Activity 16 – Support Vector Machines

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Results and Discussion

For this activity [1, 2], I used the extracted fruit color features in $a^* - b^*$ space from a previous activity. I used only the data for oranges and apples, and assigned them labels of -1 & $+1$, respectively. The objective for SVM is

$$\min \frac{1}{2}\|\mathbf{w}\|_2^2 \quad \text{subject to} \quad y_i\big(\mathbf{w}^\top \mathbf{x}_i + b\big) \geq 1 \quad \forall i \tag{1}$$

which is a quadratic and hence, convex problem. Here, $\mathbf{w}$ is the reference vector perpendicular to the decision line, $\mathbf{x}$ is the feature vector, y is the output classification, and b is the bias. Using the Python `CVXPY` library [3], we can setup the above objective and constraint as-is and directly obtain $\mathbf{w}$. Since we have two features, the separating hyperplane is a line defined by

$$g(x) = -\frac{w_1}{w_2}x - \frac{b}{w_2} \tag{2}$$

where w_i are the elements of $\mathbf{w}$. The width of the margin is defined by

$$m = \frac{1}{\|\mathbf{w}\|_2} \tag{3}$$

so we can plot the margins on opposite sides of the decision line using trigonometric identities:

$$g_\pm(x) = g(x) \pm m\sqrt{1 + \left(\frac{w_1}{w_2}\right)^2} \tag{4}$$

Figure 1 shows the optimum decision boundary with maximized margins in the $a^* - b^*$ feature space, along with the input data points and support vectors.

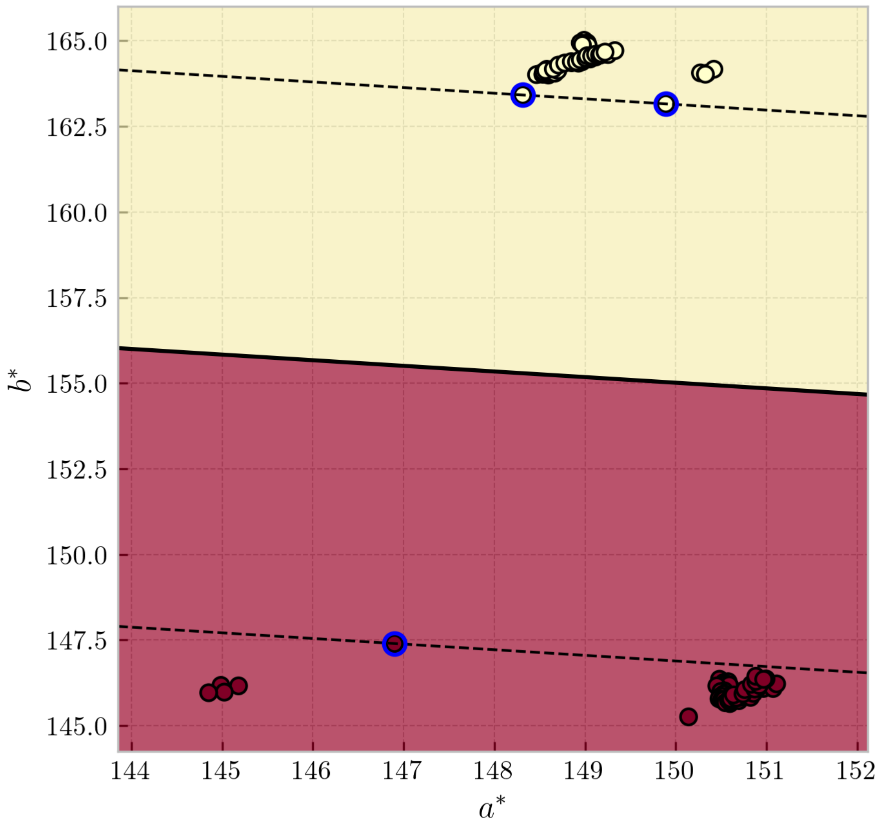

Figure 1: Decision boundary for oranges and apples data in $a^* - b^*$ feature space. The yellow region corresponds to a classification of -1 (oranges), while the red region corresponds to $+1$ (apples). The vectors highlighted in blue are the support vectors. The solid line is the decision boundary, while the dashed lines are the margins.

Table 1: Self-evaluation.

Technical correctness	5
Quality of presentation	5
Initiative	0
TOTAL	**10**

References

[1] M. N. Soriano, *A16 – Support Vector Machines* (2019).
[2] O. Veksler, *CS434a/541a: Pattern Recognition – Lecture 11* (n.d.).
[3] S. Diamond and S. Boyd, CVXPY: A Python-embedded modeling language for convex optimization, *Journal of Machine Learning Research* **17**, 1 (2016).