UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 8 Examination in Engineering: November 2016

Module Number: EE8208 **Module Name: Intelligent Systems Design**

[Three Hours]

[Answer all questions. Marks for each question is indicated in the page]

Q1 a) i) What is a fuzzy set? Describe by characterizing the 'universe of discourse', 'membership function', and 'fuzzy elements'.

ii) Contrast fuzzy sets with crisp sets.

iii) Who is considered as the founder of fuzzy logic?

iv) Mention two properties of fuzzy sets.

[5 Marks]

b) Room temperature felt by human beings is to be modeled (described) via fuzzy sets.

i) Define the universe of discourse.

ii) Give 5 linguistic variables describing the room temperature.

iii) Define the fuzzy sets giving the membership functions for the variables identified in part ii).

iv) Describe the technique to define the fuzzy sets in iii).

[8 Marks]

Q2 Figure Q2 shows a water-level controlling system of a tank T. Main task of the fuzzy controller C is to keep the water level at SV [m] (*set value*) by controlling the water flow to the tank via the valve V1. The flow control of V1 is contiguous and proportional to the fuzzy controller's output du. Actual water level PV (*process value*) is available to the fuzzy controller through its feedback loop.

a) Define the error and the rete of error of the fuzzy controller.

b) Define the rule-base of the controlling action.

c) Identify the linguistic variables of the rule-base and define the corresponding fuzzy sets.

d) Assume certain numerical values for error and rate of error, and calculate the corresponding controller output-change du. Use the following fuzzy operators wherever necessary.

Zadeh AND: $\mu = \min(\mu_A, \mu_B)$

Lukasiewicz OR: $\mu = \min(\mu_A + \mu_B, 1)$

Mamdani THEN: $\mu = \min(\mu_A . \mu_B)$

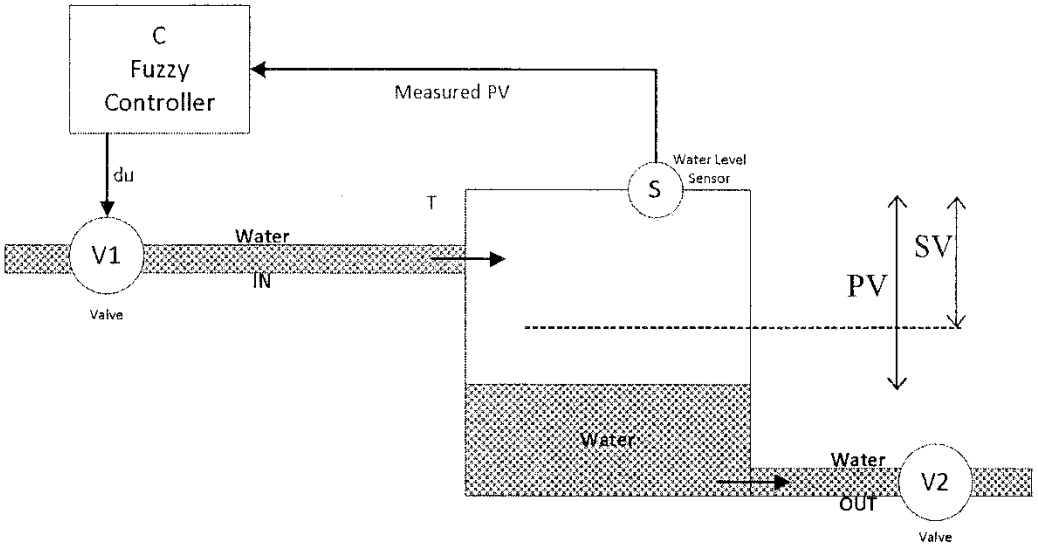

Figure Q2 : Fuzzy logic based water level-controlling system

[12 Marks]

Q3 a) Briefly explain the followings

i) An artificial neural network

ii) The Supervised learning of artificial neural networks

iii) A decision boundary

[3 Marks]

b) i) Write down an algorithm for perceptron learning.

ii) By starting with weight vector $W = [0.1 \quad -0.2]$ and bias 0.5, use perceptron learning rule to determine the decision boundary for the data set

$$\left\{\left(\begin{bmatrix}0\\1\\1\end{bmatrix}, 1\right), \quad \left(\begin{bmatrix}1\\-1\\0\end{bmatrix}, 0\right)\right\}$$

[7 Marks]

Q4 a) Describe the learning process

i) supervised Hebbian rule.

ii) pseudo inverse rule.

[2 Marks]

b) Let (x, t_1) and (x_2, t_2) be two prototype input/output vectors such that

$$(x, t_1) = \left(\begin{bmatrix} 1 \\ -1 \\ 0 \\ 1 \end{bmatrix}, \begin{bmatrix} 1 \\ 0 \end{bmatrix} \right) \text{ and } (x_2, t_2) = \left(\begin{bmatrix} -1 \\ 0 \\ 1 \\ 1 \end{bmatrix}, \begin{bmatrix} 0 \\ 1 \end{bmatrix} \right)$$

i) Are x_1 and x_2 orthonormal

ii) Use supervised Hebbian rule to determine the weight matrix of the network

iii) Repeat part ii. using the pseudo inverse rule.

iv) Compare the answers in parts ii. and iii.

[6 Marks]

c) Consider the artificial neural network with the architecture $2 - 2 - 1$ with weights between input and hidden layers

$$W = \begin{bmatrix} 0.2 & 0.1 \\ -0.1 & 0.2 \end{bmatrix}$$

and weights between hidden and output layer $V = [0.2 \quad -0.1]$.

Use the back propagation algorithm to compute the error between desired and actual output after 2 iterations for the dataset

$$\left(\begin{bmatrix} 1 \\ 0 \end{bmatrix}, 1 \right)$$

Use log sigmoid and linear activation functions for hidden and output layers respectively, and learning rate is 0.1.

[7 Marks]