Machine Learning

Support Vector Machines

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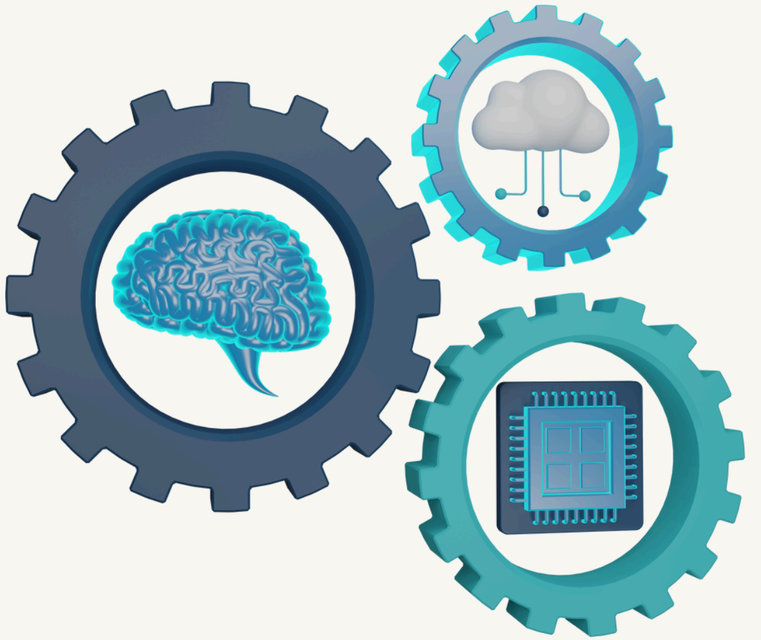
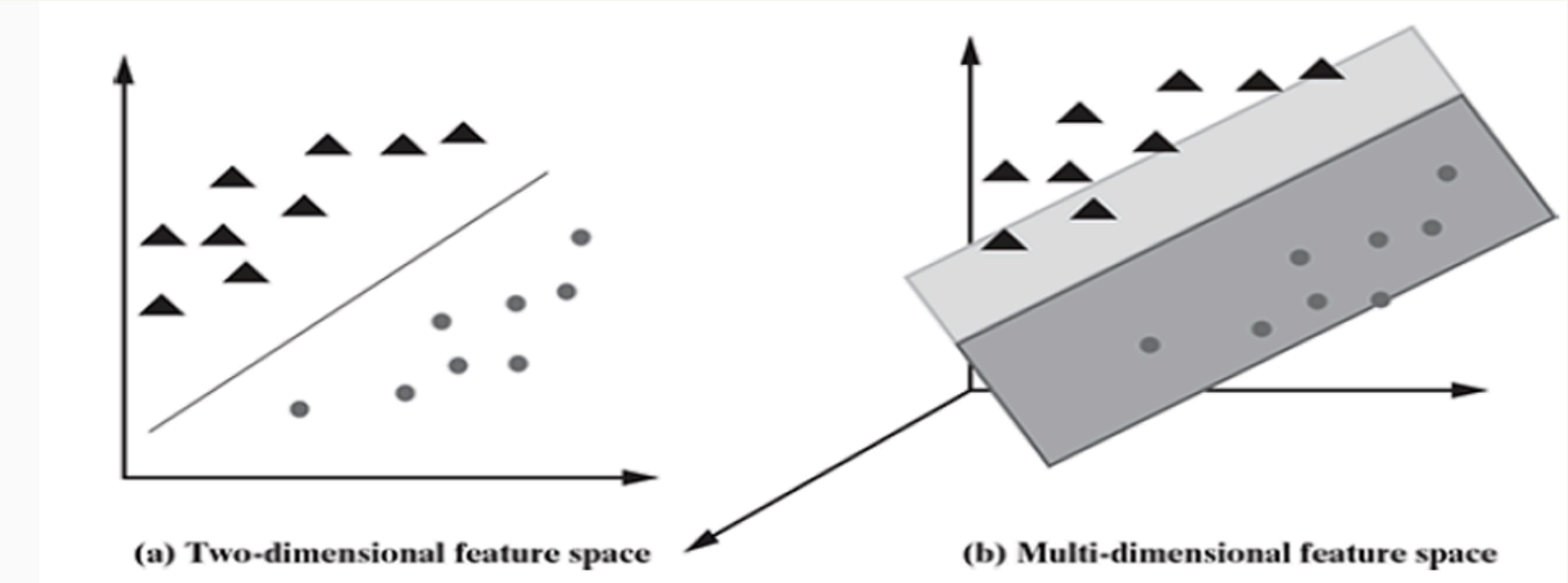
INTRODUCTION

- SVM is a supervised learning algorithm used for classification and regression tasks.
- It identifies the optimal hyperplane that separates data points of different classes.
- Support vectors are the key data points that influence the position of the hyperplane.
- SVM uses kernel functions to handle non-linear data by mapping it to higher-dimensional spaces.
- SVM is a model, which can do linear classification as well as regression.
- SVM is based on the concept of a surface, called a hyperplane, which draws a boundary between data instances plotted in the multi-dimensional feature space.



How SVM Works

1. **Define the Problem:**
   - Identify if the data is linearly separable or non-linearly separable.
   - If data is linearly separable, a straight-line or plane can be used as the decision boundary.
2. **Construct the Hyperplane:**
   - In an n-dimensional space, a hyperplane is an (n-1)-dimensional subspace that divides the data.
   - The objective is to find the hyperplane that maximizes the margin between the classes.



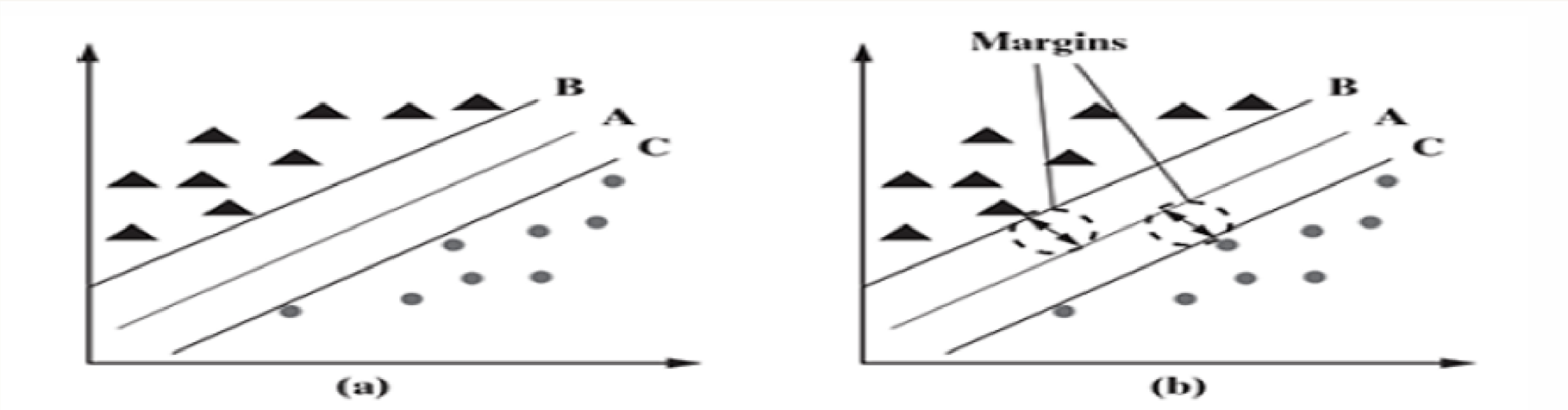
How SVM Works

3. Identify Support Vectors:

- Data points closest to the hyperplane are the support vectors.
- These points determine the position and orientation of the hyperplane.

4. Maximize the Margin:

- The margin is the distance between the hyperplane and the nearest data points from each class.
- SVM maximizes this margin to ensure better generalization.



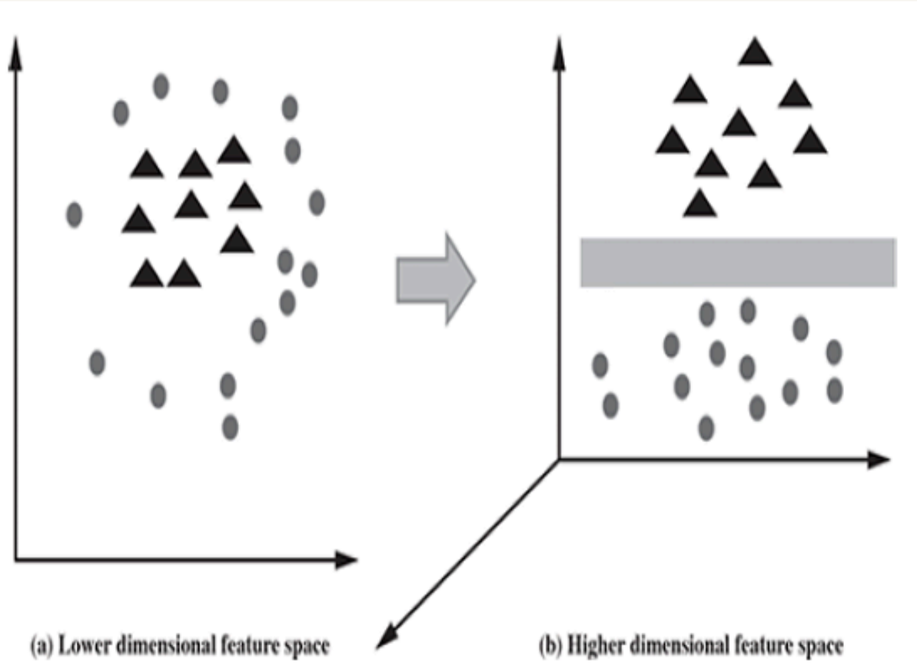
How SVM Works

5. Handle Non-Linear Data:

- For non-linearly separable data, SVM uses the kernel trick to map data into a higher-dimensional space where it becomes linearly separable.

6. Solve Optimization Problem:

- SVM solves a quadratic optimization problem to find the optimal hyperplane.
- Regularization parameter (C) controls the trade-off between maximizing the margin and minimizing classification error.



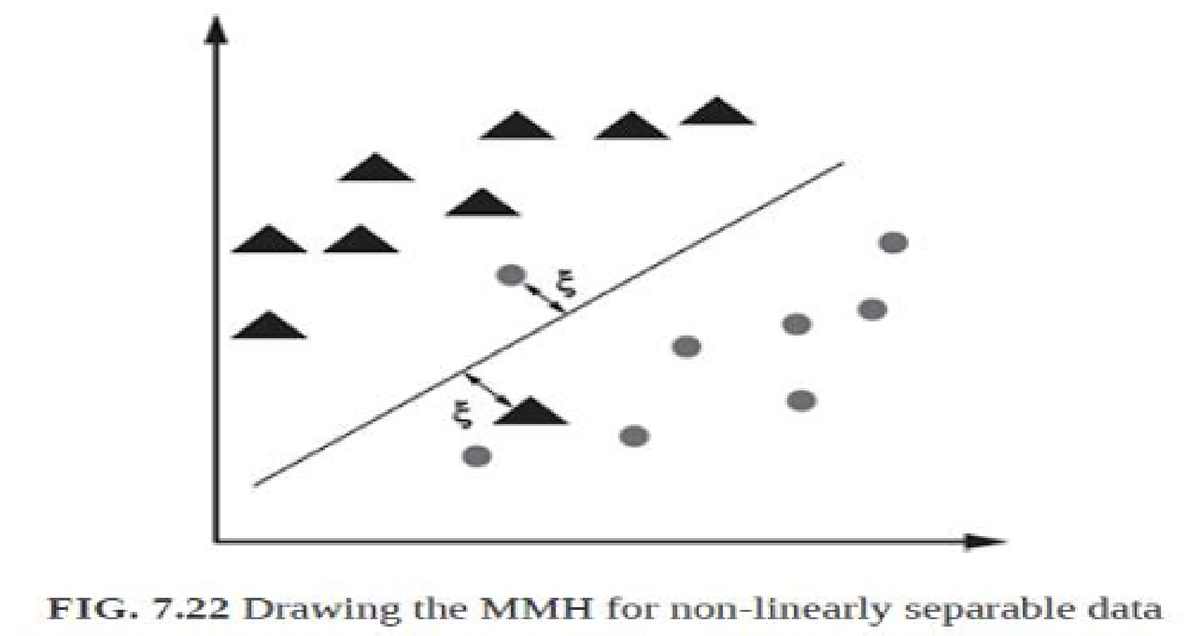
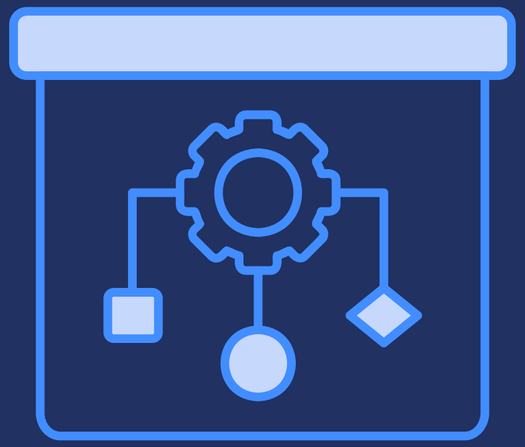


FIG. 7.22 Drawing the MMH for non-linearly separable data

USE CASES

Image Classification

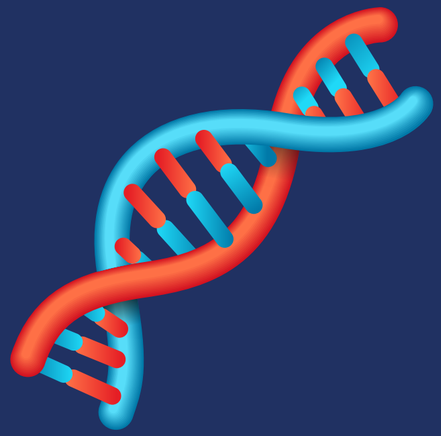


Handwritten digit recognition
(e.g., MNIST dataset).

Educational Tools

Spam email detection and sentiment analysis.

Bioinformatics



Protein structure prediction and gene classification.

ADVANTAGES

1. High performance on small and medium-sized datasets.
2. Effective in high-dimensional spaces (e.g., text or image data).
3. Versatile due to the use of different kernel functions.
4. Robust to overfitting, especially with appropriate regularization.
5. Works well with clear margins of separation.
6. Applicable to both classification and regression problems.

DISADVANTAGES

1. Inefficient for large datasets due to high computational complexity.
2. Sensitive to the choice of kernel function and hyperparameters.
3. May struggle with overlapping classes or noisy data.
4. Memory-intensive for large-scale problems.
5. Difficult to interpret results when using complex kernels.
6. Requires extensive tuning of parameters like C and gamma.

CONCLUSION

- Summary:
  - SVM is a powerful and versatile machine learning algorithm for various tasks.
  - Works best with small to medium-sized datasets and well-separated classes.
  - Choosing the right kernel and proper hyperparameter tuning is essential for optimal performance.
- Key Takeaway:
  - SVM remains a cornerstone algorithm in machine learning, offering strong theoretical foundations and practical applications.

Thank You