q1(c)**. While the repulsive angle universe of discourse is $[-100^o \quad 100^0]$ by seven fuzzy subset: Zero (Z), Positive Small (PS), Positive Medium (PM), Positive Large (PL), Negative Small (NS), Negative Medium (NM), and Negative Large (NL) as shown in **Figure Q1(d)**. Rule tabulation related to input output of fuzzy control system is shown in **Table Q1**. If $\theta_{obs} = 70^o$ and $d_{obs} = 11$ cm,

(a) Find the possible rule fire based on max-min method.

(5 marks)

(b) Calculate each rule quantification.

(16 marks)

(c) Graph the clipping of the rule quantification result.

(2 marks)

(d) Estimate the real value of $\theta_{rep}$ using Centre of Gravity (COG) method.

(2 marks)

**Q2** Multi Input Multi Output (MIMO) Neural Network as shown in **Figure Q2** is trained using Momentum Backpropagation (MOBP) algorithm. The activation function ($f$), hidden layer and output layer delta weights ($\Delta w$) are as below:
Network activation function

$$f(net) = \frac{1}{1+e^{-net}}$$

Hidden layer delta weight
$\Delta w_1, \Delta w_2, \Delta w_3, \Delta w_4, \Delta w_5, \Delta w_6, \Delta w_7, \Delta w_8, \Delta w_9, \Delta w_{10}, \Delta w_{11}, \Delta w_{12}$

Output layer delta weight
$\Delta w_{13}, \Delta w_{14}, \Delta w_{15}, \Delta w_{16}, \Delta w_{17}, \Delta w_{18}, \Delta w_{19}, \Delta w_{20}$

If $\alpha$ is momentum and $\eta$ is learning rate, derive the network weights updating and convergence evaluating using Mean Square Error (MSE).

(25 Marks)

**Q3** Three layer neural network as in **Figure Q3** is trained using Steepest Descent Backpropagation (SDBP) algorithm. The initial weights ($w$) for hidden layer and output layer as below:

Hidden layer weights:

$w_1 = 0.2,\ w_2 = 0.3,\ w_3 = -0.1,\ w_4 = 0.24,\ w_5 = -0.2,\ w_6 = 0.22, w_7 = -0.31,\ w_8 = -0.15$

Output layer weights:

$w_9 = -0.25,\ w_{10} = 0.35,\ w_{11} = -0.21,\ w_{12} = 0.41$

Learning rate ($\eta$) and activation function ($f$) for hidden layer and output layer are:

$$\eta = 75,\ f(net) = \frac{1}{1+e^{-net}}$$

(a) Estimate the one iteration network weights updating value for given $x_1 = 0, x_2 = 1$ and target $(t) = 1$.

(20 Marks)

(b) Analyze if the network converges.

(5 marks)

**Q4** (a) Write the brief history of neural network.

(6 marks)

(b) Outline four (4) the potential advantages of neural network for intelligent control.

(4 marks)

(c) Explain the neural network working mechanism.

(4 marks)

(d) Outline why neural network must be trained before applying to solve the problem.

(2 marks)

(e) Write the importance of input and output variables in designing fuzzy control system.

(2 marks)

(f) Compare the structure of neural network and fuzzy logic.

(7 marks)

**- END OF QUESTION -**

**FINAL EXAMINATION**

| | | | |
|---|---|---|---|
| SEMESTER/SESSION | : SEM I /2015/2016 | PROGRAMME | : 4 BEJ |
| COURSE NAME | : INTELLIGENT CONTROL SYSTEM | COURSE CODE | : BEH 41803 |

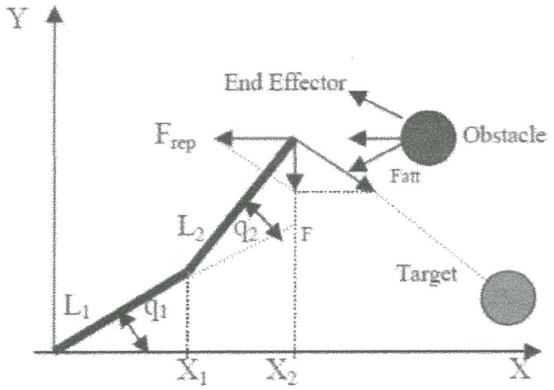


**FIGURE Q1(a)**

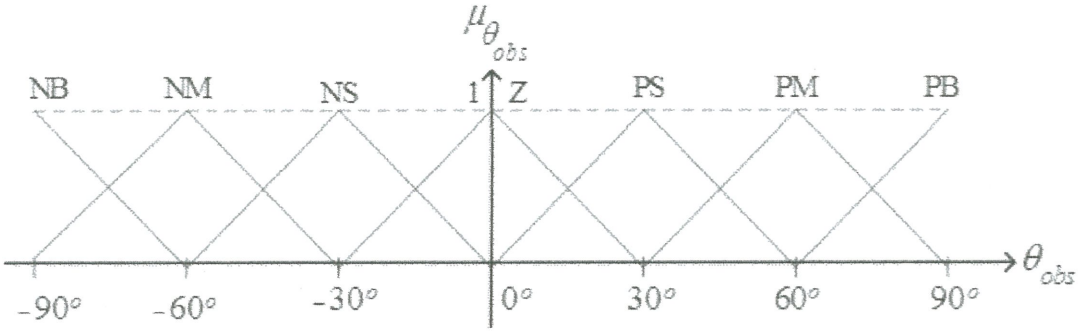


**FIGURE Q1(b)**

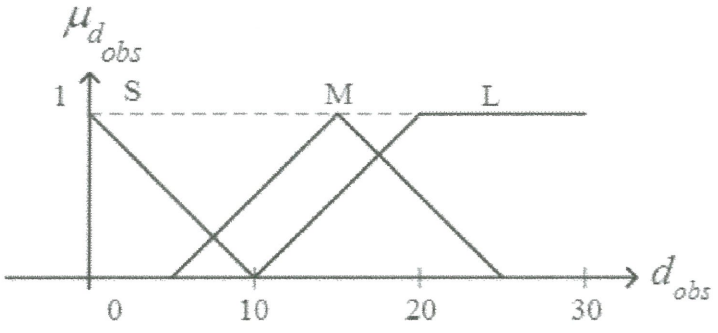


**FIGURE Q1(c)**

**FINAL EXAMINATION**

SEMESTER/SESSION : SEM I /2015/2016
COURSE NAME : INTELLIGENT CONTROL SYSTEM
PROGRAMME : 4 BEJ
COURSE CODE : BEH 41803

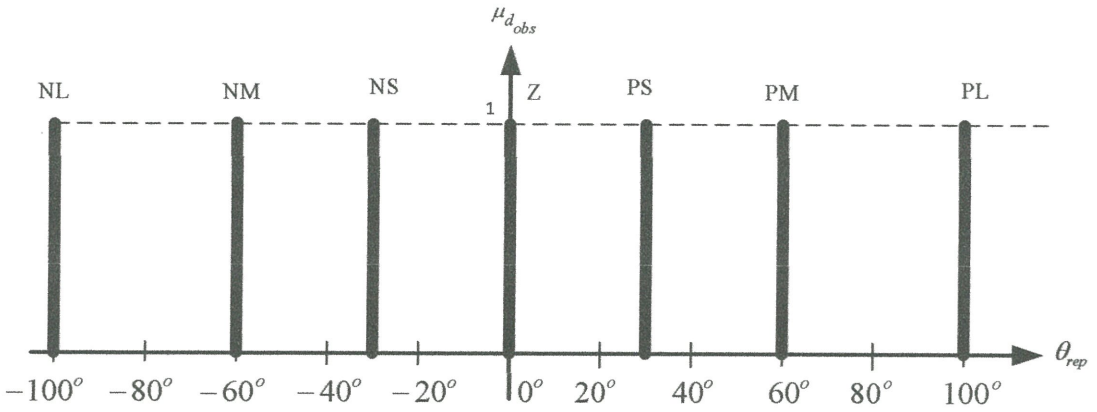


**FIGURE Q1(d)**

**Table Q1**

| $\theta_{rep}$ | | $\theta_{obs}$ | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | NB | NM | NS | Z | PS | PM | PB |
| $d_{obs}$ | S | PM | PS | PL | NL | NL | NM | NS |
| | M | PS | PM | PL | NL | NM | NS | NS |
| | L | Z | PS | PM | NM | NS | NS | Z |

**FINAL EXAMINATION**

SEMESTER/SESSION : SEM I /2015/2016
COURSE NAME : INTELLIGENT CONTROL SYSTEM
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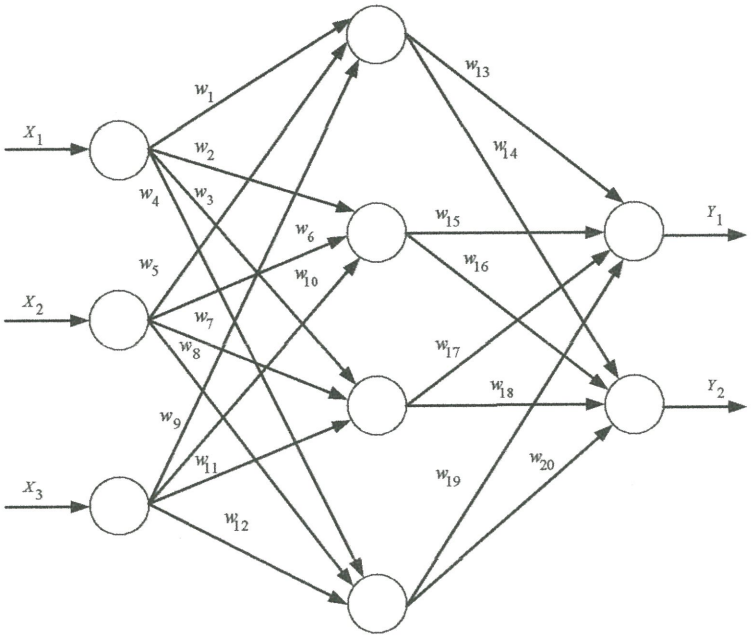


**FIGURE Q2**

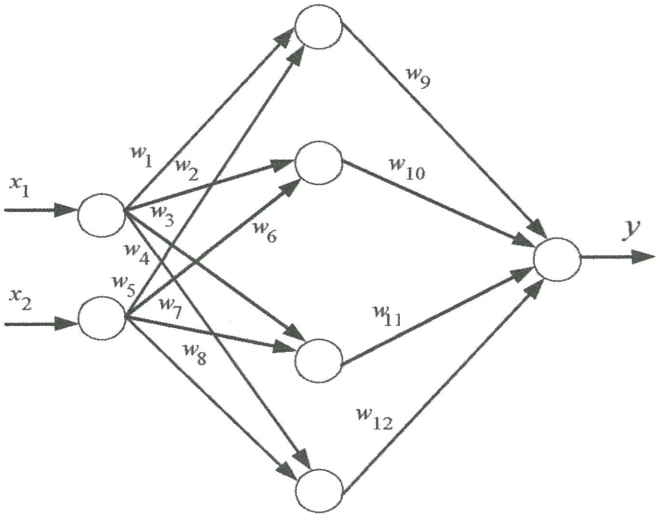


**FIGURE Q3**