PRINCE OF SONGKLA UNIVERSITY
FACULTY OF ENIGNEERING

Final Examination: Semester II — Academic Year: 2004
Date: 3 March 2005 — Time: 9:00-12:00
Subject: 240-650 Principles of Pattern Recognition — Room: R300

Instructions:

This exam has 5 problems, 13 pages and 80 points. Please show all your work. If your answer is incorrect, this will maximize your partial credit for a problem. If your answer is correct, this is required for full credit. You may use the back of the pages for scratch work. This exam is open book, so books, notes, calculators, and other related materials are allowed.

Problem	Points	Score
1	20	_____
2	20	_____
3	10	_____
4	20	_____
5	10	_____

Name:_____

Student ID: _____

Problem 1

Given two 3-state hidden Markov models each one is defined by a transitional probability matrix and a symbol emission probability matrix as shown below:

HMM 1:

$$A1 = \begin{bmatrix} 0.7 & 0.3 & 0 \\ 0 & 0.6 & 0.4 \\ 0 & 0 & 1 \end{bmatrix} \qquad B1 = \begin{bmatrix} 0.2 & 0.2 & 0.2 & 0.2 & 0.2 \\ 0.1 & 0.3 & 0.1 & 0.4 & 0.1 \\ 0.4 & 0.2 & 0.2 & 0.1 & 0.1 \end{bmatrix}$$

HMM 2:

$$A2 = \begin{bmatrix} 0.6 & 0.4 & 0 \\ 0 & 0.5 & 0.5 \\ 0 & 0 & 1 \end{bmatrix} \qquad B2 = \begin{bmatrix} 0.2 & 0.2 & 0.4 & 0.1 & 0.1 \\ 0.2 & 0.2 & 0.4 & 0.1 & 0.1 \\ 0.6 & 0.1 & 0.1 & 0.1 & 0.1 \end{bmatrix}$$

Let the set of possible emitting symbols V_k be {a, b, c, d, e}

Ignore the entry and exit states and assume that state 1 is the first state and state 3 is the last state. Answer the following questions:

a) Sketch the two HMM's and label each link with the appropriate probability.

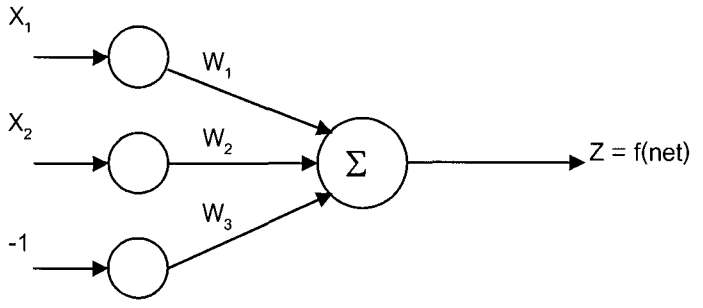
b) Use Trellis diagram to determine the most likely model that generates the following symbol sequence:

$$V_k = \{c,b,b,c,a,a\}$$

c) From the most likely model obtained in part (b), determine the most likely state sequence.

Problem 2

A single neuron has two inputs and a bias term as shown:



This problem deals with the algorithm for adjusting the 3 weights to minimize the error measure

$$J = (t-z)^4$$

Assume the neurons are unipolar sigmoid, i.e. $f(net) = \frac{1}{1+e^{-net}}$

a) Determine specific equations for the gradient of J, using all 3 weights. That is, determine

$$\frac{\partial J}{\partial W_1}, \quad \frac{\partial J}{\partial W_2}, \quad \text{and} \quad \frac{\partial J}{\partial W_3}$$

b) Numerically evaluate the equations from part a) if $x_1=1$, $x_2=0$, $W_1=W_2=W_3=1$, $t=0$.

c) Determine the next updated values of the weights, using a gradient search technique, and a learning rate of 0.8.

d) Compute and compare errors before and after the weight adjustment.

Problem 3

Given a set of 2D patterns

Pattern 1	(0,2)
Pattern 2	(2,4)
Pattern 3	(2,2)
Pattern 4	(3,1)
Pattern 5	(3,4)

a) Use the k-mean clustering technique to cluster the patterns into two categories. Show the cluster's center of each category

b) Should pattern (3,3) and (2.5,3) belong to the same class?

Problem 4

Given a set of 2D feature vectors:

[1,2], [2,2], [3,3], [4,5], [2,2.5], [3,2], [1,3], [4,4], [4,3.5], [3.5,4]

a) Determine the mean vector and the covariance matrix of the features

b) Compute Principle Component Analysis (PCA) transform

Problem 5

Consider the sigmoid activation function:

$$f(net) = a\tanh(b.net) = a\left[\frac{1-e^{-b.net}}{1+e^{-b.net}}\right] = \frac{2a}{1+e^{-b.net}} - a$$

Show that its derivative $f'(net)$ can be written simply in terms of $f(net)$ itself.

---------- End of Exam ----------