Face Recognition Using Fisherfaces (LDA)

1 Overview

The Fisherfaces method is a face recognition technique that utilizes Linear Discriminant Analysis (LDA) to project face images into a lower-dimensional space where the separation between different classes (identities) is maximized. This approach improves upon PCA by considering class labels and enhancing class separability.

2 Algorithm

2.1 1. Load and Preprocess the Dataset

Load a dataset of facial images and preprocess it.

Formula 2.1: Mean Face

$$\text{mean\_face} = \frac{1}{n} \sum_{i=1}^{n} \mathbf{x}_i$$

- mean_face is computed as the average of all facial images.

Formula 2.2: Center the Data

$$\mathbf{X}_{\text{centered}} = \mathbf{X} - \text{mean\_face}$$

- $\mathbf{X}_{\text{centered}}$ is the matrix of centered face images.

2.2 2. Compute Scatter Matrices

Formula 2.3: Within-Class Scatter Matrix

$$S_W = \sum_{c} \sum_{\mathbf{x}_i \in \mathbf{X}_c} (\mathbf{x}_i - \text{mean}_c)(\mathbf{x}_i - \text{mean}_c)^T$$

- S_W measures the spread of data within each class.

Formula 2.4: Between-Class Scatter Matrix

$$S_B = \sum_{c} n_c (\text{mean}_c - \text{overall\_mean})(\text{mean}_c - \text{overall\_mean})^T$$

- S_B measures the spread of the class means around the overall mean.

2.3 3. Solve the Generalized Eigenvalue Problem

Formula 2.5: Eigenvalues and Eigenvectors

$$S_W^{-1} S_B \mathbf{v} = \lambda \mathbf{v}$$

- Solve the generalized eigenvalue problem to obtain eigenvalues λ and eigenvectors $\mathbf{v}$.

2.4 4. Project Faces into the Fisherface Space

Formula 2.6: Project Faces

$$\mathbf{X}_{\text{lda}} = \mathbf{X}_{\text{centered}} \mathbf{V}$$

- $\mathbf{X}_{\text{lda}}$ is the matrix of face images projected onto the Fisherface space.

2.5 5. Classification and Evaluation

Train a classifier using the projected data and evaluate it.

- Use classifiers like LDA or SVM with the projected data $\mathbf{X}_{\text{lda}}$.
- Evaluate using metrics such as confusion matrix, precision, recall, and F1 score.

3 Mathematical Formulas

Formula 3.1: Mean Face

$$\text{mean\_face} = \frac{1}{n} \sum_{i=1}^{n} \mathbf{x}_i$$

Formula 3.2: Centered Data

$$\mathbf{X}_{\text{centered}} = \mathbf{X} - \text{mean\_face}$$

Formula 3.3: Within-Class Scatter Matrix

$$S_W = \sum_c \sum_{\mathbf{x}_i \in \mathbf{X}_c} (\mathbf{x}_i - \text{mean}_c)(\mathbf{x}_i - \text{mean}_c)^T$$

Formula 3.4: Between-Class Scatter Matrix

$$S_B = \sum_c n_c (\text{mean}_c - \text{overall\_mean})(\text{mean}_c - \text{overall\_mean})^T$$

Formula 3.5: Generalized Eigenvalue Problem

$$S_W^{-1} S_B \mathbf{v} = \lambda \mathbf{v}$$

Formula 3.6: Projection

$$\mathbf{X}_{\text{lda}} = \mathbf{X}_{\text{centered}} \mathbf{V}$$