3.8.1 Principal Component Analysis

- Example
  - Eigenfaces for face recognition

    - Training:
      - Calculate the eigenspace for all faces in the training database
      - Project each face into the eigenspace
        → feature reduction

    - Classification:
      - Project new face into eigenspace
      - Nearest neighbor in the eigenspace

3.8.1 Principal Component Analysis

- Eigenfac

$\Gamma_i (i = 1..M)$

M faces

$$\psi = \frac{1}{M}\sum_{i=1}^{M}\Gamma_i$$

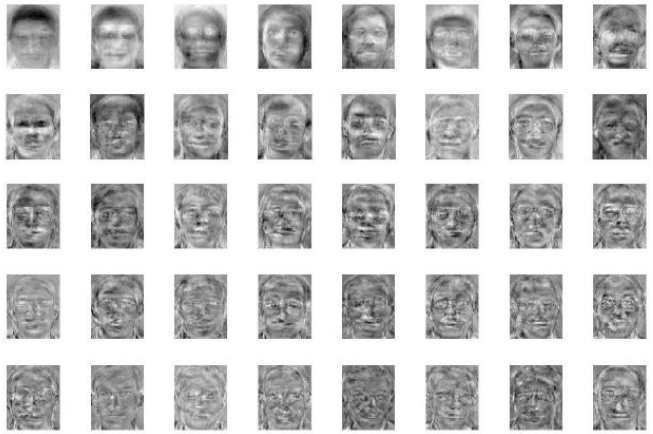
Average face ψ

$$\Phi_i = \Gamma_i - \psi$$

$$C = AA^T$$

$$A = [\Phi_1 \Phi_2 ... \Phi_M]$$

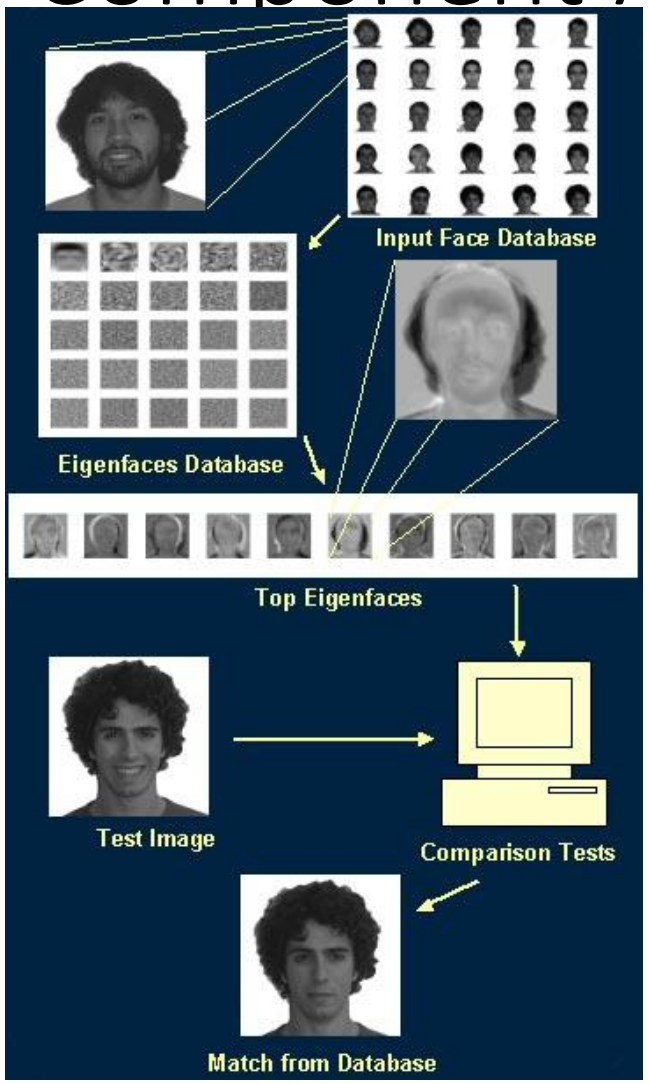
Face Space



Eigenfaces

3.8.1 Principal Component Analysis

- Eigenface



Training stage

Recognition stage

3.8.1 Principal Component Analysis

- Example (con't)
  - Eigenfaces for face recognition

$$X = \{x_1, x_2, \cdots, x_n\}$$

    - Step 1 : a set of trair

3.8.1 Principal Component Analysis

- Example (con’t)
  - Eigenfaces for face recognition
    - Step 2 : Image Norm

3.8.1 Principal Component Analysis

- Example (con’t)
  - Eigenfaces for face recognition
    - Step 3 : Calculate the mean

$$\mu = \frac{1}{n}\sum_{i=1}^{n} X_i$$

3.8.1 Principal Component Analysis

- Example (con't)
  - Eigenfaces for face recognition
    - Step 4 : Calculation of difference between training vector and mean vector

$$\Psi_i = X_i - \mu$$

    - Step 5 : Covariance matrix

$$C = \frac{1}{n}\sum_{i=1}^{n} \Psi_i \Psi_i^T$$

3.8.1 Principal Component Analysis

- Example (con't)
  - Eigenfaces for face recognition
    - Step 6 : Eigenvector of covariance

$$\Phi_i = \sum_{j=1}^{K} w_j u_j \quad \Rightarrow w_j = u_j^T \Phi_i \quad \Rightarrow \Omega_i = [w_1 \ldots w_K]^T \quad (i = 1..M)$$

    - Step 7 : (Face Recognition) Project new face into eigenspace

Input (the probe): $\Gamma \quad \Rightarrow \Phi = \Gamma - \psi$
Project Φ into the face space: $\Omega = [w_1' \ldots w_K']^T$
Compute: e_r
$= \min_{1 \le i \le M} ||\Omega - \Omega_i|| \quad$, $||.||$ is a distance measure
If $e_r \le \theta$, the probe is recognized

Identification mode

Input : $\boldsymbol{\Gamma_1}, \boldsymbol{\Gamma_2} \quad \Rightarrow \Phi_1 = \boldsymbol{\Gamma_1} - \psi, \Phi_2 = \boldsymbol{\Gamma_2} - \psi$
Project into the face space:Ω_1, Ω_2
Compute: $e_r = ||\Omega_1 - \Omega_2||$
If $e_r \le \theta$, **matched (accpted) and vice**

Verification mode

3.8.1 Principal Component Analysis

- Eigenface