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	:	2012/2013
Date	:	02nd of August 2013
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. All questions carry equal marks.
3. Question 1 is compulsory. Answer any three from questions 2 to 6.

Q1.

a) (25 marks)

Consider the fuzzy controller design of an automatic braking system for motor cars. The fuzzy logic system need to process the two inputs for the system that are **Vehicle Speed(V)** and **Distance between the motor car and the vehicle in the front(D),** and need to produce a single output **Braking Force(B)** which controls the brakes.

The following fuzzy quantities are defined, with the corresponding states:

V: Vehicle Speed (PS: Positive Small, PM: Positive Medium, PL: Positive Large)

D: Distance between the motor car and the vehicle in the front (PS: Positive Small, PM: Positive Medium, PL: Positive Large)

B: Braking Force (PS: Positive Small, PM: Positive Medium, PL: Positive Large)

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

A Simple rule base that is used in the fuzzy controller for the fuel supply unit is given below.

R1: IF ***D*** is ***PM*** and ***V*** is **PM** then ***B*** is ***PM***

R2: IF ***D*** is ***PM*** and ***V*** is **PL** then ***B*** is ***PM***

R3: IF ***D*** is ***PL*** and ***V*** is **PM** then ***B*** is ***PM***

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

- **Vehicle Speed – 55Km/hr**
- **Distance between the motor car and the vehicle in the front – 40m**

i. List the Linguistic variables and Linguistic values of this fuzzy system.
ii. Determine the corresponding inference membership function for the **Braking Force(B)** to be applied.
iii. Determine the crisp value for the control action.

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

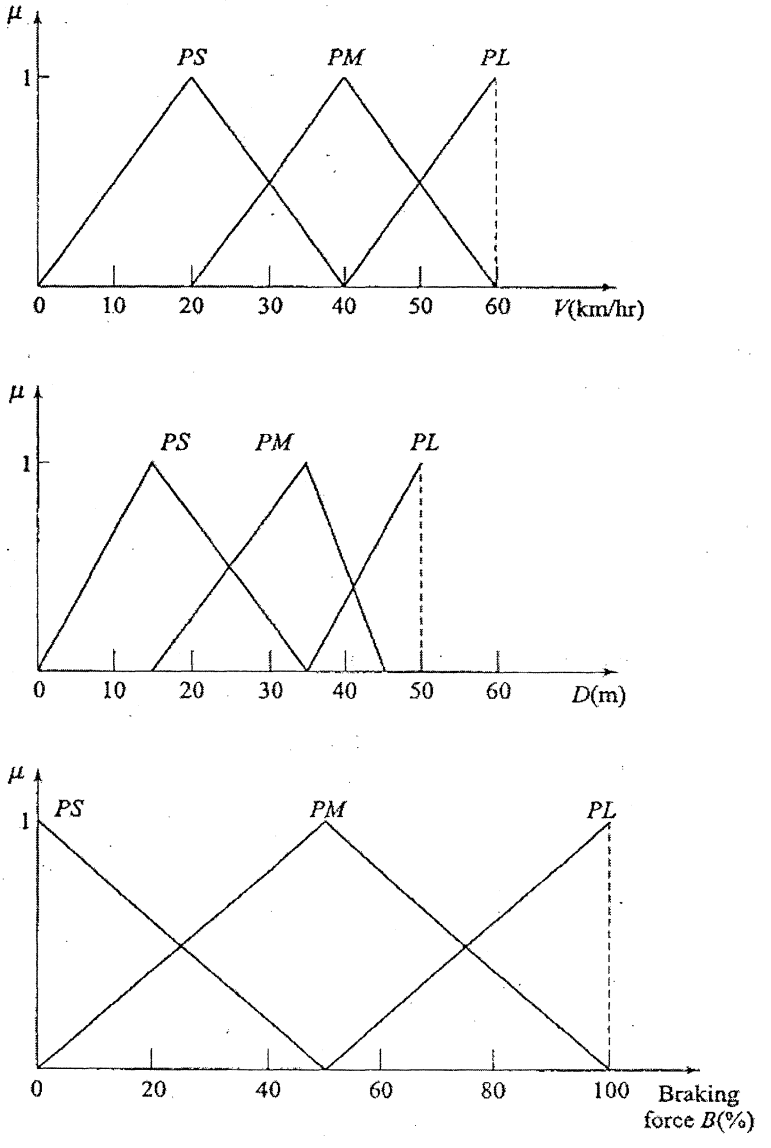


Figure Q1.a

b) (15 marks)

i. A neuron M receives sensory information from five inputs with the values of 8, -10, 4, -2 and 5. The synaptic weights of neuron M are 0.8, 2.0, 1.0, -0.9 and 0.6. Calculate the output of the M neuron if the neuron is represented based on the sigmoid function

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

ii.

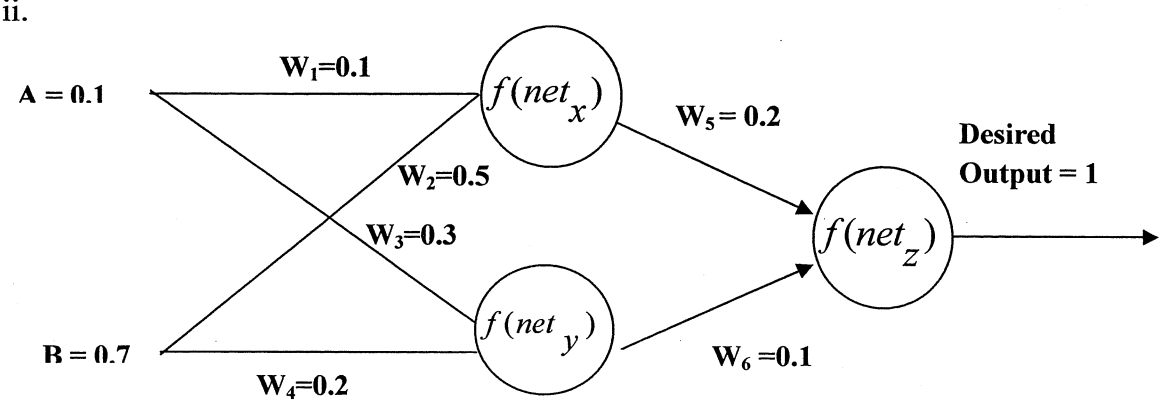


Figure Q1.b

Consider the simple network given in Figure Q1.b.
Assume that the neurons have a Unipolar continuous activation function and the learning rate (η) is 1 and λ is 1.
After a forward pass is performed on the network the outputs of three neurons are as follows. $f(net_x) = 0.589$, $f(net_y) = 0.5424$ *and* $f(net_z) = 0.5429$.

i. Find the Error using the standard error finding method
i.e [Error = Output(1-Output)(Target-Output)]
ii. Use Backpropagation method to find the new synaptic weights of the hidden layer nodes.

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 j^{th} fuzzy 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. $R = \begin{bmatrix} 0.1 & 0.4 \\ 0.8 & 1.0 \end{bmatrix}$

ii. $R = \begin{bmatrix} 0.1 & 0.3 \\ 0.2 & 0.4 \end{bmatrix}$

b) State the Lyapunov stability theorems which can be used to find the stability of a fuzzy control system.

Q3. (20 marks)

a) Let $A = \frac{0.3}{1} + \frac{1}{2} + \frac{0.2}{3}$ and $B = \frac{0.7}{1} + \frac{0.2}{2} + \frac{0.5}{3}$ be two fuzzy sets. Find the following

i. $A \cup B$
ii. $\bar{A} \cup B$
iii. $A \cap B$
iv. $A \cap \bar{B}$

b) Considering the two fuzzy sets A_1 and A_2, determine the fuzzy relation between the sets A_1 and A_2.

$$A_1 = \frac{0.2}{x_1} + \frac{0.9}{x_2} \qquad A_2 = \frac{0.6}{y_1} + \frac{0.1}{y_2} + \frac{1}{y_3}$$

c) The logical implication in 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×B) ∪ ($\bar{A}$×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.

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

$$T = \frac{0.6}{(a,x,\&)} + \frac{0.2}{(b,x,\&)} + \frac{1}{(a,y,\&)} + \frac{0.9}{(a,y,*)} + \frac{0.2}{(b,y,*)}$$

i. Find T_1 and T_2
ii. Find T_{12}

Q4. (20 marks)

a) Compare and contrast supervised learning and unsupervised learning in artificial neural networks considering at least 3 points.
b) List three training rules used in artificial neural network and briefly discuss for which situation each is best used.
c) Construct an architectural graph for a recurrent network with no self feedback loops and no hidden neurons.
d) Artificial neural network training includes the process of applying momentums to learning rules. Describe the functionality of momentums.
e) Compare and contrast static and dynamic artificial neural network architectures.

Q5. (20 marks)

a) List 3 characteristics of *Conventional control.*
b) Briefly explain the concepts of *Genetic Algorithms.*
c) Briefly explain *Neuro – fuzzy systems* and *Fuzzy neural networks.*
d) List two characteristics of *intelligence* and state whether they are applicable for ANN.
e) Identify the AI technique relevant for each and every characteristic given below.
   i. Not capable of explaining the reasons for getting an answer
   ii. Capable of answering for systems which has frequently varying data

Q6. (20 marks)

a) Draw the complete architecture of a Fuzzy logic controller. Name all parts of it and using suitable examples, explain their functionalities.
b) What is the difference between a fuzzy proportional controller and a fuzzy proportional integral controller?
c) Figure Q6. Shows Confusion matrix plots using MATLAB software to check the accuracy of a trained ANN. (Artificial neural network). Answer the following questions considering Figure Q6.
   i. How many samples are consided for the training of the ANN and how many samples for the testing of the ANN?
   ii. How many target classes are available in this ANN?
   iii. What is the overall accuracy percentage of the trained ANN.

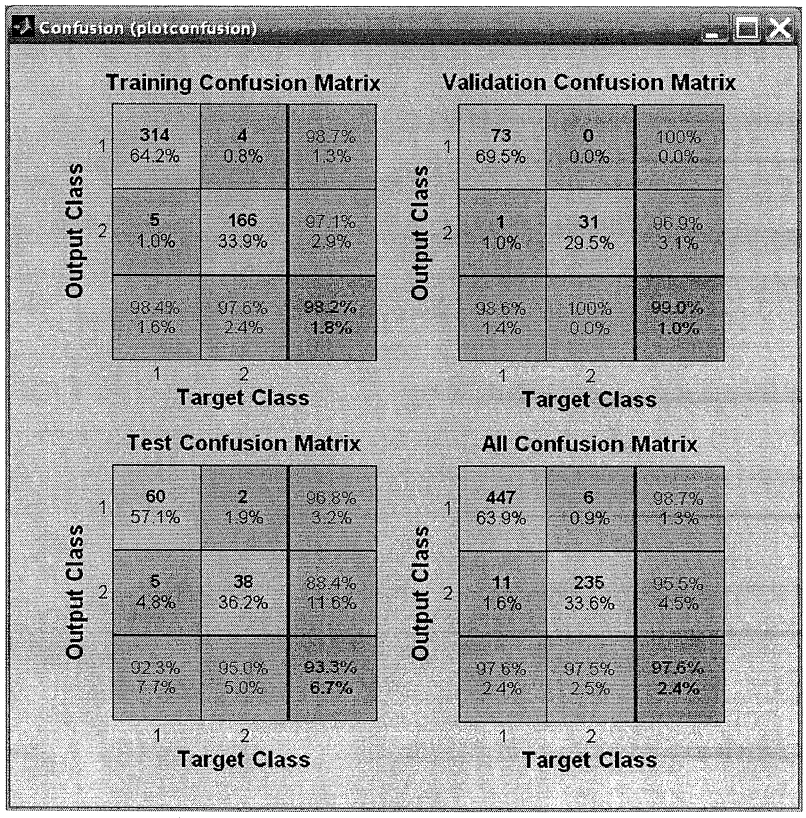


Figure Q6

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