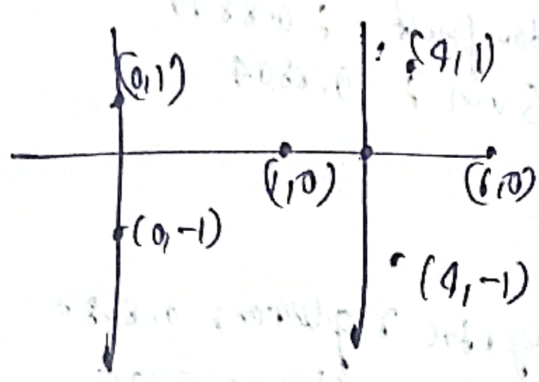
7/5/2025

Lab-6

Support Vector Machines

Q) points (4,1), (4,−1) and (6,0) belong to positive class and points (1,0), (0,1) and (0,−1) belong to negative class. Draw an optimal hyperplane.



$S_1 = \begin{pmatrix} 1 \\ 0 \end{pmatrix} \quad S_2 = \begin{pmatrix} 4 \\ 1 \end{pmatrix} \quad S_3 = \begin{pmatrix} 4 \\ -1 \end{pmatrix}$

$\tilde{S}_1 = \begin{pmatrix} 1 \\ 0 \\ 1 \end{pmatrix} \quad \tilde{S}_2 = \begin{pmatrix} 4 \\ 1 \\ 1 \end{pmatrix} \quad \tilde{S}_3 = \begin{pmatrix} 4 \\ -1 \\ 1 \end{pmatrix}$

$\alpha_1 \tilde{S}_1 \tilde{S}_1 + \alpha_2 \tilde{S}_2 \tilde{S}_2 + \alpha_3 \tilde{S}_3 \tilde{S}_3 = 0$

$\alpha_1 \tilde{S}_2 \tilde{S}_1 + \alpha_2 \tilde{S}_2 \tilde{S}_2 + \alpha_3 \tilde{S}_2 \tilde{S}_3 = 0$

$\alpha_1 \tilde{S}_3 \tilde{S}_1 + \alpha_2 \tilde{S}_3 \tilde{S}_2 + \alpha_3 \tilde{S}_3 \tilde{S}_3 = 0$

$2\alpha_1 + 5\alpha_2 + 5\alpha_3 = 0$

$5\alpha_1 + 18\alpha_2 + 16\alpha_3 = 0$

$5\alpha_1 + 16\alpha_2 + 18\alpha_3 = 0$

$\alpha_1 = -\frac{22}{9}$

$\alpha_2 =$ [illegible]

$\alpha_3 =$ [illegible]

$w = \sum \alpha_i \tilde{S}_i = \alpha_1 \tilde{S}_1 + \alpha_2 \tilde{S}_2 + \alpha_3 \tilde{S}_3$

$= \begin{pmatrix} -22/9 \\ 0 \\ -22/9 \end{pmatrix} + \begin{pmatrix} 28/18 \\ \text{[illegible]} \\ \text{[illegible]} \end{pmatrix} + \begin{pmatrix} \text{[illegible]} \\ \text{[illegible]} \\ \text{[illegible]} \end{pmatrix}$

$\Rightarrow w = \begin{pmatrix} 2/3 \\ 0 \\ \text{[illegible]} \end{pmatrix}$

Eqn ⇒ $\frac{2}{3}x_1 + 0\,x_2 + \left(-\frac{5}{3}\right) = 0$

$\frac{2}{3}x_1 - \frac{5}{3} = 0$

$2x_1 - 5 = 0$

$x_1 = \frac{5}{2}$

$x_1 = 2.5$

Eqn of hyperplane and boundary, $X_1 = 2.5$

Q) For iris.csv dataset, what is accuracy of classifier using linear and RBF kernel? Which of the two has better performance.

Ans Linear Kernel ≥ 100%

RBF Kernel ≥ 100%

Generally, RBF performs better but since we had small dataset, we get equal accuracy.

We use non-linearly separable dataset.

Linear kernel draws a straight hyperplane and struggles with curved boundaries.

RBF allows for more accurate and flexible boundaries.

Q) For "digit recognition (8x8)" dataset print and interpret confusion matrix. Are there any specific letters frequently confused with others? What is AUC score and how does it reflect model performance? How does performance of SVM model of dataset compare to its performance on IRIS dataset?

Ans The confusion matrix shows how many times each letter was predicted or actual.

Row → Actual

Column → predicted.

Diagonal → Correct prediction.

Interpretations

High values on diagonal = good performance
Off-diagonal values = misclassifications.
letters like O, Q and C, G might get confused due to
similar features.

* AUC score measures how well the model
distinguishes between classes
In AUC → 1 (perfect) if AUC = 0.5 (random guess).

Interpretation

Most letters AUC = 0.95 to 1.00
Harder letters AUC = 0.85 – 0.93

IRIS models do well — IRIS is a much smaller and simpler dataset, so most
letters recognition is much more complex.
* more classes
* more samples
* more ambiguities

SVM performs better on IRIS but still does better on letters.