CS 332 Visual Processing in Computer and Biological Vision Systems

The Analysis of Faces in Brains and Machines

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

How good are we at face recognition?

Face recognition performance in humans

Duchaine & Nakayama, 2006

Wilmer et al., 2012

Cambridge Face Memory Test

Welcome to Cambridge Face Memory Test

In the following task you will be required to memorize the faces of different individuals. You will then be asked to identify a face you memorized out of a line-up of three faces. The test will begin with a very easy practice round and then will become progressively more challenging. Instructions will be given throughout the task, please follow them carefully. The test will take approximately 30 minutes to complete.

If you have any questions about this on-line test, please contact Sue Nicholas (s.nicholas@birk.ac.uk) for further information. If you wish to lodge a complaint or concern, please contact the Head of the Brain and Behaviour Lab, Professor Martin Eimer (m.eimer@birk.ac.uk).

If you are 18 years of age or older, understand the statements above, and freely consent to participate in the study, click on the "I Agree" button to begin the experiment.

I Agree
Face recognition performance in humans

Which of the 10 photos on the bottom depicts the target face?

Viewers are ~ 70% correct

Performance degrades with changes in pose, expression

Only slight improvement with short video clip of target

Importance of familiar vs. unfamiliar face recognition!

Bruce et al., 1999

How good are the best machines?

Public databases of face images serve as benchmarks:

> 13,000 images of celebrities, 5,749 different identities

YouTube Faces Database (YTF, http://wwwcs.tau.ac.il/~wolf/ytffaces)
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

<table>
<thead>
<tr>
<th></th>
<th>LFW</th>
<th>YTF</th>
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<tbody>
<tr>
<td>Facebook DeepFace</td>
<td>97.4%</td>
<td>91.4%</td>
</tr>
<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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Machine vision applications of face recognition

security, forensics

access control

surveillance

More applications of face recognition

content-based image retrieval

social media

Google Glass Face Recognition App Coming This Month, Whether Google Likes It Or Not

facial recognition app matches strangers to online profiles

Facebook's New Face-Recognition Software Is Scary Good

graphics, HCI

humanoid robots
Aspects of face processing

Face detection – find image regions that contain faces

Face identification – who is the person?

Categorization – gender, age, race

Facial expression – mood, emotion

*Non-verbal social perception and communication*

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...

One or more images per person
Aligned & cropped to common pose, size
Simple background

Sample images from the Yale face database

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 data set

First components capture most of the variation across the data set, 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 $E_i(x,y)$:

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

http://vismod.media.mit.edu/vismod/demos/facerec/basic.html
Representing individual faces

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

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

Recognition process:

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

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

Faces everywhere...