UIN: 678393073

CS 412 - Introduction to Machine Learning
Assignment 10

Q1 a) Slope of line 1 (L1) : Marginal Hyperplane

$= \left(\frac{5-2}{11-7}\right) = \left(\frac{3}{4}\right)$

Slope of line 2 (L2) : Marginal Hyperplane

$= \left(\frac{9-6}{8-4}\right) = \left(\frac{3}{4}\right)$

∴ The slope of the hyperplane (L3) will also be 3/4.

Distance between L1 and L2 = perpendicular distance between the two points on the lines.

$\therefore \text{dist} = \sqrt{(7-4)^2 + (2-6)^2}$

$= 5$

Distance between the 2 points = 5

$\therefore \text{Margin } (\rho) = \left(\frac{5}{2}\right) = 2.5$

Q1 b) Choose three support vectors, write out system of equation's for those support vector data points

$y_i(w_0 + w_1 x_{i,1} + w_2 x_{i,2}) = 1$

A: 3 support vectors : (7,2) (11,5) (4,6)

class labels : 1, 1, -1

∴ We get the following set of equations:

$7w_1 + 2w_2 + w_0 = 1$ .. (i)

$11w_1 + 5w_2 + w_0 = 1$ .. (ii)

$4w_1 + 6w_2 + w_0 = -1$ .. (iii)

Solving equation's (i) & (ii)

$4w_1 + 3w_2 = 0$ — (iv)

Solving eq. (ii) & (iii)

$7w_1 - w_2 = 2$ .. (v)

Solving eq. (v) & (iv)

$25w_1 = 6$

$w_1 = (6/25) = 0.24$

Substituting w_1 in (iv)

$4\left(\frac{6}{25}\right) + 3w_2 = 0$

$w_2 = -8/25 = -0.32$

Solving eq. (i)

$$7\left(\frac{6}{25}\right) + 2\left(\frac{-8}{25}\right) + w_0 = 1$$

$$\left(\frac{42}{25}\right) + \left(\frac{-16}{25}\right) + w_0 = 1$$

$$\therefore w_0 = \frac{-1}{25} = -0.04$$

$$\therefore w_1 = 0.24$$
$$w_2 = -0.32$$
$$w_0 = -0.04$$

Q1. c) Removals are independent

i) No

As we have 4 points on the marginal hyperplanes & we only need 3 points as support vectors to solve for w_0, w_1, w_2. The fourth point is redundant.

ii) No

It is not a support vector.

iii) No

(10,0) is not a support vector.

iv) Yes

As we are deleting 2 support vectors on one side. It will change the decision boundary.

v) Yes

Both are support vector. The decision boundary will shift.

Q1. d)

i) No

It does not lie between two marginal hyperplanes.

ii) Yes

Since it is within the two marginal hyperplanes.

iii) ~~Yes~~ No

Since it ~~is~~ does not lie within the two marginal hyperplanes.

iv) No

Because both the points do not lie between the two marginal hyperplanes.

v) Yes

Since both points are within the two marginal hyperplanes.

Q2.

subplot	1	2	3	4	5	6
model	d	f	b	a	c	e

a) Linear SVM meaning a linear boundary.
small value of C (0.1), ∴ more errors are allowed
As c focuses on loss (how much it violates the margin)
4 fig - The line does not separate properly.

b) Linear SVM meaning a linear boundary.
large value of C (10) ∴ less errors
3 fig - The line separates properly.

c) Decision function of quadratic kernel

$$f(x) = \Sigma_i \alpha_i (x_i \cdot x + (x_i \cdot x)^2) + b$$

$$\therefore f(x) = 0$$

∴ x can either be an ellipse or a hyperbolic curve
∴ fig. 5.

d) Deasion function

$$f(x) = \Sigma_i \alpha_i \exp(-\gamma ||x_i - x||^2)$$

if γ is large, kernel value is small and vice versa.
~~less~~ number of support vectors
more

$\gamma = 1/4$ for fig. 1, classification is difficult if kernel value is small.

Q2.

e) γ is large, more number of support vectors based on Q2.d)

$\gamma = 4$

fig. 6

Q2

f) None of the above - fig.2.