[ESS30]

UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

MSC SYSTEMS ENGINEERING AND ENGINEERING MANAGEMENT

SEMESTER ONE EXAMINATION 2019/2020

INTELLIGENT SYSTEMS

MODULE NO: EEM7010

Date: Monday 13th January 2020 **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) Critically define the supervised learning, unsupervised learning and reinforcement learning in neural networks. **(6 marks)**

(b) Explain the perceptron network architecture, decision boundary and learning rules. **(6 marks)**

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

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

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

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

Class 4: {p4 = $\begin{bmatrix}1\\0\end{bmatrix}$, t4 = 1},

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

$$W(0) = [0\ 0.5]; \quad b(0) = [0.5]$$

Apply each input vector in order to complete 4 repetitions to generate values of weights W(4) and biases b(4) for the problem. **(10 marks)**

ii) Using the values of weights W(4) and biases b(4) 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 Hebb's learning rules

(a) Describe Hebb's Postulate and suggest how to interpret this postulate into Hebb's supervised learning rule. **(8 marks)**

(b) Consider the three prototype patterns P1, P2, and P3 shown in Figure Q2 (b) below.

i) Check if P1 and P2 patterns are orthogonal. **(3 marks)**

ii) Normalise the input P3 **(2 marks)**

iii) Use Hebb supervised rule to design an autoassociator network that will recognise these three patterns. **(7 marks)**

iv) Find the response of the network to the pattern Pt and check if the response is correct. **(5 marks)**

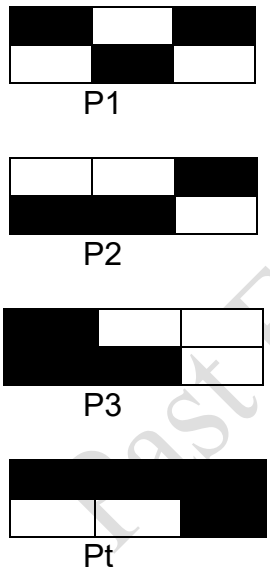

Figure Q2(b)

Total 25 marks

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Question 3

This question relates to the back propagation supervised neural network

(a) Using back propagation algorithm to approximate the function:

$$f(p) = 1 + \sin(p) \ for -1 \leq p \leq +1$$

A 1 – 2 – 1 network architecture with transfer functions in the first layer are LogSigmoid and second layer is Linear shown in Figure Q3 below:

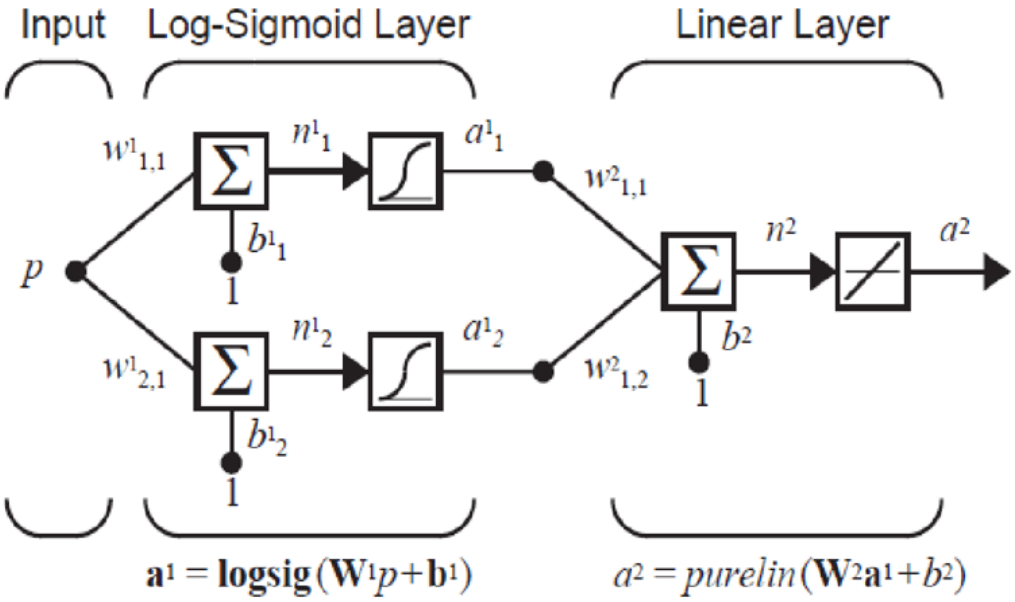

Figure Q3

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

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

$$W^2(0) = [-0.4 \quad 0.2] \qquad b^2(0) = [0.3]$$

Perform one iteration of back propagation with input $a^0 = p = 1$ and learning rate $\alpha = 0.4$ **(20 marks)**

(b) Briefly comments two issues that will impact on the practical implementation of back propagation algorithm. **(5 marks)**

Total 25 marks

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Question 4

This question is related to Competitive Kohonen Neural Network (winner-take-all)

(a) A competitive neural network has three-neuron layers with three input vectors p1, p2 and p3, and three initial weight vectors ${}_1W$, ${}_2W$, and ${}_3W$, where

p1 = $\begin{bmatrix}1\\0\end{bmatrix}$, p2 = $\begin{bmatrix}0\\1\end{bmatrix}$, p1 = $\begin{bmatrix}-0.7071\\0.7071\end{bmatrix}$

${}_1W$ = $\begin{bmatrix}0.7071\\0.7071\end{bmatrix}$, ${}_2W$ = $\begin{bmatrix}-0.8660\\0.5\end{bmatrix}$, ${}_3W$ = $\begin{bmatrix}-1\\0\end{bmatrix}$,

i) Draw a diagram to show these input vectors and weight vectors. **(2 marks)**

ii) Calculate the resulting weights found after training the competitive layer with Kohonen rule and use a learning rate α of 0.7, on the series of inputs: p1, p2, p3 **(15 marks)**

(b) Explain the application areas for competitive neural network and discuss possible problems with this learning algorithm. **(8 marks)**

Total 25 marks

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Question 5

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

a) Broadly speaking what is a feature map? **(4 marks)**

b) Outline the main components of the SOFM process that is used to train a Kohonen's neural network. **(6 marks)**

c) Discuss the following main aspects of the algorithm for the Kohonen self organising feature map (SOFM)

i) the weight update rule for the SOFM

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

(8 marks)

d) Give one application example for using SOFM and provide the learning processes

(7 marks)

Total 25 marks

END OF QUESTIONS