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Exercise 10

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Problem 1. (*Support Vector Machine Example*)

- Apply SVM algorithm to the dataset 2classPub.txt. Find supporting vectors and the separating hyperplane. Compare the results with linear discriminant analysis.
- Apply SVM algorithm to the dataset 2classPubll.txt. Find supporting vectors and the separating hyperplane. Compare the results with linear discriminant analysis.

Problem 2. (*One-against-One Multiclass Support Vector Machine*) In this exercise, we extend the SVM solution in case of two classes to multiple classes. One way to do this is take each pair of classes independently and find $\frac{k(k-1)}{2}$ different separating hyperplanes for k classes. When a new point is to be classified, each pair of classes is considered independently and a decision is made in favor of one of the classes for each comparison. The class with maximum number of decisions in its favor is the output of the classifier.

- Apply SVM algorithm to the dataset 3classPub.txt. Find separating hyperplanes and see how it divides the space into regions. Compare the results with ML discriminant analysis.
- Apply SVM algorithm to the dataset 3classPubll.txt. Find separating hyperplanes and see how it divides the space into regions. Compare the results with ML discriminant analysis.

Problem 3. (*Support Vector Machine for Non-separable Classes*) Consider the following SVM optimization problem for a non-separable dataset:

$$\begin{aligned} \min_{\mathbf{a}, b, \xi} \quad & \frac{1}{2} \|\mathbf{a}\|^2 + c \sum_{i=1}^n \xi_i \\ \text{s.t.} \quad & y_i(\mathbf{a}^T \mathbf{x}_i + b) \geq 1 - \xi_i \quad i = 1, \dots, n \\ & \xi_i \geq 0 \quad i = 1, \dots, n. \end{aligned} \tag{1}$$

- Find the dual problem of this optimization problem.
- Suppose that support vectors and optimal \mathbf{a}^* are given. Find the optimal \mathbf{b}^* .