

ML Lab Week 10: Support Vector Machines

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Analysis Questions

This section contains the answers to all 8 analysis questions from the notebook.

Moons Dataset Questions

1. Inferences about the Linear Kernel's performance. The Linear Kernel performed poorly on the Moons dataset. Because the dataset has a non-linear crescent shape, a straight-line decision boundary is fundamentally incapable of separating the two classes effectively. This resulted in a low accuracy score of **0.87** and significant misclassifications, as seen in the classification report and the decision boundary plot.
2. Comparison between RBF and Polynomial kernel decision boundaries. Both RBF and Polynomial kernels create non-linear decision boundaries suitable for the Moons dataset.
 - The **RBF kernel** created a highly flexible, wave-like boundary that closely followed the curve of the data points.
 - The **Polynomial kernel** created a single, smooth, C-shaped curve.
3. For this dataset, the **RBF** kernel's decision boundary appears to be a better fit, as it more accurately captures the distinct separation between the two crescent shapes.

Banknote Dataset Questions

1. Which kernel was most effective for this dataset? Based on the classification reports, the **RBF kernel** was the most effective. It achieved the highest overall F1-score of **0.93**, indicating a superior balance of precision and recall compared to the Linear and Polynomial kernels.
 2. Why might the Polynomial kernel have underperformed here? The Polynomial kernel likely underperformed because its fixed-degree curve was not the optimal shape for the decision boundary in the Banknote dataset's feature space. If the underlying data separation is more complex or doesn't follow a simple polynomial curve, this kernel can struggle compared to the highly flexible RBF kernel or even a simple linear one if the data is largely linearly separable.
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Hard vs. Soft Margin Questions

1. Which margin (soft or hard) is wider? The **soft margin** ($C=0.1$) is visibly wider.
2. Why does the soft margin model allow "mistakes"? A soft margin model allows mistakes because its primary goal is to create a wider, more generalized margin rather than perfectly classifying every single training point. This tolerance for error, controlled by a small C value, helps the model avoid overfitting to noise in the training data.
3. Which model is more likely to be overfitting and why? The **hard margin model** ($C=100$) is more likely to be overfitting. A large C value heavily penalizes misclassification, forcing the model to create a narrow, complex boundary that fits the training data as perfectly as possible. This makes the model highly sensitive to the specific training points, including outliers and noise, which hurts its ability to generalize.
4. Which model would you trust more for new data and why? I would trust the **soft margin model** more for new data. Its wider margin is less influenced by the specific noise and outliers of the training set, making it more robust. A model that generalizes better is more reliable when making predictions on unseen data, which is the primary goal of a predictive model.

Screenshots

This section contains all 14 required screenshots, clearly labeled as per the instructions.

Training Results (6 Screenshots)

Moons Dataset

1. Classification Report for SVM with LINEAR Kernel with SRN

SVM with LINEAR Kernel <PES2UG23CS357>				
	precision	recall	f1-score	support
0	0.85	0.89	0.87	75
1	0.89	0.84	0.86	75
accuracy			0.87	150
macro avg	0.87	0.87	0.87	150
weighted avg	0.87	0.87	0.87	150

2. Classification Report for SVM with RBF Kernel with SRN

SVM with RBF Kernel <PES2UG23CS357>				
	precision	recall	f1-score	support
0	0.95	1.00	0.97	75
1	1.00	0.95	0.97	75
accuracy			0.97	150
macro avg	0.97	0.97	0.97	150
weighted avg	0.97	0.97	0.97	150

3. Classification Report for SVM with POLY Kernel with SRN

SVM with POLY Kernel <PES2UG23CS357>				
	precision	recall	f1-score	support
0	0.85	0.95	0.89	75
1	0.94	0.83	0.88	75

Banknote Dataset

4. Classification Report for SVM with LINEAR Kernel

SVM with LINEAR Kernel <PES2UG23CS357>				
	precision	recall	f1-score	support
Forged	0.90	0.88	0.89	229
Genuine	0.86	0.88	0.87	183

5. Classification Report for SVM with RBF Kernel

SVM with RBF Kernel <PES2UG23CS357>				
	precision	recall	f1-score	support
Forged	0.96	0.91	0.94	229
Genuine	0.90	0.96	0.93	183
accuracy			0.93	412
macro avg	0.93	0.93	0.93	412
weighted avg	0.93	0.93	0.93	412

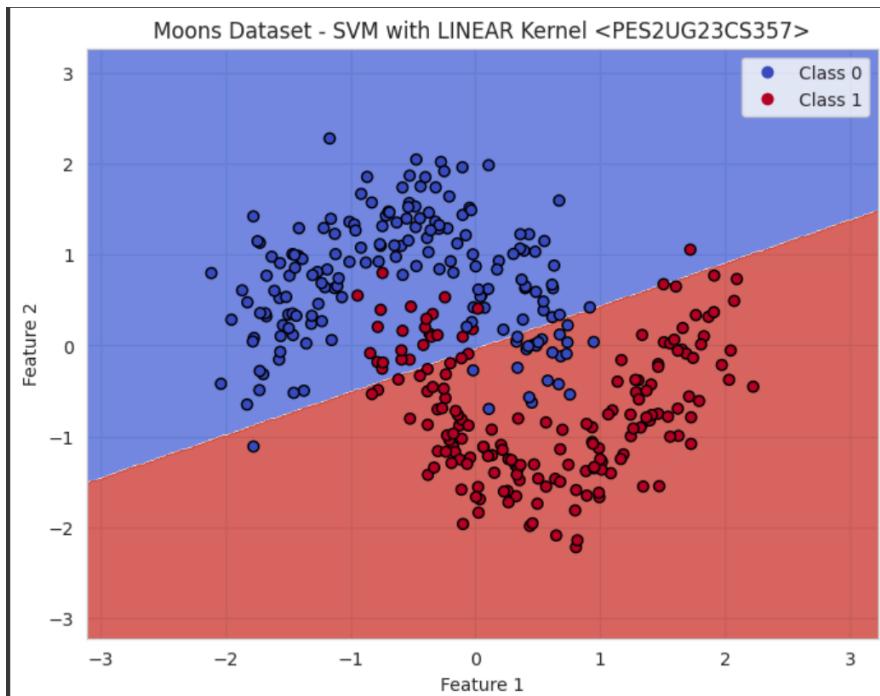
6. Classification Report for SVM with POLY Kernel

SVM with POLY Kernel <PES2UG23CS357>				
	precision	recall	f1-score	support
Forged	0.82	0.91	0.87	229
Genuine	0.87	0.75	0.81	183
accuracy			0.84	412
macro avg	0.85	0.83	0.84	412
weighted avg	0.85	0.84	0.84	412

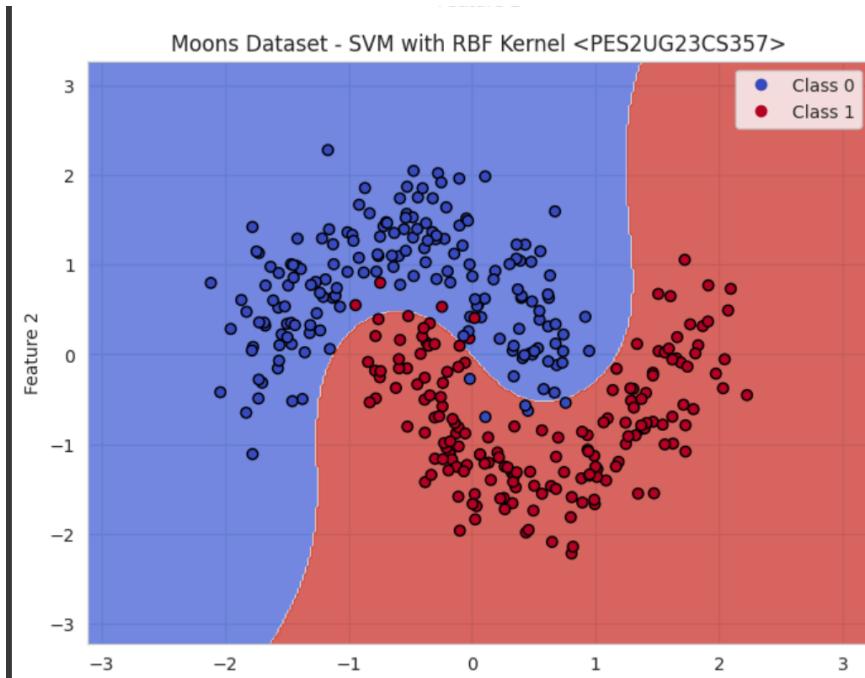
Decision Boundary Visualizations (8 Screenshots)

Moons Dataset

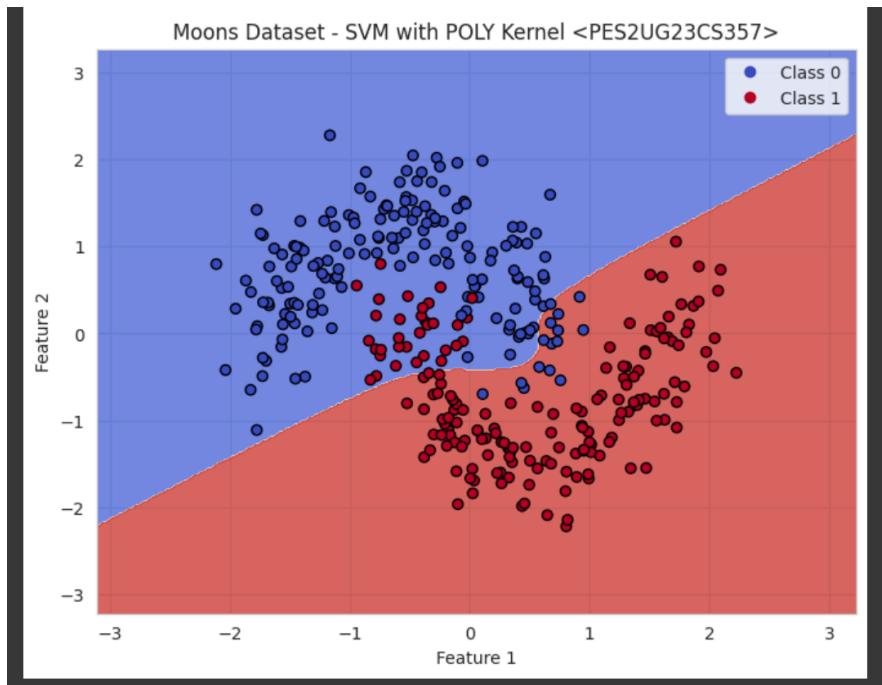
7. Moons Dataset - SVM with LINEAR Kernel



8. Moons Dataset - SVM with RBF Kernel

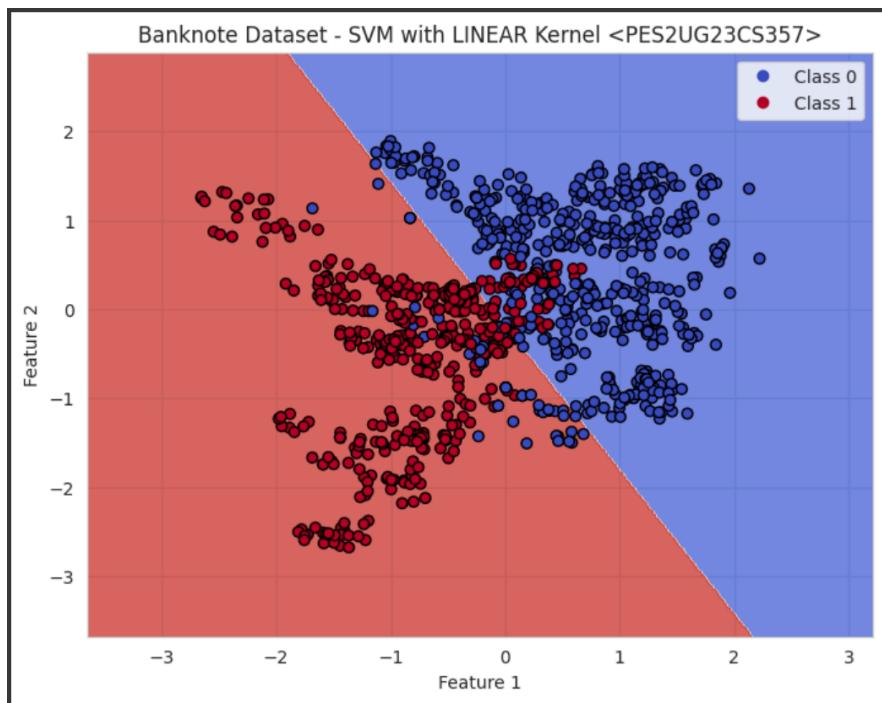


9. Moons Dataset - SVM with POLY Kernel

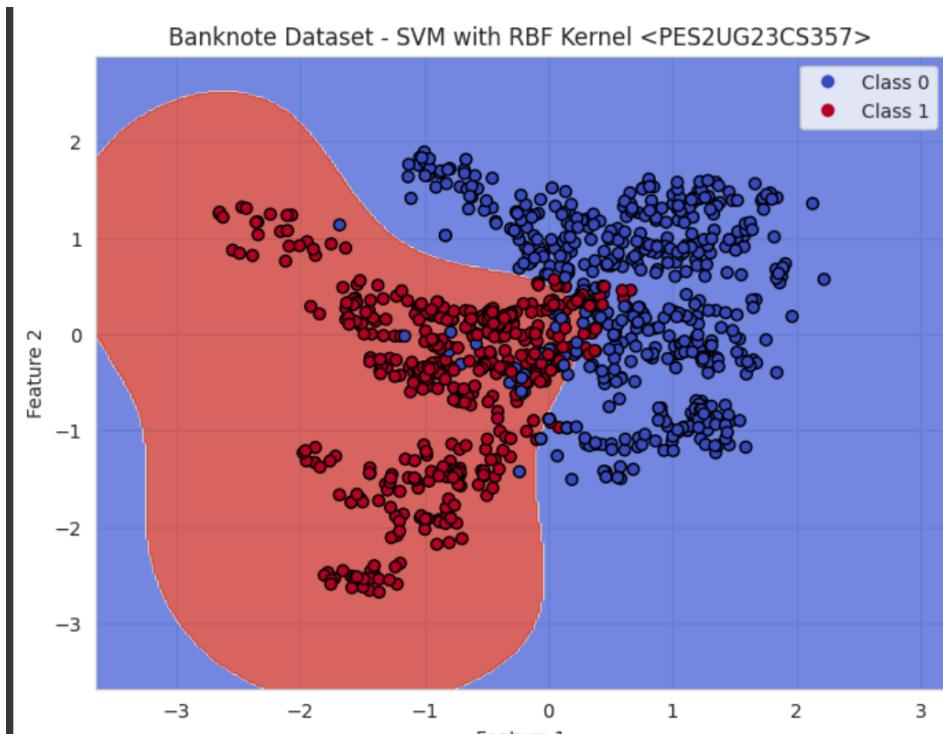


Banknote Dataset

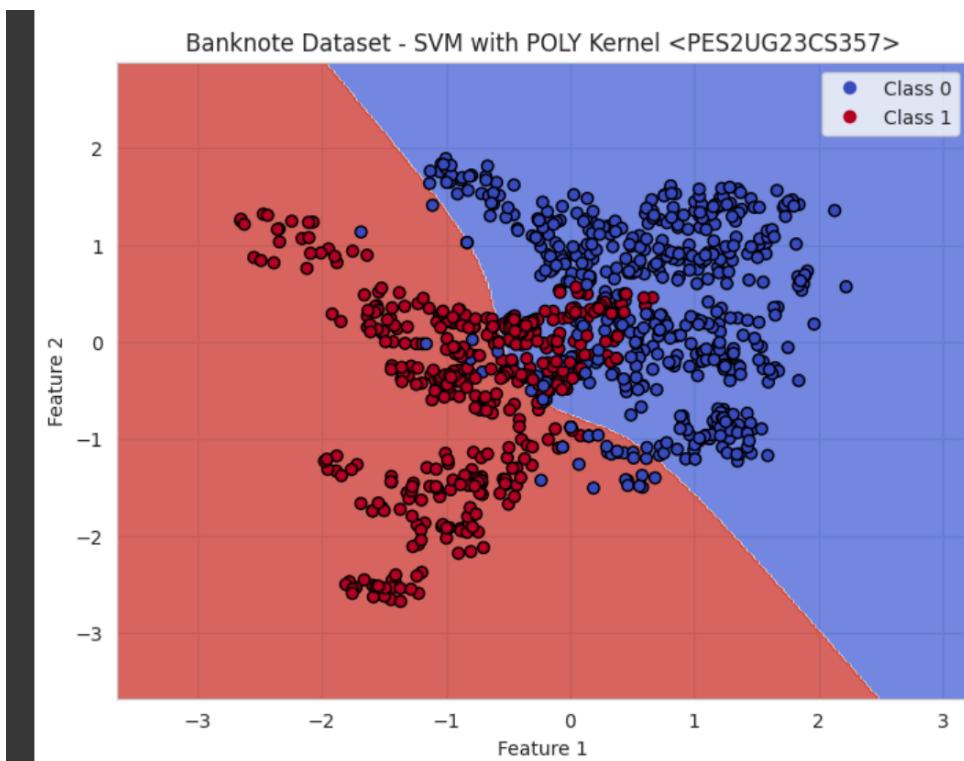
10. Banknote Dataset - SVM with LINEAR Kernel



11. Banknote Dataset - SVM with RBF Kernel

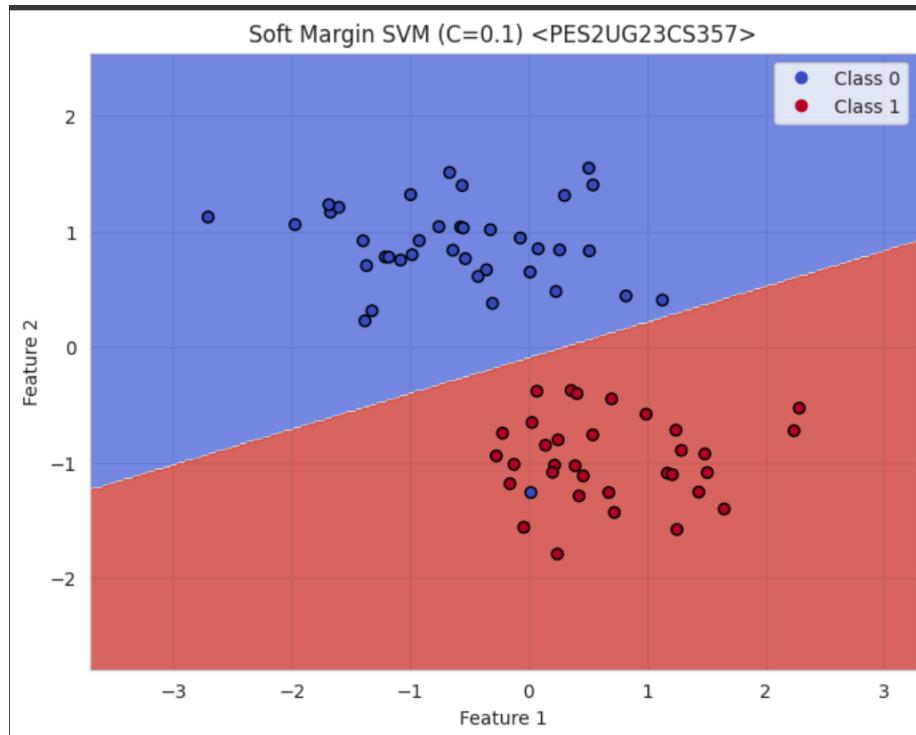


12. Banknote Dataset - SVM with POLY Kernel



Margin Analysis

13. Soft Margin SVM (C=0.1)



14. Hard Margin SVM (C=100)

