

# Face Recognition using PCA (Eigenfaces)

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Implementation: Github

## Objective

The objective of this lab is to implement a facial recognition system using Principal Component Analysis (PCA). The approach projects images into a lower-dimensional subspace spanned by Eigenfaces and applies this representation for image reconstruction and recognition.

## Dataset

The AT&T (ORL) Face Dataset was used:

- 400 grayscale face images (40 subjects  $\times$  10 images).
- Resolution:  $92 \times 112$  pixels.
- Includes variations in lighting, expression, glasses, and pose.

## Implementation Steps

### 1. Data Preprocessing

- Images were loaded from the ORL dataset and flattened into 1D vectors.
- Each image was converted to grayscale and standardized.
- Dataset was split into training (70%) and testing (30%) using stratified sampling.

### 2. PCA using SVD

- Mean face was computed and subtracted from each image.
- Singular Value Decomposition (SVD) was used to extract eigenfaces.
- Top 200 principal components were retained.
- Eigenvalues were used to compute explained variance.

### 3. Eigenfaces Visualization

Mean Face

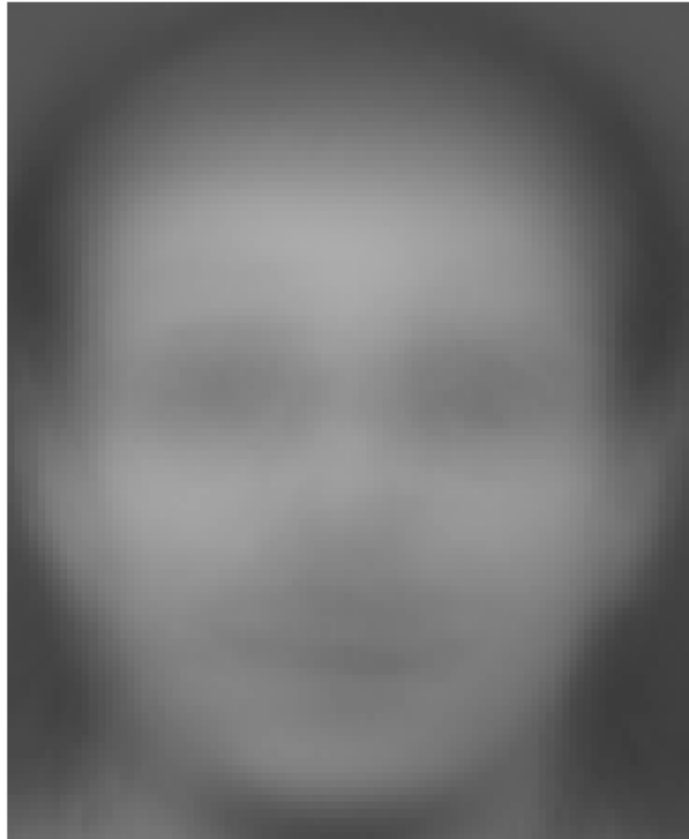


Figure 1: Mean face computed from dataset.

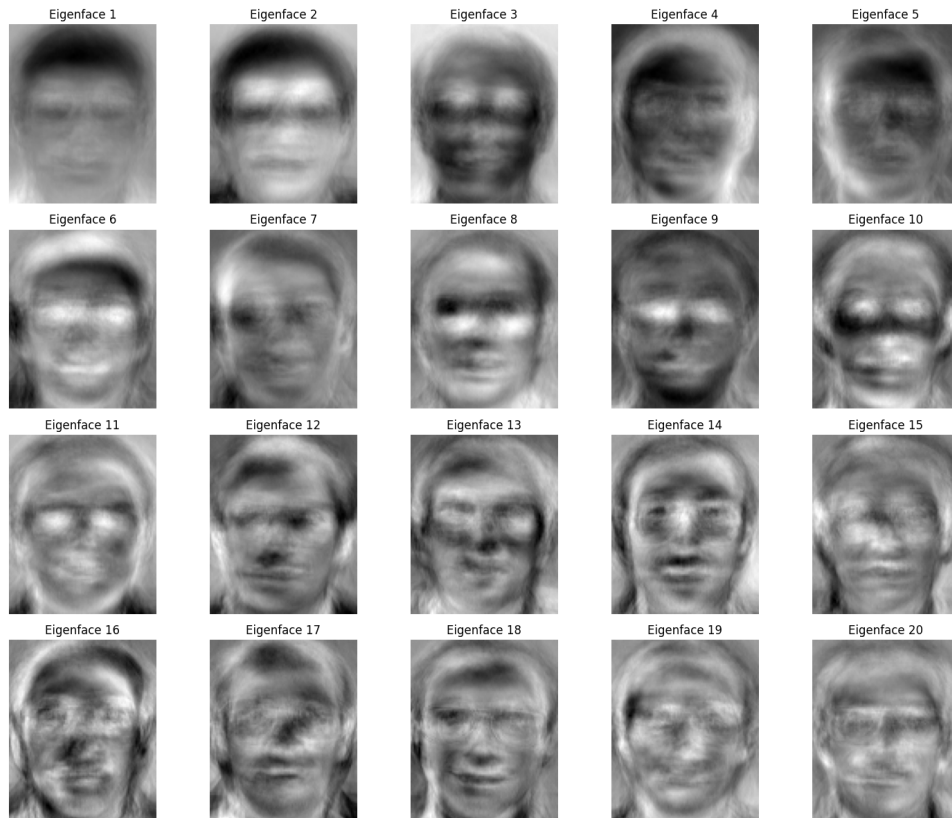


Figure 2: First 20 Eigenfaces visualized.

## 4. Image Reconstruction

Sample test images were reconstructed using different values of  $k$  (number of components).

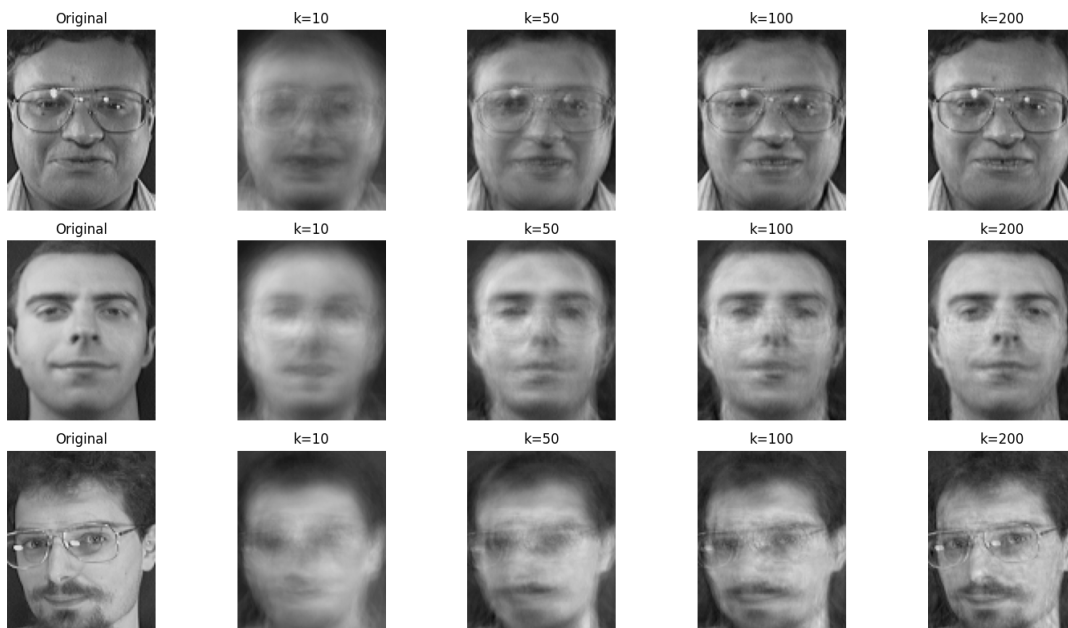


Figure 3: Reconstruction of test images with  $k = 10, 50, 100, 200$ .

## 5. Face Recognition

Nearest neighbor classification was performed in PCA space.

Number of Components ( $k$ )	Accuracy (%)
5	85.83
10	93.33
20	95.00
50	96.67
100	96.67
150	95.00
200	95.83

Table 1: Recognition accuracy vs. number of principal components.

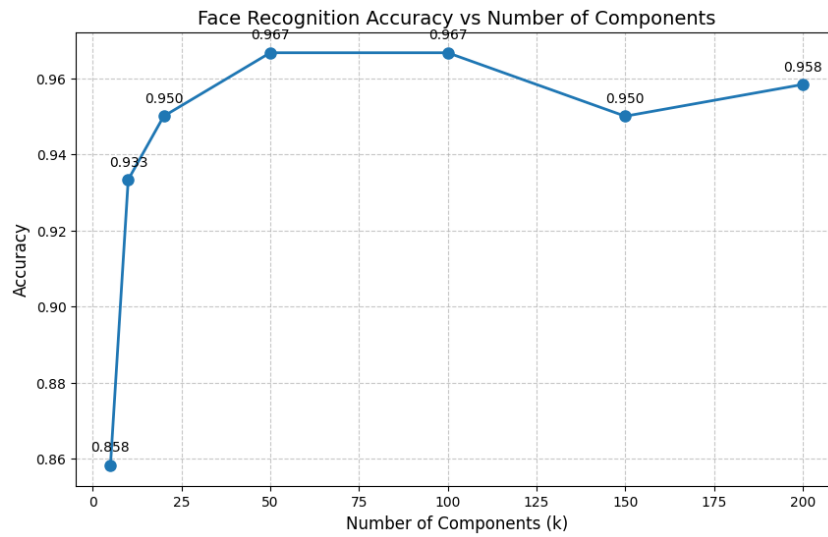


Figure 4: Recognition accuracy as a function of  $k$ .

## 6. t-SNE Visualization

t-SNE was applied on the top 50 PCA features to reduce to 2D.

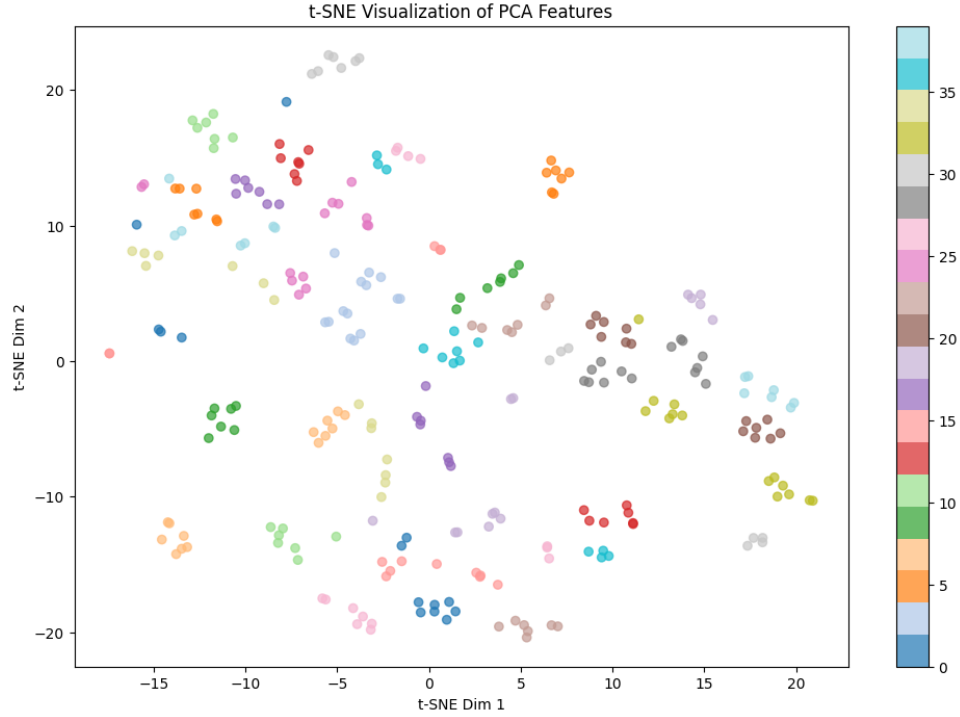


Figure 5: t-SNE visualization showing clustering of different subjects.

## Results and Analysis

- Best recognition accuracy was obtained at  $k = 50$  with accuracy = 96.67%.
- Top 10 explained variance ratios were printed in the notebook.
- Cumulative explained variance for top 50 components was reported as 0.8161.
- Reconstruction quality improved as  $k$  increased and later decreased.
- t-SNE visualization showed clear clustering of different subjects.

## Conclusion

This experiment showed that PCA reduces dimensionality effectively while retaining key facial features. Using Eigenfaces with nearest neighbor classification achieved high recognition accuracy. t-SNE further confirmed separability of subjects in reduced space.