UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 8 Examination in Engineering: December 2018

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

[Three Hours]

[Answer all questions, each question carries 15 marks]

Q1. a) Briefly explain what does it mean by supervised learning and unsupervised learning of Artificial Neural Networks. [5 Marks]

b) Describe the following activation functions.

i. Hard Limit Function

ii Log Sigmoid Function [4 Marks]

c) Consider two input/output data sets of a neural network.

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

Let the initial weights and bias are given as $W = [0.1\ \ -0.1\ \ 0.1]$ and $b = 0.5$ respectively. Determine the weight vector and the bias if the network trained by the perceptron learning rule when the learning rate $m = 1$. [6 Marks]

Q2. a) i Explain what is meant by orthonormal vectors.

ii Show that x_1, x_2 of the following input/output vectors are orthonormal.

$$(x_1, t_1) = \left(\begin{bmatrix}0.5\\-0.5\\0.5\\-0.5\end{bmatrix},\begin{bmatrix}1\\1\end{bmatrix}\right) \qquad (x_2, t_2) = \left(\begin{bmatrix}-0.5\\-0.5\\0.5\\0.5\end{bmatrix},\begin{bmatrix}-1\\1\end{bmatrix}\right)$$

Use Hebbian rule to determine the weight vector for the network of (x_1, t_1) and (x_2, t_2) [5 Marks]

b) i Write down the 4 major steps of Back Propagation algorithm.

ii Train the below specified neural network with the data set $\left(\begin{bmatrix}1\\-1\end{bmatrix},1\right)$ by using the backpropagation algorithm, and compute the output error after first 2 iterations.

Hidden layer of the Neural Network contains 3 neurons and the initial weights between the input layer and the hidden layer are

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

and weights between hidden layer and output layer are

$$V = [0.1\ \ -0.1\ \ 0.2].$$

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

Hint: The delta value of output and hidden layers (h) are given in usual notations by

$$\delta_j = e_j f_o'(net_j)$$

and $$\delta_j^h(n) = f_h'\left(net_j^h(n)\right)\sum_{k=1}^{h_{n+1}} \delta_k^{h+1}(n) w_{kj}^{h+1}(n)$$

Weight between j^{th} neurons of h^{th} hidden layer k^{th} neurons $(h+1)$ hidden layer is updated in n^{th} iteration according to the equation

$$w_{ji}(n+1) = w_{ji}(n) + \eta_j \delta_j f_h(net_i))$$

[10 Marks]

Q3. a) Describe what are *linguistic variable* and the *values* it can take. Use an appropriate example to answer. [3 Marks]

b) Compare and contrast *classical Set* and *Fuzzy Set*. [3 Marks]

c) Define fuzzy sets Cold, Cool, Pleasant, Warm and Hot to represent room temperature, appropriately for local conditions. Clearly define the Universe of Discourse. [3 Marks]

d) Define operations i) min(μA, μB), ii) max(μA, μB), iii) 1-μA, iv) min[μA+μB, 1], by using the Membership Functions of the Fuzzy Sets A and B. Also interpret these operations in diagrams of Universe of Discourse vs Fuzzy Membership and mention alternative names used for these operations [3 Marks]

e) Explain how to evaluate a rule of type "If x is A AND y is B THEN z is C" by using an appropriate membership functions and operators. [3 Marks]

Q4. A Fuzzy Logic controller is to be designed for a classical feedback control system.

a) Draw the classical feedback control diagram with Process, Fuzzy Controller and the feedback path. Define the Control Error e(k) and Rate of Error r(k) with respect to the SV (Set Value) and PV (Process Value). [2.0 Marks]

b) Define an appropriate Rule Base for control action, based on the Linguistic Variables; Error e(k), Rate of Error r(k) and Control Output du(k), with meaningful linguistic values.

[2.0 Marks]

c) Define the membership functions for the linguistic values identified in b) and show them in diagrams; Membership vs Universe of Discourse. [3.0 Marks]

d) Show how to calculate the Control Output du(k) for a given values of e(k) and r(k) by using a numerical example. Use the method "Center of Gravity" to calculate the du(k). [3.0 Marks]

e) Re-design the Rule Base if the controller inputs are Error e(k), Rate of Error r(k) and Sum of Error ∑e(k) for k=k, k-1, ..k-50. [5 Marks]