Object/Face Recognition (+PCA Review)

René Magritte, “The Familiar Objects”

Many slides from
Noah Snavely, Derek Hoeim

CSC320: Introduction to Visual Computing
Michael Guerzhoy
Simple idea for face recognition

1. Treat face image as a vector of intensities

\[ x \]

2. Recognize face by nearest neighbor in database

\[ y_1 \cdots y_n \]

\[ k = \arg \min_k \| y_k - x \| \]
Recognition ~ Detection of One Person

• Note that this is the same idea that we first considered for detection
  – No surprise, detecting faces is like recognizing everyone’s faces
The space of all face images

- When viewed as vectors of pixel values, face images are extremely high-dimensional
  - 100x100 image = 10,000 dimensions
  - Slow and lots of storage
- But very few 10,000-dimensional vectors are valid face images
- We want to effectively model the subspace of face images
The space of all face images

- Eigenface idea: construct a low-dimensional linear subspace that best explains the variation in the set of face images

![Diagram showing face images in a 2D space with two pixel values, one principal component direction indicated by $u_1$.]
Representation and reconstruction

• Face $\mathbf{x}$ in “face space” coordinates:

$$\mathbf{x} \rightarrow [\mathbf{u}_1^T (\mathbf{x} - \mu), \ldots, \mathbf{u}_k^T (\mathbf{x} - \mu)]$$

$$= w_1, \ldots, w_k$$

• Reconstruction:

$$\mathbf{x} = \mu + w_1 u_1 + w_2 u_2 + w_3 u_3 + w_4 u_4 + \ldots$$
After computing eigenfaces using 400 face images from ORL face database
Recognition with Eigenfaces

• For an unknown face:
  – Project to eigenspace: $X_{pca} = V(:, k)^T X$
  – Optional check reconstruction error $VX - VX_{pca}$ to determine whether image is really a face
  – Find the person whose face in eigenspace is the closest to $X_{pca}$

• Remember denoising with PCA: projecting to eigenspace gets rid of irrelevant details (hopefully), keeps the parts of the face that make it a face
Limitations

Global appearance method: not robust to misalignment, background variation