Nanjing University of Science & Technology

Department of Computer Science
Pattern Recognition Course

Take Home Exam **(100 points)**
Due December 16, 2005

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1. The data set XORN.DAT is to be used to find a neural network to distinguish between the two classes. Use the LCL Neural Simulator for the design.

(a) Run the simulator and record the number of iterations required for the design to be obtained for the following structure.

2 layers, 3 nodes, first layer, 1 node output layer
bipolar activation function, train by sample
learning $\eta = 0.7$, momentum $\alpha = 0.8$
error tolerance = 0.01, Ng-Widrow on.
Max iterations 8000

(b) Illustrate your design showing weights, etc.

(c) For $\eta = 0.7$ and $\alpha = 0.3$ and the same structure above run the simulator 10 times and record the number of iterations required. If convergence did not occur use another value and then compute the average number of iterations required to get convergence.

2. You are given 3x3 images with the following notation and the training patterns as follows.

$$\begin{bmatrix} x_1 & x_2 & x_3 \\ x_4 & x_5 & x_6 \\ x_7 & x_8 & x_9 \end{bmatrix}$$

Class 1:

$$x_1 = \begin{bmatrix} 1 & 1 & 1 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} \quad x_2 = \begin{bmatrix} 0 & 0 & 0 \\ 1 & 1 & 1 \\ 0 & 0 & 0 \end{bmatrix} \quad x_3 = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix} \quad \text{"}rows\text{"}$$

Class 2:

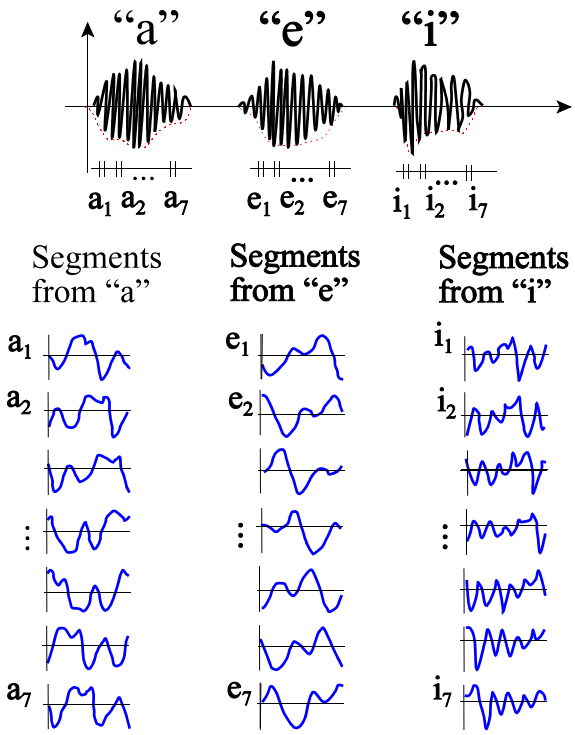
$$x_4 = \begin{bmatrix} 1 & 0 & 0 \\ 1 & 0 & 0 \\ 1 & 0 & 0 \end{bmatrix} \quad x_5 = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 1 & 0 \\ 0 & 1 & 0 \end{bmatrix} \quad x_6 = \begin{bmatrix} 0 & 0 & 1 \\ 0 & 0 & 1 \\ 0 & 0 & 1 \end{bmatrix} \quad \text{"}columns\text{"}$$

(a) Use the LCL Neural Simulator to train a neural network to perform class separation using training samples above and illustrate your design.

(b) Use the neural network in (a) to classify the following patterns and comment on your results.

$$x_7 = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix} \quad x_8 = \begin{bmatrix} 0 & 0 & 0 \\ 1 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix} \quad x_9 = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 1 & 1 \\ 0 & 1 & 0 \end{bmatrix} \quad x_{10} = \begin{bmatrix} 0 & 1 & 0 \\ 1 & 1 & 1 \\ 0 & 1 & 0 \end{bmatrix} \quad x_{11} = \begin{bmatrix} 1 & 1 & 1 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

3. In this problem you are asked to design a pattern recognizer for segments of speech containing only the vowels "a", "e", and "i". Data was collected from a given student using a sound blaster board for recording. The vowels were voiced in succession but with a null space in between to eliminate vocal connectiveness between utterances. An example of the total waveform is shown in Figure P5.37.



P5.37

Data sets vowelt2.dat and vowelt3.dat each contain 21 "snipits", short time segments of the vowels, seven from each one at different times through out the vowel segments.
(a) Use the snipits in vowelt2.dat as pattern vectors to train an artificial neural net to distinguish between the three vowels. Call the classes 1,2, and 3 for vowels a, e, and i respectively. Illustrate your final design, showing weight vectors and the results of using your design to classify the training set.
(b) Using the design from part (a), classify the patterns given in the testing data set vowelt3.dat.
(c) The testing data vowelt3.dat has the correct classification given, so determine the confusion matrix using the 21 pattern vectors of that data set. The confusion matrix gives an estimate of the effectiveness of your design to extrapolate outside the training set. Did your results surprise you? Explain.
(d) fvowelt2.dat and fvowelt3.dat are the magnitudes of some of the components of the Fourier transforms of vowelt2.dat and vowelt3.dat respectively. Use this transformed data to repeat (a), (b) and (c). Compare your design with that of using the samples directly(Part (a)).
(e) Comment on the importance of feature extraction to the pattern recognition problem.

4. Use the K-means algorithm and the Euclidean distance to cluster the following set of pattern vectors

$$\boldsymbol{x}_1 = \begin{bmatrix}0\\0\end{bmatrix} \quad \boldsymbol{x}_2 = \begin{bmatrix}-1\\0\end{bmatrix} \quad \boldsymbol{x}_3 = \begin{bmatrix}1\\-1\end{bmatrix} \quad \boldsymbol{x}_4 = \begin{bmatrix}2\\-1\end{bmatrix} \quad \boldsymbol{x}_5 = \begin{bmatrix}2\\1\end{bmatrix} \quad \boldsymbol{x}_6 = \begin{bmatrix}3\\1\end{bmatrix}$$

(a) Assume the initial cluster centers are the first three pattern vectors as follows

$$M_1(1) = \mathbf{x}_1,\ M_2(1) = \mathbf{x}_2,\ M_3(1) = \mathbf{x}_3$$

and distribute the samples among those centers.(do not use the LCLKmean.exe program for this part.).

(b) Compute the new cluster centers using the results of part (a).

(c) Describe the technique from here on out and tell how you know when to stop.

(d) Use LCLKmean.exe program and find the best three clusters result.

5. The students in a digital signal processing course had the following test scores. Names have been withheld to protect the innocent.

$$\textit{Averages} = \left\{ \begin{matrix} 99 & 95 & 94 & 93 & 88 & 87 & 85 & 85 & 84 & 83 & 82 & 82 \\ 79 & 78 & 76 & 70 & 70 & 68 & 65 & 59 & 58 & 52 & & \end{matrix} \right\}$$

(a) Use the K-means algorithms with K = 4 to find 4 clusters of grades.
Try a number of different initial conditions. Did anything unusual happen.

(b) Using the results of part (a) what can you say about local and global minimums?

(c) Which of the clusters would you pick to assign grades and live to tell about it?

6. Use the K-means algorithm, LCLKmeans.exe, to cluster the set of pattern vectors given in the data set fvowsnip.dat

(a) Find and identify 2 clusters..

(b) Repeat (a) for five choices of random initial cluster centers compare the results with those of (a) and comment on your results.

(c) find and identify 3 clusters using LCLKmeans.exe. Try different initial conditions and select the one that you think is best. What did you use for your measure of best? Comment on your results.

7. Use the samples given below and the Hierarchical clustering program LCLHier.exe

(a) Construct the dendrogram for the Hierarchical clustering results.

(b) Determine your results for three clusters using your tree.

(c) Determine result for three clusters using LCLkmean.exe and compare results with those from (b) using LCLHier.exe

$$\boldsymbol{x}_1 = \begin{bmatrix}0\\0\end{bmatrix} \quad \boldsymbol{x}_2 = \begin{bmatrix}0\\1.2\end{bmatrix} \quad \boldsymbol{x}_3 = \begin{bmatrix}0\\3\end{bmatrix} \quad \boldsymbol{x}_4 = \begin{bmatrix}0\\4.1\end{bmatrix} \quad \boldsymbol{x}_5 = \begin{bmatrix}1.2\\1\end{bmatrix} \quad \boldsymbol{x}_6 = \begin{bmatrix}2\\3.5\end{bmatrix} \quad \boldsymbol{x}_7 = \begin{bmatrix}.95\\4\end{bmatrix}$$

8. Use the Fuzzy C-means program LCLFuzz.exe to cluster the data fvowsnip.dat
(a) Show the resulting fuzzy clusters for C = 3 using m = 1.5.
(b) Obtain the Crisp clusters for the results in (a)
(c) Compare your crisp results for three clusters from (b) with those determined using the LCLKmean.exe to obtain three clusters. Were they the same?.
(d) Repeat part (a) using m=3 and compare to results in (a). How do your fuzzy results change?
(e) Using your results from (d), obtain the hard or crisp clusters showing results in set notation.
(e) How do your crisp results change for this problem.? Will this always be the case.

9. (a) Use the K-means algorithm, LCLKmeans.exe, to obtain three clusters.for the set of pattern vectors given in vowelt2c.dat. This data file is snipits from the three vowels "a", "e", and "i" from Problem 3..Did your result surprise you? Why or why not?
(b) Repeat (a) using fvowelt2c.dat .(The magnitudes of 17 coeficients of the Fourier transform of vowelt2c.dat
(c) Compare and comment on your results of (a) and (b).

Note: the formats for the LCLNET and the LCL cluster programs are slightly different in that the first two values for number of samples and vector size are interchanged. I am sorry for the reversal. The data sets for each of the data files have been adjusted for you.