The Open University of Sri Lanka
Faculty of Engineering Technology

Study Programme	:	Bachelor of Technology (Engineering)
Name of the Examination	:	Final Examination
Course Code and Title	:	**MEX6272 Intelligent Control**
Academic Year	:	2013/2014
Date	:	15th of August 2014
Time	:	9.30am – 12.30 pm
Duration	:	3 hours

General instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of 6 questions.
3. Question 1 is compulsory. Answer any three from questions 2 to 6.

Q1.

a) (25 marks)

Consider the fuzzy controller design of a washing machine to automate the *wash time*. The fuzzy logic system need to process the two inputs for the system that are ***Dirt(D)***and***Grease(G)***of theclothes to be washed**.** A fuzzy logic control system will process these, giving a single output, ***Wash time(T).***

The following fuzzy quantities are defined, with the corresponding states:
D: Dirt (**SD**: Small Dirt, **MD**: Medium Dirt, **LD**: Large Dirt)
G: Grease (**NG**: No Grease, **MG**: Medium Grease, **LG**: Large Grease)
T: Wash Time(**VS**: Very Short, **S**: Short, **M**: Medium, **L**: Long, **VL**: Very Long)

The membership functions of these quantities are given in Figure Q1.a

The rule base isgiven in Table1as follows:

		Grease		
		NG	*MG*	*LG*
Dirt	*SD*	**VS**	**M**	**L**
	MD	**S**	**M**	**L**
	LD	**M**	**L**	**VL**

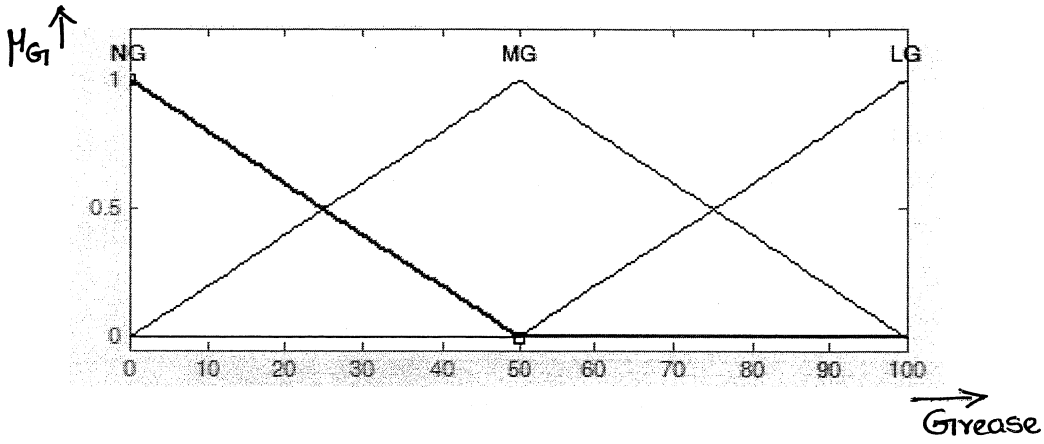
Table Q1

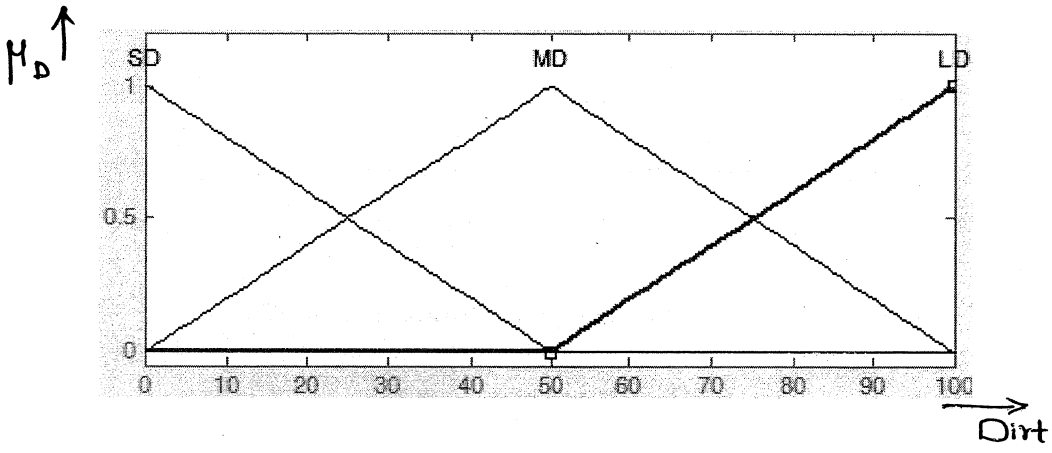
At a given instant, the following set of sensor data is available:

- **Dirt– 60**
- **Grease– 75**

i. List the Linguistic variables and Linguistic values of this fuzzy system.
ii. Write down rules that would **fire** for the given instance.
iii. Determine the corresponding inference membership function for the **Wash Time**.
iv. Determine the crisp value for the control action.

(Hint: Use Max-Min inference method and Centroid method as applicable.)





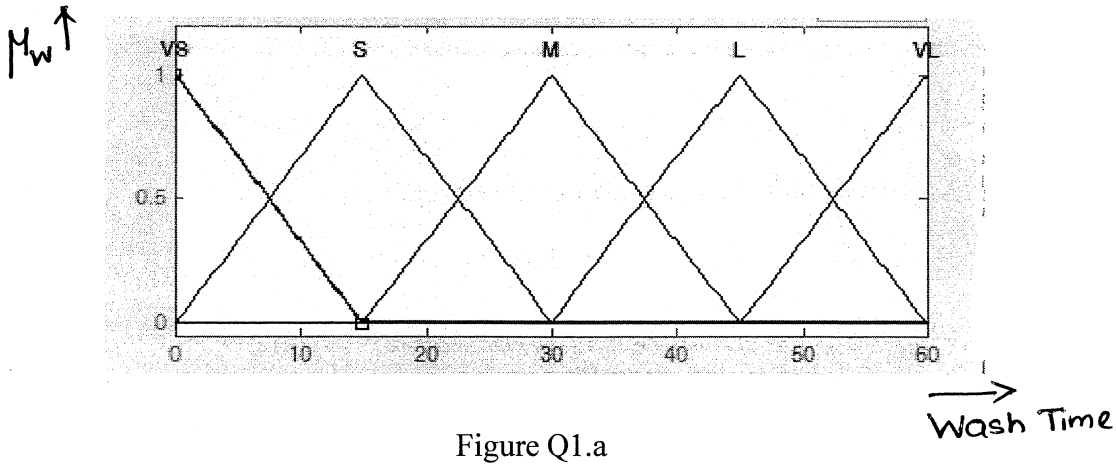


Figure Q1.a

b) (15 marks)

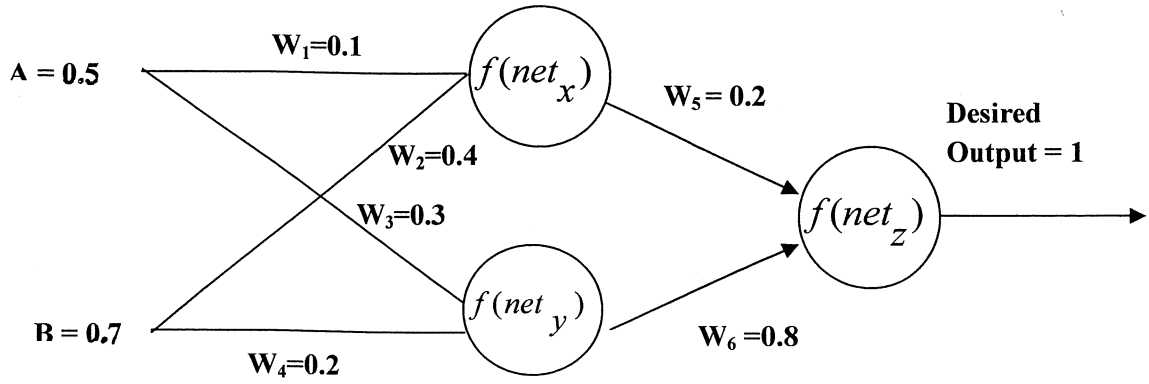


Figure Q1.b

Assume that the neurons have a Bipolar continuous activation function and that $\lambda = 1$ and η =1. Use Backpropagation method to find the old and new errors of the trained network.

Use the standard error finding method to find the error.

[Error = Output(1-Output)(Target-Output)]

Q2. (20 marks)

a)Consider a first order fuzzy dynamic system whose free (unforced; input =0) response is given by

$X_{j+1} = X_j \; o \; R$

Where

X_j= discrete membership function of the jthfuzzy state transition.

R = matrix representing the fuzzy rule base relation of state transition.

Find whether the fuzzy systems are stable or not for the following cases.

i. $R = \begin{bmatrix} 0.5 & 0.4 \\ 0.4 & 0.5 \end{bmatrix}$

ii. $R = \begin{bmatrix} 0.4 & 0.4 \\ 0.5 & 0.4 \end{bmatrix}$

b) A fuzzy system is represented by

P^1: If x(k) is A^1 then x^1(k+1) = 1.2x(k) -0.6x(k-1)

P^2: If x(k) is A^2 then x^2(k+1) = x(k) -0.4x(k-1)

Where A^i, i=1,2 are shown in the Figure Q2. Check if the system is stable by Lyapunov's method if the positive definite matrix is $P = \begin{bmatrix} 2 & -1.2 \\ -1.2 & 1 \end{bmatrix}$.

Figure Q2

Q3. (20 marks)

a) Let U={a, b ,c, d} be the domain and A and B be fuzzy sets on U as given on the Table Q3.

	a	b	c	d
A	0.5	0.8	0.0	0.3
B	0.2	1.0	1.0	0.7

Table Q3

Proof the following property of fuzzy sets A and B which is known as De Morgan's law $(A \cup B)^1 = A^1 \cap B^1$ considering the above values.

b) Consider the ternary fuzzy relation T on $U \times V \times W$, where U={a,b}, V={x,y} and W={&,*} are fuzzy sets;

$$T = \frac{0.1}{(a,x,\&)} + \frac{0.8}{(b,x,\&)} + \frac{0.5}{(a,y,\&)} + \frac{0.9}{(a,y,*)} + \frac{0.2}{(b,y,*)}$$

i. Find T_1 and T_2

ii. Find T_{12}

c) The logical implicationin the linguistic rule form: *if A then B,*can be translated into a relation R using the Cartesian products sets A and B as $R = (A \times B) \cup (\bar{A} \times Y)$.

Let the two universes of discourse be described by X={1,2,3,4} and Y={1,2,3,4,5,6}. If the crisp set A is defined as A={1,4} on X and B is defined as B ={1,3,5,6} on Y.

Determine the deductive inference IF A, THEN B.

Q4. (20 marks)

a) Draw a suitable diagram to show the main components of an **artificial neuron**.

b) The "glass data set" is a famous dataset that has been used in pattern recognition. A neural network can be built to predict the type of the glass (window glass or non-window glass)based on the measurements of the chemical content.
The data set consists of 214 samples.
Attribute information:

Refractive index
Sodium
Magnesium
Aluminum
Silicon
Potassium
Calcium
Barium
Iron

State the following with **reasons** for the neural network that you propose for the glass classification.

i. Number of input nodes
ii. Number of hidden layers
iii. Number of output nodes

c) Compare and contrast Hebbian and Delta training rules considering neural networks.
d) Briefly discuss the difference between Binary and Continuous Activation functions.
e) Back Propagation Algorithm is an example of Supervised Learning method. Comment on this statement.

Q5. (20 marks)

a) Draw the complete architecture of a Fuzzy logic controller. Name all parts of it and **using suitable examples**describe their functionalities.
b) Figure Q5 shows a ROC (Receiver Operating Characteristic)plot obtained after training anANN (Artificial Neural Network) using MATLAB software. Answer the following questions considering Figure Q5.

i. What does a ROC curve demonstrate?
ii. What comment can you make about the Training ROC plot.
iii. Indicate the number of the worst classifier. (Please select a number from 1 to 4 according to the labels)
iv. What is the reason to consider three different ROC plots as Training ROC plot, Validation ROC plot and Test ROC plot?

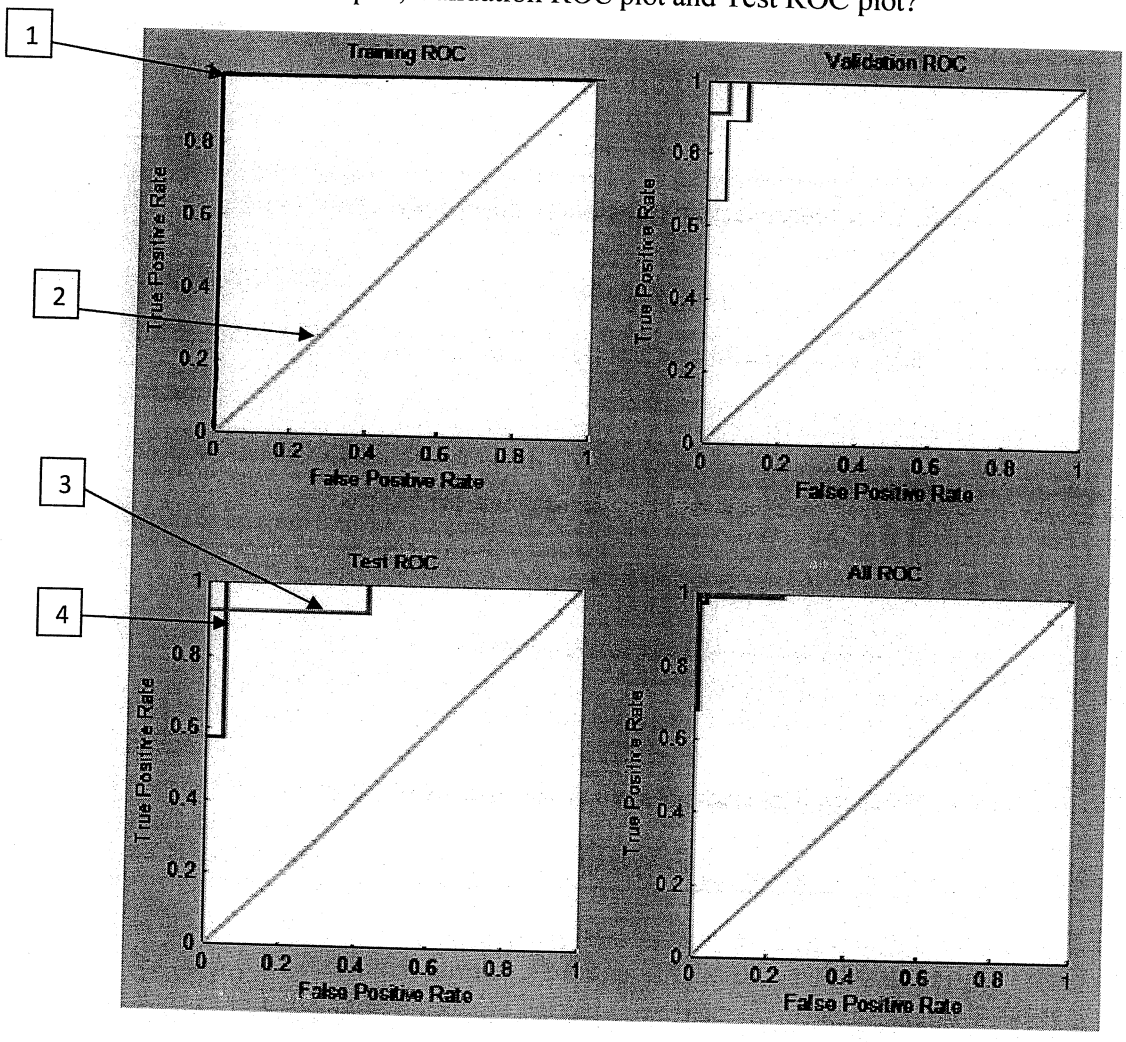


Figure Q5

Q6. (20 marks)

a) Briefly explain an application of *Genetic Algorithm.*

b) List two characteristics of *intelligence* and state whether they are applicable for ANN.

c) Name the suitable *AI technique* to use for each application given below.

   i. Medical diagnosis system

   ii. Signature recognition system

   iii. Autonomous underwater vehicle control system

d) Discuss the characteristics of intelligent machines.

e) What are the main components of an expert system?

END