Face Recognition

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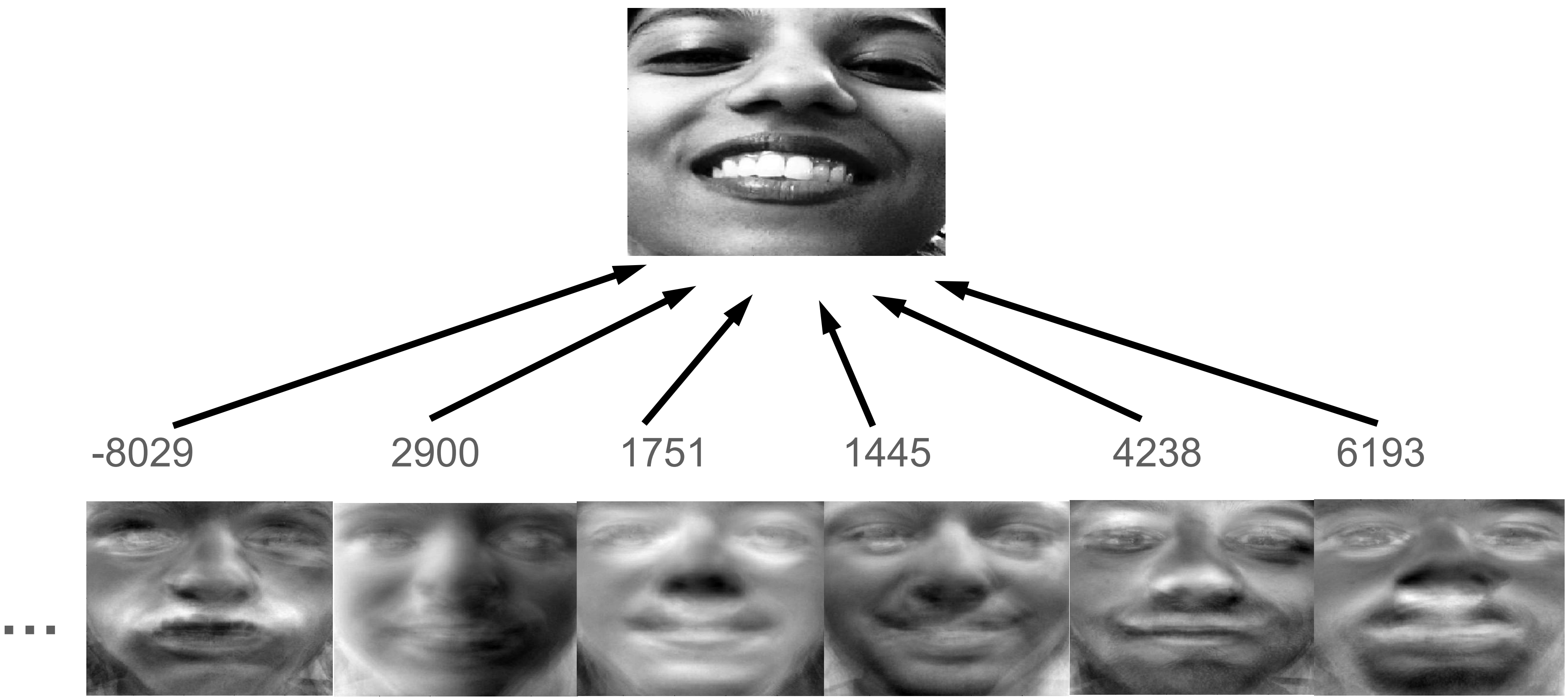
Plan

- Eigenfaces: the idea
- Eigenvectors and Eigenvalues
- Co-variance
- Learning Eigenfaces from training sets of faces
- Recognition and reconstruction

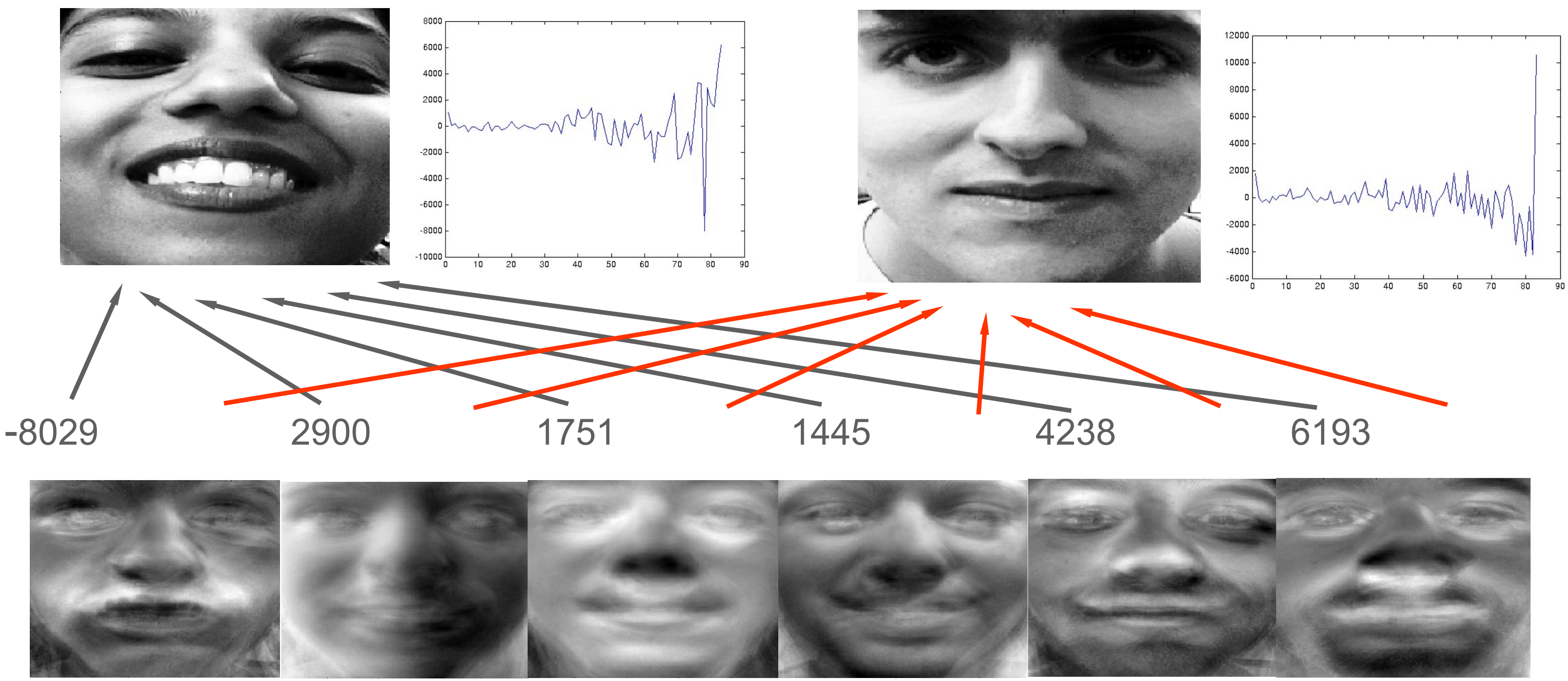
Eigenfaces: the idea

- Think of a face as being a weighted combination of some “component” or “basis” faces
- These basis faces are called eigenfaces



Eigenfaces: representing faces

- These basis faces can be differently weighted to represent any face
- So we can use different vectors of weights to represent different faces



Learning Eigenfaces

Q: How do we pick the set of basis faces?

A: We take a set of real training faces

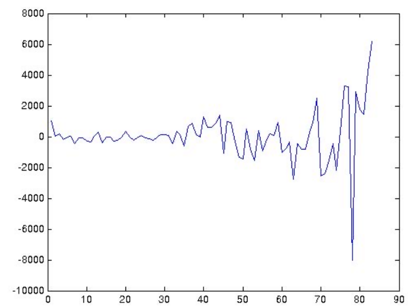
Then we find (learn) a set of basis faces which best represent the differences between them

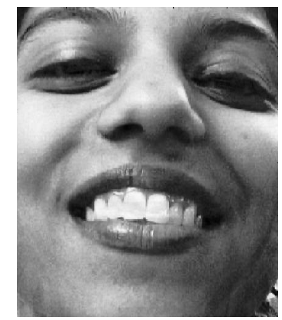
We'll use a statistical criterion for measuring this notion of "best representation of the differences between the training faces"

We can then store each face as a set of weights for those basis faces

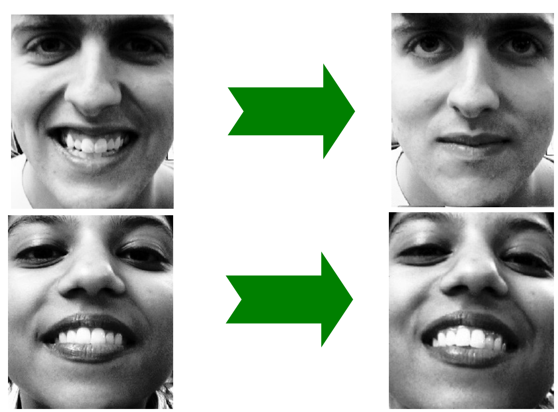
Using Eigenfaces: recognition & reconstruction

- We can use the eigenfaces in two ways
- 1: we can store and then reconstruct a face from a set of weights





- 2: we can recognise a new picture of a familiar face



Learning Eigenfaces

- How do we learn them?
- We use a method called Principle Components Analysis (PCA)
- To understand this we will need to understand
  - What an eigenvector is
  - What covariance is
  - what is happening in PCA qualitatively

Eigenfaces

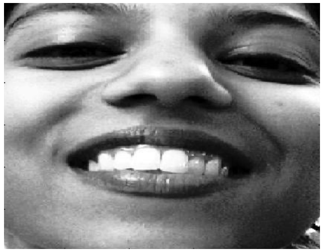
- All we are doing in the face case is treating the face as a point in a high-dimensional space, and then treating the training set of face pictures as our set of points
- To train:
  - Take your images, and re-arrange as a 2Dmatrix
    - Rows: Each image
    - Columns: Each pixel value
  - We calculate the covariance matrix of the faces
  - We then find the eigenvectors of that covariance matrix
- These eigenvectors are the eigenfaces or basis faces
- Eigenfaces with bigger eigenvalues will explain more of the variation in the set of faces, i.e. will be more distinguishing

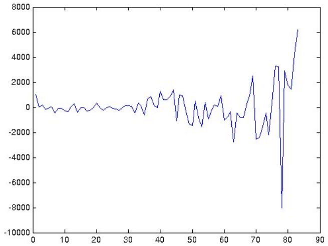
Eigenfaces: image space to face space

- When we see an image of a face we can transform it to face space

$$\mathbf{w}_k = \mathbf{x}^{\mathbf{i}} . v_k$$

- There are k=1…n eigenfaces v_k
- The ith face in image space is a vector x^i
- The corresponding weight is w_k
- We calculate the corresponding weight for every eigenface



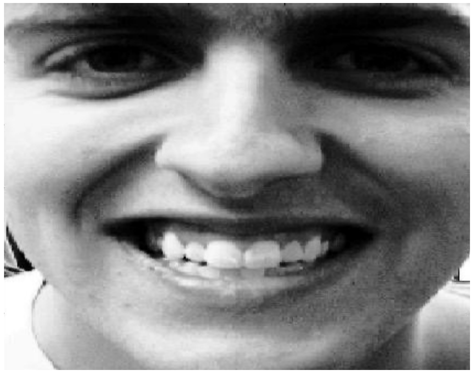


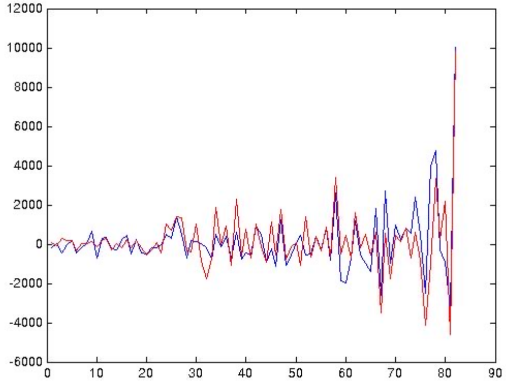
Recognition in face space

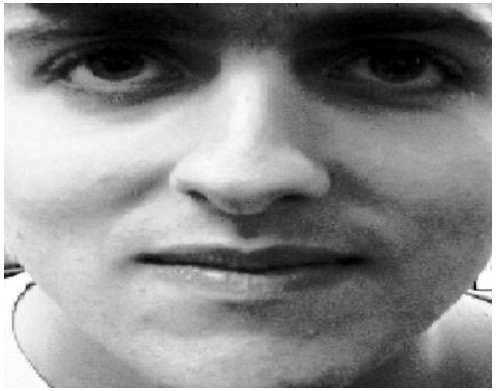
- Recognition is now simple. We find the euclidean distance ***d*** between our face and all the other stored faces in face space:

$$d(w^1, w^2) = \sqrt{\sum_{i=1}^{n} \left(w_i^1 - w_i^2\right)^2}$$

- The closest face in face space is the chosen match

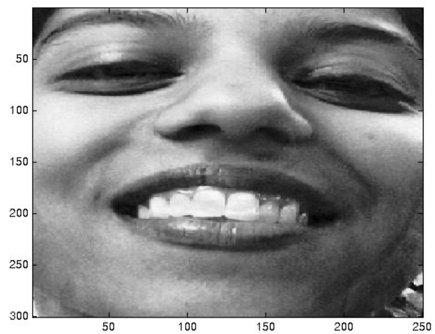






Reconstruction

- The more eigenfaces you have the better the reconstruction, but you can have high quality reconstruction even with a small number of eigenfaces



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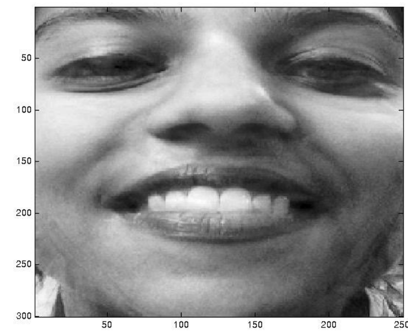

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Summary

- Statistical approach to visual recognition
- Also used for object recognition
- Problems
- Reference: M. Turk and A. Pentland (1991). Eigenfaces for recognition, *Journal of Cognitive Neuroscience*, 3(1): 71–86.


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