NANYANG TECHNOLOGICAL UNIVERSITY

SEMESTER 1 EXAMINATION 2015-2016

CZ4042/CPE422/CSC422 - NEURAL NETWORKS

Nov/Dec 2015 Time Allowed: 2 hours

INSTRUCTIONS

1. This paper contains 4 questions and comprises 4 pages.

2. Answer **ALL** questions.

3. This is a closed-book examination.

4. All questions carry equal marks.

---

1. (a) Given a set of training patterns and their desired outputs, write the modified simple perceptron learning algorithm.

(8 marks)

(b) A three-layer perceptron network is to be trained to approximate the function f of inputs x and y:

$$f(x,y) = 0.5Cos(\pi x)Sin(\pi y) \quad \text{for} \quad -1.0 \le x,y < +1.0.$$

(i) Describe the architecture of the network.

(7 marks)

(ii) State how you generate the training patterns.

(3 marks)

(iii) Describe a method to determine the number of neurons at the hidden layer.

(7 marks)

2. (a) A three-layer perceptron network has two input nodes, three hidden layer neurons, and two output layer neurons. The activation functions of the hidden and output layer neurons are given by the functions g and f, respectively. Consider one iteration of learning of the input pattern $\mathbf{x} = (x_1, x_2)^T$ to produce a desired output $\mathbf{d} = (d_1, d_2)^T$. The augmented weight matrices of the hidden and output layers are initialized to $\mathbf{W} = \{w_{ij}\}_{3\times 3}$ and $\mathbf{V} = \{v_{jk}\}_{2\times 4}$, respectively. The learning factor for both layers is α. For the hidden and output layers, write the expressions for

(i) the synaptic inputs and the output activations,

(5 marks)

(ii) the error terms $\boldsymbol{\delta}$, and

(4 marks)

(iii) the updated weight matrices.

(4 marks)

(b) A generalized Gaussian radial basis function network has two hidden layer neurons and one output neuron. The centroids, $\boldsymbol{\mu}_1$ and $\boldsymbol{\mu}_2$, and covariance matrices, $\boldsymbol{\Sigma}_1$ and $\boldsymbol{\Sigma}_2$, corresponding to the hidden layer neurons are given by

$$\boldsymbol{\mu}_1 = (0.42 \quad 0.94)^T, \quad \boldsymbol{\mu}_2 = (-0.25 \quad 0.50)^T,$$

$$\boldsymbol{\Sigma}_1 = \begin{pmatrix} 0.57 & -0.34 \\ -0.34 & 0.44 \end{pmatrix}, \quad \boldsymbol{\Sigma}_2 = \begin{pmatrix} 0.92 & -0.48 \\ -0.48 & 0.71 \end{pmatrix}.$$

(i) Find the hidden layer activations for an input pattern $\mathbf{x}_1 = (-1.2 \quad 1.5)^T$.

(6 marks)

(ii) Given that the hidden layer activations for the input patterns $\mathbf{x}_2$ and $\mathbf{x}_3$ are $(0.586 \quad 0.171)^T$ and $(0.805 \quad 0.656)^T$, respectively. The desired outputs for input patterns $\mathbf{x}_1$, $\mathbf{x}_2$, and $\mathbf{x}_3$ are -0.6, 0.1, and 0.4, respectively. Find the weights connecting the hidden layer neurons to the output neuron.

(6 marks)

3. A single-layer recurrent network without self-feedback connections comprises of three neurons. Figure Q3 shows a portion of the state-transition diagram when the neurons fire with a Boltzmann-Gibbs distribution at temperature $T = 1.0$.

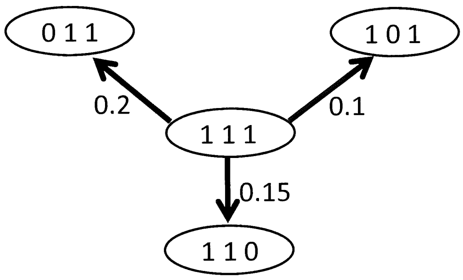

Figure Q3

(a) Determine the synaptic inputs, u_1, u_2, and u_3, of the neurons.

(10 marks)

(b) If the neurons change to fire with a unipolar unit-step activation function, find

(i) the probabilities of transitions from state (1 1 1) to the other states, and

(8 marks)

(ii) the change of the entropy of state (1 1 1).

(7 marks)

4. (a) With the learning equations and a flow chart, describe the operation of the Adaptive Resonance Theory – 1 (ART-1) network.

(13 marks)

Note: Question No. 4 continues on Page 4

(b) A Kohonen network has two nodes at the input layer and three neurons at the competitive layer. The initial weight vectors connected to the competitive layer are initialized as

$$\mathbf{w}_1 = \begin{pmatrix} -0.20 \\ -1.00 \end{pmatrix}, \quad \mathbf{w}_2 = \begin{pmatrix} -0.80 \\ 0.60 \end{pmatrix}, \quad \mathbf{w}_3 = \begin{pmatrix} -0.30 \\ 1.00 \end{pmatrix}.$$

Find the new weights after performing one cycle of iteration of the Kohonen's self-organizing feature map learning for input patterns

$$\mathbf{x}_1 = \begin{pmatrix} -1.00 \\ -0.30 \end{pmatrix}, \quad \mathbf{x}_2 = \begin{pmatrix} 0.30 \\ 1.00 \end{pmatrix}.$$

Assume that the neurons in the competitive layer are placed in a natural order and the neighborhood for learning includes only the nearest neighbors. Use learning factor 0.8 and 0.5 for the winner and the neighbors, respectively.

(12 marks)

END OF PAPER

CZ4042 NEURAL NETWORKS
CPE422 NEURAL NETWORKS
CSC422 NEURAL NETWORKS

Please read the following instructions carefully:

1. **Please do not turn over the question paper until you are told to do so. Disciplinary action may be taken against you if you do so.**

2. You are not allowed to leave the examination hall unless accompanied by an invigilator. You may raise your hand if you need to communicate with the invigilator.

3. Please write your Matriculation Number on the front of the answer book.

4. Please indicate clearly in the answer book (at the appropriate place) if you are continuing the answer to a question elsewhere in the book.