THE OPEN UNIVERSITY OF SRI LANKA
FACULTY OF ENGINEERING TECHNOLOGY - LEVEL 6
FINAL EXAMINATION – 2010/2011
MEX6272 – INTELLIGENT CONTROL

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The Open University of Sri Lanka

DATE : 11th March 2011
TIME : 0930HRS. – 1230 HRS.
DURATION : THREE HOURS (3)

Common Instructions

1. *This paper consists of 6 questions.*
2. *Answer four questions including* ***Question 1.*** ***Question 1 is compulsory.***

Q1.

a. (25 marks)

An automatic watering plant uses a fuzzy logic controller for its control action considering temperature and moisture of soil as the control parameters. The watering plant controls the watering duration. The following fuzzy quantities and corresponding states are considered while designing the controller.

Temp: Temperature (Cold, Cool, Normal, Warm, Hot)
MS: Moisture of soil (Wet, Moist, Dry)
WD: Watering duration (Short, Medium, Long)

Both temperature and moisture of soil have triangular type membership functions. Corresponding crisp values are as follows.

Temperature - ^{0}C

Cold	Cool	Normal	Warm	Hot
30-47	40-70	60-84	75-98	90-110

Moisture of soil -%

Wet	Moist	Dry
0-35	30-65	60-80

Watering Duration - s

Short	Medium	Long
0-40	35-75	70-110

The relationship between the 2 inputs 'temperature', 'moisture of soil' and output 'watering duration' is as follows.

Moisture of soil	**Temperature**				
	Cold	Cool	Normal	Warm	Hot
Wet	Short	Short	Short	Short	Short
Moist	Short	Medium	Medium	Medium	Medium
Dry	Long	Long	Long	Long	Long

Simple rule base used in the fuzzy controller for the water supply unit is given below.

R1: IF **Temperature** is Hot AND Soil is Dry THEN **Watering Duration** is long
R2: IF **Temperature** is Warm AND Soil is Moist THEN **Watering Duration** is Medium
R3: IF **Temperature** is Warm AND Soil is Dry THEN **Watering Duration** is long
R4: IF **Temperature** is Hot AND Soil is Moist THEN **Watering Duration** is Medium

The crisp measurements of the process at a given instance are

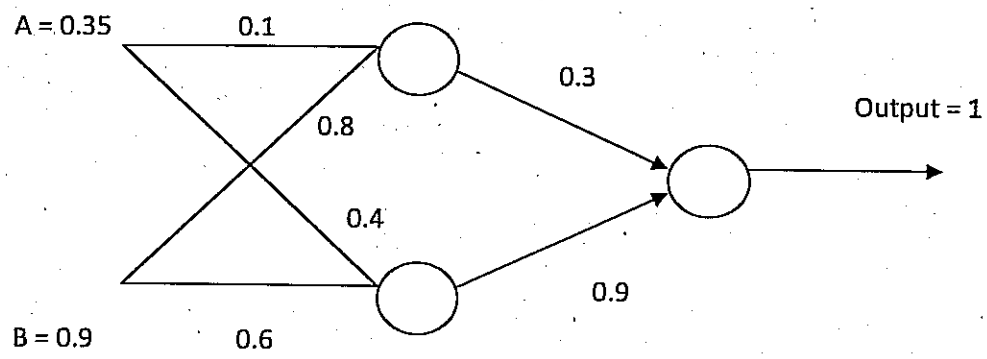
- **Temperature – 40^0 C**
- **Moisture – 40%**

Determine the corresponding inference membership function for the watering duration and a crisp value for the control action.
Use the following techniques as applicable.

- Max-Min inference method
- Centroid method

b. (15 marks)

Consider the simple network given below.



Assume that the neurons have a 'Uniploar continuous activation function' and that $\lambda = 1$. Use 'Backpropagation method' once to find the old and new errors of the trained network. Find the new weights for the hidden layers as well.

Hint: The formula to find the output error is as follows.

$$\mathbf{Error} = (\mathbf{DesiredOutput} - \mathbf{Output})^2$$

Q2. (20 marks)

a. Draw the block diagram of a classical PID controller and derive an equation for the incremental control action $\Delta u(k)$.

b. Draw the complete architecture of a Fuzzy logic controller. Name all parts of it and give a brief explanation of their functionalities.

c. How does the incremental control action ($\Delta u(k)$) is computed in a 'Mamdani type' Fuzzy logic controller?

Q3. (20 marks)

a. Consider U = {1,2,3,4,5} and fuzzy sets A and B on U which are given by

$$A = \{\frac{0.1}{1}, \frac{0.9}{2}, \frac{0.1}{3}, \frac{0.3}{4}, \frac{0.2}{5}\}$$

$$B = \{\frac{0}{1}, \frac{1}{2}, \frac{0.1}{3}, \frac{0.2}{4}, \frac{0.4}{5}\}$$

Answer the following questions.

i. Find the complement of the fuzzy set A.
ii. Find the union of fuzzy sets A and B.
iii. Find the intersection of fuzzy sets A and B.
iv. Is the fuzzy set A, a 'Normal Fuzzy set'? Give reasons.

b. Let R be a BFR on U X V and S be a BFR on V X W, where U= {a,b}, V={x,y} and W={&,*}.

$$R = \begin{matrix} 0.6 & 0.4 \\ 1.0 & 0.9 \end{matrix} \qquad S = \begin{matrix} 0.7 & 0.9 \\ 0.5 & 0.4 \end{matrix}$$

i. Write the formula to find the max-min composition of two fuzzy relations.
ii. Find the max-min composition of the given two fuzzy relations.

c. Consider the fuzzy set $A = \{\frac{0.7}{a}, \frac{0.5}{b}, \frac{1}{c}, \frac{0.2}{d}\}$. Write all $\propto$- cuts of this fuzzy set.

Q4. (20 marks)

a. Compare 'supervised learning' and 'unsupervised learning' found in neural networks. Your answer should clearly state the difference between the two learning methods and an application for each of the two learning methods.
b. What is the common format for all learning rules in neural networks? Briefly describe 'Hebbian' and 'Delta' learning rules.
c. List down 3 commonly used activation functions in neural networks.
d. Construct an architectural graph for the following artificial neural network.
   A Fully connected feed forward (acyclic) network has 3 source nodes, 2 hidden layers, one with 4 neurons and the other with 2 neurons and a single output neuron.

Q5. (20 marks)

a. Briefly explain the following terms found in different Artificial Intelligent (AI) techniques.
   i. 'Mutation' in Genetic Algorithms (GA).
   ii. 'Knowledge base' in Expert Systems.
   iii. 'Inference Engine' in Expert Systems.
   iv. 'Crossover' in Genetic Algorithms (GA).
b. Name the suitable AI technique to use for each application given below.
   i. Medical diagnosis system
   ii. Camera aiming for the telecast of sporting events
   iii. Face recognition system
c. Briefly explain what an 'Expert control system' is.
d. What do you understand by 'Intelligent Control'?

Q6. (20 marks)

a. List down four (4) reasons why fuzzy logic controllers must be used instead of classical controllers for a control application?

b. Clearly list down a difference between 'Mamdani-type' and 'Sugeno-type' fuzzy inference methods.

c. Consider the following application to answer questions i, ii, iii and iv of Q6 **c.**

A data set is available of a chemical analysis of wines grown in the same region in Italy but derived from three different cultivators. The analysis determined the quantities of 13 constituents found in each of the three types of wines. A neural network can be used to identify the cultivator when the 13 constituents are given as inputs.

i. State the following for the network
   1. Number of nodes for Input Layer
   2. Number of Hidden Layer/s
   3. Number of nodes for Output Layer

ii. Briefly describe 'Scaled Conjugate Gradient algorithm' which can be used as the training algorithm in this case.

iii. Briefly describe 'Mean squared Error Performance Function' which can be used as the Performance Function in this case.

iv. How would you explain the results obtained, using a 'Confusion Matrix' if the training was done using 'Matlab'?

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