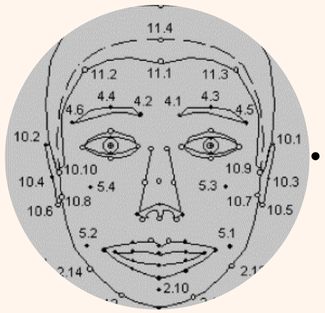
Facial Recognition

Using Eigenfaces and Eigen Vector

START

Process

Data PreProcessing



Eigen Face Extraction

Training the SVM

Testing and Evaluation

Qualitative Evaluation

SVM Clasification Model

Support Vector Machines (SVM) is a powerful supervised machine learning algorithm used for classification tasks.

SVM aims to find a hyperplane that best separates data points of different classes.

In this project, SVM is employed as a classifier to recognize and classify faces based on the extracted eigenfaces.

PCA?

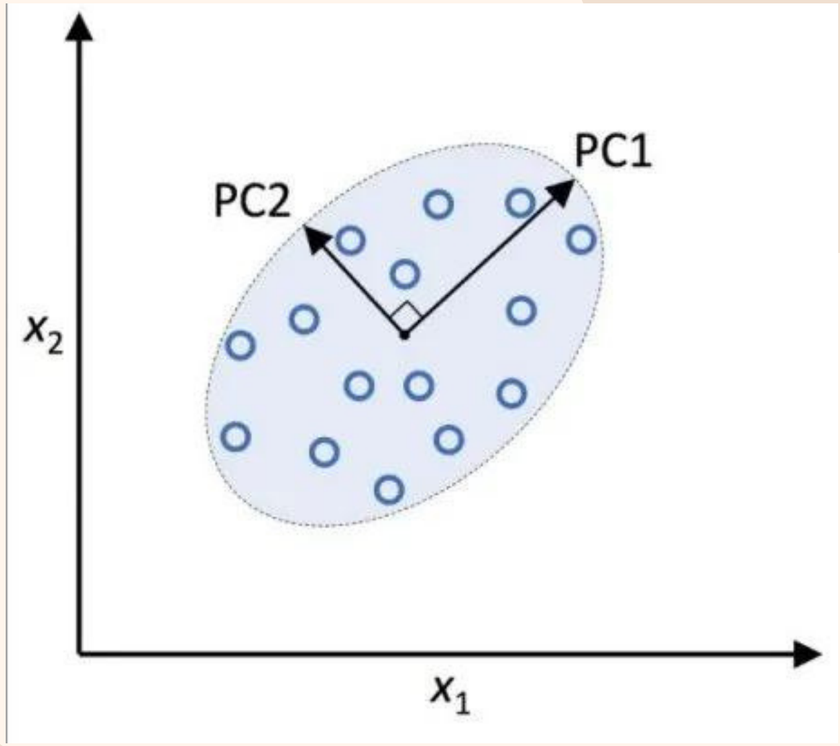
- Dimension reduction
- Feature Extraction
- In the figure, x1 and x2 are the original feature axes, and PC1 and PC2 are the principal components
- Why PCA in face recognition?

Algorithm:

$$x = [x_1, x_2, \dots, x_d], \qquad x \in \boldsymbol{R}^d$$

$$\downarrow xW, W \in \boldsymbol{R}^{d*k}$$

$$z = [z_1, z_2, \dots, z_k], \qquad z \in \boldsymbol{R}^k$$



Continuing with algorithm

2. Construct the covariance matrix:

$$\Sigma = \begin{bmatrix} \sigma_1^2 & \sigma_{12} & \sigma_{13} \\ \sigma_{21} & \sigma_2^2 & \sigma_{23} \\ \sigma_{31} & \sigma_{32} & \sigma_3^2 \end{bmatrix}$$

3. Decompose the covariance matrix into its eigenvectors and eigenvalues.\

$$\det(A-\lambda I)=0$$

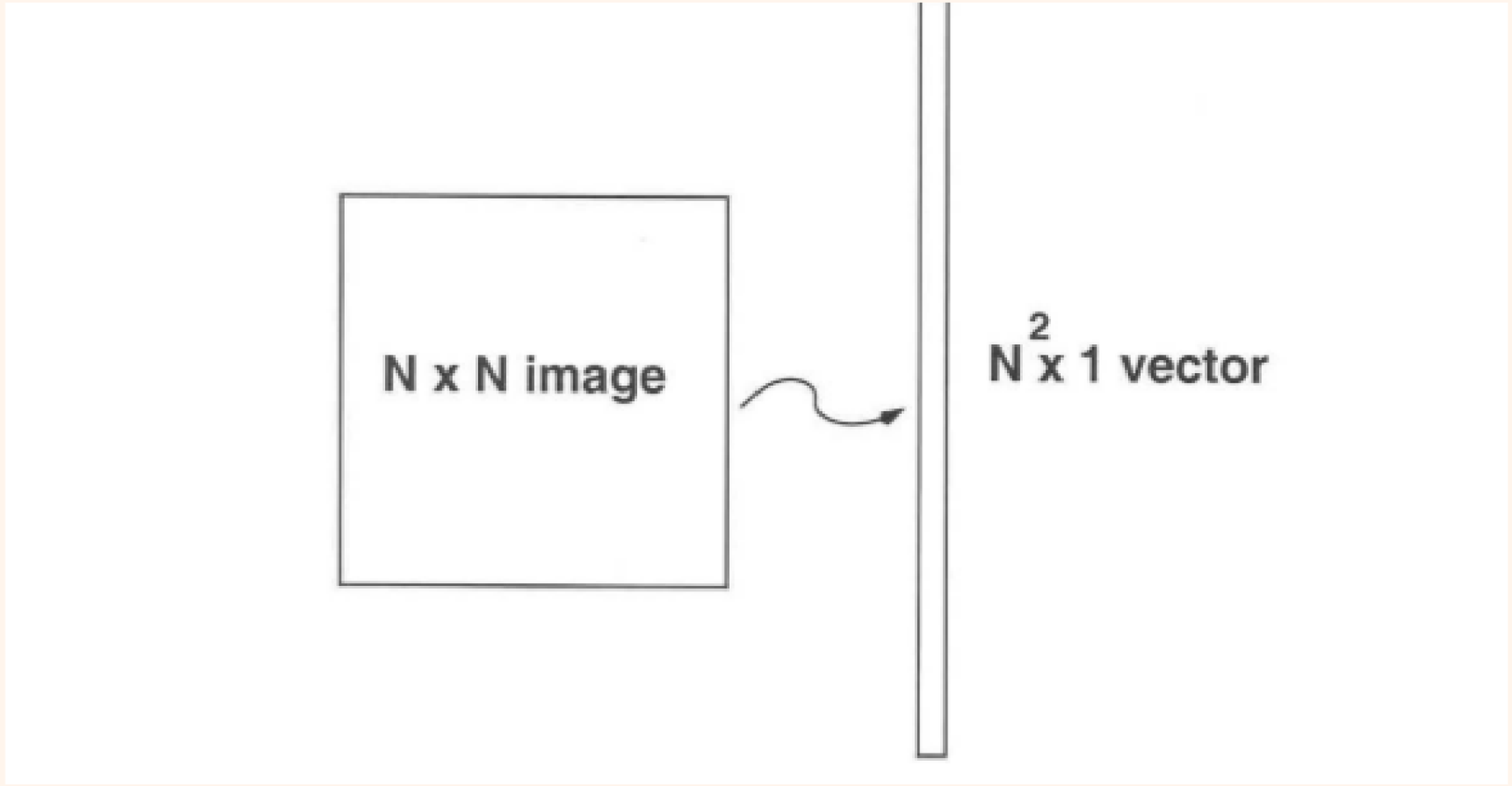
Continuing with algorithm

4.Eigen values in decreasing order
5.Select k eigenvectors which correspond to the k largest eigenvalues, where k is the dimensionality of the new feature subspace (k ≤ d).
6.Transform the d-dimensional input dataset X using the projection matrix W to obtain the new k-dimensional feature subspace:
In this step, we use the matrix W that we just computed to transform our samples onto the new subspace via the equation y = W′ × x where W′ is the transpose of the matrix W.

PCA in python

In Python, you can perform Principal Component Analysis (PCA) using the scikit-learn library. The scikit-learn library provides a PCA class that implements the PCA algorithm and provides various methods and functionalities for performing PCA on datasets.

Calculation



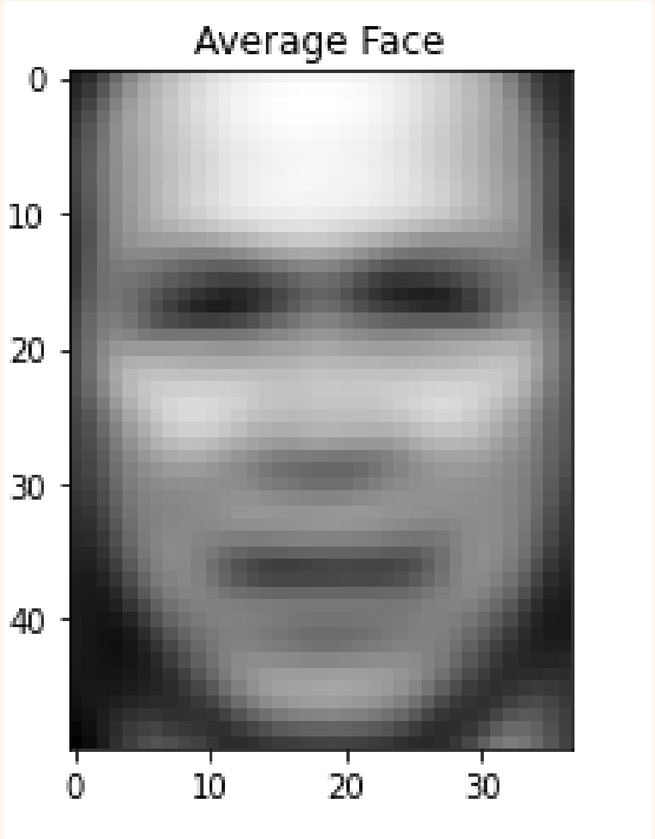
N*N

M number of images

We calculate the average of all these face vectors and subtract it from each vector

$$\psi = \frac{1}{m} \sum_{i=1}^{m} x_i$$

$$\mathrm{a}_i = x_i - \psi$$



Then we take all face vectors so that we get a matrix of size of N2 * M.

$$A = \begin{bmatrix} a_1 & a_2 & a_3 & .... & a_m \end{bmatrix}$$

Covariance matrix $Cov = A^T A$

To calculate eigen values and eigenvectors of above covariance matrix use the formula:

where, $C' = AA^T$ **and** $u_i = A\nu_i$

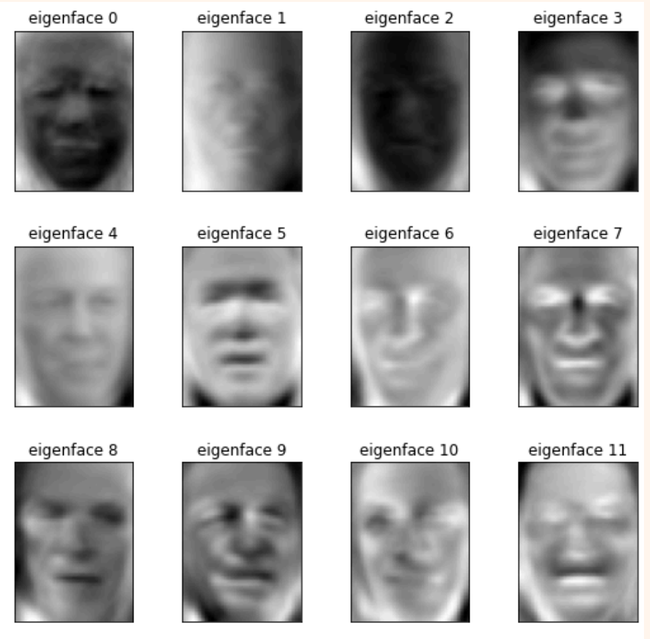
$$A^T A\nu_i = \lambda_i \nu_i$$

$$AA^T A\nu_i = \lambda_i A\nu_i$$

$$C' u_i = \lambda_i u_i$$

Select the K eigenvectors of C' corresponding to the K largest eigenvalues (where K < M). These eigenvectors has size N ^2 .

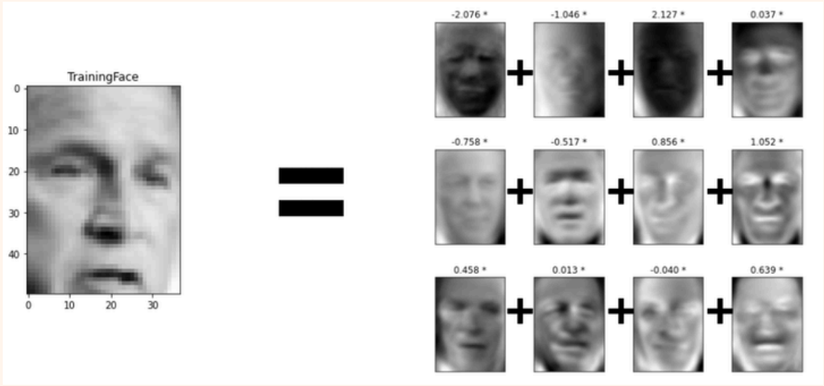
After that we used the eigenvectors that we got in previous step. We take the normalized training faces (face – average face) x_i and represent each face vectors in the linear of combination of the best K eigenvectors (as shown in the diagram).



$$x_i - \psi = \sum_{j=1}^{K} w_j u_j$$

After that we take the coefficient of eigenfaces and represent the training faces in the form of a vector of those coefficients.

$$x_i = \begin{bmatrix} w_1^i \\ w_2^i \\ w_3^i \\ . \\ . \\ w_k^i \end{bmatrix}$$



Testing

- Given an unknown face y, we need to first preprocess the face to make it centered in the image and have the same dimensions as the training face
- Now, we subtract the face from the average face ψ

$$\phi = y - \psi$$

- Now, we project the normalized vector into eigenspace to obtain the linear combination of eigenfaces. $\phi = \sum_{i=1}^{k} w_i u_i$
- From the above projection, we generate the vector of the coefficient such that

$$\Omega = \begin{bmatrix} w_1 \\ w_2 \\ w_3 \\ . \\ . \\ w_k \end{bmatrix}$$

- We take the vector generated in the above step and subtract it from the training image to get the minimum distance between the training vectors and testing vectors

$$e_r = min_l \|\Omega - \Omega_l\|$$

  - If this e_r is below tolerance level Tr, then it is recognised with l face from training image else the face is not matched from any faces in training set.