The recognition of faces

Why is face analysis important?

Remember/recognize people we've seen before
Categorization – e.g., gender, race, age, kinship
Social communication – emotions/mood, intentions, trustworthiness, competence or intelligence, attractiveness
Scene understanding, e.g., direction of gaze suggests focus of attention

Why is face recognition hard?

changing pose
changing illumination
aging
changing expression
clutter
occlusion

Face recognition performance in humans

Duchaine & Nakayama, 2006
Wilmer et al., 2012

Chance

Proportion correct
How good are the best machines?

Public databases of face images serve as benchmarks:
> 13,000 images of celebrities, 5,749 different identities
3,425 videos, 1,595 different identities

Private face image datasets:
(Facebook) Social Face Classification dataset
4.4 million face photos, 4,030 different identities
(Google) 100-200 million face images, ~ 8 million different identities

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<thead>
<tr>
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<th>LFW</th>
<th>YTF</th>
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<tbody>
<tr>
<td>Facebook DeepFace</td>
<td>97.4%</td>
<td>91.4%</td>
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<tr>
<td>Google FaceNet</td>
<td>99.6%</td>
<td>95.1%</td>
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<tr>
<td>Human performance</td>
<td>97.5%</td>
<td>89.7%</td>
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It all began with Takeo Kanade (1973)...


- Special purpose algorithms to locate eyes, nose, mouth, boundaries of face
- ~ 40 geometric features, e.g. ratios of distances and angles between features

Eigenfaces for recognition (Turk & Pentland)

Principal Components Analysis (PCA)

Goal: reduce the dimensionality of the data while retaining as much information as possible in the original dataset

PCA allows us to compute a linear transformation that maps data from a high dimensional space to a lower dimensional subspace
**Typical sample training set...**

Sample images from the Yale face database

- one or more images per person
- aligned & cropped to common pose, size
- simple background

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Prepare image data for PCA:

- For each image in dataset, place columns end-to-end to create one long column vector
- Place column vectors for each image side-by-side in an $M \times N$ matrix
- Subtract the mean vector (average face) from each column

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Each image in the dataset has unique set of weights

$$F(x,y) = \Psi(x,y) + \Sigma w_i^* E_i(x,y)$$
Eigenfaces for recognition (Turk & Pentland)

Perform PCA on a large set of training images, to create a set of eigenfaces, $E_i(x,y)$, that span the dataset.

First components capture most of the variation across the dataset, later components capture subtle variations.

$\Psi(x,y)$: average face (across all faces)

Each face image $F(x,y)$ can be expressed as a weighted combination of the eigenfaces $E_i(x,y)$:

$$F(x,y) = \Psi(x,y) + \sum_i w_i E_i(x,y)$$

Representing individual faces

Each face image $F(x,y)$ can be expressed as a weighted combination of the eigenfaces $E_i(x,y)$:

$$F(x,y) = \Psi(x,y) + \sum_i w_i E_i(x,y)$$

Recognition process:

1. Compute weights $w_i$ for novel face image.
2. Find image $m$ in face database with most similar weights, e.g.,

$$\min \sum_{i=1}^k (w_i - w_i^m)^2$$

http://vision.media.mit.edu/vision/demos/face/rec/basic.html