UNIVERSITY OF ESWATINI
MAIN EXAMINATION, JUNE 2020

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

TITLE OF PAPER:	**INTELLIGENT SYSTEMS**
COURSE NUMBER:	**EEE532 / EE533**
TIME ALLOWED:	**THREE HOURS**

INSTRUCTIONS:

1. There are four questions in this paper. **Answer ALL questions.**
2. Each question carries its own mark as shown in all questions.
3. Marks for different sections are shown on the right hand margin.
4. Show the steps clearly in all your calculations including any assumptions made.

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THIS PAPER HAS FOUR (4) PAGES INCLUDING THIS PAGE

QUESTION 1 *(25 marks)*

a- Explain and differentiate between the following ANN learning methods: *(6-marks)*

i - Supervised learning,
ii- Unsupervised learning, and
iii- Reinforced learning.

b- What is the Stability-Plasticity Dilemma? *(4-marks)*

c- What is the features of McCulloch-Pitts Neuron? Construct simple neural networks for the 3-input functions, $F = (\overline{A + B}).C$ using single layer perceptron classifier with Step activation function (hardlim). Draw a diagram to show the decision boundary of this network. Draw a diagram to show the decision boundary of this network. Find out the proper weights and threshold of this network? *(10-marks)*

d- Define Sigmoid activation function. Write a program/script in MATLAB code for Sigmoid activation function. *(5-marks)*

QUESTION 2 *(25 marks)*

a- Discuss the dilemma of implementing XOR gate using McCulloch-Pitts neuron? How you can solve it? *(5-marks)*

b- Explain the Gradient Decent algorithm? *(3-marks)*

c- Why the error in ANN occurs? *(2-marks)*

d- Explain the Learning Rule in the hidden and output layers of a multi-layer NN? *(3-marks)*

e- What is Backpropagation in a multi-layer NN? How it works? Use the Backpropagation algorithm for one-epoch to update the weights and biases of the shallow multi-layer NN given in Fig. 1 by using learning rate (α) = 0.2. Apply the error-weight derivative technique to predict your new weights. The initial weights, bias and the training data are given in Table 1. *(12-marks)*

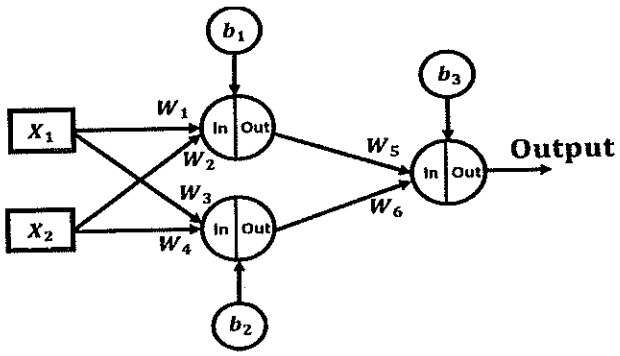

Fig. 1.

Table 1.

Training Data			Initial Weights and Biases								
X1	X2	Output	W_1	W_2	W_3	W_4	W_5	W_6	b_1	b_2	b_3
0.2	0.7	0.07	0.4	0.3	0.75	0.4	-0.25	0.7	0.5	-0.8	1.5

QUESTION 3 ***(25 marks)***

a- Define the following:

1- Non-Random Uncertainty ***(2-marks)***

2- Crisp and Fuzzy sets, and ***(2-marks)***

3- Membership function. ***(2-marks)***

b- Let $X = \{x_1, x_2, x_3, x_4\}$ be the reference set of motor speed. Let $\tilde{A}$ be the fuzzy set of "high" speed, $\tilde{B}$ be the fuzzy set of "medium" speed, and $\tilde{C}$ be the fuzzy set of "low" speed. Assume that a discrete membership is used. If the fuzzy sets have the following values:

$$\tilde{A} = \{(x_1, 0.5), (x_2, 0.7), (x_3, 0.4), (x_4, 0.8)\}$$

$$\tilde{B} = \{(x_1, 0.4), (x_2, 0.8), (x_3, 0.9), (x_4, 0.2)\}$$

$$\tilde{C} = \{(x_1, 0.7), (x_2, 0.3), (x_3, 0.7), (x_4, 0.6)\}$$

Determine:

1- $\tilde{A} \cap \tilde{B} \cap \tilde{C}$ ***(2-marks)***

2- $\tilde{A} \cdot \tilde{B}$ ***(2-marks)***

3- $(\tilde{B} \cup \tilde{C})^C$ ***(3-marks)***

4- $2(\tilde{B} - \tilde{C})$ ***(3-marks)***

5- $[(\tilde{A} - \tilde{B}) \cap \tilde{C}] (+) \tilde{A}^2$ ***(4-marks)***

c- If the universes of discourse: $X = \{x_1, x_2, x_3\}$, $Y = \{y_1, y_2\}$ and $Z = \{z_1, z_2, z_3\}$ and the Fuzzy relations: ***(5-marks)***

$$\tilde{R} = \begin{matrix} x\backslash y \\ x_1 \\ x_2 \\ x_3 \end{matrix} \begin{matrix} y_1 & y_2 \end{matrix} \begin{bmatrix} 0.6 & 0.2 \\ 0.4 & 0.7 \\ 0.7 & 0.8 \end{bmatrix}, \quad \tilde{S} = \begin{matrix} y\backslash z \\ y_1 \\ y_2 \end{matrix} \begin{matrix} z_1 & z_2 & z_3 \end{matrix} \begin{bmatrix} 0.7 & 0.3 & 0.5 \\ 0.4 & 0.7 & 0.2 \end{bmatrix}$$

Find $\tilde{R} o \tilde{S}$?

QUESTION 4 ***(25 marks)***

a- Explain the following terminology in Fuzzy Logic:

1- Fuzzification, ***(2.5 marks)***

2- Rule Base, ***(2.5 marks)***

3- Inference Mechanism, and ***(2.5 marks)***

4- Defuzzification ***(2.5 marks)***

b- In an air conditioning control system, the inputs are: the difference in temperature (ΔT) and the change in temperature with respect to the time ($\frac{d\Delta T}{dt}$). The ΔT can be expressed by:
$\Delta T = T - T_0$, where T is the actual temperature and T_0 is the set temperature. The output is the control dial D. In which cool is negative rotation and heat being a positive rotation as shown in Fig. 2. Design a fuzzy logic control system to calculate the output if the inputs are ΔT = 4 and $\frac{d\Delta T}{dt} = -2.5$. Use a triangular fuzzy membership for your input and output. The two input have to be normalized to $\Delta T = [-30, 30]$, $\frac{d\Delta T}{dt} = [-6, 6]$and the output fuzzy sets = $[-3, 3]$. (***Hint:*** *In your answer you have to show in details: the input fuzzification, rules, output fuzzy sets and the centroid method used in defuzzification).* ***(15-marks)***

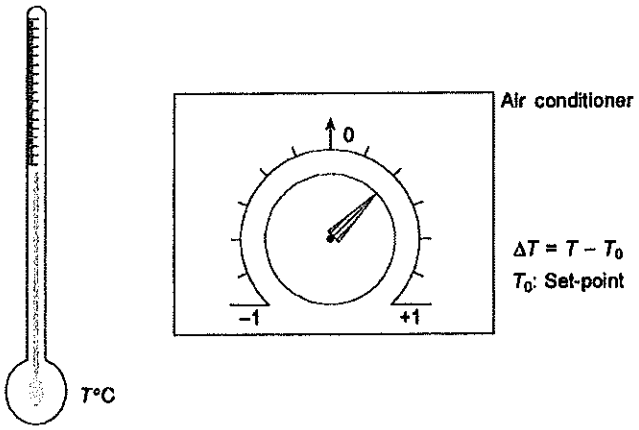

Fig. 2.

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