Philadelphia University **Student Name:**

Faculty of Engineering **Student Number:**

Dept. of Computer Engineering

Final Exam, First Semester: 2015/2016

Course Title:	**Neural Networks and Fuzzy Logic**	**Date:**	31/01/2016
Course No:	**630514**	**Time Allowed:**	2 hours
Lecturer:	Dr. Qadri Hamarsheh	**No. Of Pages:**	10

Information for candidates

1. *This exam paper contains 6 questions totaling 40 marks.*
2. *The marks for parts of question are shown in round brackets.*

Advices to candidates

1. *You should attempt all sub questions.*
2. *You should write your answers clearly.*

Basic notions: *The aims of the questions in this part are to evaluate the required minimal student knowledge and skills. Answers in the pass category represent the minimum understanding of basic concepts: different Learning Rules- Perceptron Learning Rule, backpropagation algorithm, Hopfield network, Bidirectional Associative Memory, Kohonen self-organizing map, fuzzy logic systems: Mamdani and Sugeno Fuzzy Models, and their Matlab Implementation.*

Question 1 ***Multiple Choice*** ***(12 marks)***

Identify the choice that best completes the statement or answers the question.

1) What are the advantages of biological neural networks (**BNNs**) compared to conventional **Von Neumann** computers?

(i) BNNs have the ability to learn from examples.
(ii) BNNs have a high degree of parallelism.
(iii) BNNs require a mathematical model of the problem.
(iv) BNNs can acquire knowledge by "trial and error".
(v) BNNs use a sequential algorithm to solve problems.

a) **(i), (ii), (iii), (iv) and (v)** **b)** **(i), (iii) and (iv)**

c) **(i) , (ii) and (iii)** **d)** **(i), (ii) and (iv)**

2) A multi-layer feedforward network has **5** input units, a first hidden layer with **4** units, a second hidden layer with **3** units, and **2** output units. How many weights does this network have?

a) **18** **b)** **20**

c) **26** **d)** **38**

3) Which of the following equations is the best description of **Hebbian learning**?

a) $\Delta W_k = \eta y_k X$

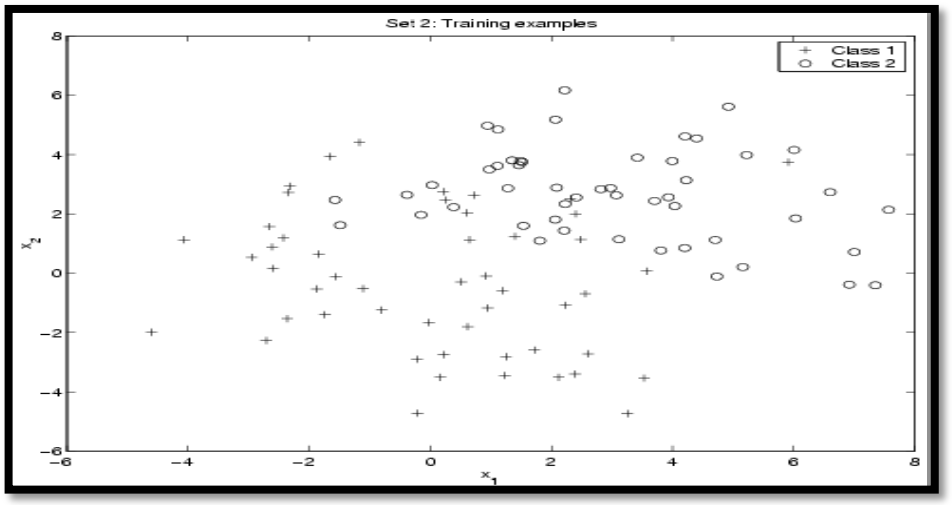
b) $\Delta W_k = \eta\,(X - W_k)$

c) $\Delta W_k = \eta\,(d_k - y_k)X$

d) $\Delta W_j = \eta_j\,(X - W_j)$, **where** $\eta_j < \eta$ **and** $j \neq k$

Where X is the input vector, η is the learning rate, W_k is the weight vector, d_k is the target output, and y_k is the actual output for unit k.

4) Is the following statement true or false? "A **perceptron** is trained on the data shown below, which has two classes (the two classes are shown by the symbols '**+**' and '**o**' respectively). After many epochs of training, the perceptron will converge and the decision line will reach a steady state."



a) **TRUE**. **b)** **FALSE**.

5) How many hidden layers are there in an **autoassociative** Hopfield network?

a) **None (0).** **b)** **One (1).**

c) **Two (2).** **d)** **unlimited**

6) The maximum number of fundamental memories $\mathbf{M_{max}}$ (**All perfectly retrieved**) that can be stored in the **n-neuron** Hopfield network is limited by

a) $M_{max} = 0.15\,n$ **b)** $M_{max} = \dfrac{n}{2\,\ln n}$

c) $M_{max} = \dfrac{n}{4\,\ln n}$ **d)** **None of above**

7) An input vector $\mathbf{x}$ and two prototype vectors $\mathbf{p_1}$ and $\mathbf{p_2}$ are given by

$\mathbf{x} = [-1.40,\ \ 2.30,\ \ 0.20]^T$
$\mathbf{p_1} = [-1.00,\ \ 2.20,\ \ 0.10]^T$
$\mathbf{p_2} = [-4.00,\ \ 7.00,\ \ 0.60]^T$

Which prototype is nearest to $\mathbf{x}$ in terms of **squared Euclidean distance**?

a) $\mathbf{p_1}$ **b)** $\mathbf{p_2}$

8) Which of the following statements is **NOT** true for a self-organizing map (**SOFM**)?

a)	**The size of the neighbourhood is decreased during training.**
b)	**The units are arranged in a regular geometric pattern such as a square or ring.**
c)	**The weights of the winning unit k are adapted by $\Delta wk = \eta\,(x - wk)$, where x is the input vector.**
d)	**The weights of the neighbours j of the winning unit are adapted by $\Delta wj = \eta_j\,(x - wj)$, where $\eta_j > \eta$ and $j \neq k$.**

9) What is the equation for **probabilistic or**?

a) **Probor (a,b) = a-b + ab**

b) **Probor (a,b) = a+b - ab**

c) **Probor (a,b) = ab + ab**

d) **Probor (a,b) = a/b x ab**

10) What is the **input** and **output** of step 2 of fuzzy logic - **Apply Fuzzy Operator**?

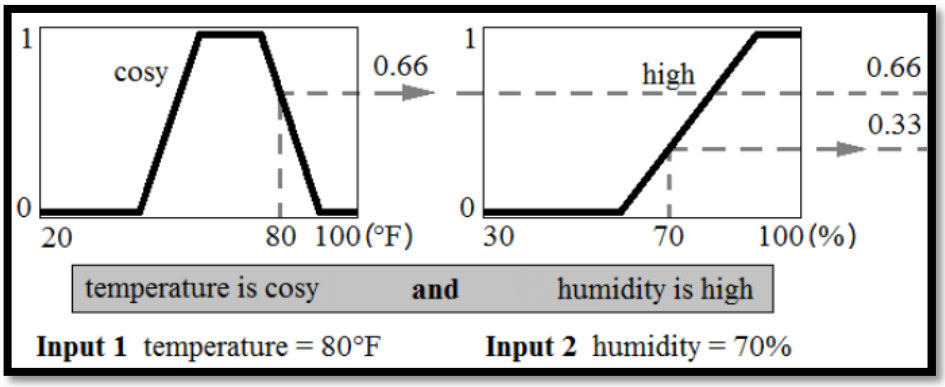
a) **The input is a single truth value and the output has two or more values.**

b) **The input is a value greater than one and the output is a value less than the input.**

c) **The input and output have both the same values.**

d) **The input has two or more values and the output has a single truth value.**

11) The result of **fuzzy operator** shown in the following figure is



a) **0.33**

b) **0.66**

c) **0.23**

d) **1**

12) What is the following sequence of steps taken in designing a fuzzy logic machine?

a) **Fuzzification->Rule evaluation->Defuzzification**

b) **Rule evaluation->Fuzzification->Defuzzification**

c) **Fuzzy Sets->Defuzzification->Rule evaluation**

d) **Defuzzification->Rule evaluation->Fuzzification**

Familiar and Unfamiliar Problems Solving: *The aim of the questions in this part is to evaluate that the student has some basic knowledge of the key aspects of the lecture material and can attempt to solve familiar and unfamiliar problems different Learning Rules- Perceptron Learning Rule, backpropagation algorithm, Hopfield network, Bidirectional Associative Memory, Kohonen self-organizing map, fuzzy logic systems: Mamdani and Sugeno Fuzzy Models, and their Matlab Implementation.*

Question 2 ***(9 marks)***

a) Explain the **Self-Organizing Maps algorithm** (Kohonen's learning). ***(5 marks)***

(Hint: 9 steps)

Solution

b) With a suitable **block diagram**, explain the **construction** and **working** of **fuzzy inference system.** ***(4 marks)***

Solution

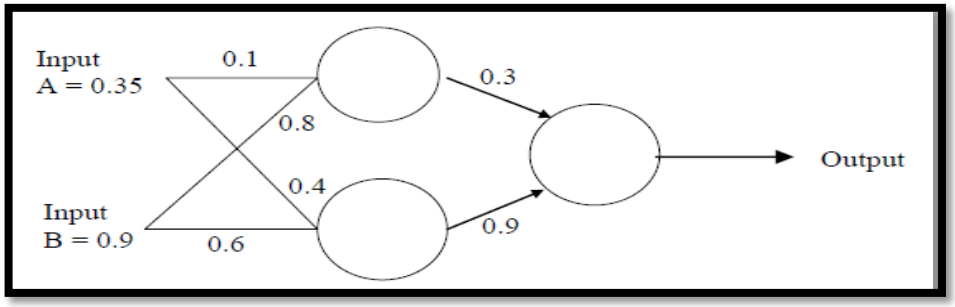
Question 3 ***(6 marks)***

Consider the **backpropagation neural network** as shown below, assume that the neurons have a **sigmoid activation function,** do the following**:**

a) Perform a **forward pass** on the network. ***(1.5 marks)***

b) Perform a **reverse pass** (training) once (**target = 0.5, ∝=1**). ***(3 marks)***

c) Perform a **further forward** pass and **comment** on the result. ***(1.5 marks)***



Solution

Question 4 *(4 marks)*

Let **X** be the **universe** of commercial aircraft of interest:

$$\boldsymbol{X = \{a10, b52, b117, c5, c130, f4, f14, f15, f16, f111, kc130\}}$$

Let $\boldsymbol{A}$ be the **fuzzy set** passenger class aircraft:

$$\boldsymbol{A = \{0.3/f16, 0.5/f4, 0.4/a10, 0.6/f14, 0.7/f111, 1.0/b117, 1.0/b52\}}$$

Let $\boldsymbol{B}$ be the **fuzzy set** of cargo:

$$\boldsymbol{B = \{0.4/b177, 0.4/f111, 0.6/f4, 0.8/f15, 0.9/f14, 1.0/f16\}}$$

Find the values of the operations performed on these fuzzy sets. The operations are **union**, **intersection**, and **complement**.

Solution

Question 5 *(4 marks)*

Write a matlab code to create a feedforward network with **1** neuron in the **hidden** layer with a **sigmoid** activation function and **1** neuron in the output layer with the **identity** activation function.
The network must approximate the following function:

$$\mathbf{y = x + 0.3\sin(2\pi x)}, \quad \mathbf{0 \leq x \leq 1}$$

In your code you must:

- Create **noisy measurements** of the function values **y** for training and **additional function values** for testing.
- **Plot** the data.
- Define suitable **learning parameters**.
- Calculate the **Maximum fitting error**.

Solution

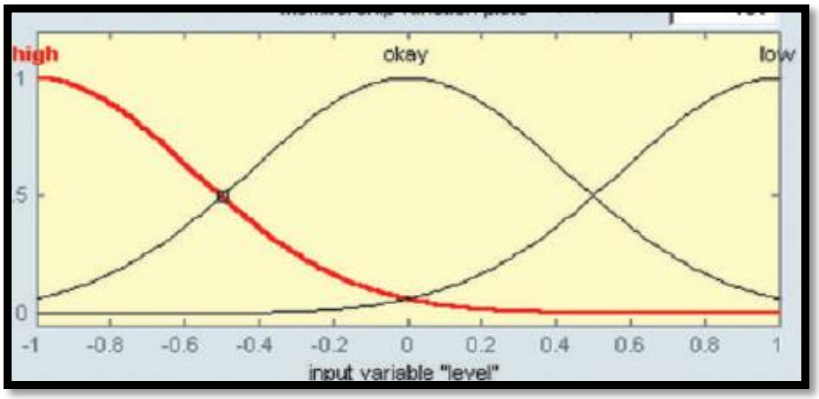
Question 6 *(5 marks)*

Consider the **water tank** with the following **fuzzy rules**:

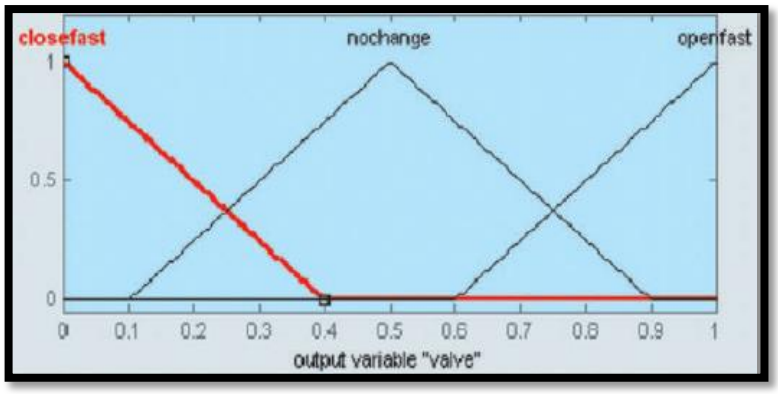
1. **IF (level is okay) THEN (valve is no change) (1)**
2. **IF (level is low) THEN (valve is open fast) (1)**
3. **IF (level is high) THEN (valve is close fast) (1)**

Membership functions are as the following:

Membership Function for **"level":**



Membership Function for **"valve":**



Write **MATLAB Program** to construct an FIS system using **Mamdani** method with the following properties:
AndMethod = min, OrMethod = max, ImpMethod = min, AggMethod = max, DefuzzMethod = centroid
Evaluate the output of a fuzzy system for a given input (**0.8**).

Solution

GOOD LUCK