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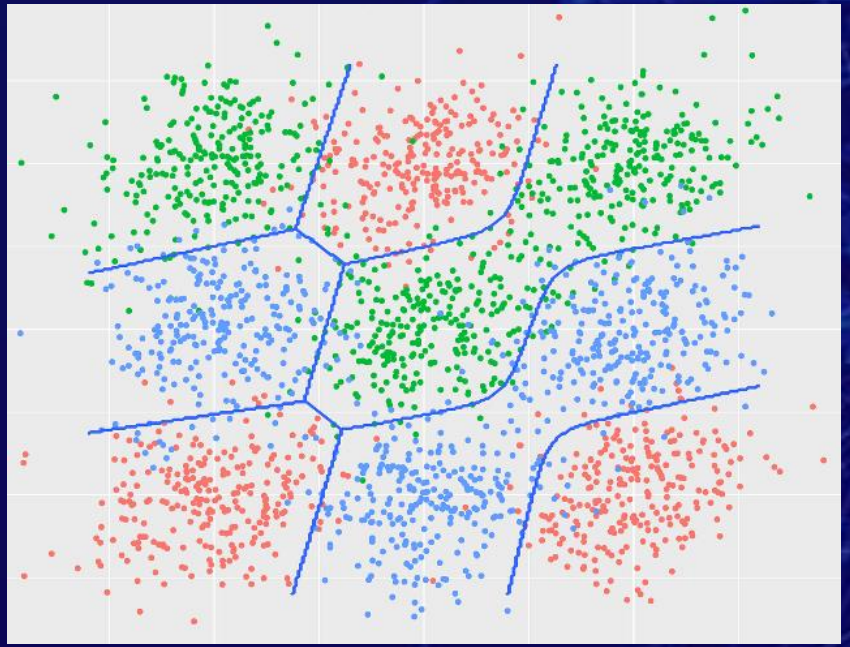
Unit 3.6
Generalized Discriminant Analysis



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Generalized Discriminant Analysis (GDA)

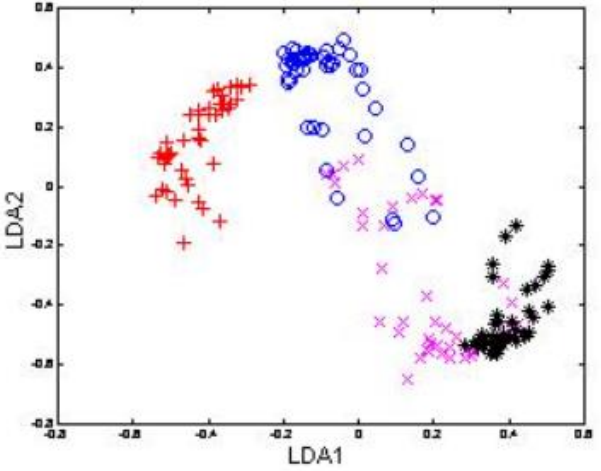
Learning Objectives

- Introduction
- What is Generalized Discriminant? Analysis?
- How Generalized Discriminant Analysis work?
- Standard kernel Functions
- Applications
- Disadvantage of GDA

Generalized Discriminant Analysis (GDA)

Introduction

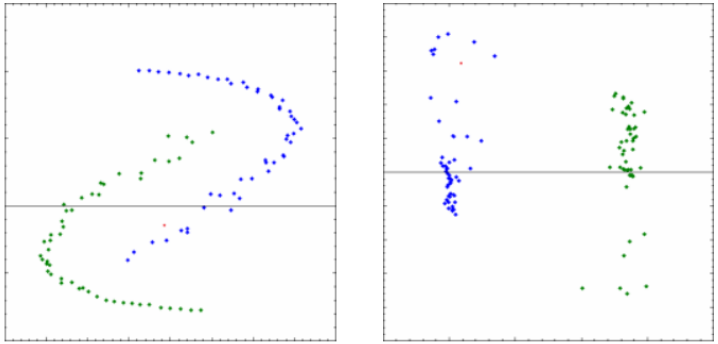
- Principal component Analysis (PCA) aims to find the most accurate data representation in a lower dimensional space spanned by the maximum variance directions.
- However, such directions might not work well for tasks like classification.
- Linear Discriminant Analysis (LDA) tries to preserve the discriminatory information between different classes of the dataset.
- But conventional LDA is not suitable for non linear datasets.
- GDA is a extension of LDA to non-linear Distribution.



LDA : Non Linear Separable dataset
Refer

What is Generalized Discriminant Analysis?

- Generalized discriminant Analysis (GDA) is a nonlinear discriminating method based on kernel techniques.
- The main idea is to map the input space into a convenient feature space in which variables are nonlinearly related to the input space.
- Also known as Kernel Discriminant Analysis (KDA)



Left image shows the original problem in the input space, right image shows the projection resultant of a KDA

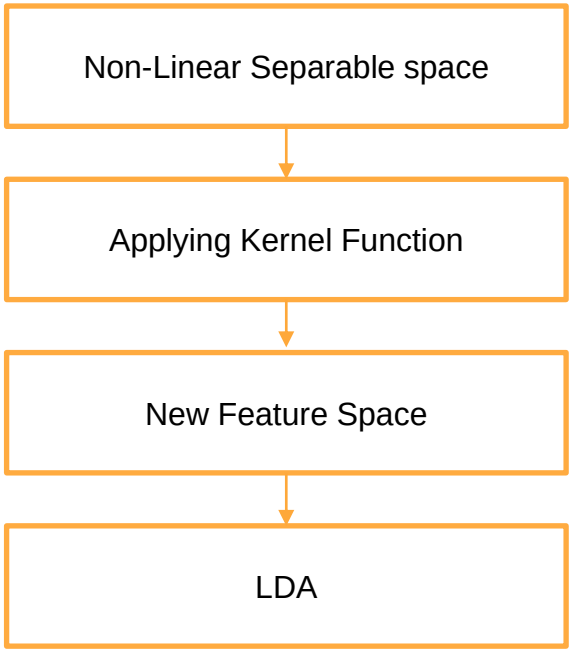
How Generalized Discriminant Analysis work?

Step 1:

- Apply kernel function on Non-Linear separable data to map to input space into high dimensional feature space.

Step 2:

- Perform LDA on new feature space to extract most significant discriminant features.



Standard Kernel Functions

- GDA generalizes LDA to nonlinear data sets by using the famous kernel trick.
- Some common Kernel functions include the Linear kernel, the Polynomial kernel, and the Gaussian kernel. Below is a simple list with their most interesting characteristics.

Linear Kernel	The Linear kernel is the simplest Kernel function. It is given by the common inner product <x,y> plus an optional constant c. Kernel algorithms using a linear kernel are often equivalent to their non-kernel counterparts, i.e., KPCA with a Linear kernel is equivalent to standard PCA.
Polynomial Kernel	The Polynomial kernel is a non-stationary kernel. It is well suited for problems where all data is normalized.
Gaussian Kernel	The Gaussian kernel is by far one of the most versatile kernels. It is a radial basis function kernel, and is the preferred kernel when we don't know much about the structure of the data we are trying to model.

Applications

- Face recognition and detection
- Hand-written digit recognition
- Palmprint recognition
- Classification of malignant and benign cluster microcalcifications
- Seed classification

Disadvantage of GDA

- The problem that raises from Kernel methods is the proper choice of the Kernel function (and the tuning of its parameters).
- This problem is often tractable with grid search and cross-validation, which are by themselves very expensive operations, both in terms of processing power and training data available.

Summary

- GDA extends traditional Discriminant Analysis techniques to handle non-linear data distributions and complex decision boundaries.
- Kernel functions play a pivotal role in GDA, enabling implicit data transformation into higher-dimensional spaces for improved class separation.
- GDA shines in scenarios involving mixed-class distributions and non-Gaussian data, enhancing classification accuracy.

Quiz

Question 1: What is the primary advantage of Generalized Discriminant Analysis (GDA) over Linear Discriminant Analysis (LDA)?

A) GDA can handle non-Gaussian data distributions.

B) GDA is computationally simpler than LDA.

C) GDA assumes equal covariance matrices for all classes.

D) GDA doesn't require class labels for training.

Answer: A) GDA can handle non-Gaussian data distributions.

Quiz

Question 2: In GDA, kernel functions are primarily used for:

A) Reducing computational complexity.

B) Generating synthetic data points

C) Creating linear decision boundaries.

D) Applying non-linear transformations to data.

Answer: D) Applying non-linear transformations to data.

Quiz

Question 3: What does GDA stand for in the context of classification?

A) General Data Approximation

B) Generalized Discriminant Analysis

C) Gaussian Decision Algorithm

D) Geometric Dimension Analysis

Answer: B) Generalized Discriminant Analysis

References

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Thank you...!