Paper Code	Examiner	Department	Ext
CSE301		Computer Science & Software Engineering	

Xi'an Jiaotong-Liverpool University
西交利物浦大學

2018/19 Semester 1 - Final Exam

Bachelor Degree - Year 4

Bio-computation

Time Allowed : 2 Hours

Instructions to Candidates

1. Total marks available are 100. This exam will count for 80% in the final assessment.
2. Answer all questions.
3. The number in the column on the right indicates marks available for each section.
4. Answers should be written in the answer booklet(s) provided.
5. All the answers must be in English.

Question 1 (2+4+4+5=15 points)

Answer the following questions regarding Hebb learning rule and Perceptron:

1. Consider the following Boolean function:

A	B	$\neg A \vee B$
1	1	1
1	0	0
0	1	1
0	0	1

Can this function be represented by a perceptron? Explain your answer.

[2 marks]

2. If the function in 1. can be represented by a perceptron, construct a perceptron network that represents the function. If not, construct a multilayer neural network that represents the function.

[4 marks]

3. What is the generalization of an artificial neural network model? What are the main factors that determine a network's generalization capability?

[4 marks]

4. Write down the perceptron learning algorithm in detail, and clearly define any necessary mathematical notation involved.

[5 marks]

Question 2 (2+3+3+3+4=15 points)

Answer the following questions with regard to commonly applied neural network models.

1. The Oja rule solves a serious problem of the Hebb rule. Explain what the problem is and how it is solved.

[2 marks]

2. A student working on a French letter recognition project has segmented a large number of letter images. He then applied the images to train a neural network model. After convergence, he visualized the connection weights as shown in the following figure.

Briefly describe the neural network model which the student applied and discuss the possible ways to use this result.

[3 marks]

3. What is the important role of the sigmoid function in back-propagation learning?

[3 marks]

4. Explain the "momentum term" that is often included in the back-propagation learning algorithm.

[3 marks]

5. Out of two of the following, which is better and why? Online, or offline training MLPs with back-propagation of error.

[4 marks]

Question 3 (6+6+6=18 points)

Answer the following questions about Hopfield associative memory model and Self-Organising Map (SOM) model.

1. First compute the weight matrix for a Hopfield network with the two memory vectors $[1,-1,1,-1,1,1]$ and $[1,1,1,-1,-1,-1]$ stored in it. Then confirm that both these vectors are stable states of the network.

[6 marks]

2. Describe the architecture of the Self-Organising Map (SOM) of Kohonen network. What can the network be useful for? The self-organising process can be said to have four major components: Initialization, Competition, Cooperation, and Adaptation. Briefly describe how each component works.

[6 marks]

3. Give an example of a task for which a Self-Organising Map network would be more appropriate than both a feed-forward network and a traditional competitive learning network.

[6 marks]

Question 4 (5+5+5+5=20 points)

Answer the following questions on deep neural network models.

1. Describe the Rectified Linear Unit (ReLU), which is the most commonly applied non-linear activation function in the Convolutional Neural Network (CNN).

[5 marks]

2. Explain the pooling operation in CNN, and compare two different forms of pooling, namely, max pooling and average pooling.

[5 marks]

3. Explain the main advantages of CNN over classical neural network models such as MLP in image classifications.

[5 marks]

4. In addition to CNN, briefly discuss two other (different) deep neural network models, and explain their differences in comparison with CNN.

[5 marks]

Question 5 (18+14=32 points)

Solve the following two practical problems.

1. Suppose you are required to classify a tumour as benign or malignant on the basis of 9 features of the tumour, such as e.g. uniformity of cell size, clump thickness, mitosis, etc. You have a data set of 699 case records of tumour. For each case record of a tumour, you have the 9 features describing the tumour, together with correct classification of this tumour as benign or malignant.

   (a) Design a neural network model for the classification task.

   [6 marks]

   (b) If the performance of your model on the training set is good, but the test set performance is significantly worse, what is the most likely problem? Discuss a simple way which may improve your results.

   [5 marks]

   (c) If you need even more accurate results, what kind of approaches would you try?

   [7 marks]

2. In this example we attempt to build a neural network that clusters iris flowers into natural classes, so that similar flowers are grouped together. Each iris flower is described by four features:

   (a) Sepal length in cm

   (b) Sepal width in cm

   (c) Petal length in cm

   (d) Petal width in cm

   This is a clustering problem, in which we would like to group samples into classes based on the similarity between the samples. We would like to create a neural network which will learn the class definitions for the known inputs, and will also be able to classify unknown inputs according to the learnt class definitions.

   (a) Design an appropriate neural network model to complete the task.

   [7 marks]

   (b) Discuss the advantages of the neural network model over classical k-means clustering algorithm for the above problem.

   [7 marks]

——— *End of paper* ———