

Biometrics

Technology for Human Recognition

Anil K. Jain

Michigan State University

<http://biometrics.cse.msu.edu>

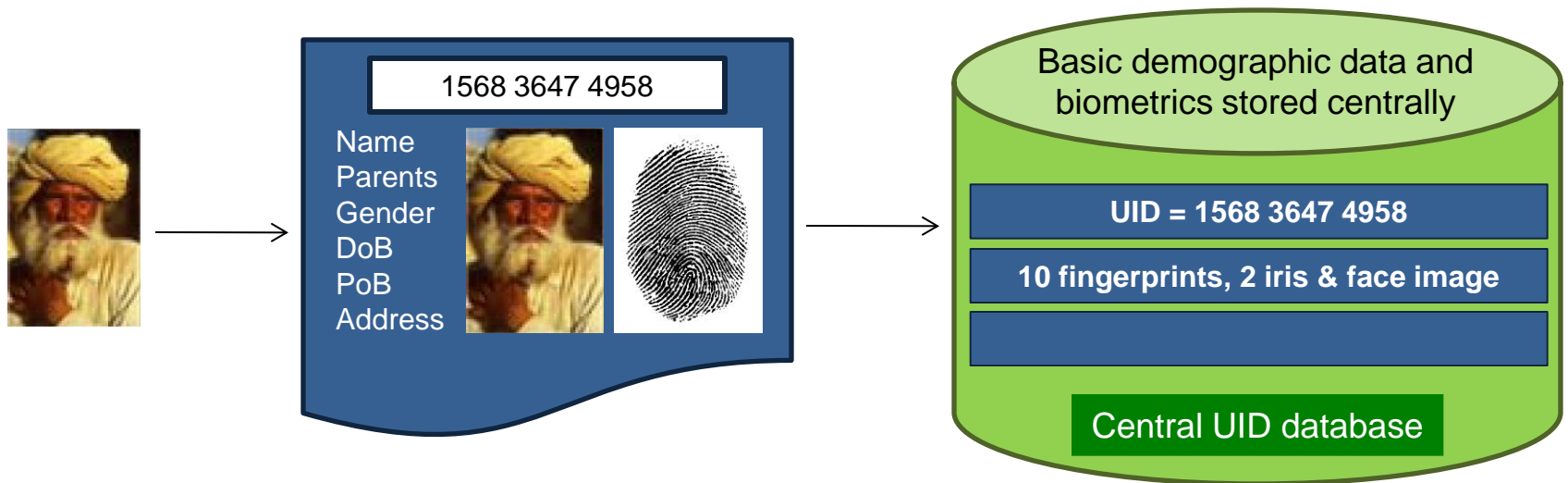
December 19, 2013

Mehrangarh Fort



Aadhar

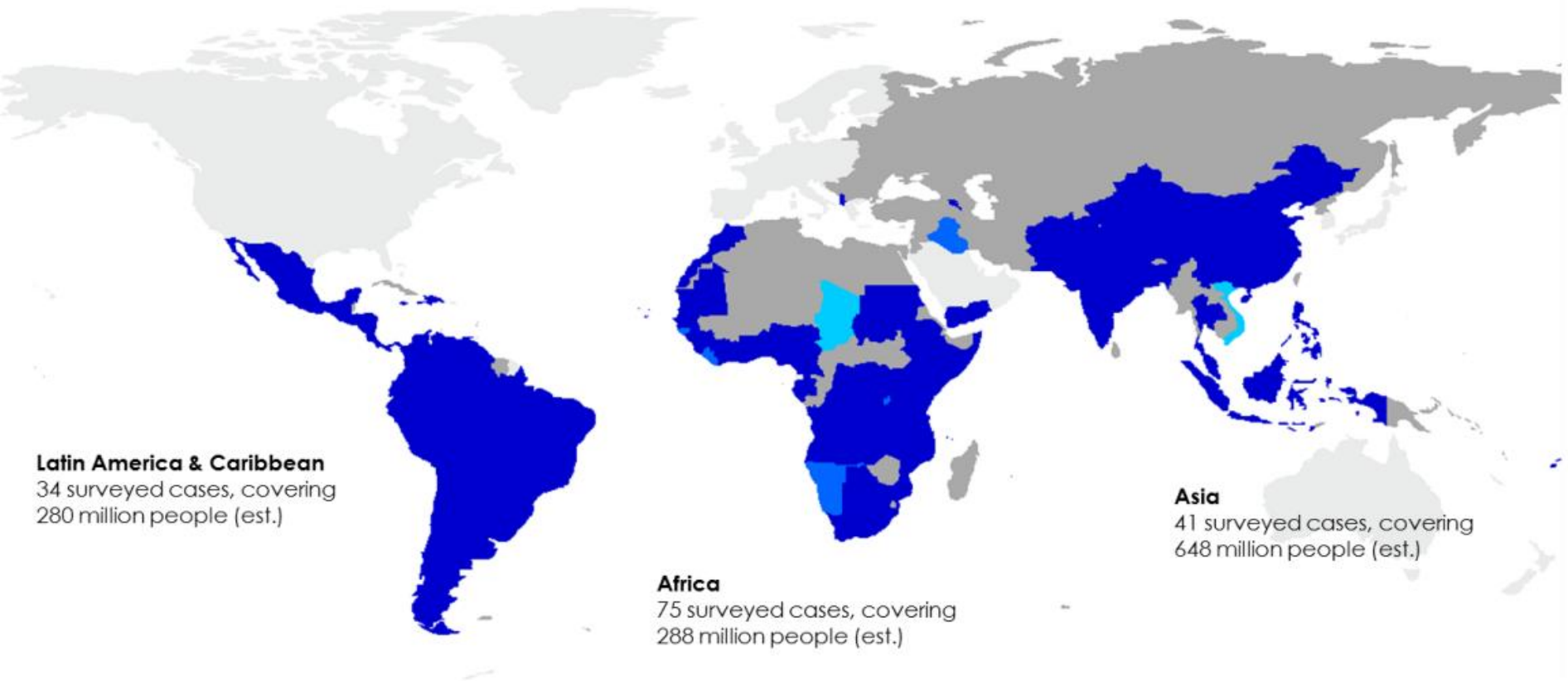
“Issue a unique identification number (**UID**) to Indian residents that can be verified and authenticated in an online, cost-effective manner, and that is robust to **eliminate duplicate and fake identities.**”



UIDAI has issued ~400 million Aadhaar numbers as of Aug 2013

Identification for **Development**: The Biometrics Revolution

Over 1 billion people have been covered by biometric identification programs in the Low Middle Income Countries



Latin America & Caribbean
34 surveyed cases, covering
280 million people (est.)

Africa
75 surveyed cases, covering
288 million people (est.)

Asia
41 surveyed cases, covering
648 million people (est.)

Prevalence of developmental biometrics:

- national ■ at least 1 country-wide application (e.g., national ID, elections)
- sub-national ■ at least 1 state or ministry-level application (e.g., civil service payroll, pensions)
- project ■ at least 1 project-level application (e.g., health and demographic survey)

*Identification for Development: The Biometrics Revolution, A. Gelb and J. Clark, Center for Global Development, NW, Washington DC, Working Paper 315, Jan. 2013, http://www.cgdev.org/sites/default/files/1426862_file_Biometric_ID_for_Development.pdf

Mobile Phones



Joseph Van Os / Getty Images

By 2014, more cell phone accounts than people; \$1 Trillion in mobile payments

Mobile Phone Security

iPhone 5s: Touch ID

얼굴인식 잠금해제 (Face Unlock)



Security Concerns

We now live in a society where people cannot be **trusted** based on **credentials**

- **Something you have**: ID card, passport
- **Something you know**: PIN, password



Fake Passports



- Two of the Sept. 11 attackers used stolen Saudi Arabian passports
- Spanish police arrested seven men, connected to al Qaeda, tasked with stealing 40 passports per month (Dec 2, 2010)

<http://press.homeoffice.gov.uk/press-releases/passport-warning?version=1>

<http://www.pbs.org/wgbh/pages/frontline/shows/trail/etc/fake.html>

<http://www.lonelyplanet.com/thorntree/thread.jspa?threadID=2071874>

Too Many Passwords!

Copyright 1996 Randy Glasbergen. www.glasbergen.com



“Sorry about the odor. I have all my passwords tattooed between my toes.”

Most common passwords: 123456, password, 12345678..

The Edible Password Pill

- Swallowed once daily, pill contains a chip that uses stomach acid to power it on
- Once activated, it emits a specific 18-bit EKG-like signal, detected by your mobile or computer, turning your body into a password



Biometric Technology Takes Off

By THE EDITORIAL BOARD, NY Times, September 20, 2013

“The use of biological markers like fingerprints, faces and irises to identify people is rapidly moving from science fiction to reality.”

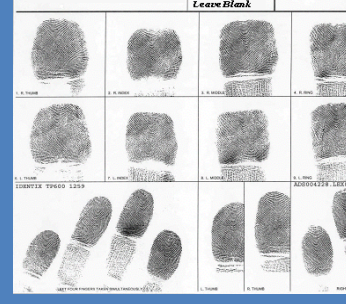
Multifactor Authentication

For a device to be secure, it should support multifactor authentication-- a combination of at least two of three components

- something users have (token)
- something users know (password)
- something users are (biometrics)

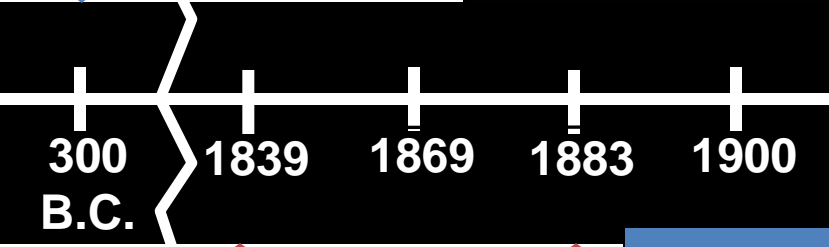


Biometric Milestones

APPLICANT Leave Blank	NAME Teacher, Theresa C.	LAST NAME Smith	DATE OF BIRTH 01/15/52	SEX F	RACE W	HAIR B	HEIGHT 5' 02"	WEIGHT 125	LEAVE BLANK
FORMERLY Theresa Smith	NYSED ID NYSED Dept-PP #3009, NY	CLASS Lea	CLASS Lea	LEAVE BLANK					
ADDRESS 308 School Street Hometown, NY 11111	ADDRESS Smart Falls Central School Dist Smart Falls, NY 11111	LEAVE BLANK							
5/01/02	LEAVE BLANK								
									



Gal
Habi
Crimin
Fir
po



State Al
A Chinese deed of sale with a fingerprint
Criminal Booking



Uniqueness



Identical twins

Persistence



1881, age 7



1890, age 17



1913, age 40

Herschel's fingerprints

Similarity values: Age 7 vs. Age 17 = 6,217; Age 7 vs. Age 40 = 5,032; Age 17 vs. Age 40 = 5,997
(Maximum score between fingerprints from two different fingers = 3,300)

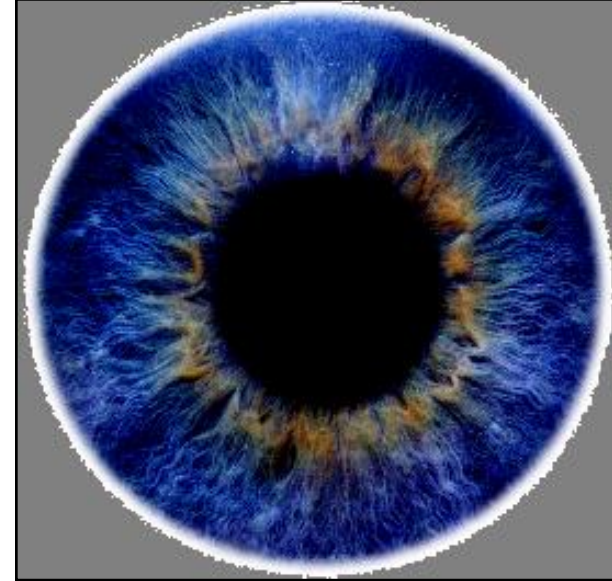
Most Popular Traits



- Legacy database
- 1:N search
- NIST evaluation

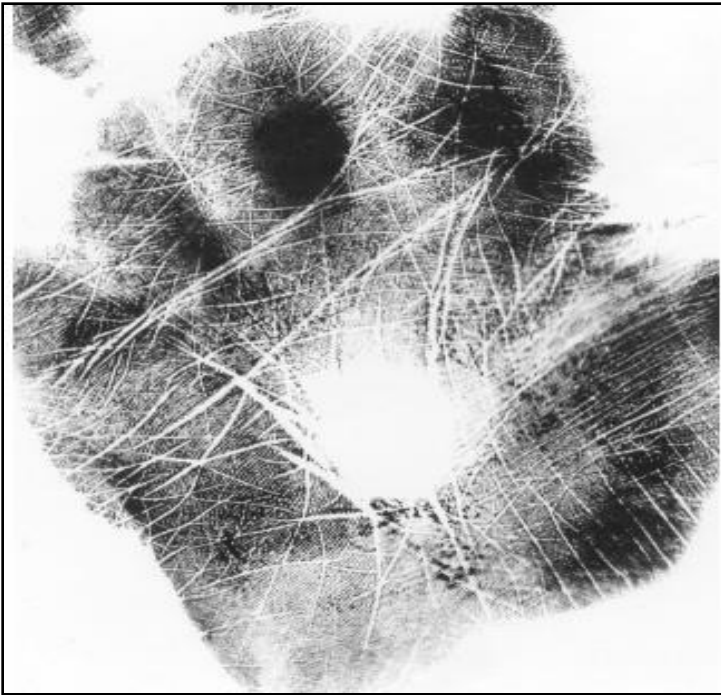


- Legacy database
- 1:N search
- NIST evaluation
- **Covert capture**



- Gaining popularity
- 1:N search
- NIST evaluation

Traits Capable of 1: N search



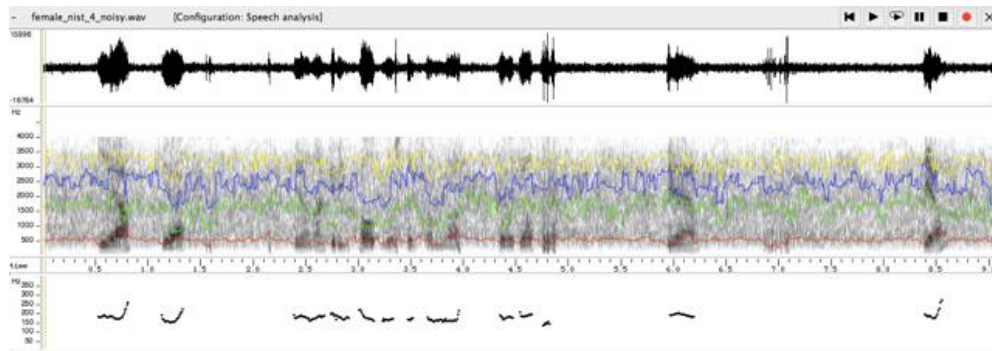
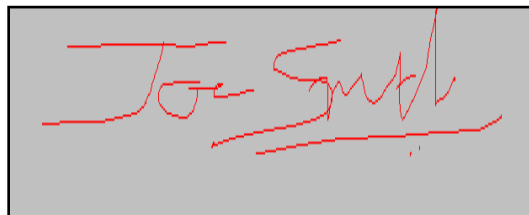
- ~30% of latents are of palmprints
- FBI's NGI will have latent palmprint matching capability



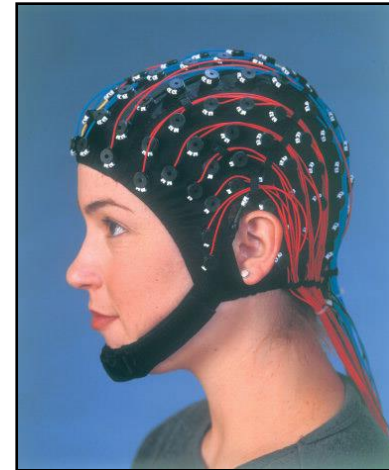
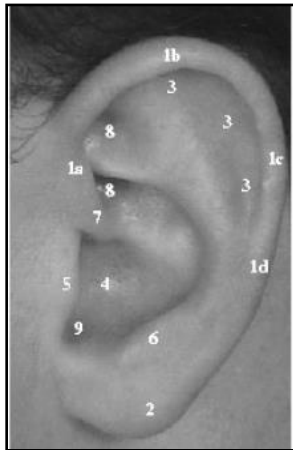
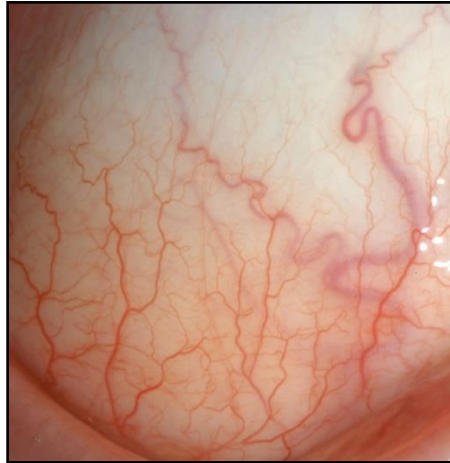
- Trace evidence
- Innocence project
- Real-time DNA matching

Traits in Commercial Systems

Primarily used for 1:1 match



Traits in Laboratory Stage



Rejected Traits



Applications

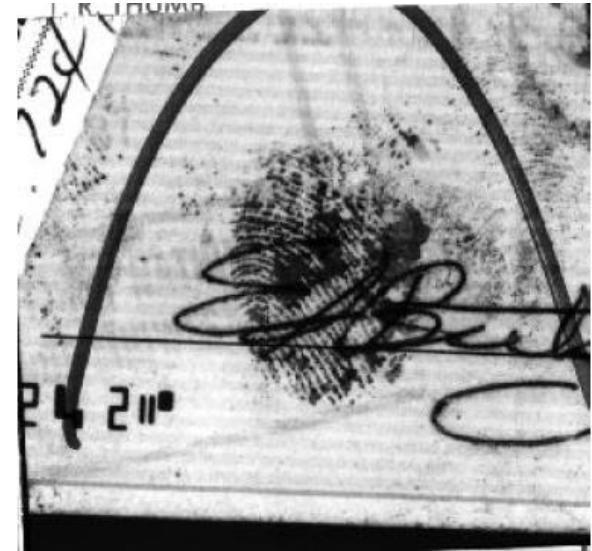
- **Security**: Does the applicant have prior criminal record?
- **Convenience**: No need to carry credentials
- **Audit trail**: Who accessed the bank vault?
- **Fraud**: Is the credit card holder the rightful owner?
- **De-duplication**: One person, one document!

In the Houston hospital system 2,488 women (among ~3.5 M patients) are named Maria Garcia and 231 of them have the same birth date!

Fingerprints in Forensics

- **Repeat Offenders:** Compare rolled or slap tenprints
- **Crime Scene evidence:** Compare **latents** to tenprints

APPLICANT		LEAVE BLANK <i>Leave Blank</i>		TYPE OR PRINT ALL INFORMATION IN BLACK LAST NAME, FIRST NAME, MIDDLE NAME <i>Teacher, Theresa C.</i>		FBI		LEAVE BLANK <i>Leave Blank</i>	
SIGNATURE OF PERSON FINGERPRINTED		ALIASES AKA <i>Formerly: Theresa Smith</i>		OR I NY9219402 NYSTED Dept-FPU ALBANY, NY		DATE OF BIRTH DOB <i>12/31/70</i>			
RESIDENCE OF PERSON FINGERPRINTED <i>318 School Street Hometown, NY 11111</i>		CITIZENSHIP CTRY <i>US</i>		SEX SEXF <i>F</i>		HEIGHT HT <i>5'7"</i>		WEIGHT WT <i>155</i>	
DATE <i>5/01/02</i>		SIGNATURE OF OFFICIAL TAKING FINGERPRINTS <i>Leave Blank</i>		HAIR HT <i>Leave Blank</i>		EYES EYE <i>Gr</i>		HAIR HAIR <i>Bro</i>	
EMPLOYER AND ADDRESS <i>(if applicable) Smart Falls Central School Dist Smart Falls, NY 11111</i>		ARMED FORCE(S) NO. MINT <i>Leave Blank</i>		SOCIAL SECURITY NO. SSNO <i>000-10-1111</i>		CLASS		LEAVE BLANK <i>Leave Blank</i>	
REASON FINGERPRINTED <i>Leave Blank</i>		BENEFIT CLAIM(S) NO. MINT <i>Leave Blank</i>		REF		LEAVE BLANK <i>Leave Blank</i>			
1. R. THUMB		2. R. INDEX		3. R. MIDDLE		4. R. RING		5. R. LITTLE	
6. L. THUMB		7. L. INDEX		8. L. MIDDLE		9. L. RING		10. L. LITTLE	
IDENTIX TP600 1259		LEFT FOUR FINGERS TAKEN SIMULTANEOUSLY		L. THUMB		R. THUMB		RIGHT FOUR FINGERS TAKEN SIMULTANEOUSLY	



Border Security



US-VISIT



UAE border crossing



Australia's SmartGate



HK smart ID card

Access Control & Transactions



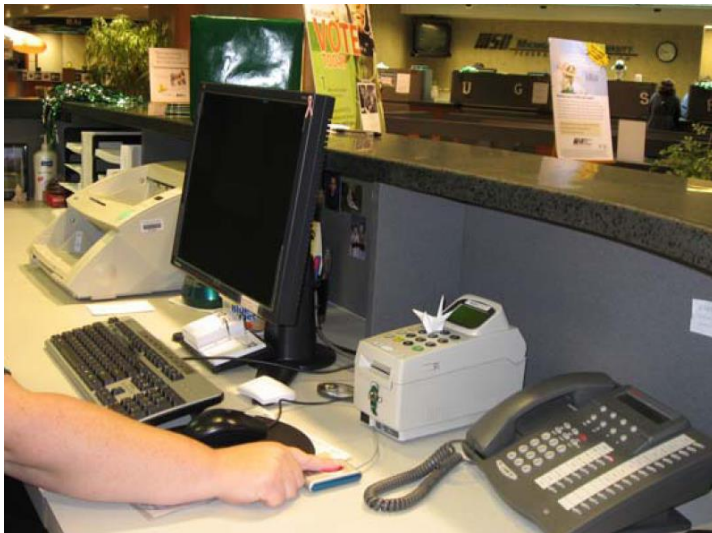
Meijer supermarket, Okemos



Time & Attendance



Palmvein ATM Bradesco bank



MSU Federal Credit Union



Cashless payment, Todholm primary school

Disney Parks

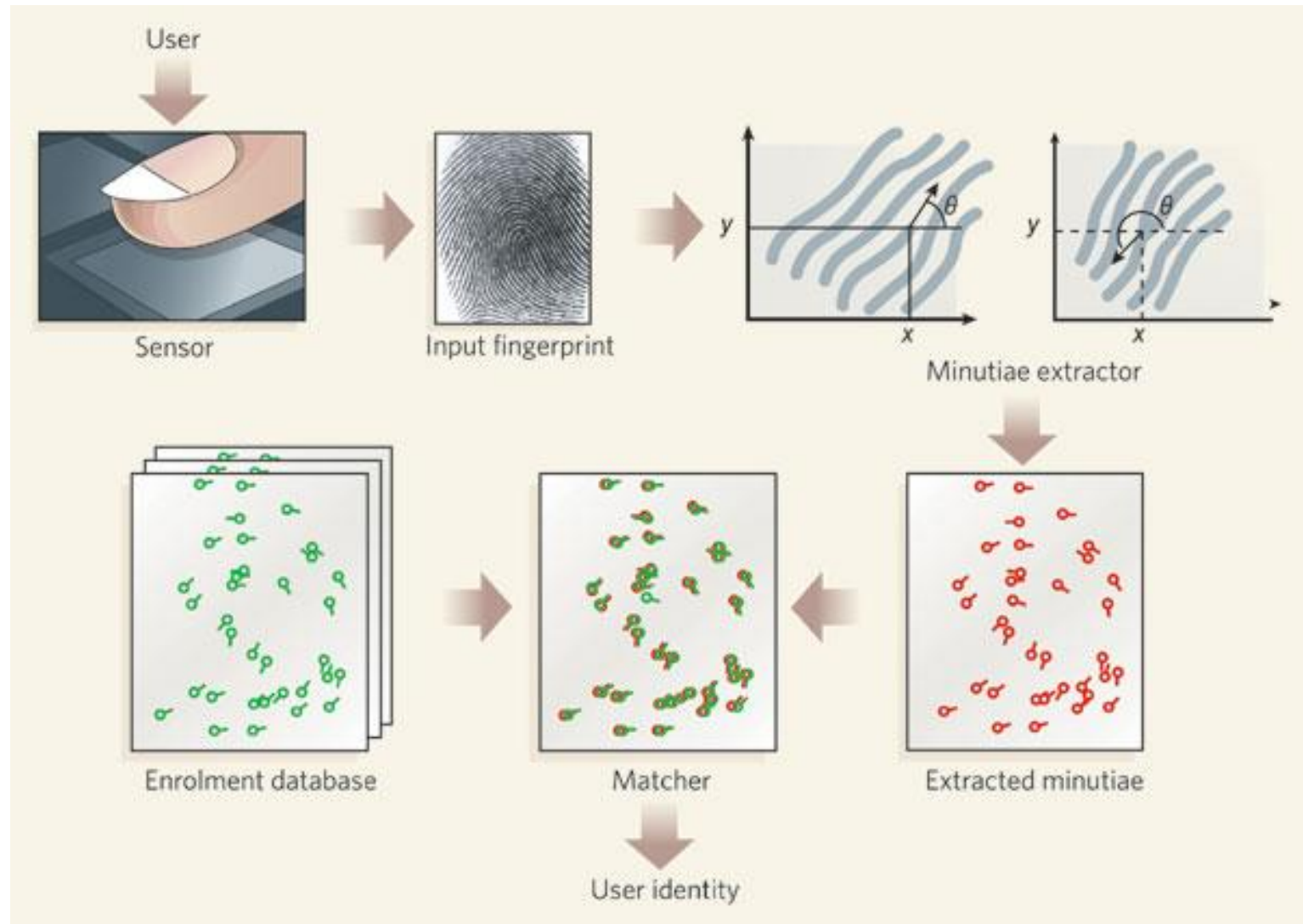


Personalization



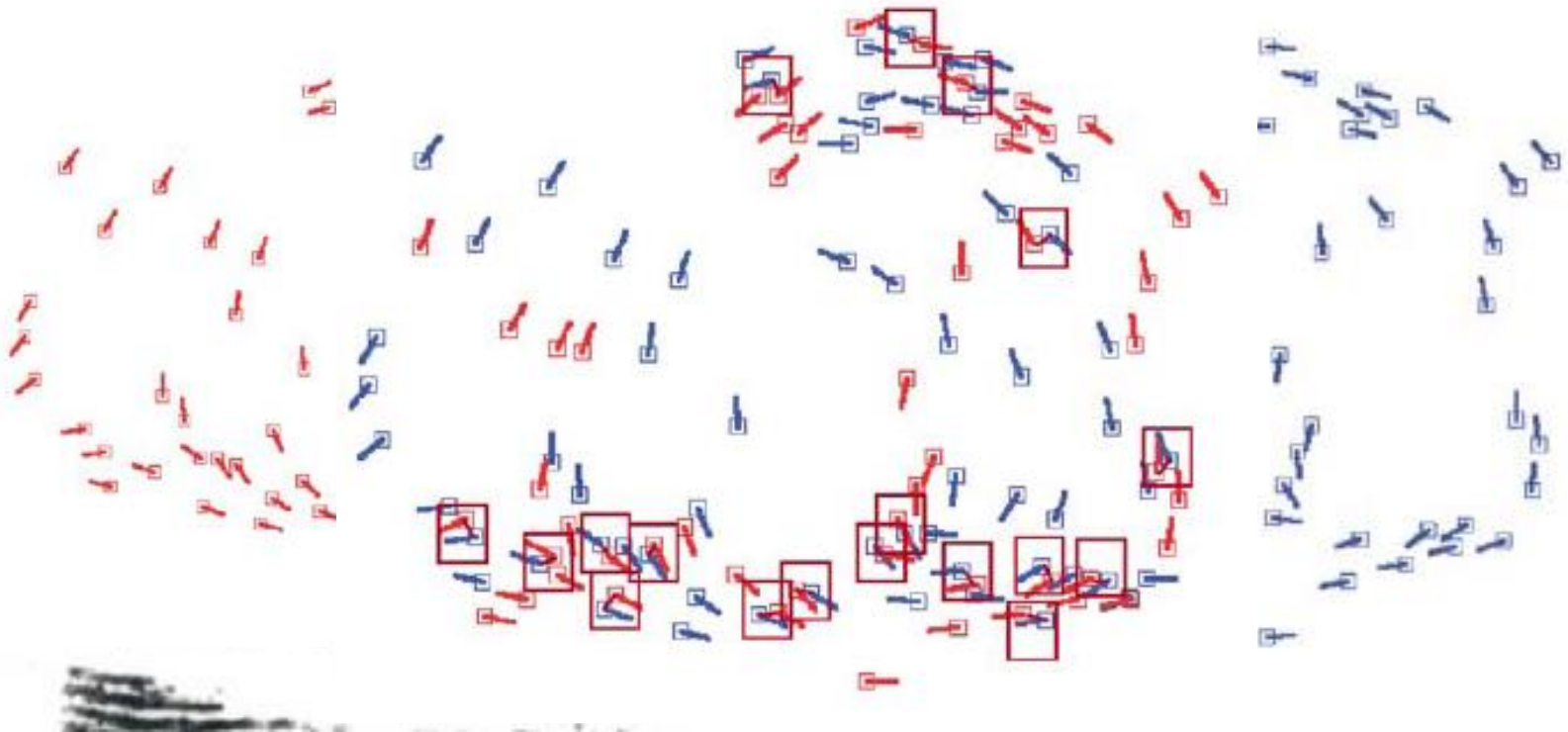
Billboard displays ad only when women are watching!

Biometric Recognition System



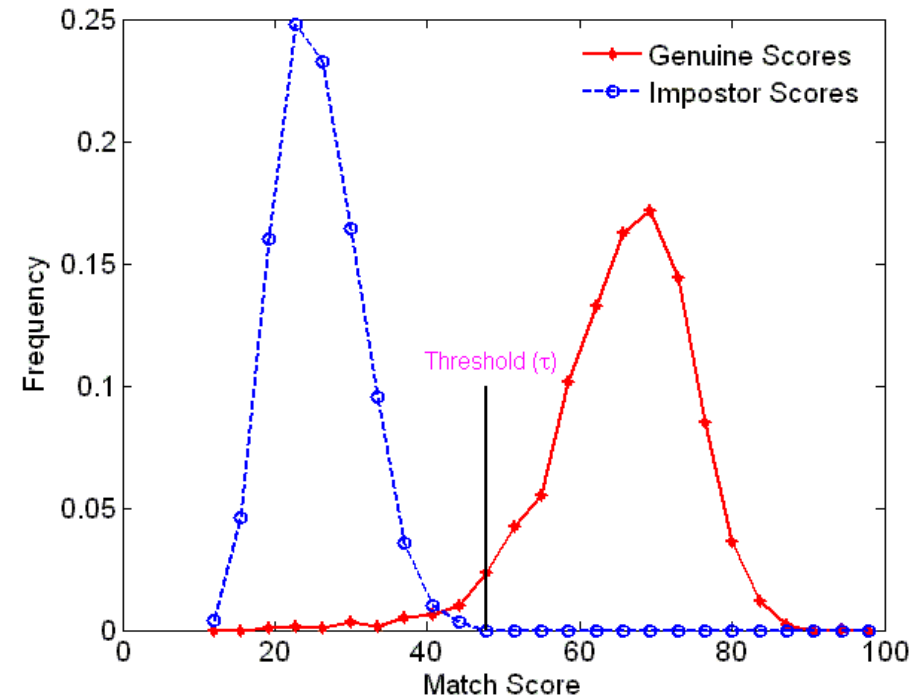
Enrolment vs. Recognition

Fingerprint Matching

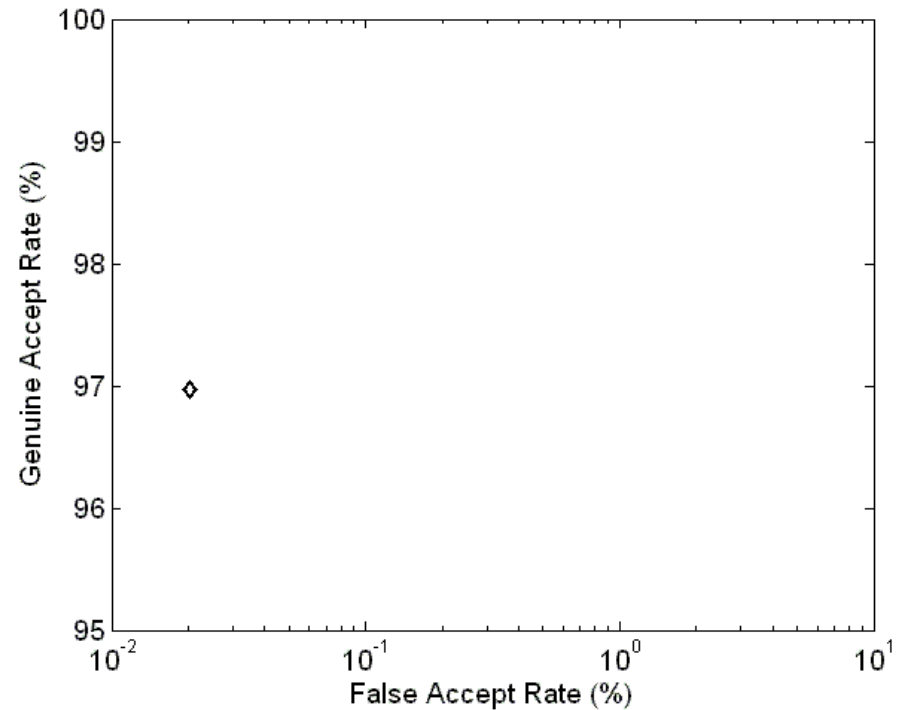


Match score = 38 on a scale of [0, 999]

Matching Performance



Match Score Distribution



ROC Curve

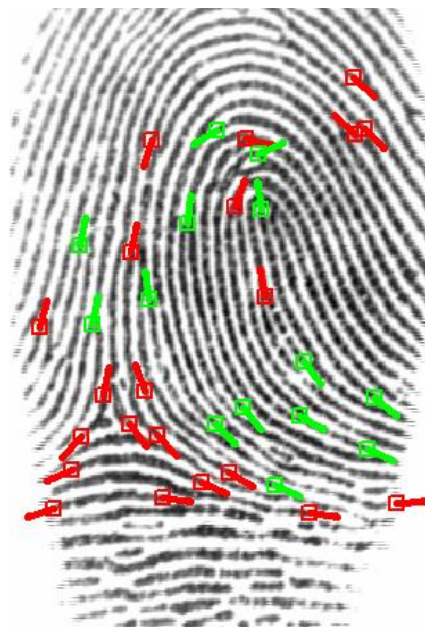
False Accept vs. False Reject

Matching Errors

- Noise & distortion
- Small overlap between template & query



False Reject



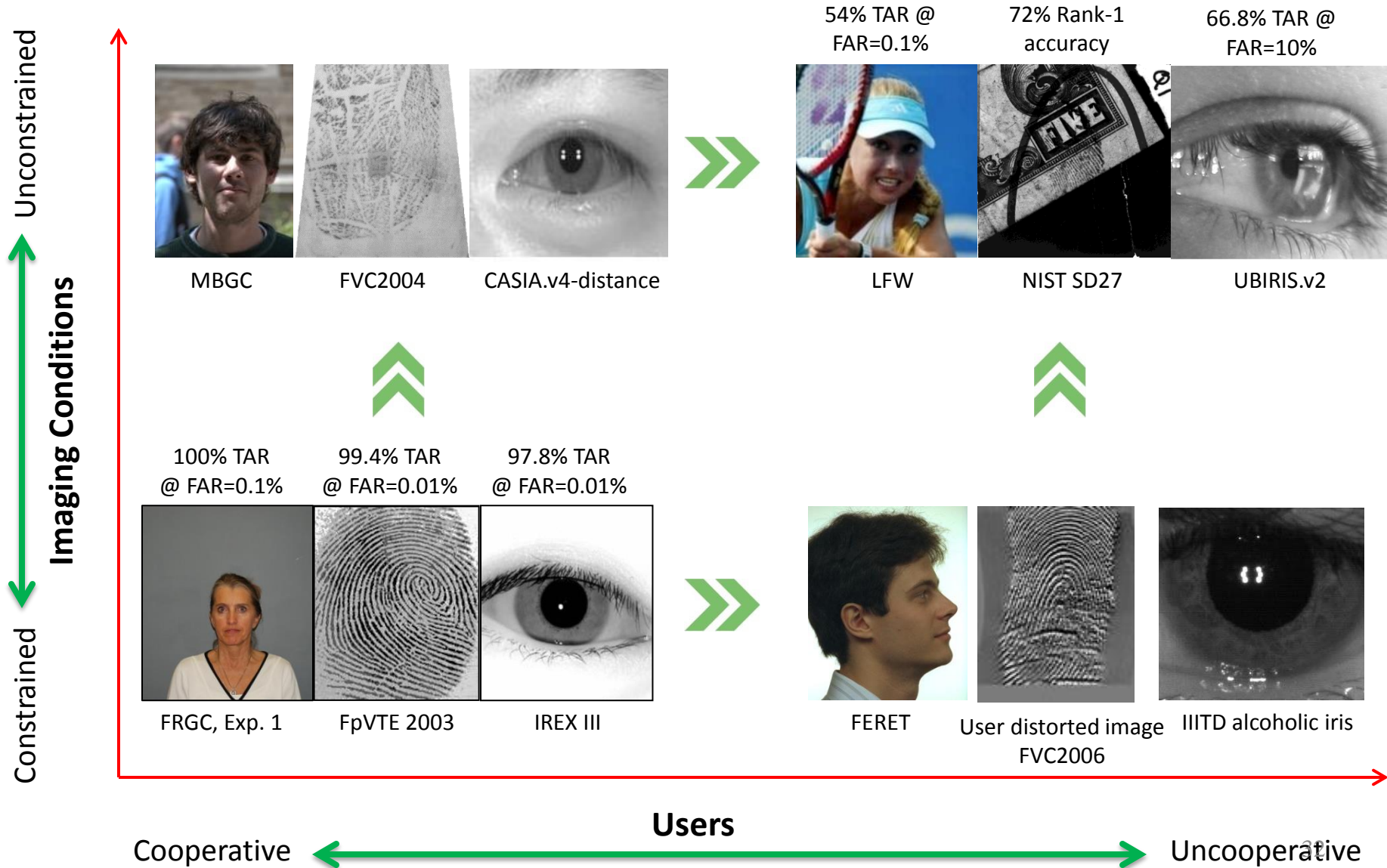
False Accept

Challenges

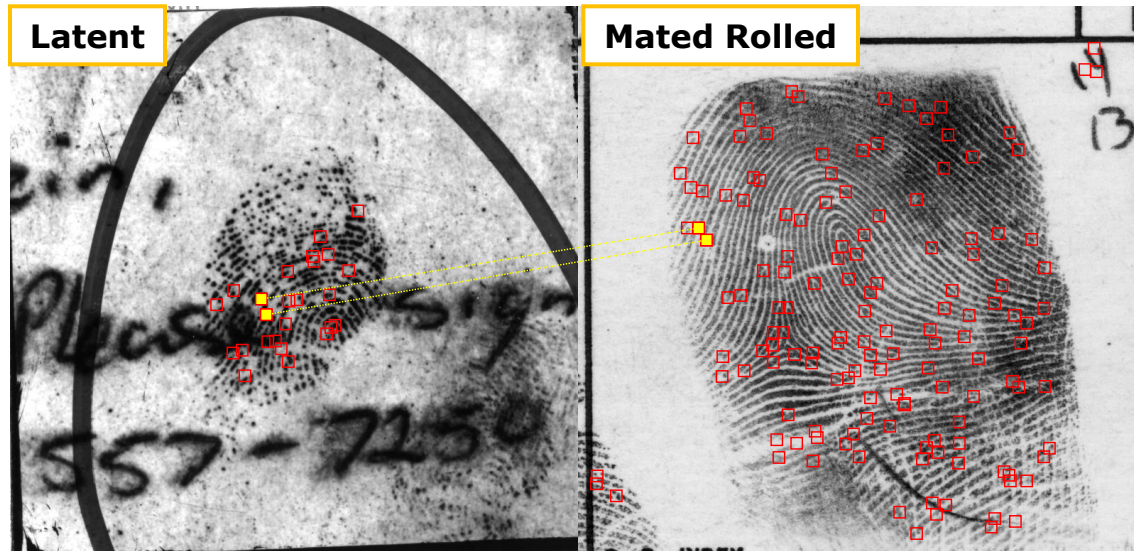
- Uncooperative users
- Unconstrained imaging conditions
- Image quality
- Intra-class variation
- Inter-class similarity
- Attacks on biometric systems
- User privacy

Salient representation and robust matching

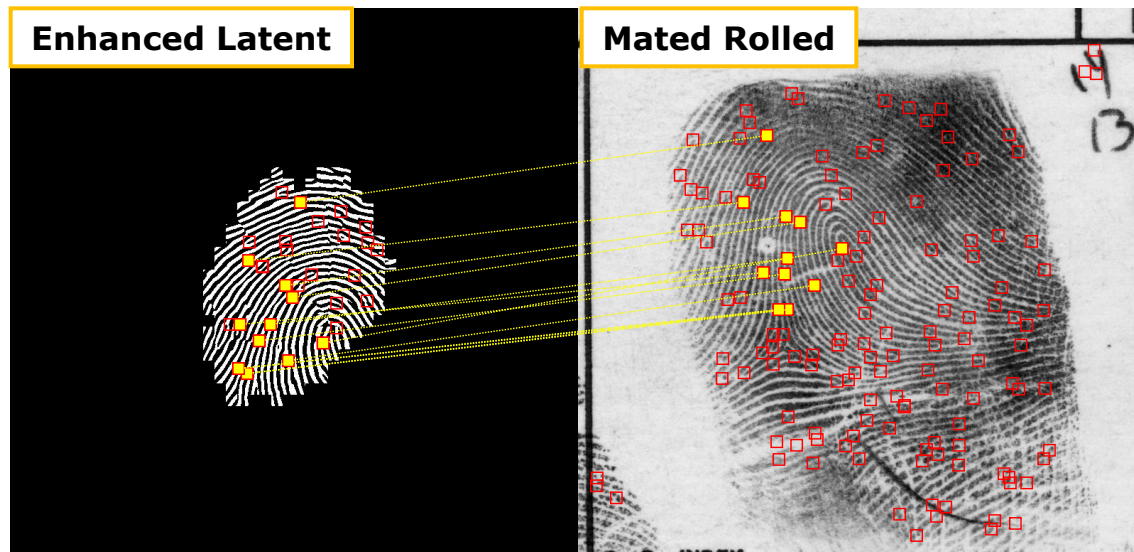
From Constrained to Unconstrained



Latent Fingerprint Enhancement



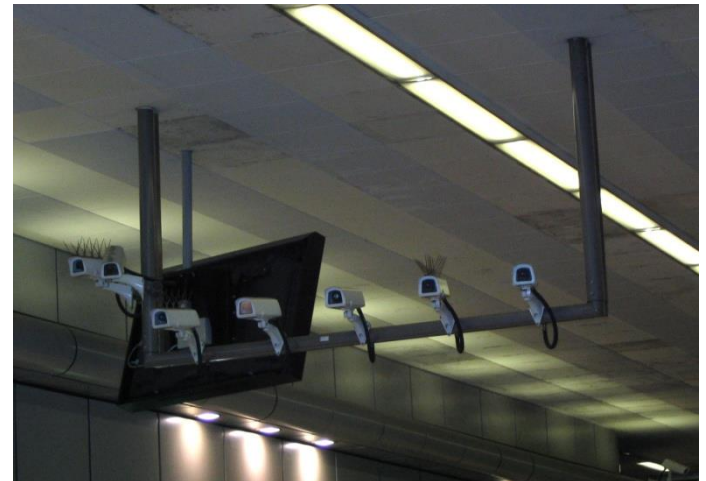
Matched Minutiae = 2
Match Score = 3



Matched Minutiae = 13
Matching Score = 38

* Latent G063 from NIST SD27; 27,258 reference prints from NIST 14 & 27 ; Neurotechnology VeriFinger SDK 4.2

Cameras Everywhere



1M CCTV cameras in London & 4M in U.K.; average Briton is seen by 300 cameras/day; 400K cameras in Beijing provide 100% coverage of public places; 150K cameras in Seoul

Face Recognition in A Crowd



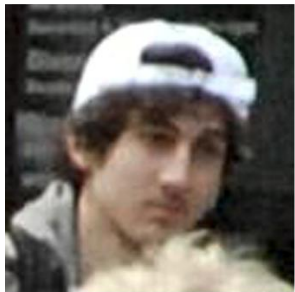
S. Liao, A. K. Jain, and S. Z. Li, "Partial Face Recognition: Alignment-Free Approach", *IEEE Trans. PAMI*, 2013

Face Recognition in Video

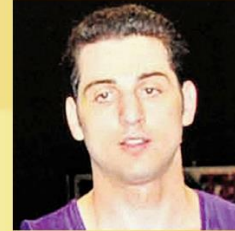


How to detect “persons of interest in a video” and then identify them?

Probes



Gallery



Tamerlan Tsarnaev



Dzhokhar Tsarnaev



1 Million PCSO Mugshots

Top Retrieval Ranks for Tsarnaev Brothers

(with demographic filtering)



116,342



12,446



87,501



1,869



1



12,622

Intra-class Variability

Jan 1995



Gallery seed

Jul 1998



Score=0.99

Nov 1999



Score=0.62

Nov 2003



Score=0.41

Feb 2005



Score=0.26

Inter-class Similarity



Haircuts help to avoid confusion among the four identical six-year-old twins

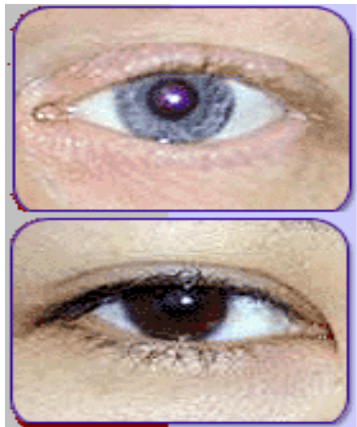
http://www.cbsnews.com/8301-503543_162-57508537-503543/chinese-mom-shaves-numbers-on-quadruplets-heads/

Soft Biometrics

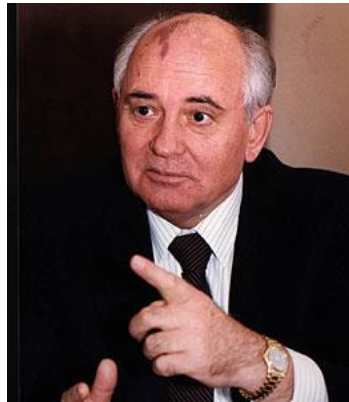
Provide some information about an individual, but lack the distinctiveness and permanence



Ethnicity, Skin Color, Hair color



Periocular



Birthmark



Height



Weight



Tattoos

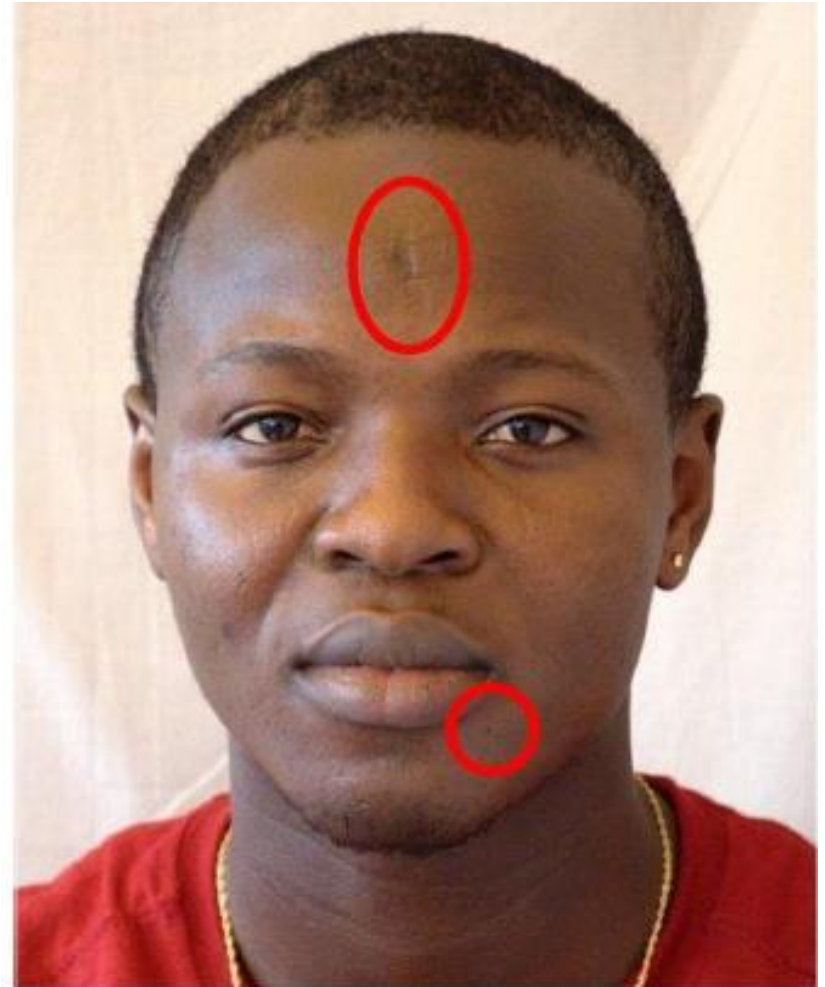
Tattoos for Suspect Identification



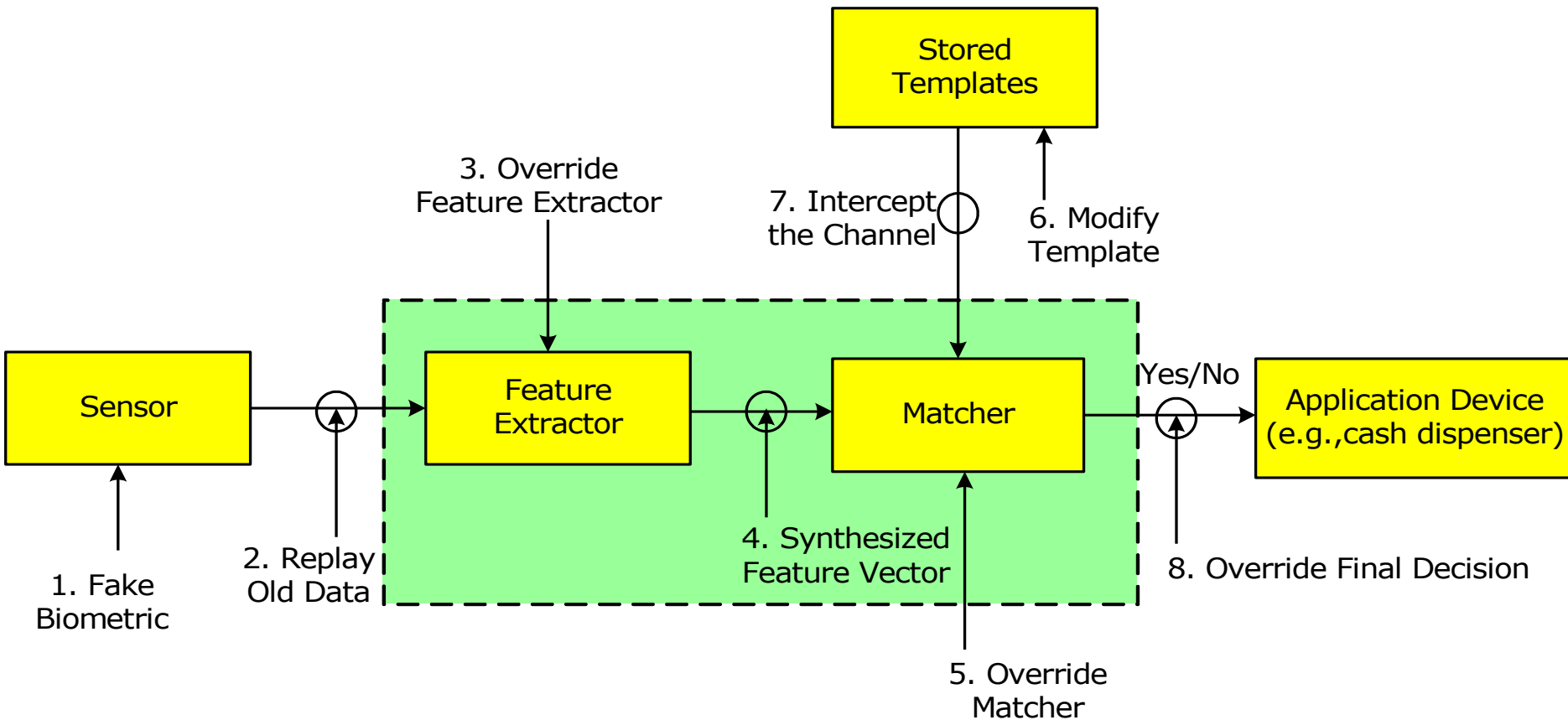
CBS 6 News: Investigators seek shirtless, heavily-tattooed suspect, May 4, 2012

<http://wtvr.com/2012/05/04/pictures-investigators-look-for-shirtless-heavily-tattooed-suspect/>

Face Marks for Distinguishing Identical Twins



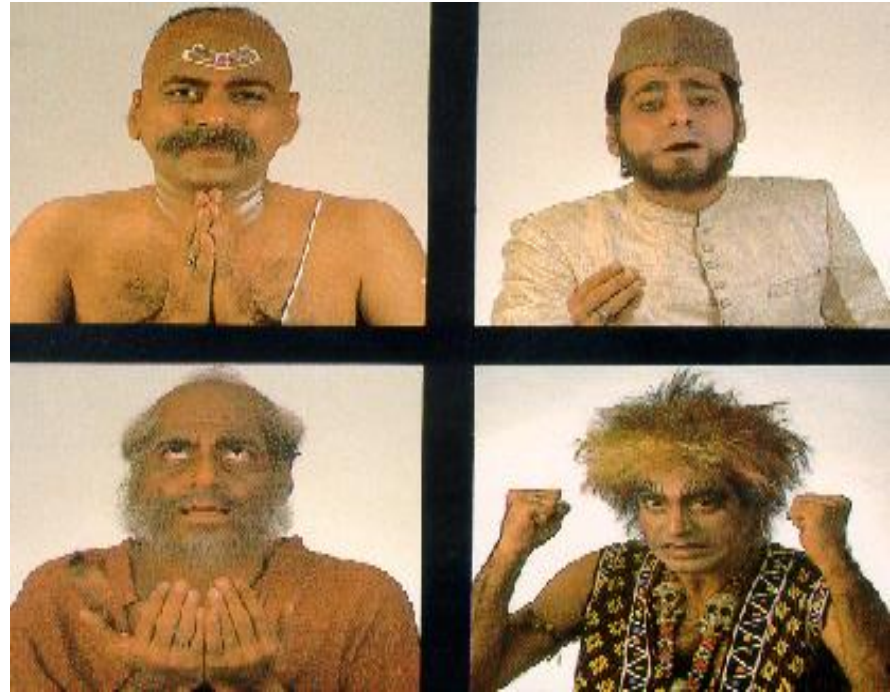
Securing Biometric Systems



Fake or Spoof Biometric Input



Dummy finger



Face disguise



Fake hand



Fake eyeball

Fingerprint Forgery

- Time and attendance systems fooled by fake fingerprints
- Employees give spoofs of their fingerprints to colleagues
- Fine for being late ~\$30; price of fake print ~\$15



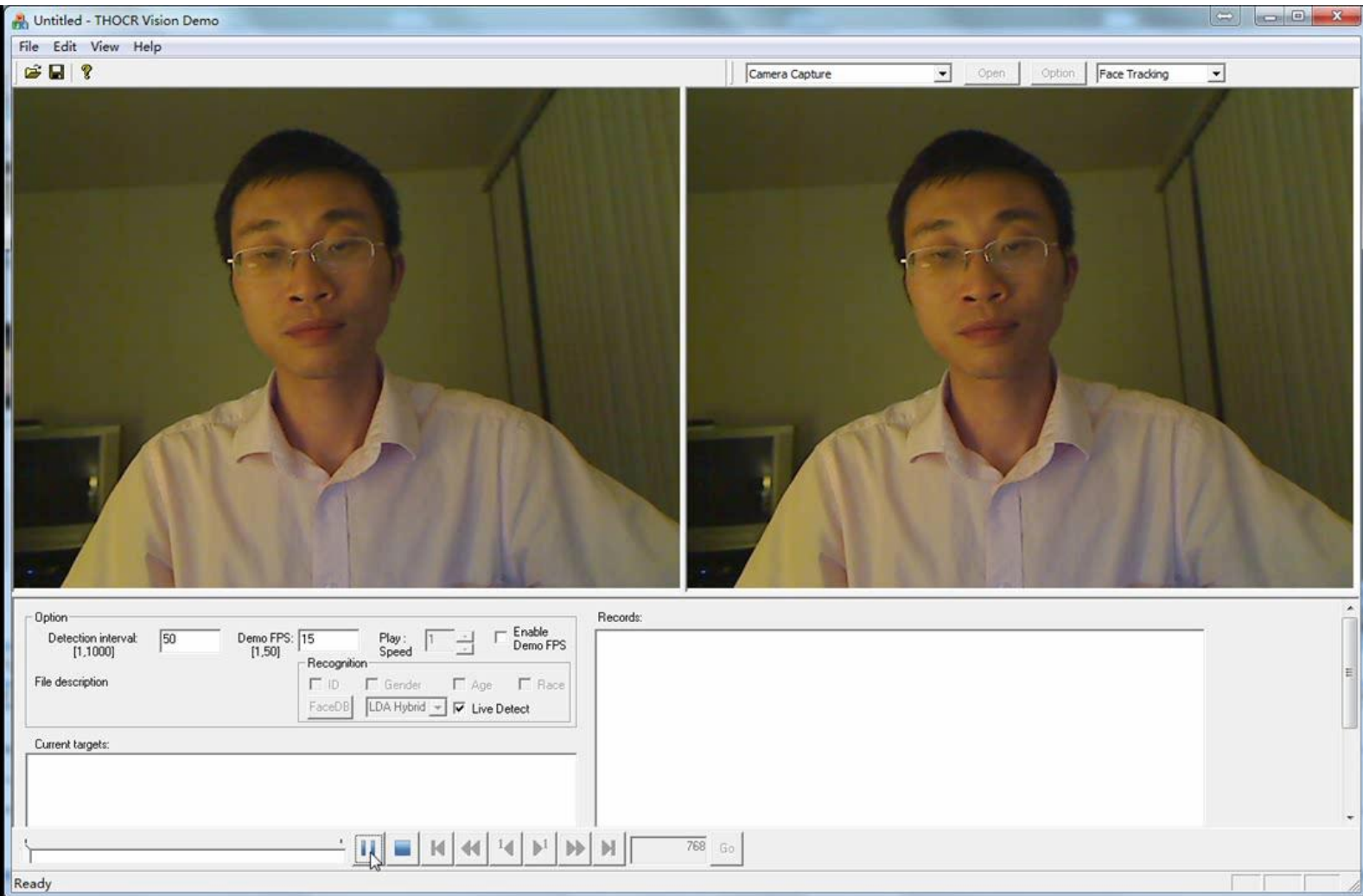
Fingerprint Alteration

Double-loop changed to left loop



Gus Winkler (1933)

Spoof Face Detection



Detecting printed photo attack

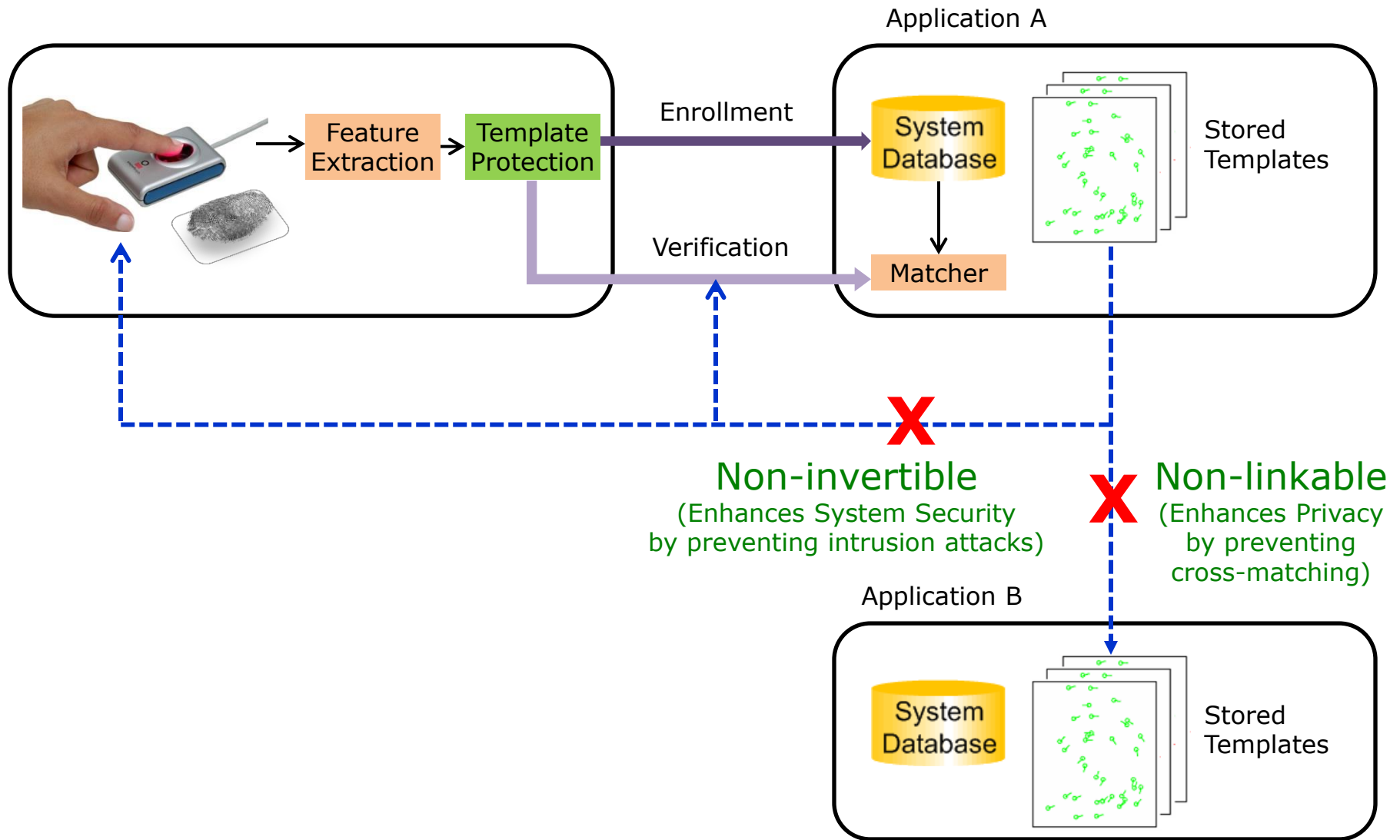
Just Switch on the LEDs to foil Facial Recognition



These nifty goggles upset cameras with outward-facing infrared lights

http://www.theregister.co.uk/2013/01/22/infrared_specs_foil_facial_recognition/

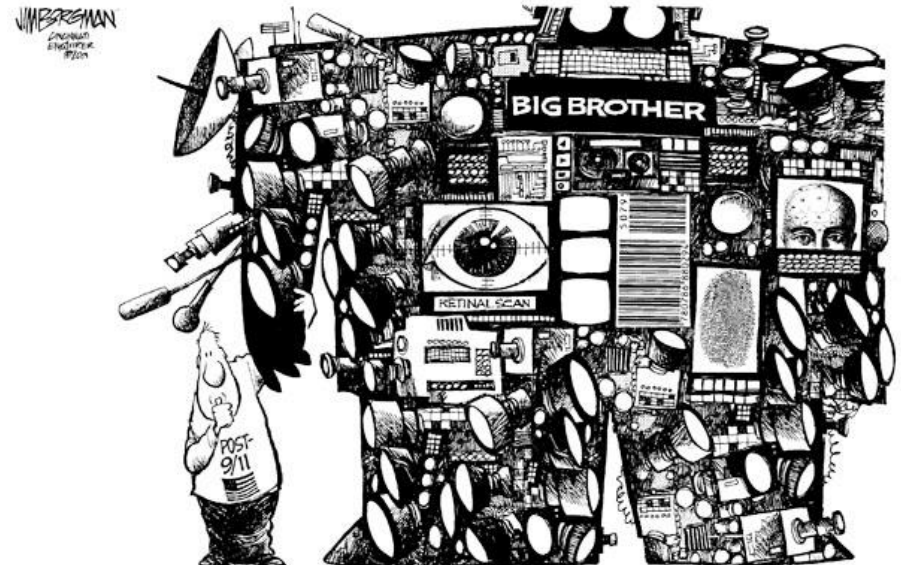
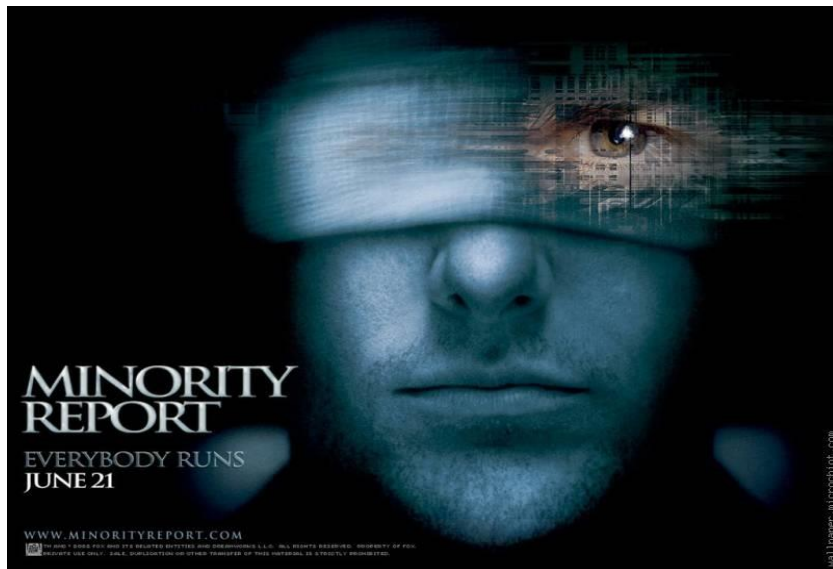
Biometric Template Protection



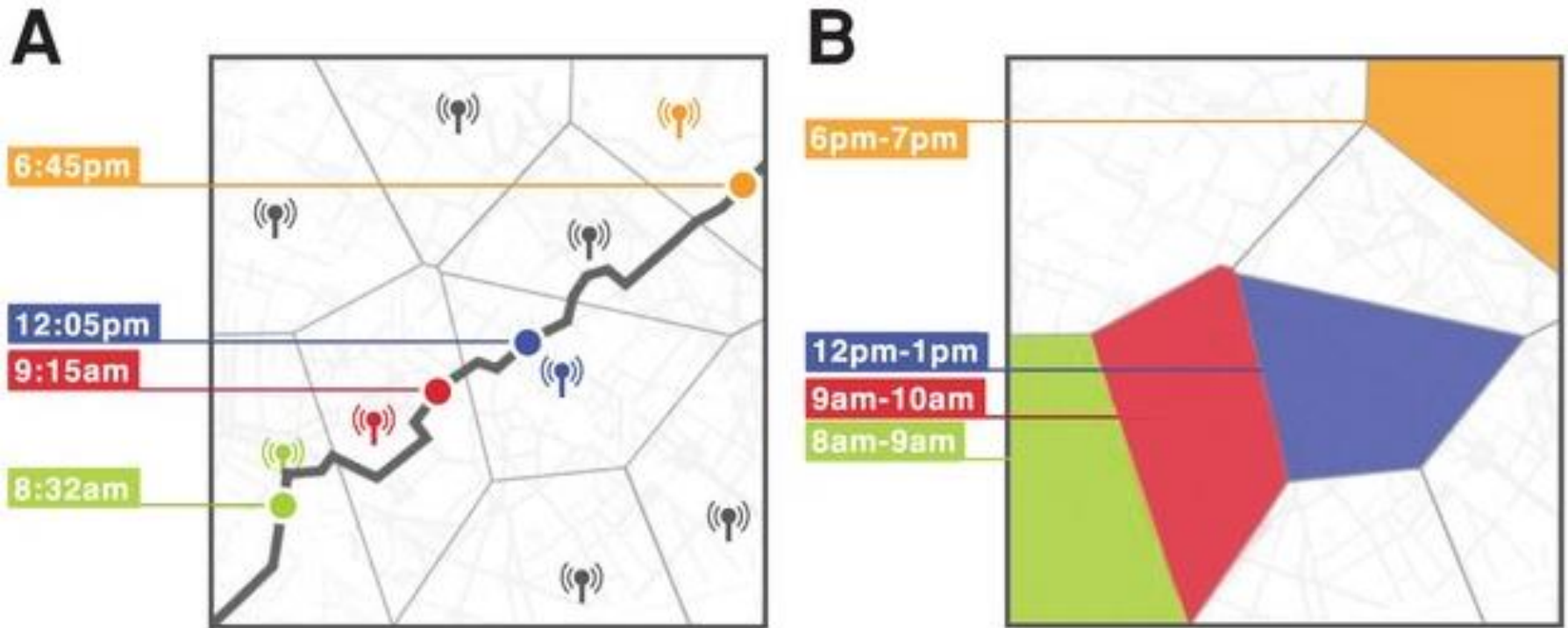
Can we generate a non-invertible AND non-linkable biometric template **without compromising the matching accuracy?**

User Concerns

- Will biometric recognition be used for
 - tracking citizens?
 - the intended purpose alone?
 - linking multiple databases?
- What to do in case of misidentification?

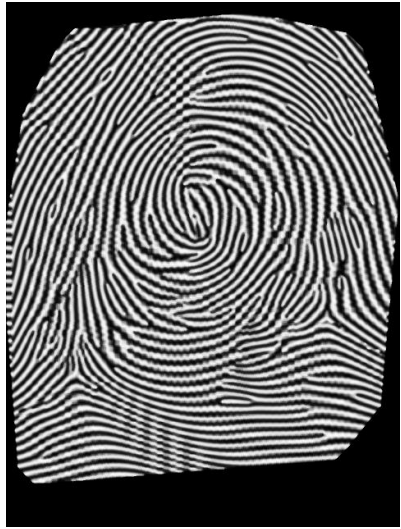


GPS Fingerprint: Identification Without Biometric Data

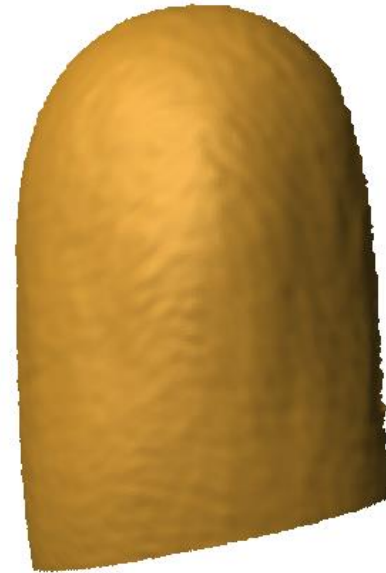


With just the anonymous location data, one can figure out “**who you are**” by tracking your smartphone. Patterns of our movements, when traced on a map, create something akin to a fingerprint, **unique** to every person.

3D Fingerprint Phantom



**2D Synthetic
Fingerprint
Image with
known
characteristics**



**Generic 3D
Finger Surface**

Summary

- Biometric recognition is indispensable in efforts to enhance security and eliminate fraud
- Fingerprint matching has been successfully used in forensics for over 100 years
- New deployments for civil registration, border crossing, financial transactions
- Market for mobile devices is emerging
- Seamless integration, recognition under non-ideal conditions, user privacy, system integrity

Security v. Privacy

