Pattern Recognition/Pattern Recognition

2016/2017

Exame Normal 19 June 2017 Duration: 2h00

Name: **Number:** **Practical Class:**

AVISO

The Exam has a duration of 2h00m. The test is composed by five questions. The last question is a Matlab practical question. Each question must be answered in the framed box below it. Questions may be answered in Portuguese or English. This is a closed book test. You are allowed to use a calculator machine. As consultation you may use only 1 Page A4 with your own manuscript notes. Violation of the last rule ends up with exam cancellation, course failure and eventually you may be subject to disciplinary procedure. If you have any questions, you may ask. Good Luck!

Question	pts	Results	Graded by:
1)	20		
2)	20		
3)	20		
4)	10		
5)	30		

Graded by:

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Question 1 - Pre-processing

□ **20pts**

Consider the pre-processing system in Figure 1. The system receives as input three features and has two main components: one that normalizes data by applying the z-score method; the other reduces data to one dimension by applying PCA. Consider that the system was trained resulting in the following system parameters:

- Normalizator
  - Mean vector: $\mu = \begin{bmatrix} 324.033 \\ 710.387 \\ 8.680 \end{bmatrix}$
  - Standard deviation vector: $\sigma = \begin{bmatrix} 201.353 \\ 361.216 \\ 2.277 \end{bmatrix}$
- PCA
  - Eigenvector matrix: $\mathbf{W} = \begin{bmatrix} -0.594 & -0.238 & -0.769 \\ -0.580 & -0.536 & 0.614 \\ -0.558 & 0.810 & 0.180 \end{bmatrix}$
  - Eigenvalues: $\lambda_1 = 2.768$, $\lambda_2 = 0.202$, and $\lambda_3 = 0.010$.

The eigenvectors are columns of $\mathbf{W}$ and are ordered by importance in decreasing order from the left to right.

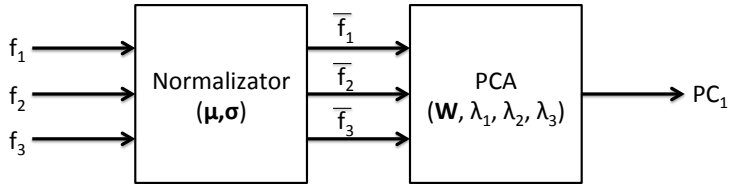

Figure 1: Pre-processing system

(a) What is the main relationship between eigenvectors? How would you prove this property?

(b) What is the percentage of variance preserved by the system?

(c) Consider that the feature vector $\mathbf{f} = \begin{bmatrix} 146.000 \\ 238.000 \\ 8.630 \end{bmatrix}$ is given at the system input. What will be the system output?

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Your answer to 1):

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Question 2 - Statistical Learning

□ **20pts**

(a) Write the Bayes Classification Rule in the simplified form of the likelihood ratio $\Lambda(\mathbf{x})$ and explain its meaning.

(b) Suppose the following likelihoods for a two-class classification problem:

$$\begin{aligned} p(\mathbf{x}|\omega_1) &= \mathcal{N}(0,1) \qquad \forall x \\ p(\mathbf{x}|\omega_2) &= \frac{1}{4} \qquad -2 < x < 2 \end{aligned}$$

Assume igual priors ($P(\omega_1) = P(\omega_2) = 0.5$.
Give the minimum error classification rule for this binary problem using formula in (a). (you may want to draw a graph plot to help in your answer).

Your answer to 2):

Your answer to 2 (cont.)):

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Question 3 - SVM - Radial Basis Function Model

☐ **20pts**

Consider the boundary decisions found by a Radial Basis Function SVM in Figure :

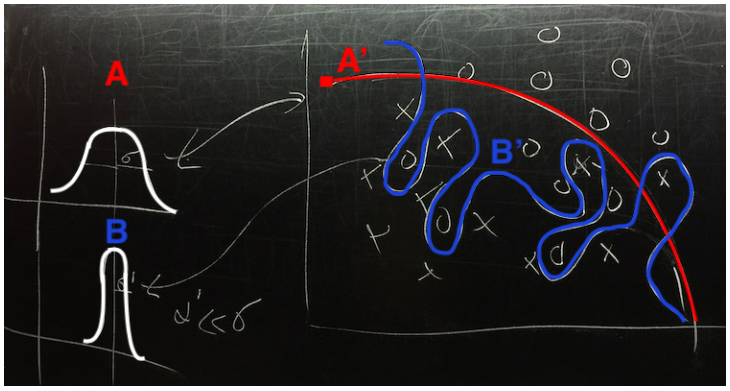

Figure 2: SVM Boundary Decision

(a) Use above SVM Radial Basis Function formula to give the rationale of the relation between A and B and the Boundary Decisions A' and B'.
(Please note that you should give a plenty justification including role of parameter σ; it is not enough to say that A corresponds to boundary decision A' and B corresponds to boundary decision B'.)

(b) According to above reasoning give your intuition which model would you choose A or B?

Your answer to 3):

Your answer to 3 (cont.)):

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Question 4 - Classification Theory

□ **10pts**

In the classes we learned that the total error rate of a classifier can be decomposed into two parts: (i)] Error rate due to the average performance of the classifier and (ii) Error rate due to the variation of training set.

(a) Identify each partial error above by their common names in pattern recognition

(b) In practical class you worked with cork stoppers dataset problem. Take the first 100 samples with classes ω_1 and ω_2. Suppose you have two linear classifiers, say, a linear Fisher Discriminant and a minimum distance classifier.

(b1.) Which of the above errors could you find?

(b2.) What would you do to determine the other error?

Your answer to 4):

Your answer to 4 (cont)):

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PR/PRT Practical Question

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Practical Question

☐ 30 pts

Bayes classifiers

Write two functions to training and testing Bayes classifiers. You can choose the programming language of your choice. In Matlab the functions should have the following prototypes:

- **function model=bayes_training(Xtr,Ttr)**

- **function [out,ss,sp]=bayes_testing(Xte,Tte,model)**

Where:

- **model** is a structure with fields that contain the Bayes classifier parameters needed for testing;
- **Xtr** is a matrix with dimensions D x Ptr, being D the problem dimensionality and Ptr the number of patterns in the training data;
- **Ttr** is the target vector in the training with dimensiona 1 x Ptr, and with"1" labeling positive patterns and "2" labeling negative patterns;
- **Xte** is a matrix with dimensions D x Pte, being D the problem dimensionality and Pte the number of patterns in the testing data;
- **Tte** is the target vector in the testing data with dimensiona 1 x Pte, and with"1" labeling positive patterns and "2" labeling negative patterns;
- **out** is the classifier output in the testing data with dimensiona 1 x Pte, and with"1" classifying positive patterns and "2" classifying negative patterns;
- **ss** is the sensitivity on the testing data;

- **sp** is the specificity on the testing data;

Your answer:

Your answer: