1. **Programming**

In this assignment, we construct SVM models with different kernel functions and slack variables using a 3-class dataset (Iris dataset).

The basic form of SVM is:

* 1. **Question 1 (SVM without slack)**
     1. **Optimization problem**

The optimization problem we are solving in this question is:

We derive the optimization problem by following steps:

The objective function of support vector machine is:

The dual Lagrange function is:

The primal and dual optimal solutions should satisfy KKT conditions:

Stationarity:

Feasibility:

Complementary slackness:

Replace the stationary condition into Lagrange function, we can derive the following dual problem:

The optimization problem is derived.

* + 1. **Manipulation**
  1. **Question 2 (SVM with slack variables)**
     1. **Optimization problem**

The optimization problem we are solving in this question is:

We derive the optimization problem by following steps:

The original SVM with slack variables is formulated as follows:

Its Lagrange function is:

The primal and dual optimal solutions should satisfy KKT conditions:

Stationarity:

Feasibility:

Complementary slackness:

Replacing all KKT conditions into Lagrange function to eliminate primal variables, we obtain the following dual problem:

The optimization problem is derived.

* + 1. **Manipulation**
  1. **Question 3 (SVM with kernel functions and slack variables)**
     1. **Optimization problem**

The optimization problem we are solving in this question is:

We can derive this optimization problem by utilizing kernel to replacing in the dual problem mentioned above.

The related kernel functions in this question are listed as following:

Polynomial kernel:

Radical Basis Function (RBF) kernel:

Sigmoidal kernel:

* + 1. **Manipulation**