Face Recognition: Some Challenges in Forensics

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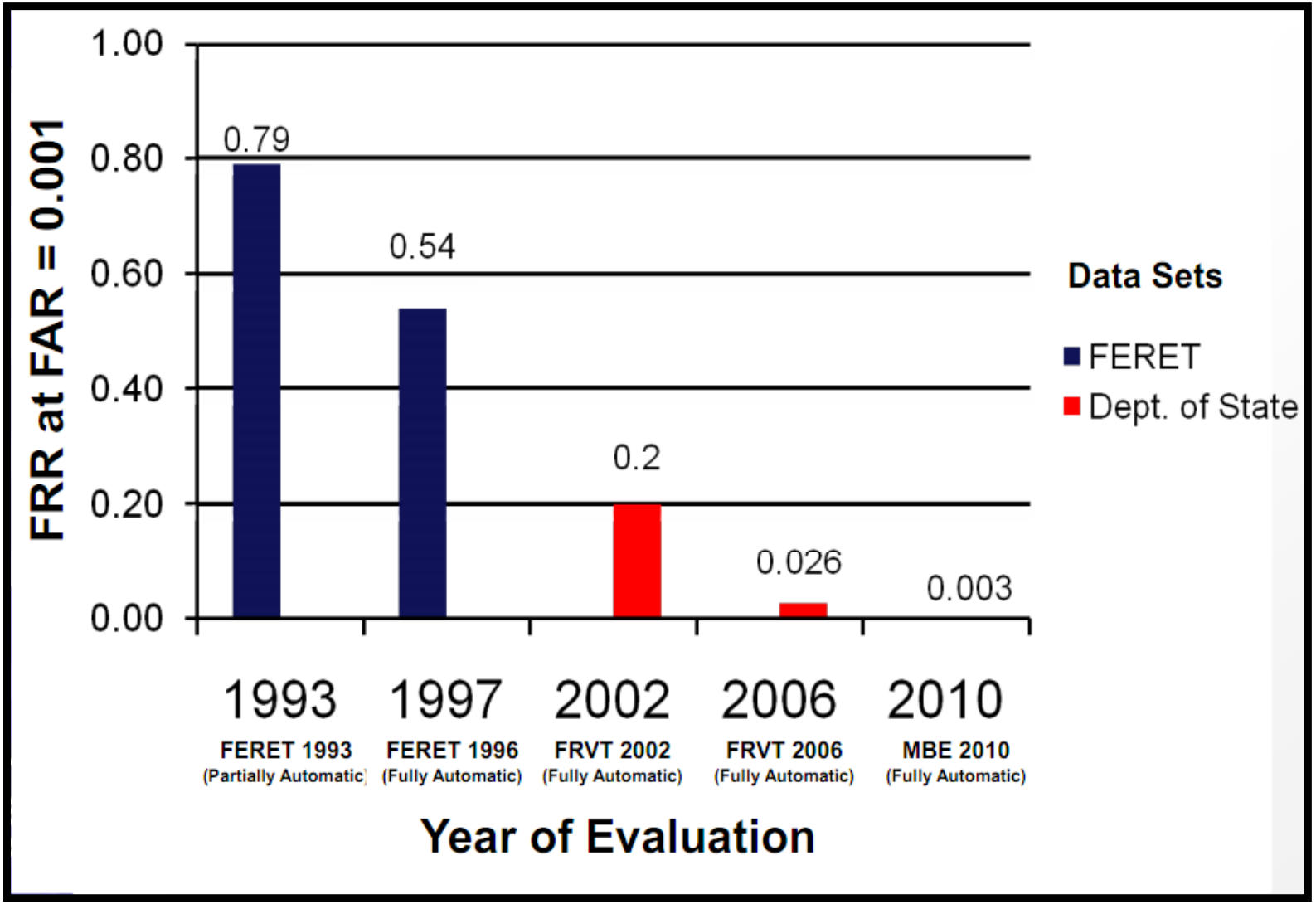
Forensic Identification

- Apply science to analyze data for identification
- Traditionally:
  - Latent FP, DNA, shoeprint, blood spatter analysis, etc.
- Today:
  - **Automated Face Recognition**

Forensic Face Recognition

- A tool for law enforcement
- Not an “end all” solution
- Make use of whatever data is available
- Probe images often “different” from gallery images (heterogeneous FR)
- Leverage legacy face databases that cover majority of population

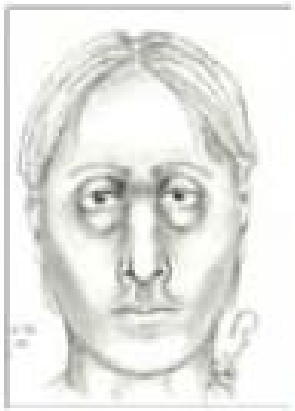
Progress in Face Recognition

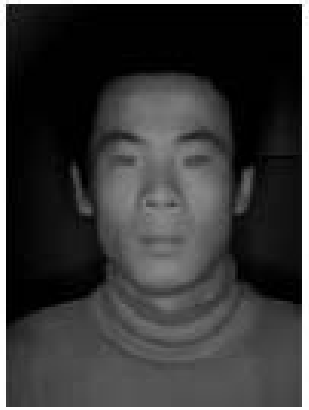


J. Phillips, IEEE Fourth International Conference on Biometrics: Theory, Applications, and Systems (BTAS 2010).

Progress in Face Recognition

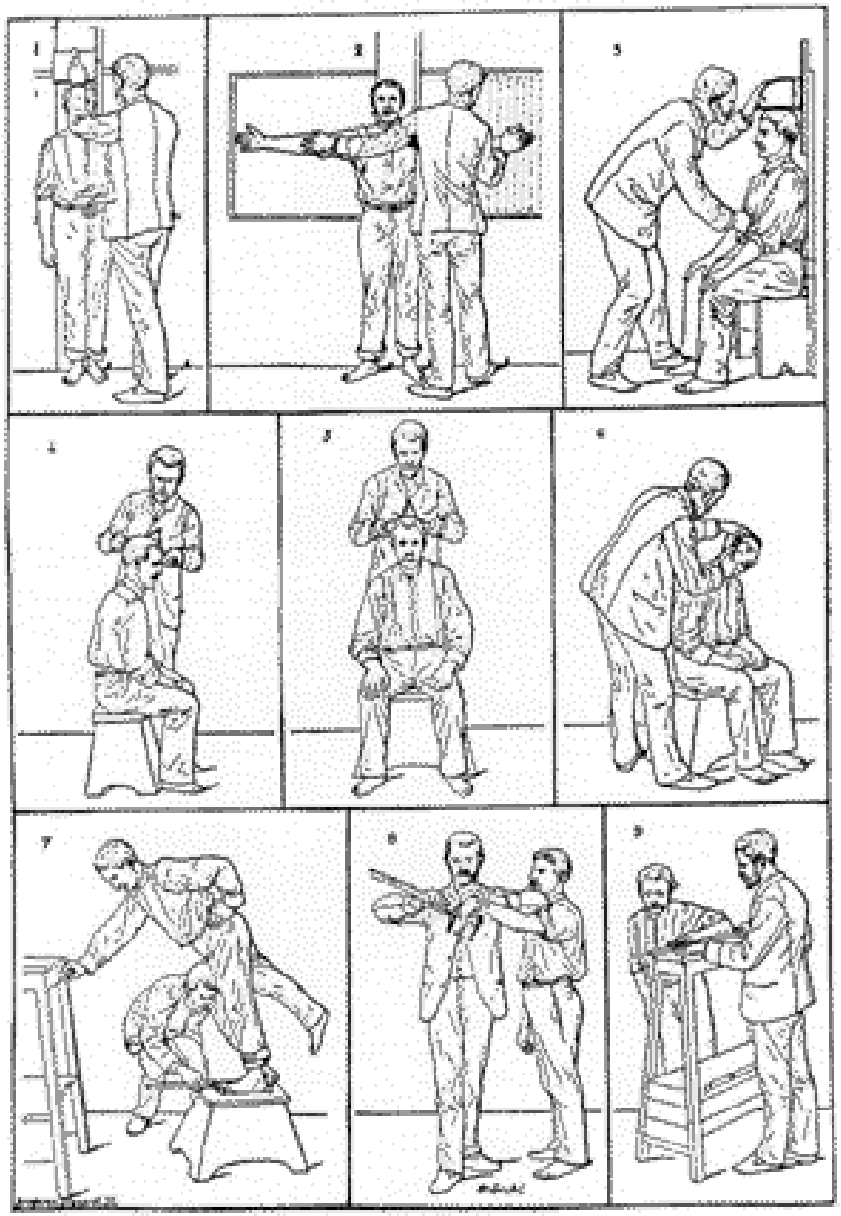
- Exponential decrease in error rates in controlled environment
- **However** - accuracy decrease due to variations in pose, expression, resolution, and illumination well documented
- Forensic face recognition faced with all these challenges
- Must make use of any available face images or ancillary data, no matter the quality



Brief History of Face Recognition

Bertillon System (1882)



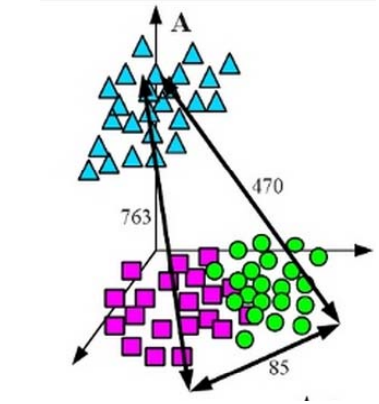
Value of photographing prisoners was recognized by the *Habitual Criminal Act, U.K.,* 1869

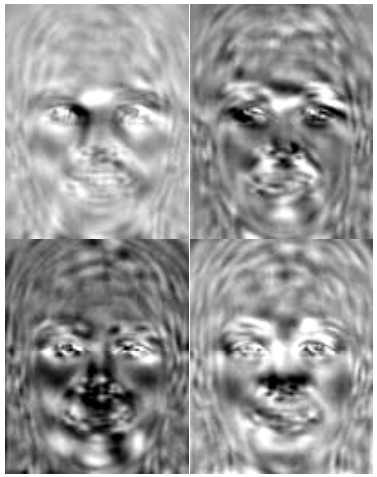
H.T.F. Rhodes, Alphonse Bertillon: Father of Scientific Detection, Harrap, 1956

Some Seminal Advances in FR

EigenFaces

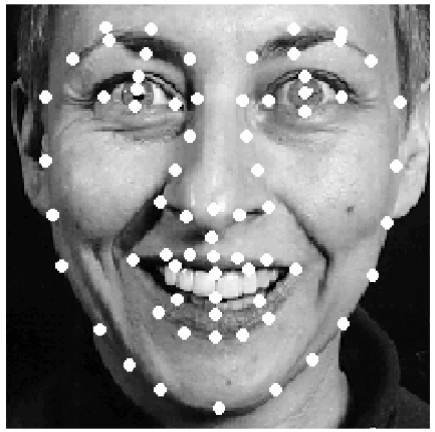
1990





Fisherfaces

1995



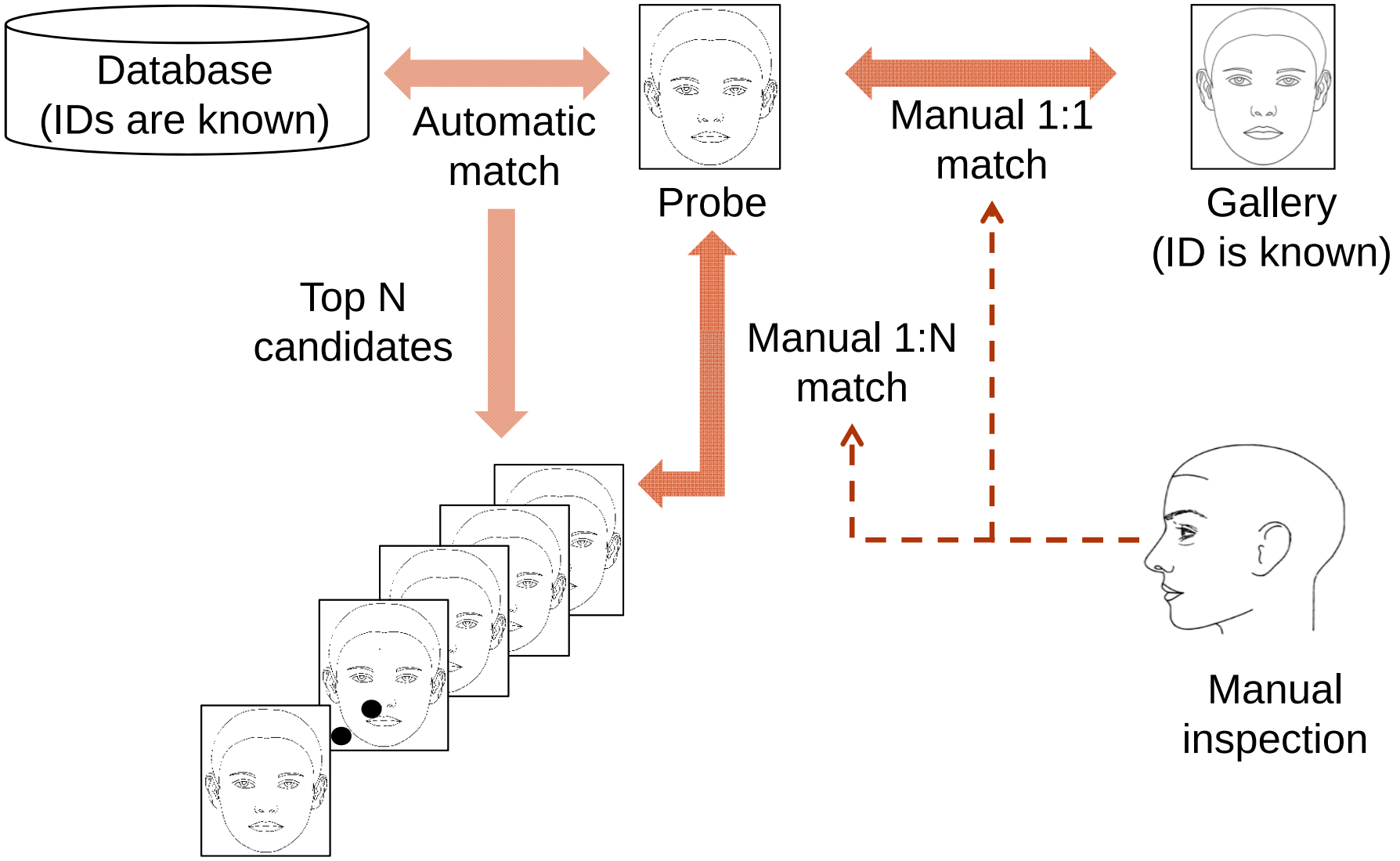
Active Appearance Models

2000

Local Binary Patterns

2005

Forensic Face Recognition Paradigm



Challenges in Forensic Face Recognition

- Facial Aging
- Facial Marks
- Forensic Sketch Recognition
- Face Recognition in Video
- Near-Infrared Face Recognition

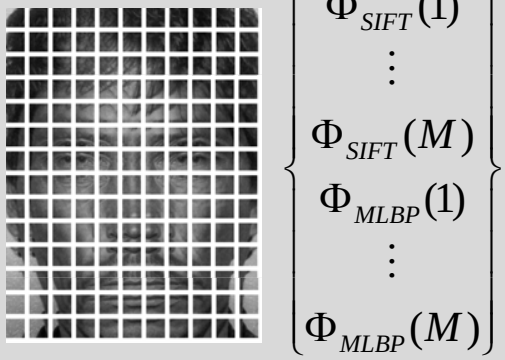
Age Invariant Face Recognition

- Face shape/texture change over time
- Current FR engines are not robust to changes incurred from aging process
  - Impact: Missing child, screening, and multiple enrollment
- Approaches:
  - Aging model for age progression/synthesis
  - Age invariant discriminative features

Age Invariant Face Recognition

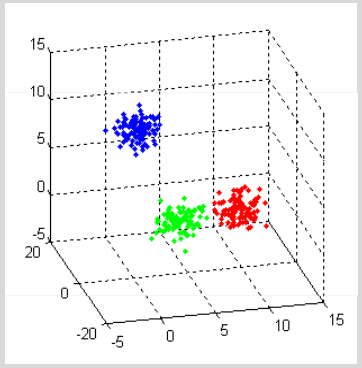
Training set
(age-separated images)

Approach #1: aging invariant subspace learning



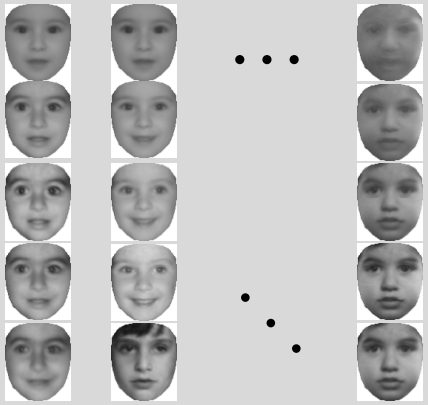
$$\begin{Bmatrix} \Phi_{SIFT}(1) \\ \vdots \\ \Phi_{SIFT}(M) \\ \Phi_{MLBP}(1) \\ \vdots \\ \Phi_{MLBP}(M) \end{Bmatrix}$$

Feature extraction & subspace learning



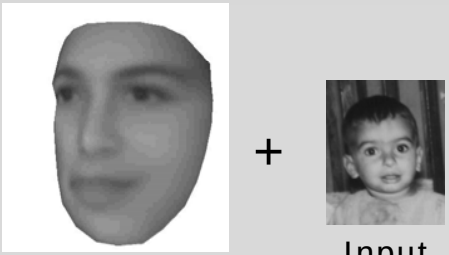
Build classifiers: Minimize within-subject variation & maximize between-subject variation

Approach #2: appearance aging model



Learn appearance aging pattern

$$\Phi' = \{\varphi_0, \varphi_1, \ldots, \varphi_N\}$$



3D aging model + Input

Aging simulation

Matching Results

Probe Images


Age 51


Age 40


Age 42


Age 62

Gallery Images


Age 41

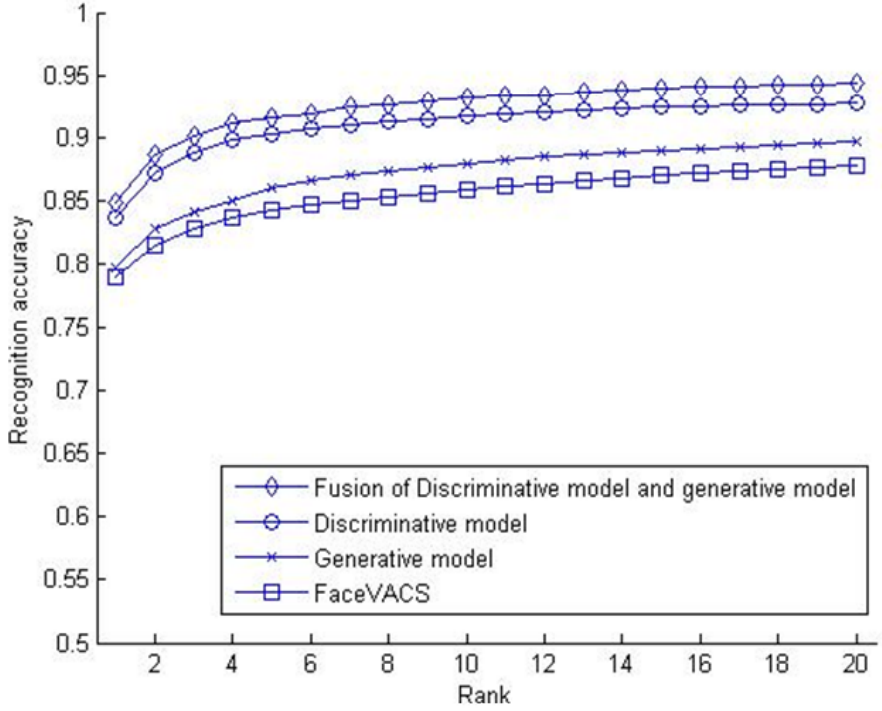

Age 34


Age 41


Age 62

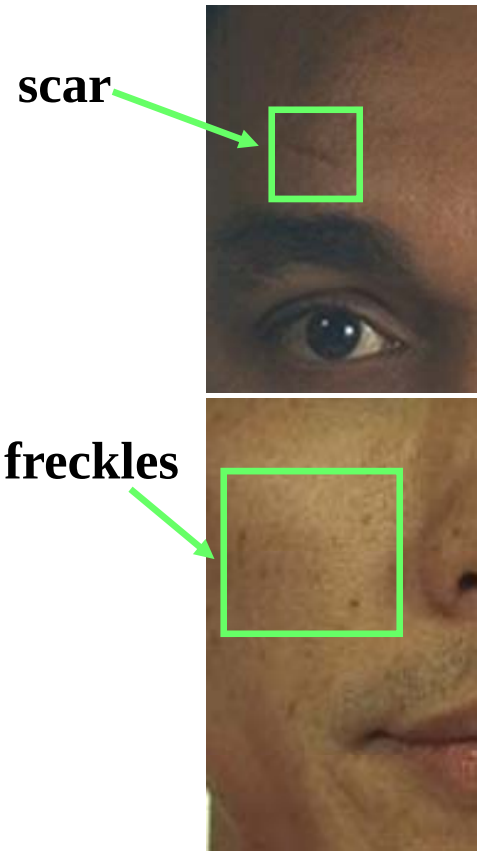
FaceVACS and generative method fail; discriminant method succeeds

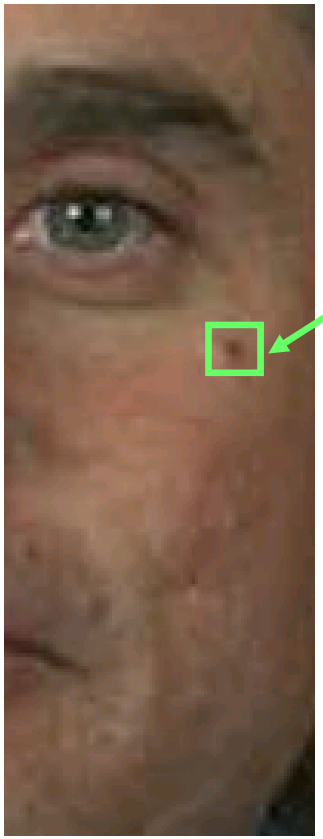
Discriminant method fails; FaceVACS and generative methods succeed



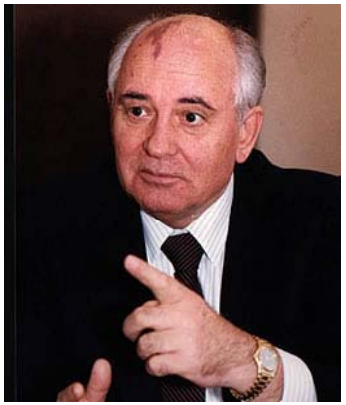
Facial Marks

- “Level 3” face features that offer additional evidence of individuality
- Support textual retrieval of candidate face images
- Matching or retrieval from a partial or non-frontal image
- Key approach to distinguishing between identical twins





Partial face

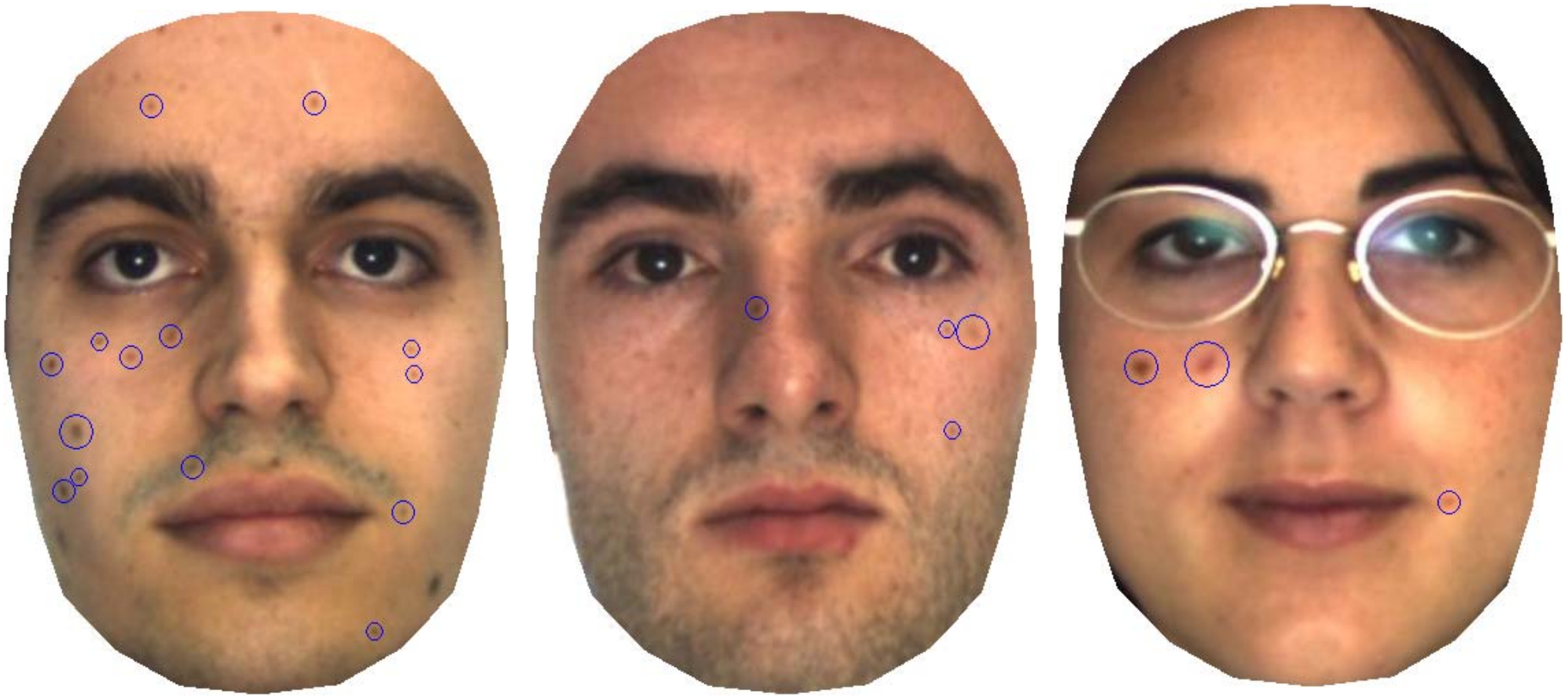


Birth mark

Non-frontal (video frame)

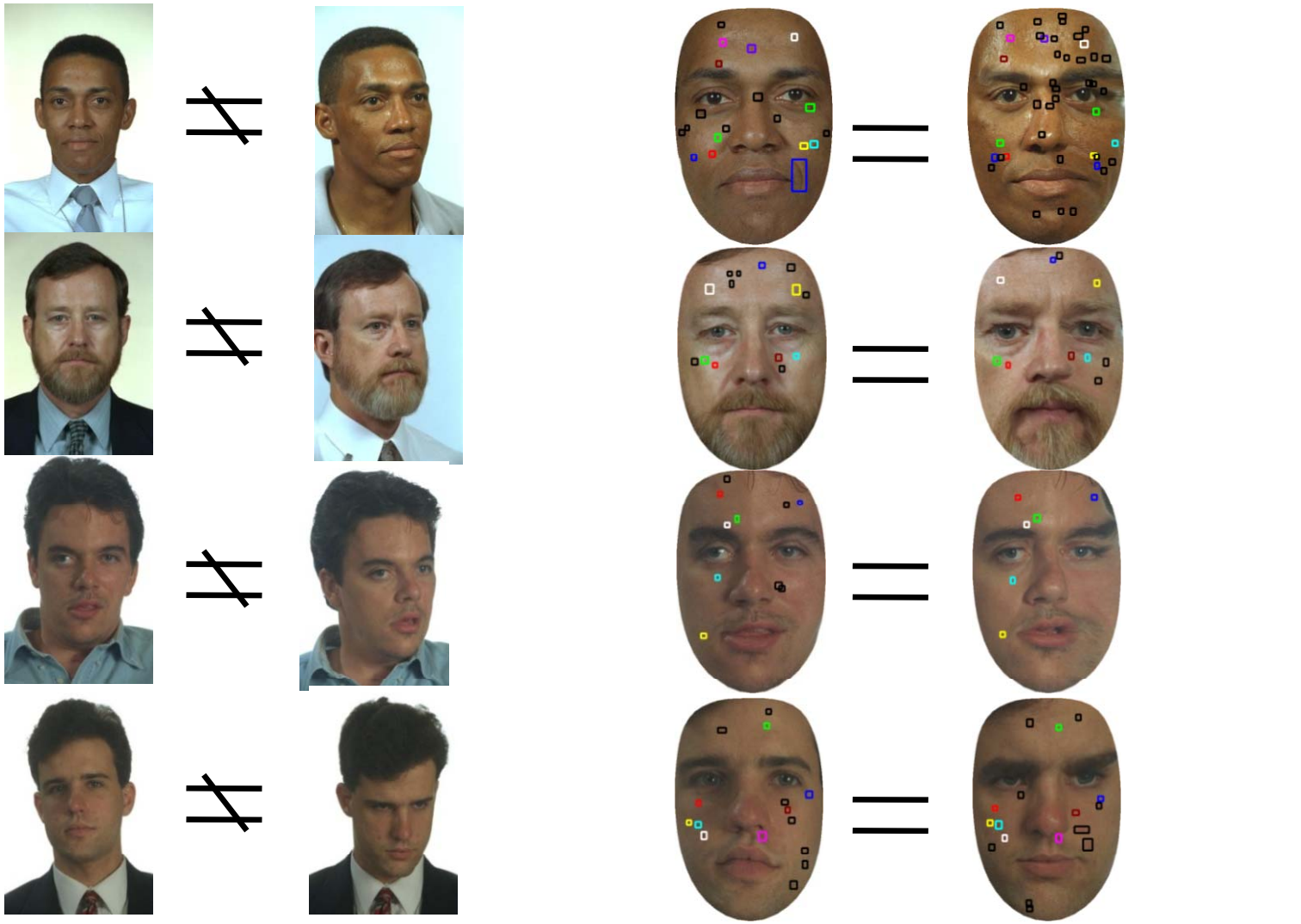
Tattoo

Automatic Facial Mark Detection



Facial Mark Detection & Matching

- Faces from FERET database where FaceVACS failed to match at Rank-1, but fusion of FaceVACS & face marks was successful



(a) Probe (b) Gallery (c) Probe (mean shape) (d) Gallery (mean shape)

Forensic Sketch Recognition

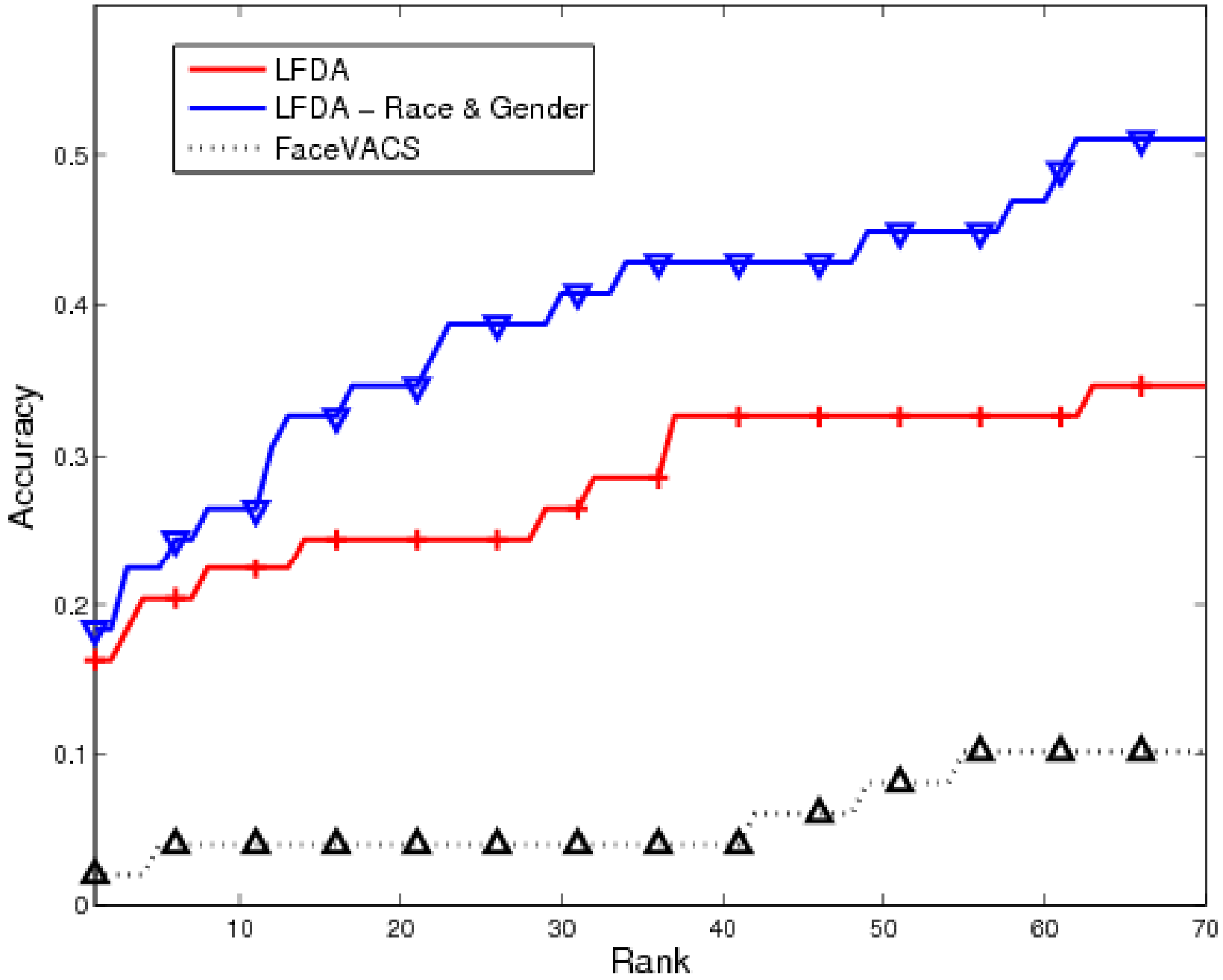
- Sketches drawn from human memory when no image available
- Worst of crimes committed (murder, sexual assualt, etc.)
- Allows to search face databases using verbal description

Method	Rank
LFDA	1
FaceVACS	320

Method	Rank
LFDA	1
FaceVACS	299

Method	Rank
LFDA	1
FaceVACS	2131

Sketch Matching Results

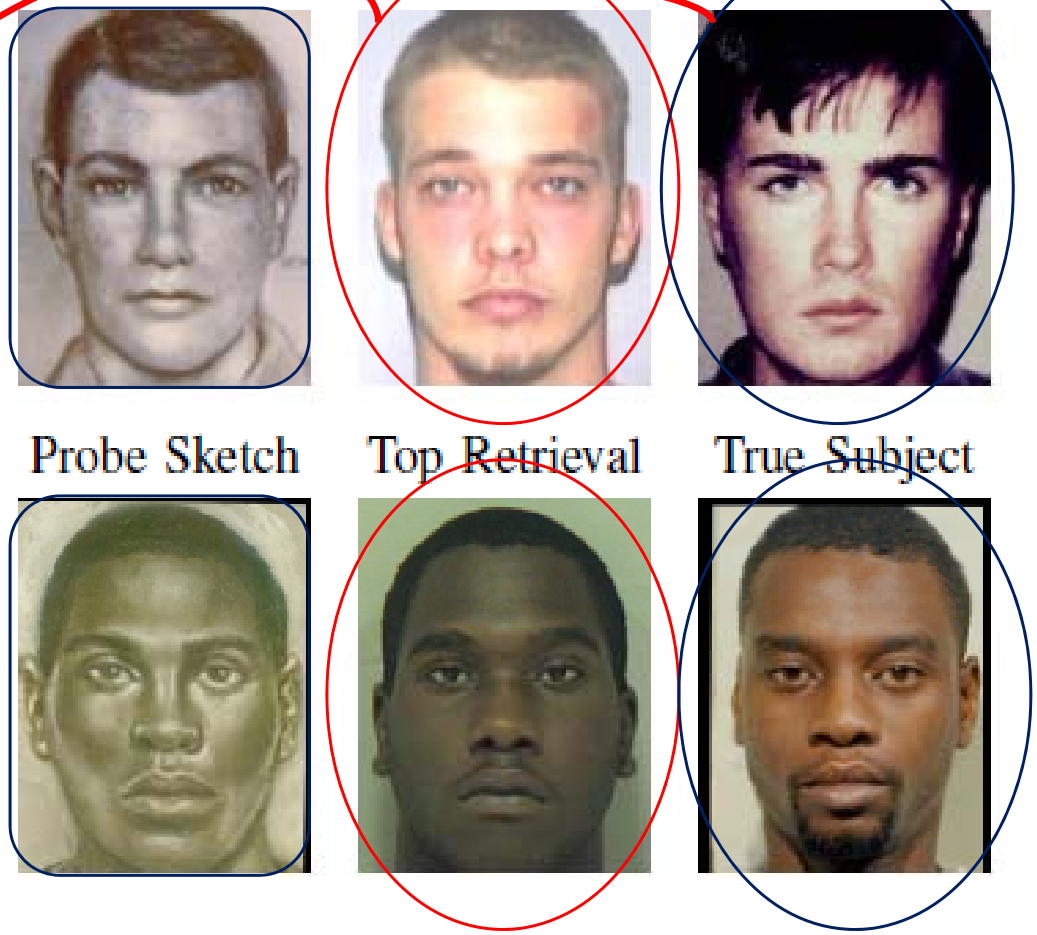


Forensic Sketch Recognition

- Critical for human investigator to vet results
- Example: system behaved correctly, but failed

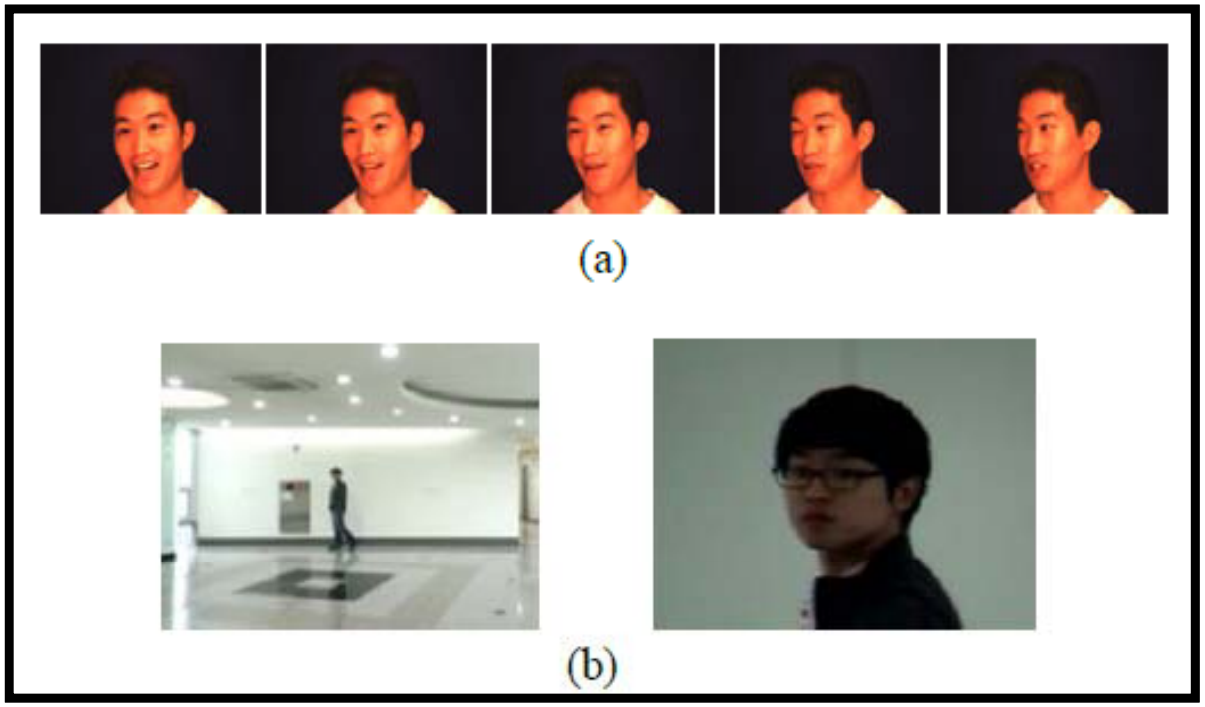
This mugshot was returned as the top match: it looks very similar to the subject

This is the true photograph. It does not look as similar.



Face Recognition in Video

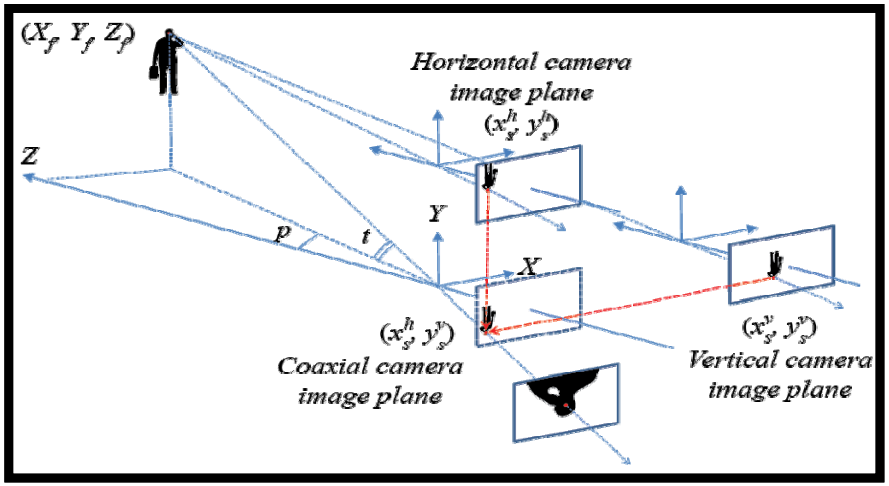
- Challenges from lighting, expression, compression, motion blur
- Benefit of temporal data (multiple frames)
- Hardware solution: PTZ + static camera
- Software solutions: Synthesis methods



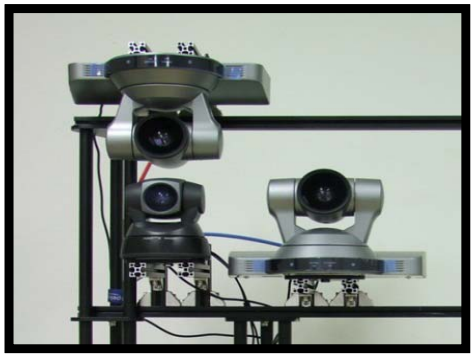
Cameras Everywhere

Face Recognition in Video

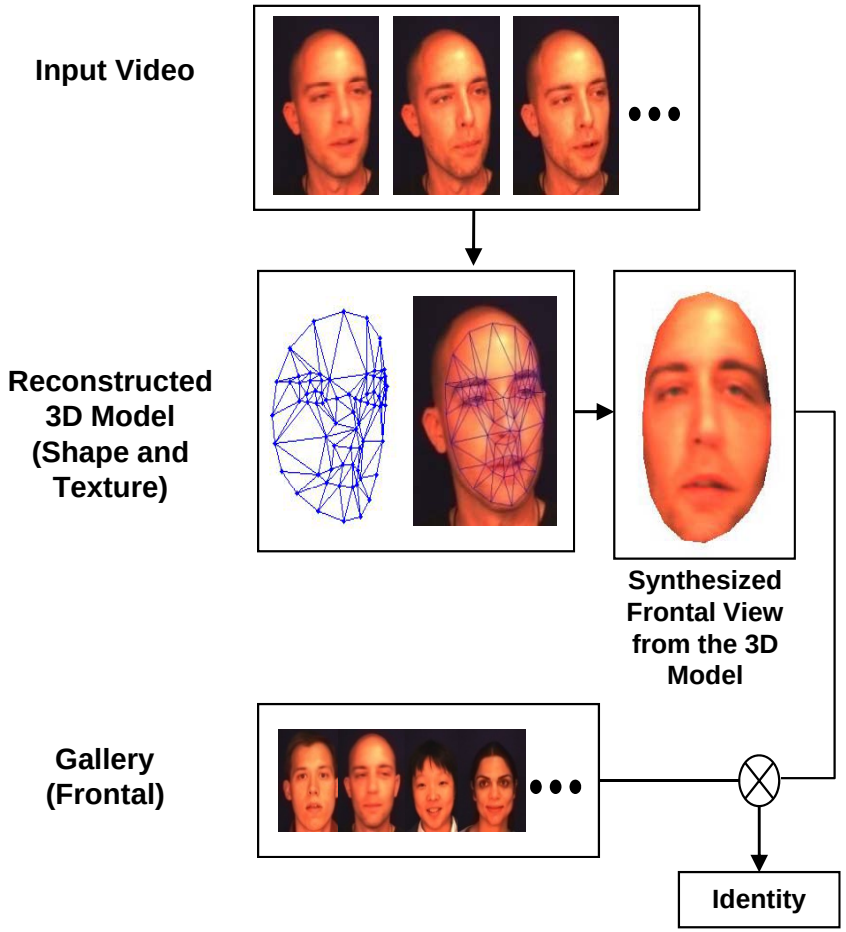
Hardware Methods



2 static + 1 PTZ cameras



Synthesis Methods

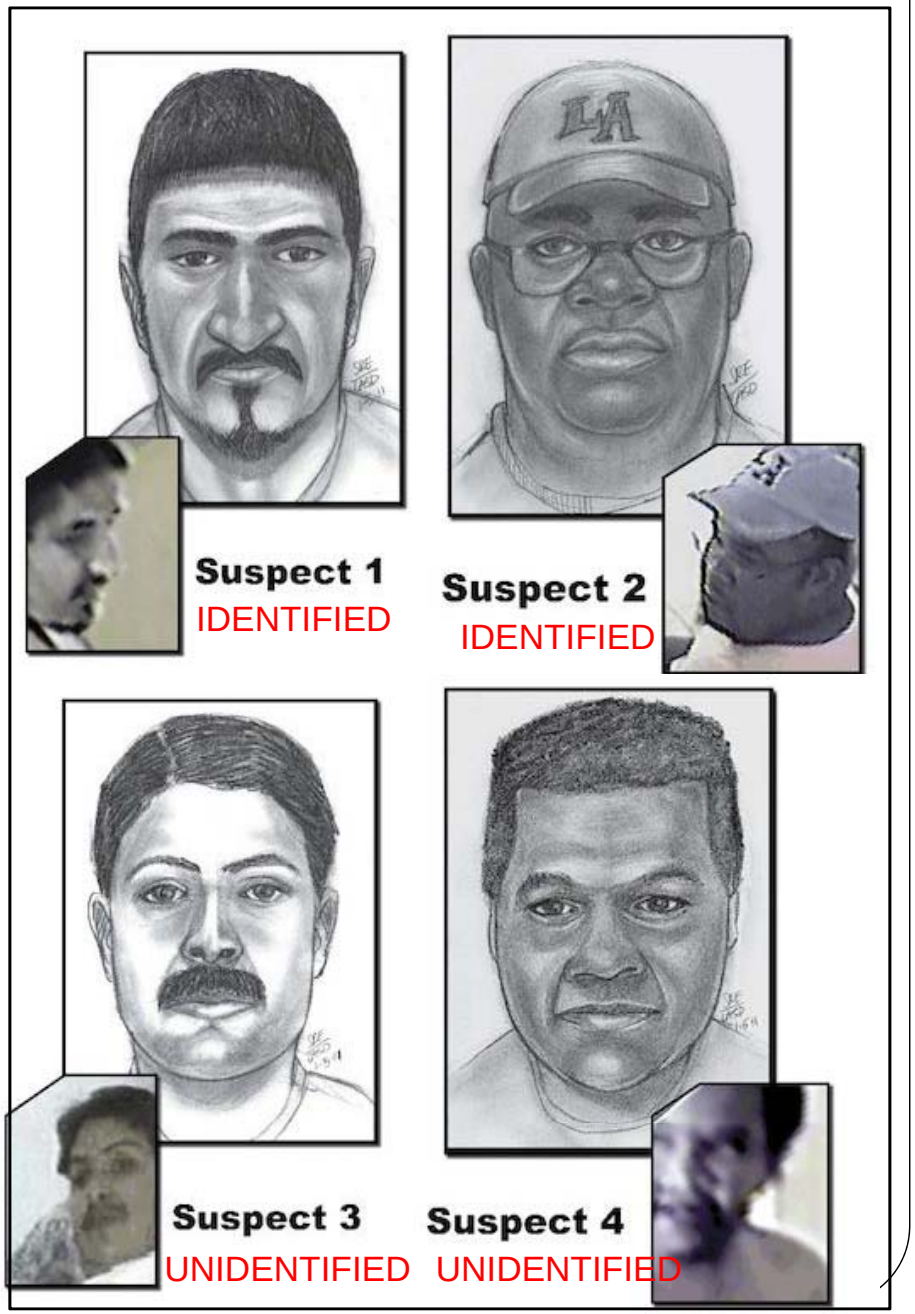


Sketch from Video

The New York Times

Los Angeles Officials Identify Video Assault Suspects

"Composite drawings of four of the suspects have been made based upon video images"



http://www.nytimes.com/2011/01/08/us/08disabled.html

http://www.lacrimestoppers.org/wanteds.aspx

Face Recognition at a Distance

Static camera, single person (6~12m)

PTZ camera, single person

Static camera, multi-person

PTZ camera, multi-person

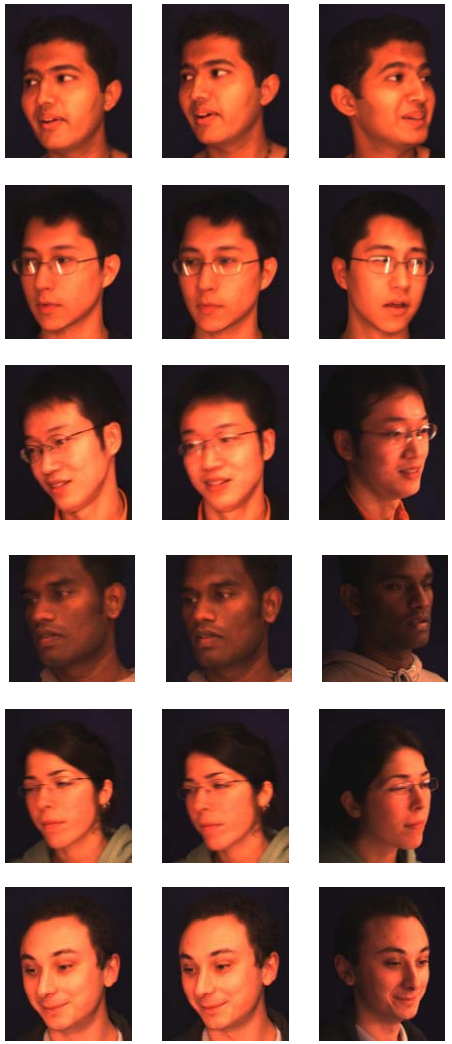
Face Recognition at a Distance

- Rank-1 face identification accuracies

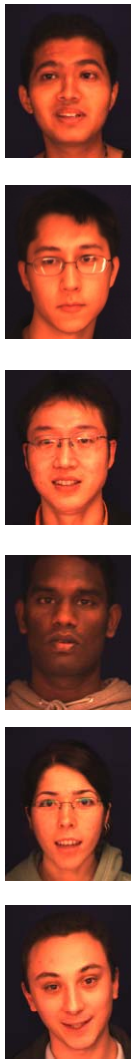
	Methods of identification	Rank-1 accuracy (%)
	Static view (conventional surveillance system)	0.1
	PTZ view, 1 frame, (coaxial camera system)	48.8
Rejection scheme (reject if score < t_r)	PTZ view, 1 frame, t_r=0.31	64.5
	PTZ view, 1 frame, t_r=0.45	78.4
Fusion	PTZ view, fusion of 10 frames	94.2
	PTZ view, fusion of 20 frames	96.9
	PTZ view, fusion of 30 frames	98.4

Examples of 3D Face Reconstruction

- Frames in test videos (a) are not correctly matched with gallery (b); frontal faces generated with 3D models in (c) are correctly matched to (b), except the last one



(a)
Example frames in the original video
(Frontal views are not included)



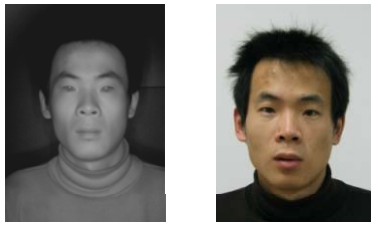
(b)
Example images in the
gallery database

(c)
Reconstructed 3D face model

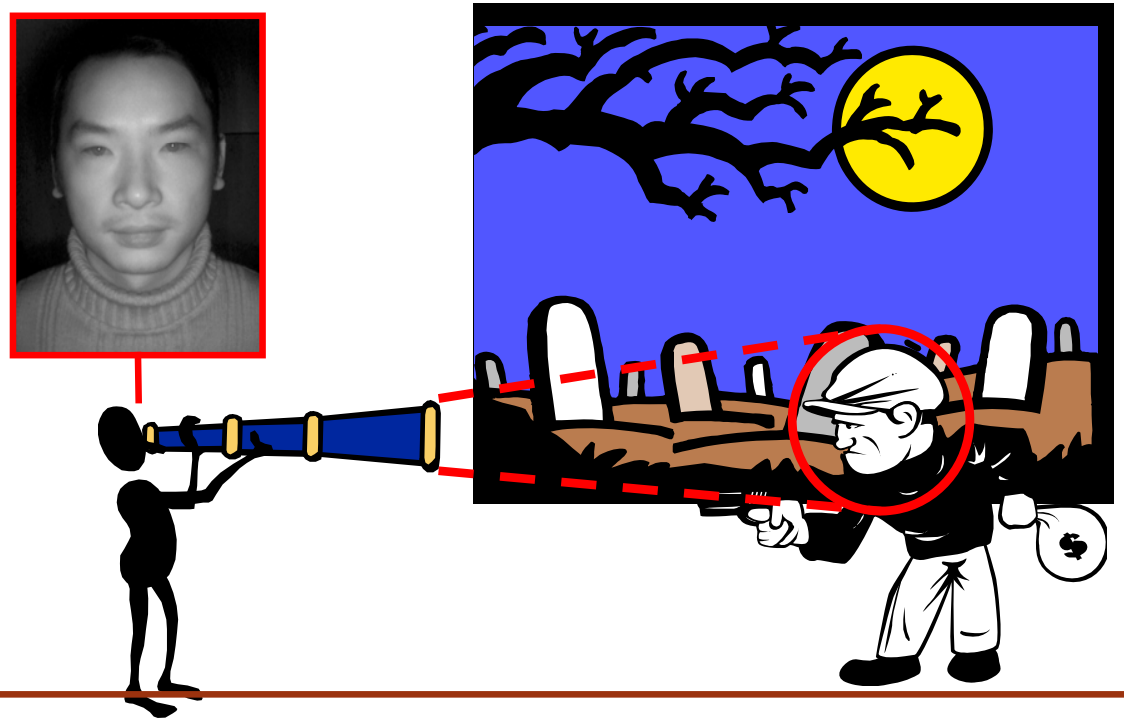
Near-Infrared Face Recognition

- Often necessary to acquire face images in the NIR spectrum
  - Nighttime surveillance, controlled indoor illumination
- Gallery databases contain visible face images
- Need for algorithms to match NIR to visible photographs

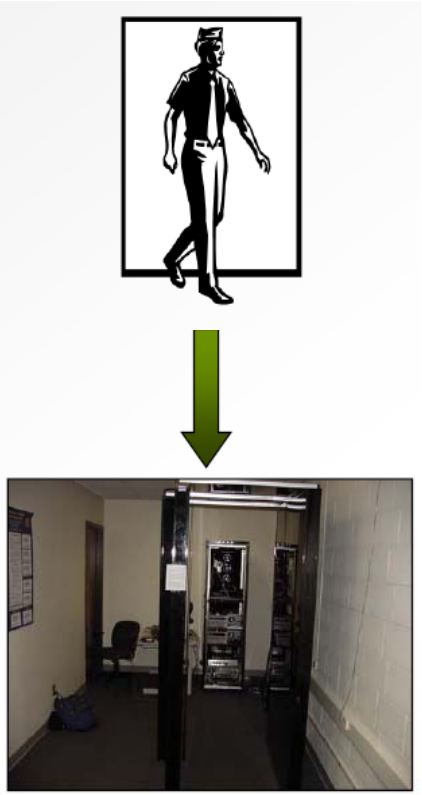
Example of NIR and VIS image



Nighttime Surveillance Face Acquisition



Portal w/ Covert Controlled Illumination

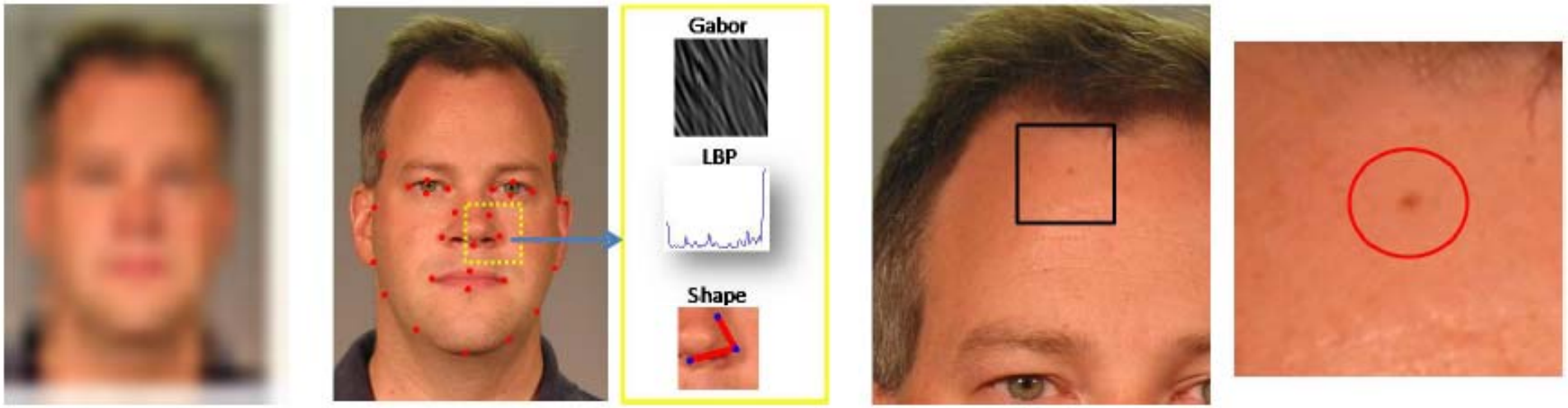


Images from: P. Jonathon Phillips. "MBGC Portal Challenge Version 2 Preliminary Results".

Open Challenges in Forensic Face Recognition

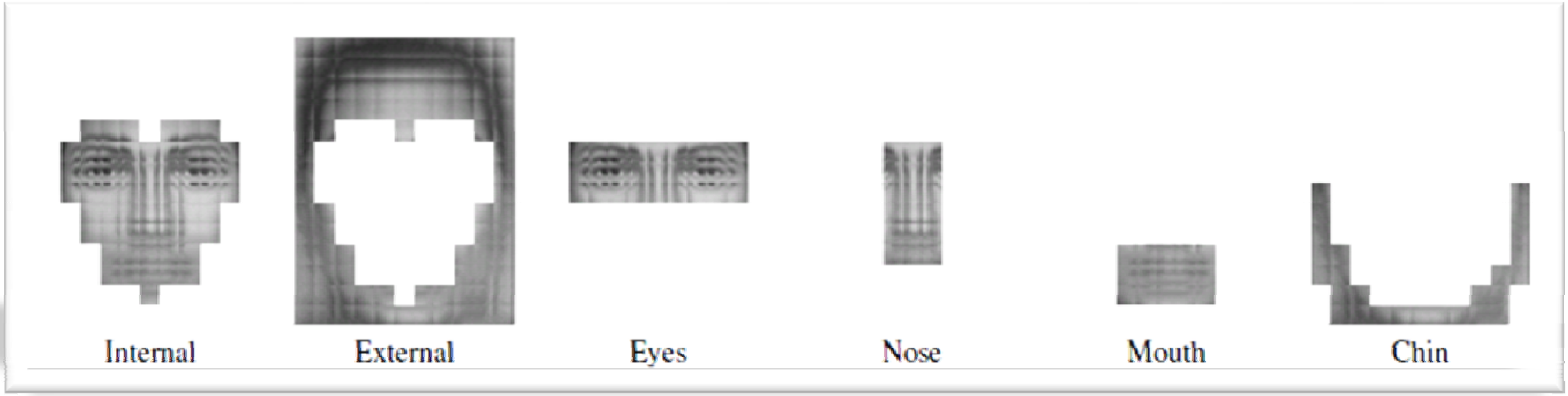
Some Future Challenges in Face Forensics

1. Face Individuality Models
   - Currently no model for probability of false match
   - Limits use of face recognition in the court system
   - Must follow lead from fingerprint



Some Future Challenges in Face Forensics

2. Component-based face recognition
   - Perform matching and retrieval per facial component
     - e.g. eyes, nose, mouth, eye brows, chin
   - Benefits partial face matching and individuality models



Summary

- Progress made on many challenging problems in forensic face recognition
- Not a lights out approach to face recognition
- Every situation is a little different for investigators
  - May need to combine multiple approaches shown
- Many open problems still remain

Questions?

- Thanks to
  - Additional collaborators:
    - Zhifeng Li, Shencai Liao, Alessandra Paulino, Hyun-Cheol Choi, and Arun Ross
  - Data collection:
    - Scott McCallum, Karl Ricanek, Insp. Greg Michaud, John Manzo, Stan Li, Lois Gibson, and Pat Flynn