

CS 332 Visual Processing in Computer and Biological Vision Systems

# The Analysis of Faces in Brains and Machines

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Test phase

Block:

1 2 3

HMAX model

Multiple levels: from neurons to patches to behavior

## 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



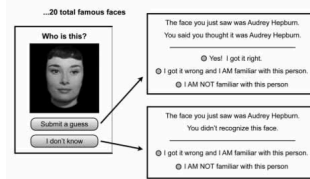
## How good are we at face recognition?



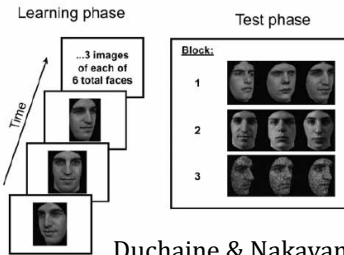
Jenkins, White, Van Montfort & Burton, *Cognition*, 2011

# Face recognition performance in humans

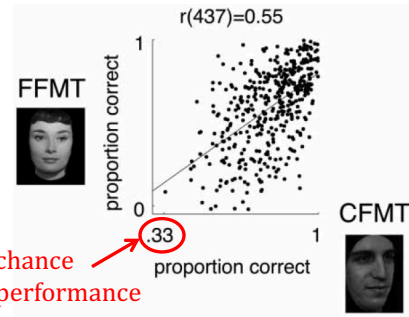
## Famous Faces Memory Test (FFMT)



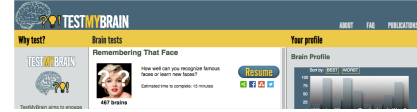
## Cambridge Face Memory Test (CFMT)



Duchaine & Nakayama, 2006



testmybrain.org




Wilmer et al., 2012

Psychology Experiments: Cami x  
 www.bbk.ac.uk/psychology/psychologyexperiments/experiments/facememorytest/startup.php

## Cambridge Face Memory Test

**Welcome to Cambridge Face Memory Test**



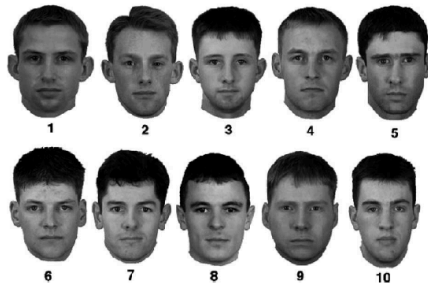
In the following task you will be required to memorize the faces of different individuals. You will then be asked to identify a face you memorized out of a line-up of three faces. The test will begin with a very easy practice round and then will become progressively more challenging. Instructions will be given throughout the task, please follow them carefully. The test will take approximately 20 minutes to complete.

If you have any questions about this on-line test, please contact Sue Nicholas ([s.nicholas@bbk.ac.uk](mailto:s.nicholas@bbk.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@bbk.ac.uk](mailto:m.eimer@bbk.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:

Labeled Faces in the Wild (LFW, <http://vis-www.cs.umass.edu/lfw>)  
 > 13,000 images of celebrities, 5,749 different identities

YouTube Faces Database (YTF, <http://www.cs.tau.ac.il/~wolf/ytfaces>)  
 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

	LFW	YTF
Facebook DeepFace	97.4%	91.4%
Google FaceNet	99.6%	95.1%
Human performance	97.5%	89.7%





# Machine vision applications of face recognition

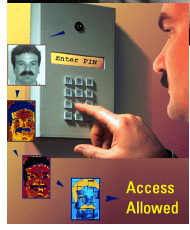
security, forensics



access control



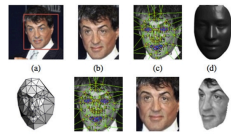
surveillance



# More applications of face recognition

### Facebook's New Face-Recognition Software Is Scary Good

By WIRED.com



content-based image retrieval

### Facial recognition app matches strangers to online profiles

See someone on the train you'd like to date? NameTag, an upcoming app for Android, iOS, and Google Glass uses facial recognition technology to match proximity to your social media and dating info.

By MICHAEL BERRY FOR WIREIMAGE.COM / JANUARY 1, 2014 10:28 AM PST



social media

SECURITY 10/18/2013 @ 9:17AM 20,302 views

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

Comment Now Follow Comments

Since Google Glass first appeared, its potential for facial recognition has been seen either as a privacy nightmare or as one of the headset's first truly intriguing uses. Google has declared itself in the first camp. Stephen Balaban is in the second, and he's about to share his vision with Glassheads everywhere, whether Google likes it or not.



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

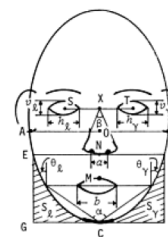
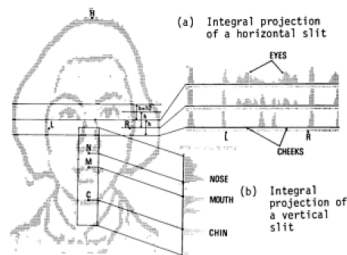
Facial expression – mood, emotion

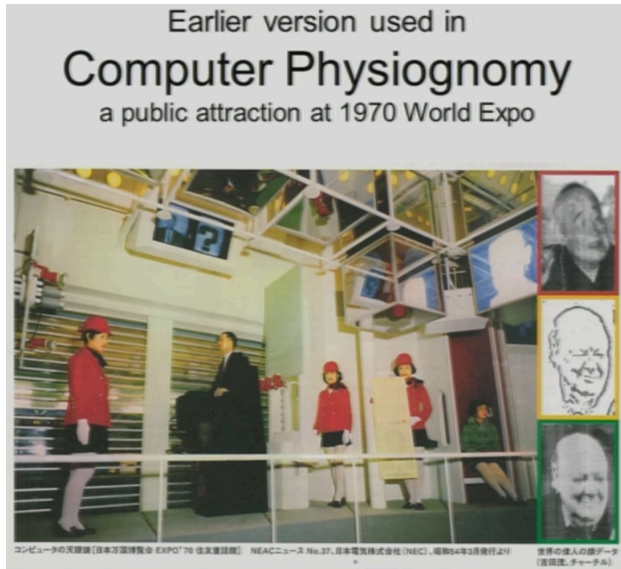
*Non-verbal social perception and communication*

## It all began with Takeo Kanade (1973)...

PhD thesis, *Picture Processing System by Computer Complex and Recognition of Human Faces*

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





- From talk by Takeo Kanade, *CBMM Face ID Challenge Workshop*

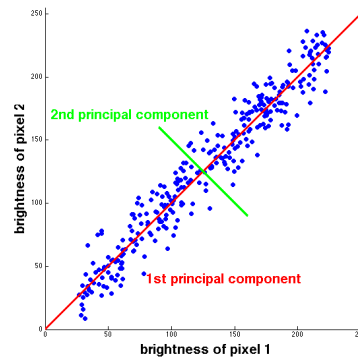
## Eigenfaces for recognition (Turk & Pentland) Principal Components Analysis (PCA)

**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



131	103	79	75	73	77	86	78	108
77	64	52	47	44	41	44	49	50
53	45	41	50	62	72	80	86	83
38	26	32	60	76	69	62	65	58
41	39	71	118	121	84	66	79	66
44	51	89	123	118	77	75	107	165
81	84	102	120	108	79	73	88	84
62	67	83	105	116	102	73	50	73



## Typical sample training set...



One or more images  
per person

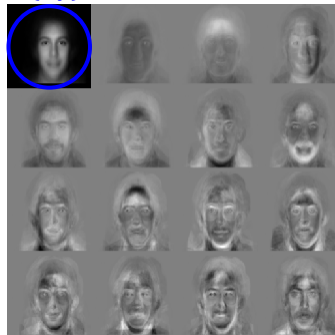
Aligned & cropped to  
common pose, size

Simple background

Sample images from the Yale face database

## Eigenfaces for recognition (Turk & Pentland)

$\Psi(x,y)$



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)

<http://vismod.media.mit.edu/vismod/demos/facerec/basic.html>

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

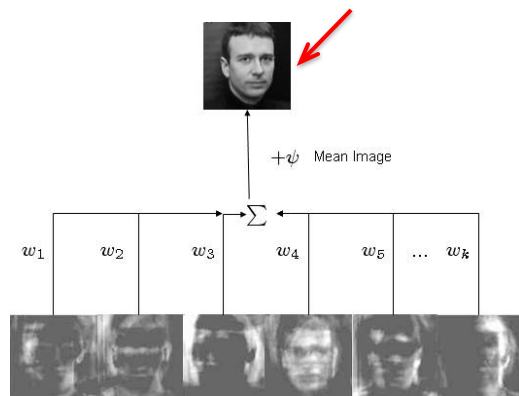
$$F(x,y) = \Psi(x,y) + \sum_i w_i * E_i(x,y)$$

1-16

## 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.

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

## Faces everywhere...

