Xi'an Jiaotong-Liverpool University

西交利物浦大学

PAPER CODE	EXAMINER	DEPARTMENT	TEL
INT301			

1st SEMESTER 2023/2024 EXAMINATION

BACHELOR DEGREE – Year 4

Bio-Computation

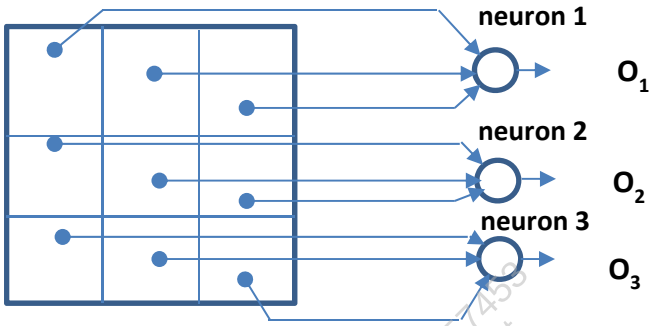
TIME ALLOWED: 2 Hours

INSTRUCTIONS TO CANDIDATES

1. **This is a closed-book examination.**
2. **Total marks available are 100. This exam will count for 80% in the final assessment.**
3. **Answer all questions. There is NO penalty for providing a wrong answer.**
4. **Answer should be written in the answer booklet(s) provided.**
5. **Only English solutions are accepted.**
6. **All materials must be returned to the exam supervisor upon completion of the exam. Failure to do so will be deemed academic misconduct and will be dealt with accordingly**.

Question 1. [25 MARKS]

(1) The network shown in the following figure



is trained to recognize the characters H and T as shown below:

If the following pattern was given

What would be the color of the network output [O_1 O_2 O_3]? **[5 MARKS]**

(2) Consider a task involving "a three-input, one-output parity detector" which outputs a 1 if the number of "1" inputs is even; otherwise it outputs a 0. Can this function be represented by a perceptron? Explain. **[5 MARKS]**

(3) What is meant by overfitting in relation to learning from data? Under what circumstances is the risk largest to get these problems? What can you do to identify/discover the problem? **[5 MARKS]**

(4) Why does the backpropagation algorithm in multilayer perceptrons sometimes not find the set of weights that gives a sufficiently good solution despite the fact that a solution exists? **[5 MARKS]**

(5) The Oja rule solves a serious problem of the Hebb rule. Explain what the problem is and how it is solved. **[5 MARKS]**

Question 2. [20 MARKS]

Apply the backpropagation algorithm to find the new weights of a feedforward neural network after applying the only data with input-output pattern ({0, 1}, 1), where {0, 1} are two inputs and 1 is the output. Assume the network has a single hidden layer with 2 neurons and all weights (including bias in hidden and output layers) are initially 0. The learning rate is 0.5 and all neurons use the sigmoid activation function. **[20 MARKS]**

Question 3. [12 MARKS]

(1) Calculate the weight matrix for a Hopfield network with bipolar nodes xi ={-1,1} to store the pattern [1 -1 1 -1]. **[4 MARKS]**

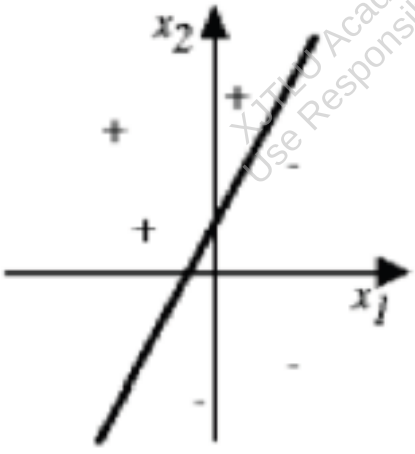
(2) Given a Hopfield network with bipolar {-1, 1} nodes and the following weight matrix:

0	-1	-2	3	4
-1	0	-1	-2	3
-2	-1	0	-1	-2
3	-2	-1	0	-1
4	3	-2	-1	0

Find two patterns that are stable states. Please show the procedure. **[8 MARKS]**

Question 4. [12 MARKS]

Provide one possible solution of weights w_0, w_1, and w_2 for the perceptron whose decision surface is illustrated in the following figure. Assume the decision surface crosses the x_1 axis at -1 and the x_2 axis at 2, and the threshold activation function is Heaviside (unit step) function with threshold of 0. **[12 MARKS]**



Question 5. [6 MARKS]

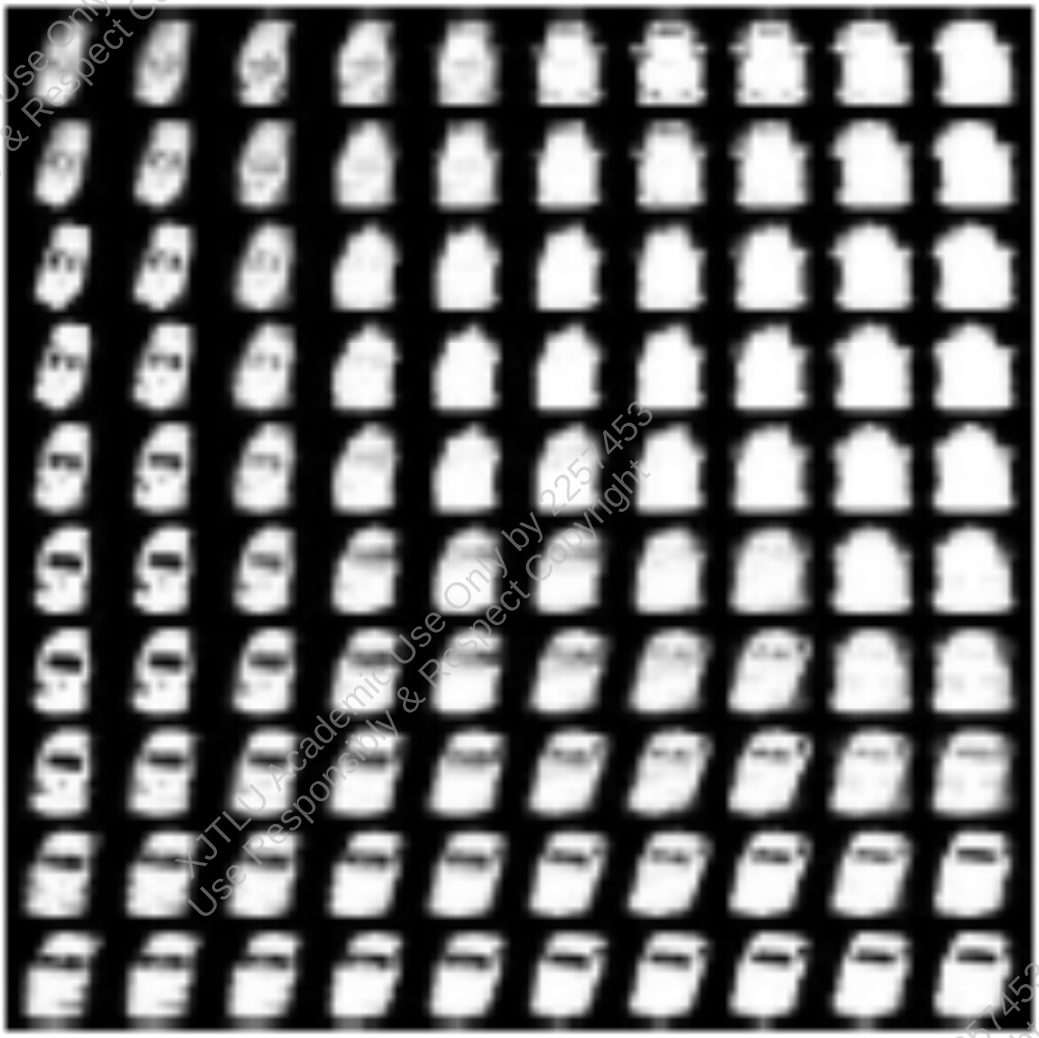
Please explain the Matlab codes related to neural networks below by providing the comments at the corresponding locations: Step 1, Step 2 and Step 3.

```
%  Define 4 clusters of input data
K = 100; % number of samples of each class
q = 0.6; % offset of classes
A = [rand(1,K)-q; rand(1,K)+q]; B = [rand(1,K)+q; rand(1,K)+q];
C = [rand(1,K)+q; rand(1,K)-q]; D = [rand(1,K)-q; rand(1,K)-q];

%  Define output coding for XOR problem
%  Encode clusters a and c as one class, and b and d as another class
a = -1; c = -1; b = 1; d = 1;

%  Step 1. [2 MARKS]
P = [A B C D];
T = [repmat(a,length(A)) repmat(b,length(B)) repmat(c,length(C)) repmat(d,length(D))];
%  Hint:
%  repmat - Repeat copies of array
%  This function returns an array containing n copies of A in the row and column dimensions.
%  e.g.: B = repmat(A,n)

%  Step 2. [2 MARKS]
net = newrb(P,T,0,1,5);
Y = sim(net,P);

%  Step 3. [2 MARKS]
figure;
plot(T'); hold on; plot(Y'); hold off;
```

Question 6. [25 MARKS]

(1) We often say that the SOM algorithm is capable of creating a topology preserving map. What does this mean? Explain how one can use the trained network (post training) to map points in a 10-dimensional space onto a two-dimensional plane. **[5 MARKS]**

(2) A student working on a video surveillance project has collected a large number of vehicles by a vehicle detection algorithm. Then he applied the vehicle images to train a neural network model. After convergence, he visualized the connection weights as in the following figure:



Briefly describe the neural network model the student used and discuss the possible uses of this result (with reasonable assumptions). **[5 MARKS]**

(3) In a network using RBF-units, what parameters are changed during learning? What is the advantage of using RBF-units over sigmoidal units? Give example of a common use of RBF-units. **[5 MARKS]**

(4) Briefly describe the structure and training algorithm of Elman network and explain the main procedure of applying Elman network in time-series prediction. **[5 MARKS]**

(5) In the care of elderly, there is a huge need for autonomous systems that can monitor the senior citizen and send an alarm in the case the person has fallen, appears confused or otherwise behaves different from normal. In a study, a set of sensors (ultrasound movement detectors, microphones etc) were installed in the home of a set of elderly. Additionally, to construct the system, video cameras were also installed. The video was later monitored by human experts and situations were labelled as "fallen" (typically

when there was very little large-scale movement), "confused" (typically erratic movement from room to room) or "normal". The time-segments corresponding to these labelled examples were then extracted from the set of sensors and the temporal nature of the data was converted into a spatial pattern using 8 dimensions per sensor, so that for each time-segment there would be data from the set of sensors as well as the human classification into one of the three classes.

Your task is to design the system that uses the available data and an algorithm covered in INT301 to solve the problem. Name the problem type, algorithm name, network topology, state what the input and output of the network is and explain how training is done. **[5 MARKS]**

END OF EXAM PAPER