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PAPER CODE	EXAMINER	DEPARTMENT	TEL
CSE301	[redacted]	COMPUTER SCIENCE & SOFTWARE ENGINEERING	[redacted]

1st SEMESTER 2019/20 FINAL EXAMINATION

UNDERGRADUATE – YEAR 4

BIO-COMPUTATION

TIME ALLOWED: 2 HOURS

INSTRUCTIONS TO CANDIDATES

1. **This is a closed-book examination, which is to be written without books or notes.**
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. [3+3+3+3+3=15 MARKS]

(a) What is "overfitting"?
[3 MARKS]

(b) What is the difference between supervised learning and unsupervised learning?
[3 MARKS]

(c) What is a spurious stable state of a Hopfield net?
[3 MARKS]

(d) A 2-layer feed-forward neural network with 5 input nodes, 3 hidden nodes and 2 output nodes contains how many weights (biases included)? Show your work.
[3 MARKS]

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

Question 2. [5+5+5=15 MARKS]

(a) We often say that the SOM (Self-Organizing Maps) 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]

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

(c) 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]

Question 3. [5+10+5+10=30 MARKS]

For a feedforward neural network with two inputs and one output, please use the BP (Back Propagation) algorithm with momentum as shown below to update the weights after each of the training examples {(1, 0), 1} and {(0, 1), 0} in order (the format of the training example is {(input_1, input_2), output}).

$$\Delta w(t) = -\eta \frac{\partial E_e}{\partial w(t)} + \alpha \Delta w(t-1)$$

Assume the network has a single hidden layer with one neuron and all neurons use the logistic activation function. All weights (including bias) are initially equal to 1, learning rate η=0.2 and momentum term α=0.8.

(a) Show the feedforward process using 1st example {(1, 0), 1}.
[5 MARKS]

(b) After the feedforward process using 1st example, show the backward process (including weights update) using 1st example {(1, 0), 1}.
[10 MARKS]

(c) After training using 1st example, show the feedforward process using 2nd example {(0, 1), 0}.
[5 MARKS]

(d) After training using 1st example and the feedforward process using 2nd example, show the backward process (including weights update) using 2nd example {(0, 1), 0}.
[10 MARKS]

Question 4. [7+7=14 MARKS]

Rotating machinery is a common electrical and mechanical equipment in industry. The subsystems of rotating machinery include motors, gearboxes, bearings, loads etc. To conduct fault diagnosis in rotating machinery (i.e.: identify and classify the fault types and locations), it is required to measure various signals from different sensors (velocity, vibration, force, torque etc.) which are thought to be relevant to faults. In a practical scenario, the mechanical engineers have asked you to help them analyze the new measured data for fault diagnosis. History data measured from both faulty and healthy machines are available.

(a) Explain what you could do with supervised learning techniques (you can make reasonable assumptions). Indicate clearly the algorithm name, network topology, training algorithm and input/output.
[7 MARKS]

(b) Explain what you could do with unsupervised learning techniques (you can make reasonable assumptions). Indicate clearly the algorithm name, network topology, training algorithm and input/output.
[7 MARKS]

Question 5. [5+6=11 MARKS]

(a) Suppose we have a 4x4 matrix shown in Figure 1, which represents an image matrix, and the 2x2 convolutional filter (i.e. kernel) shown in Figure 2. What is the output by applying the convolutional filter to the image matrix?
[5 MARKS]

2	1	0	2
0	1	1	0
2	1	2	1
0	1	1	0

Figure 1: a 4x4 image matrix

0	-1
1	0

Figure 2: a 2x2 convolutional filter

(b) Suppose we have a 4x4 matrix shown in Figure 3, which represents a feature map from one layer in CNN. Define a 2x2 pooling filter over this feature map and assume no region overlap in the pooling process. What are the outputs by applying max pooling and average pooling (i.e. mean pooling) in the 2x2 pooling filter respectively?
[6 MARKS]

1	0	-5	3
2	-2	5	0
2	-1	-5	5
0	3	2	3

Figure 3: a 4x4 feature map

Question 6. [15 MARKS]

You are the organizer of a world exhibition. As the exhibition hall is very large with many exhibitors, you would like to arrange the booth locations in the hall such that the exhibitors with similar products are located together. Thus, you asked each exhibitor to tag their products according to a list of labels you prepared. You thought these labels can cover all aspects of the interest of the visitors, but cannot cover all aspects of the properties of products. This tagging is done by exhibitor by giving a yes/no to whether each label applies to the product or not. After collecting the tagging information from all exhibitors, explain in detail how would you design the system by choosing one algorithm covered in CSE301 to solve the problem. Indicate relevant information clearly including the problem type, algorithm name, network topology, training algorithm and input/output. You can make reasonable assumptions. You can also explain using figures or tables if necessary.

END OF EXAM PAPER