[ENG32]

UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

MSC SYSTEMS ENGINEERING AND ENGINEERING MANAGEMENT

SEMESTER ONE EXAMINATION 2018/2019

INTELLIGENT SYSTEMS

MODULE NO: EEM7010

Date: Monday 14th January 2019 **Time: 10:00 – 12:00**

INSTRUCTIONS TO CANDIDATES:

There are FIVE questions.

Answer ANY THREE questions.

All questions carry equal marks.

Marks for parts of questions are shown in brackets.

All working must be shown. A numerical solution to a question obtained by programming an electronic calculator will not be accepted.

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Question 1

This question relates to the perceptron neural network

a) Using diagrams to clearly identify, with reasons, the type of applications the perceptron network could be used and the types it couldn't be used. **(6 marks)**

b) A classification problem with three classes of input vectors **p** and corresponds to their targets **t** is shown below:

Class 1: {p1 = $\begin{bmatrix} -1 \\ 0 \end{bmatrix}$, t1 = 1},

Class 2: {p2 = $\begin{bmatrix} 1 \\ -1 \end{bmatrix}$, t2 = 1},

Class 3: {p3 = $\begin{bmatrix} 0 \\ 1 \end{bmatrix}$, t3 = 0}

i) Draw a diagram of the perceptron network and determine the minimum number of neurons needed to solve this problem.
(4 marks)

ii) Critically define the transfer function, the neuron output and learning rules for the perceptron neural network designed in i) above.
(6 marks)

iii) If the initial values for the network weights and biases have been chosen as

W(0) = [0.5 0.5] b(0) = [0]

Apply each input vector in order to complete 3 repetitions to generate values of weights W(3) and biases b(3) for the problem. **(6 marks)**

iv) Using the values of weights W(3) and biases b(3) generated to check whether the problem has been solved or not. **(3 marks)**

Total 25 marks

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Question 2

This question relates to the back propagation supervised neural network

a) Using back propagation algorithm to approximate the function:

$f(x) = x + \cos\left(\frac{\pi}{4}\right)$

for $0 \le x \le +2$

A 1 – 2 – 1 network architecture with transfer functions in the first layer are Log-Sigmoid and second layer is Linear shown in Figure Q2 below:

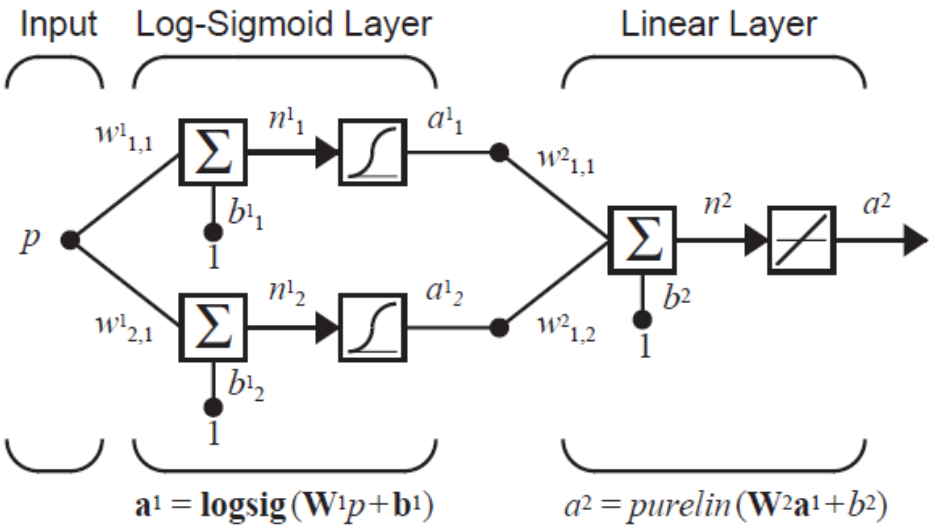

Figure Q2

If the initial values for the network weights and biases have been chosen as

$$W^1(0) = \begin{bmatrix} 0.1 \\ -0.2 \end{bmatrix} \qquad b^1(0) = \begin{bmatrix} -0.5 \\ -0.3 \end{bmatrix}$$

$$W^2(0) = \begin{bmatrix} 0.3 & 0.2 \end{bmatrix} \qquad b^2(0) = \begin{bmatrix} 0.4 \end{bmatrix}$$

Perform one iteration of back propagation with input $a^0 = p = 1$ and learning rate $\alpha = 0.6$.

(20 marks)

b) Explain possible difficulties during using the basic back propagation algorithm on practical problems. **(5 marks)**

Total 25 Marks

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Question 3

This question relates to the Hebbian neural network

a) Describe Hebb's Postulate and how his learning law been applied into supervised and unsupervised neural network algorithms. **(10 marks)**

b) Consider the two prototype patterns shown in Figure Q3(b).

i) Check if these two patterns are orthogonal. **(3 marks)**

ii) Normalise the input P1 **(2 marks)**

iii) Use the Hebb rule to design an autoassociator network that will recognise these two patterns and determine the weight matrix. **(6 marks)**

P1

P2

Pt

Figure Q3 (b)

iv) Find the response of the network to the pattern. **(4 marks)**

Total 25 Marks

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Question 4

This question is related to Kohonen Network and the winner-takes-all neural network:

a) Clearly identify the differences between a supervised learning and an unsupervised learning. **(4 marks)**

b) Explain the function of biases used in the Kohonen Network **(3 marks)**

c) Draw an architecture of the Kohonen Network and explain its working principles. **(8 marks)**

d) A Kohonen network receives the four input pattern P

$$P = \begin{bmatrix} 0.2 \\ 0.5 \\ -0.7 \\ 0.1 \end{bmatrix}$$

and with three neurons in the network which have weights

$$W1 = \begin{bmatrix} -0.1 \\ 0.4 \\ 0.8 \\ 0 \end{bmatrix}, \quad W2 = \begin{bmatrix} 0.5 \\ 0.3 \\ -0.6 \\ 0.2 \end{bmatrix}, \quad W3 = \begin{bmatrix} 0.2 \\ -0.5 \\ -0.8 \\ 0.1 \end{bmatrix}$$

Using the "winner-takes-all" learning algorithm to determine

- the neuron that will have its weights adjusted **(7 marks)**
- the new values of the weights, suppose that the learning coefficient is 0.5. **(3 marks)**

Total 25 Marks

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Question 5

This question relates to a self organising map (SOM) neural network

a) Compare and contrast the SOM neural network with the winner-takes-all neural network **(8 marks)**

b) Discuss the following main aspects of the algorithm for the Kohonen self organising map (SOM)

i) the best matching node (BMN) *m*

ii) the neighbourhood (*Nm*) of the BMN and its spatial extent as training progresses

iii) the Gaussian form for the learning function $\alpha = \alpha(N_i, t)$

(10 marks)

c) Using sketches to identify the difference between a pattern space and a feature space and explain the importance to map a pattern space into a feature space in SOM neural network.

(7 marks)

Total 25 Marks

END OF QUESTIONS