Next Generation Biometrics

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Security Threats

We now live in a global society of increasingly desperate and dangerous people who can not be trusted based on identification documents

- Are the credentials genuine?

- Are they in the possession of authorized persons?

Security: National, corporate, individual

Biometric Recognition

Recognition of a person by his body, then linking that body to an externally established "identity", is now the preferred method for identity management
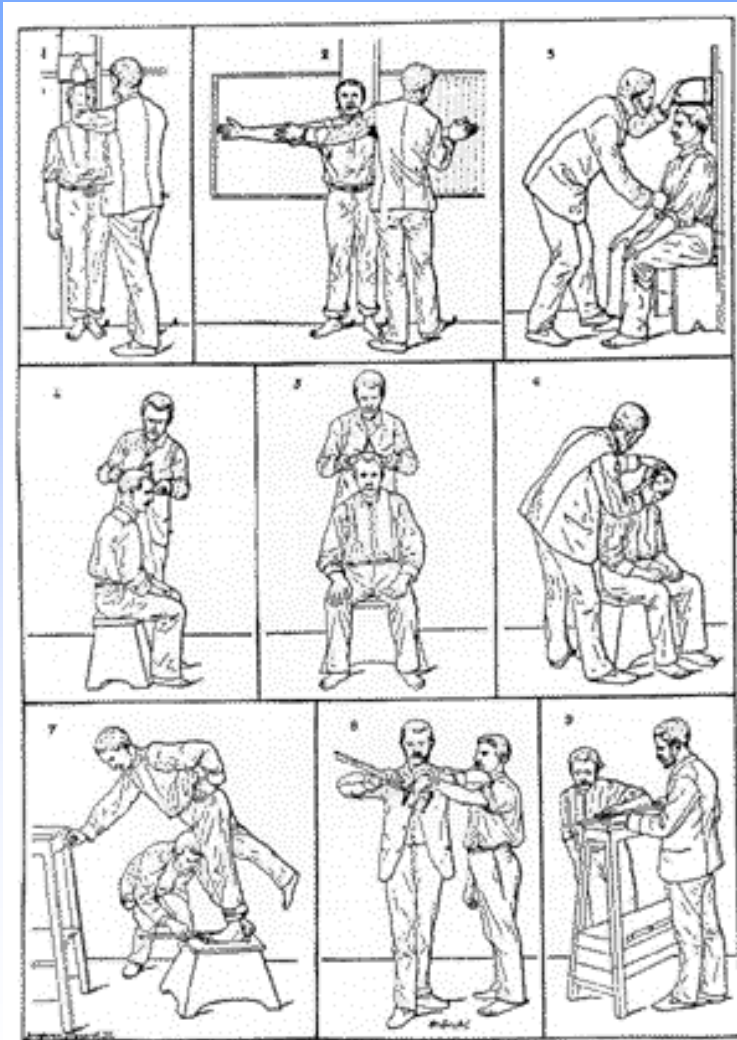

Biometric passport

Cashless payment system, Todholm primary school (Courtesy: Fujitsu)

Bertillon System

Invented in 1882; earliest multibiometric system

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

Friction Ridge Patterns

Ridged (friction) skin on fingers, palms & soles
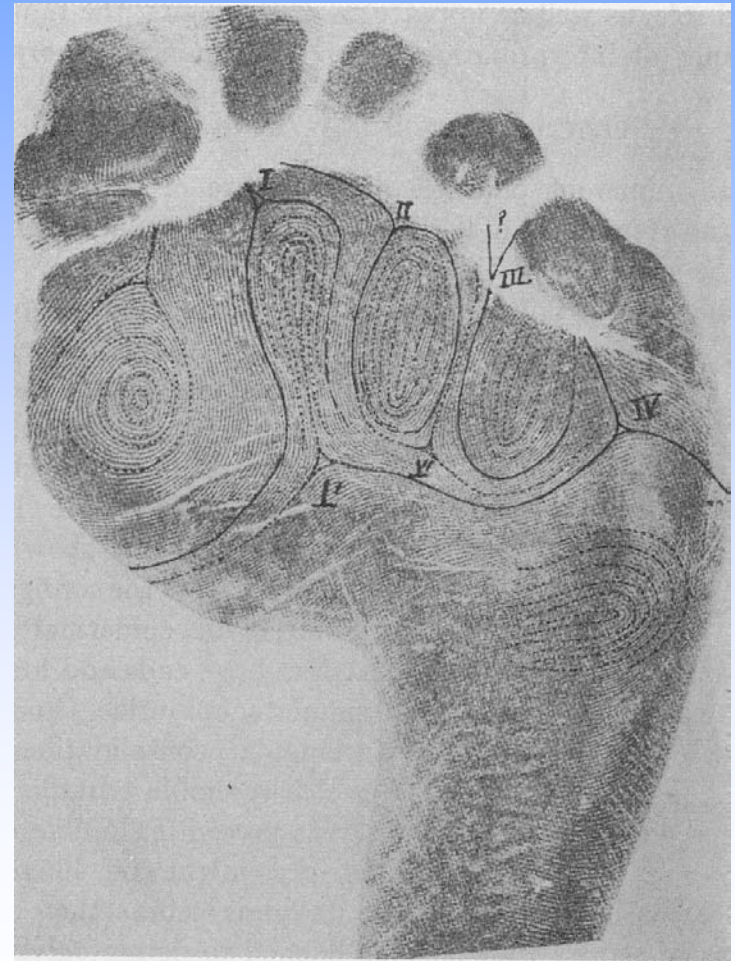
Cumins and Midlo, Finger Prints, Palms and Soles, Dover, 1961

Fingerprints in Forensics

- Repeat Offenders: compare rolled inked impressions (ten prints)

- Crime Scenes: compare latent prints with forensic database

- First reported use of fingerprints in a criminal case was in Argentina (1895)

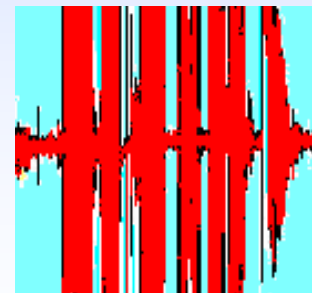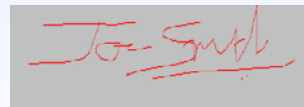IAFIS: ~ 80 million 10 prints; ~80K searches/day;
Goal: lights out capability for automatic latent search

FBI Next Generation Identification (NGI)

- Use multibiometrics (face, iris, voice...)

- Increase matching throughput

- Improve latent fingerprint matching

- National palmprint identification system

- Photo search capability (scar, mark & tattoo)
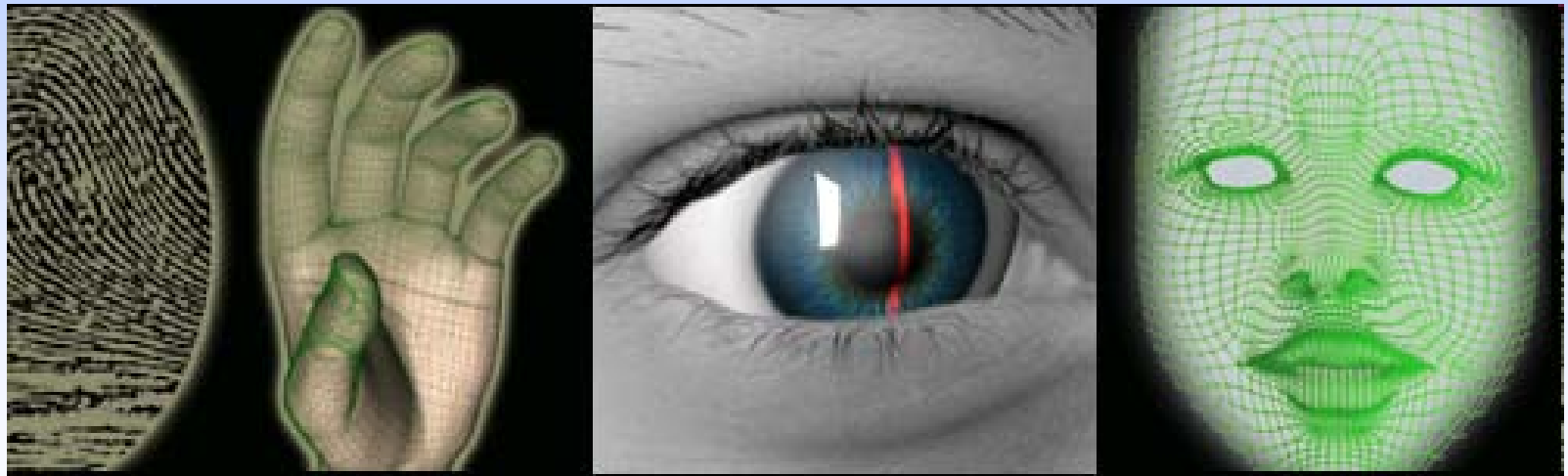
Biometric Traits
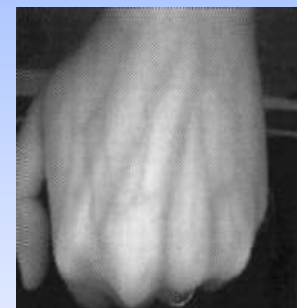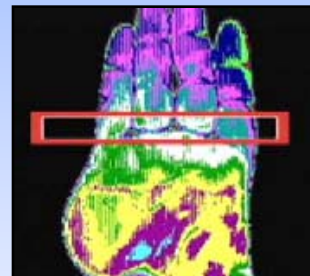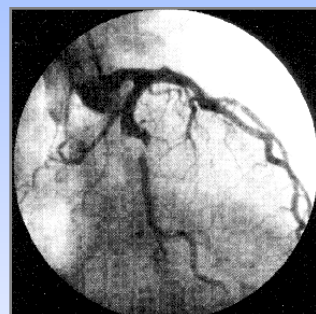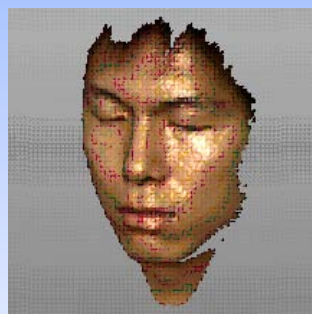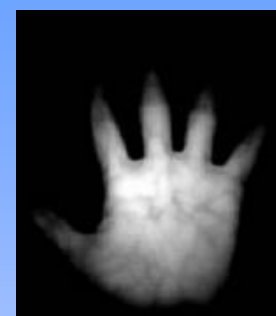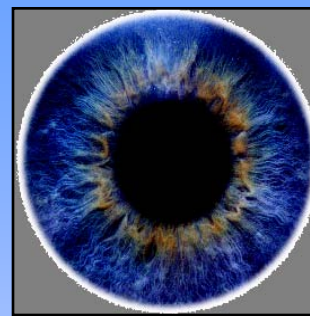
Fundamental Premise

Biometric traits are unique & permanent

- Intra-class variability is small
- Inter-class separability is large
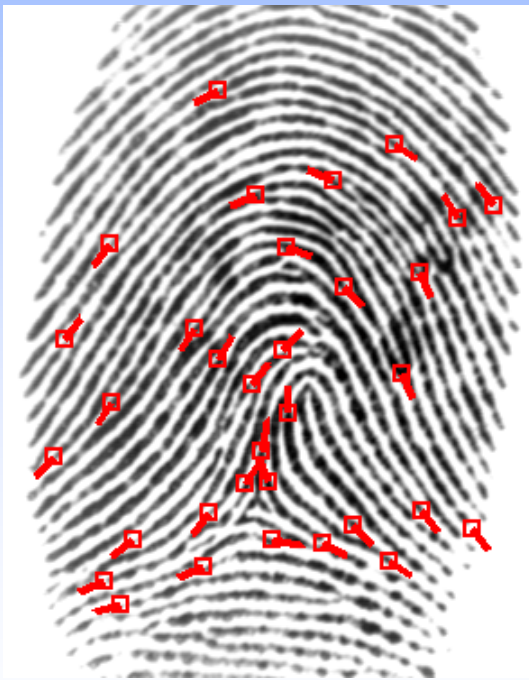
New Biometric Traits!

Its All About The Applications!

- Biometrics is a means for identifying people; successful companies find solutions for niche security applications
- Hand geometry system by Identimation (1965); now IR
- User acceptance is the key!

Physical Access Control

Logical Access Control

Smart Card

Border Control

Forensics

Financial

Consumer Products

Border Security Applications

US-VISIT

UAE border crossing

Australia's SmartGate

HK smart ID card

Iris Recognition in Afghanistan

Courtesy: http://online.wsj.com/article/SB125910374196463061.html

U.S. forces use Handheld Interagency Identity Detection Equipment (HIIDE), devices during neighborhood patrols. Camera scans fingerprints or irises in an effort to find insurgents. The devices connect to a remote Defense Department database, called the Automated Biometric Information System (ABIS), which gathers identification data from U.S. and coalition partners.

Disney World, Orlando

Not all applications deal with security!

200K visitors per day, 365 days per year

Failed Biometric Systems
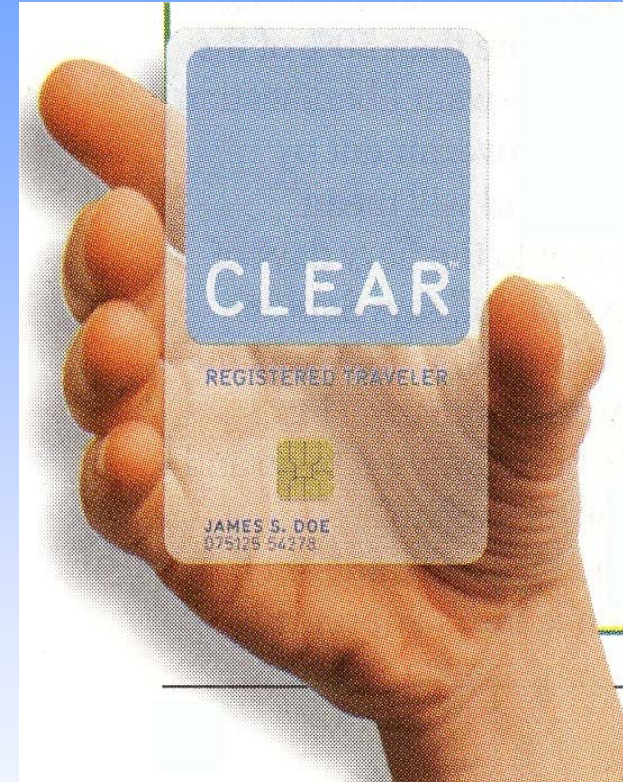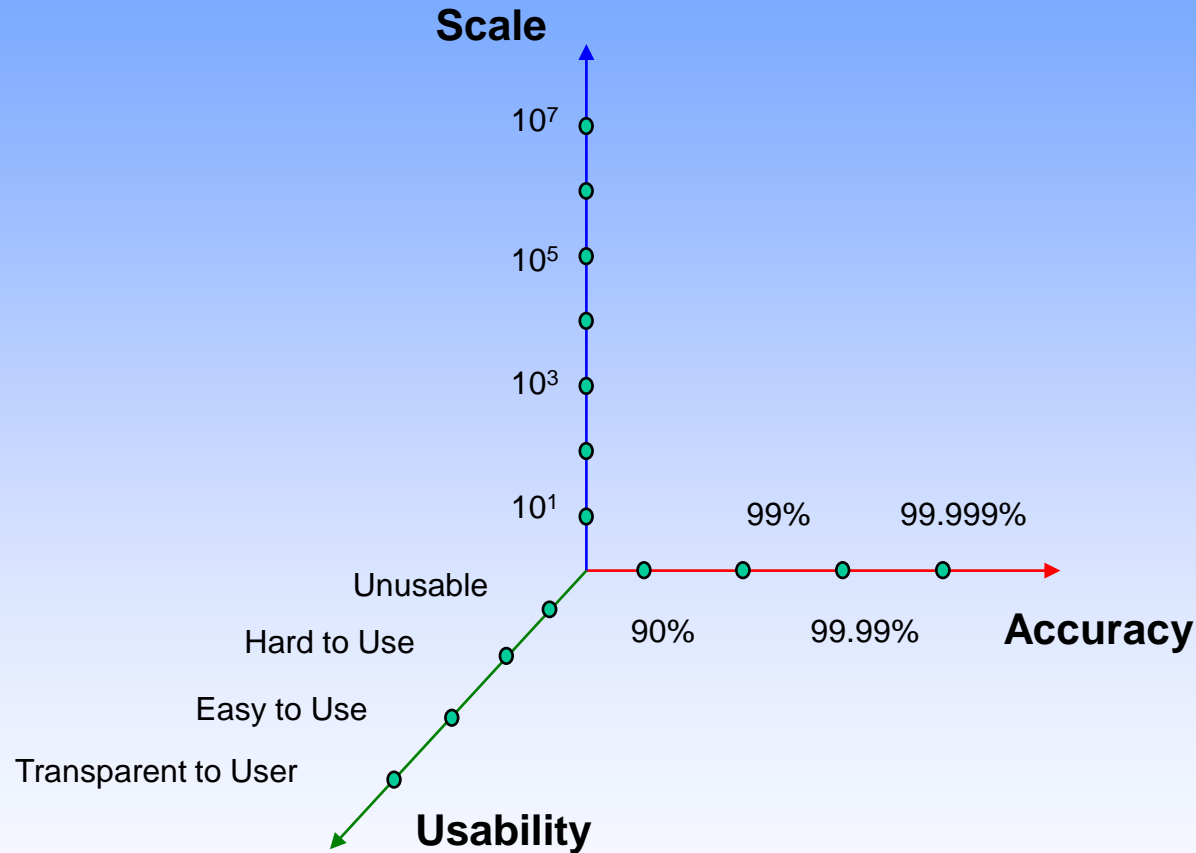

NJ School Access

Pay by Touch

Verified Identity Pass

Why did Pay By Touch fail? No value proposition for end user and merchants & mismanagement; failure not due to system error rate

Next Generation Systems

Identify everyone, everywhere, all the time

Accuracy, throughput, interoperability, ease of use, cost, reliability, user privacy, uniformity across systems, integration

Challenges

- Address application requirements
- Large scale systems
- Multibiometric systems
- Sensors & interoperability
- Less controlled data acquisition
- Soft biometrics
- Continuous authentication
- Biometric system security
- Uniqueness of biometrics traits

Multiple Enrollment

Florida DMV found ~5,000 duplicates by matching
700K face images against a database of 51M faces
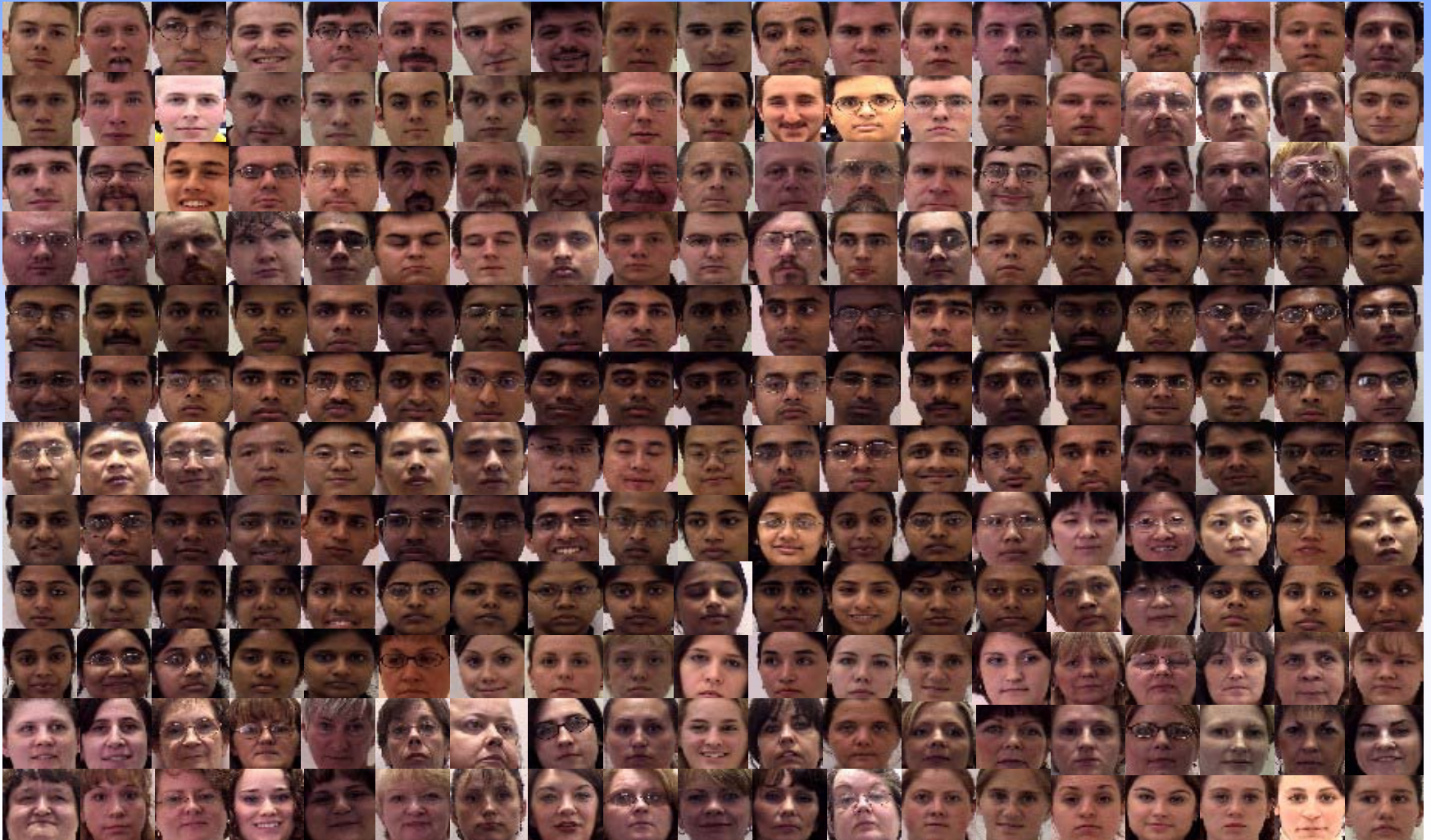
Providing Legal Identity to Citizens

- Many citizens lack identity documents, excluding them from social, political, and economic life

- ~500 million in India have no definitive identity

- Unique ID Authority of India plans to issue UID
  - Robust to duplicates & fake IDs
  - Verification is quick & cost effective
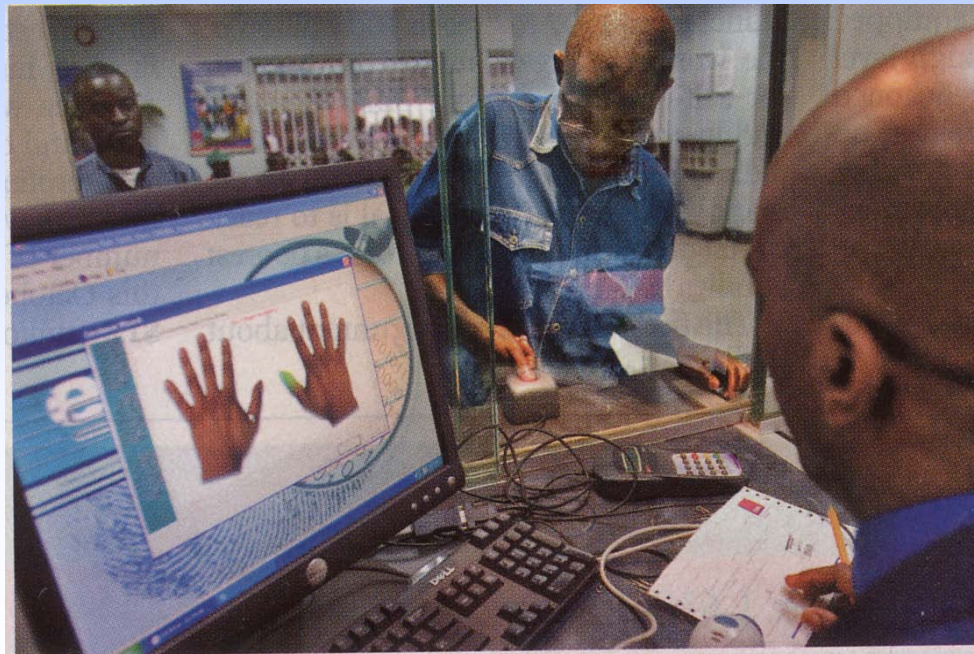
Bank in Malawi uses fingerprint smart cards for micro-loans

Large-Scale Identification

- India's Unique ID card project; ~1 billion users
- Identification system performance
  - False Negative Identification Rate (FNIR)
    user is enrolled, but his identity is not returned
  - False Positive Identification Rate (FPIR)
    user is not enrolled, but an identity is returned
- Suppose for $N = 10^9$ users, we require

  FNIR= 1 in a million=0.0001%

  FPIR=1 in 100,000=0.001%
- To meet this criteria, we need a matcher with

  FMR ≈ 10^{-12} % and FNMR = 0.0001%
- Best matcher: FMR = 0.01% at FNMR = 0.6%

Evolution of Fingerprint Sensors

Competing requirements: good quality, cheap, compact

Identix (Optical)
Dimensions: 12.5cm x 18cm x 6cm; Weight: ~1 pound

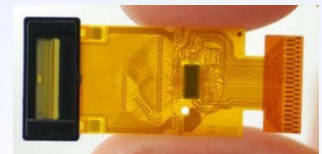Digital Persona (Optical)

Hitachi (Pressure)

Imtech & Cross-match (Capacitive foil)
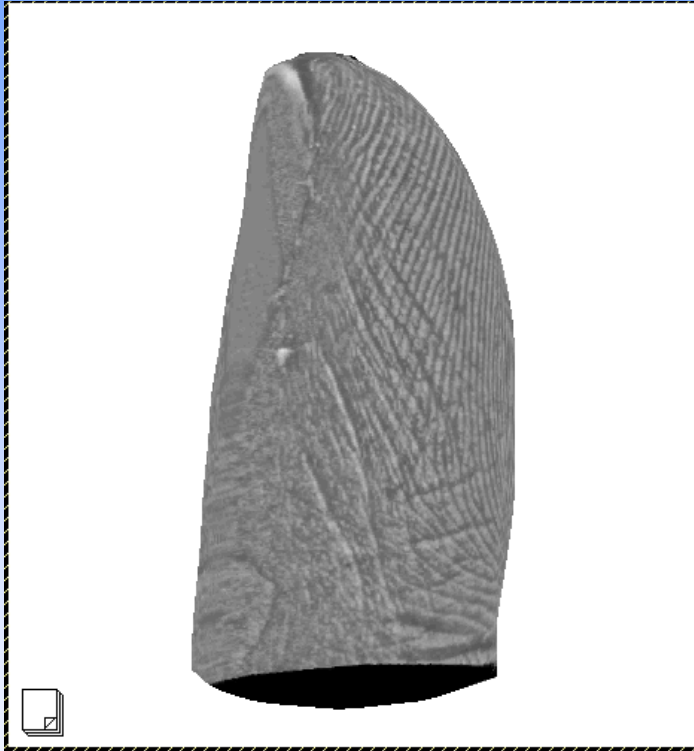
TesTech (Electro optical)
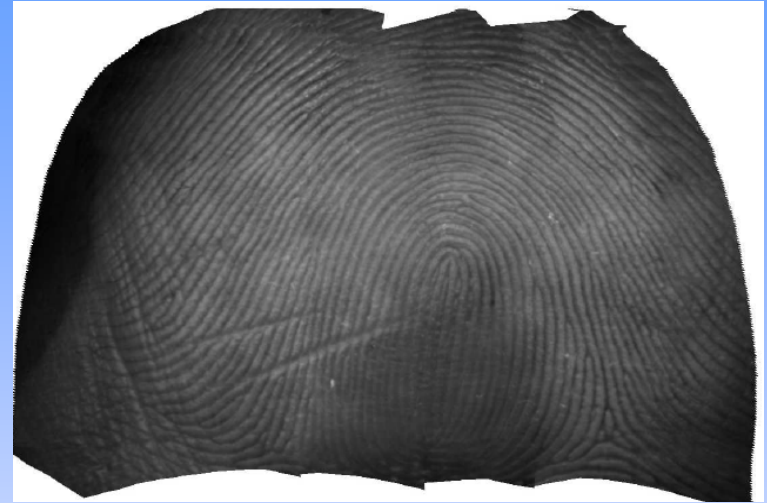
ID3: Atmel (Thermal)

Sonavation (Ultrasound)

Sensor Interoperability

TBS Touchless 3D image

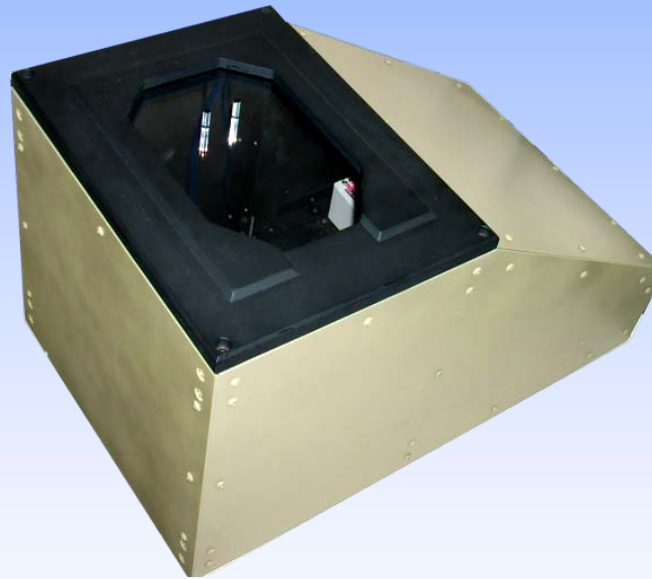Virtual "rolled" image

Ink on paper

Multibiometric Devices

Cell phone

Cogent Fusion
Fingerprint, face, iris

Lumidigm and MSU
Fingerprint, palmprint, hand shape

Less Controlled Data Acquisition

- Latent fingerprint/palmprint matching
- Surveillance video
- Recognition at a distance
- Diversity of population (e.g., age, occupation)
- Cross-modal matching

Latent Fingerprint Matching

- NIST ELFT 2007; best rank-1 identification ~80% (probe: 100 latents, gallery: 10,000 rolled prints)
- Lower accuracy than rolled matching (99.4%)
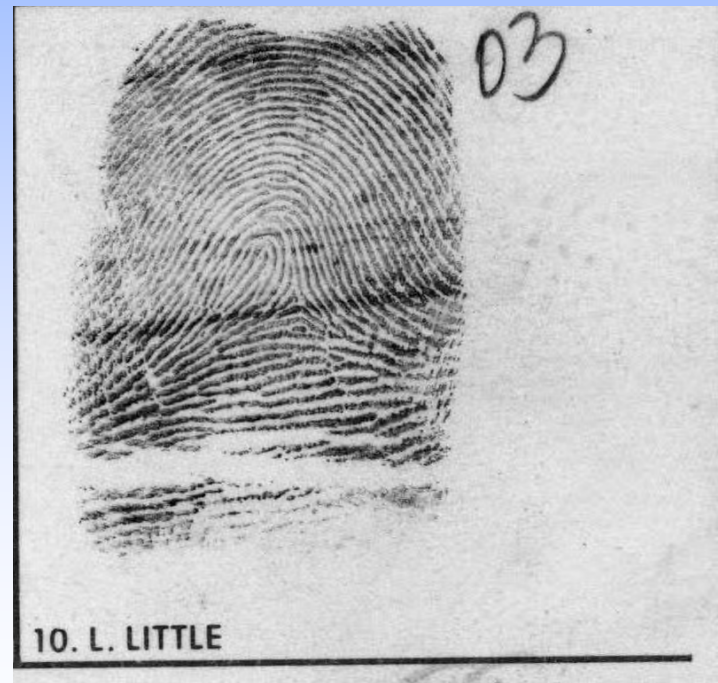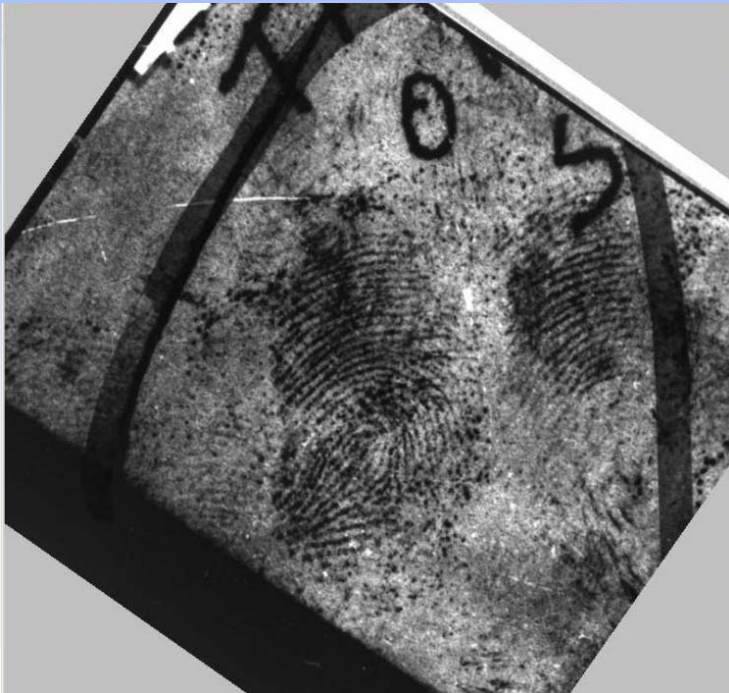
Example of moderately difficult search successfully hit by most SDKs

Latent Fingerprint Matching
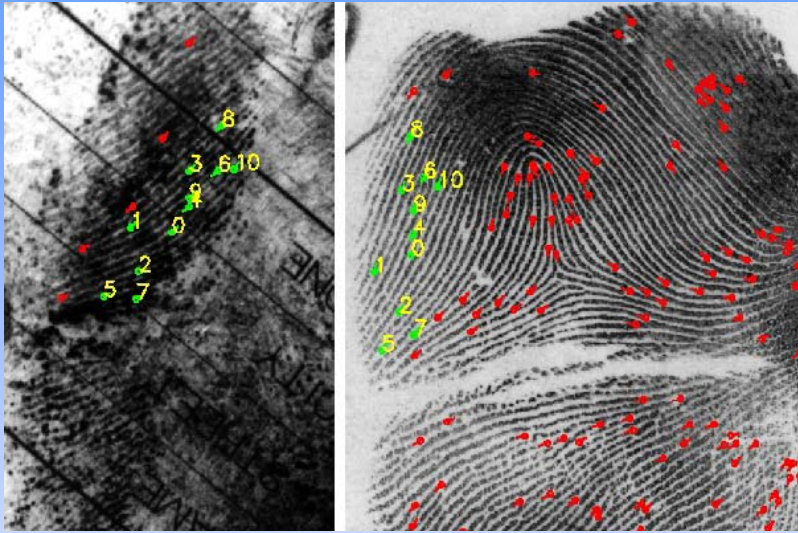
Good
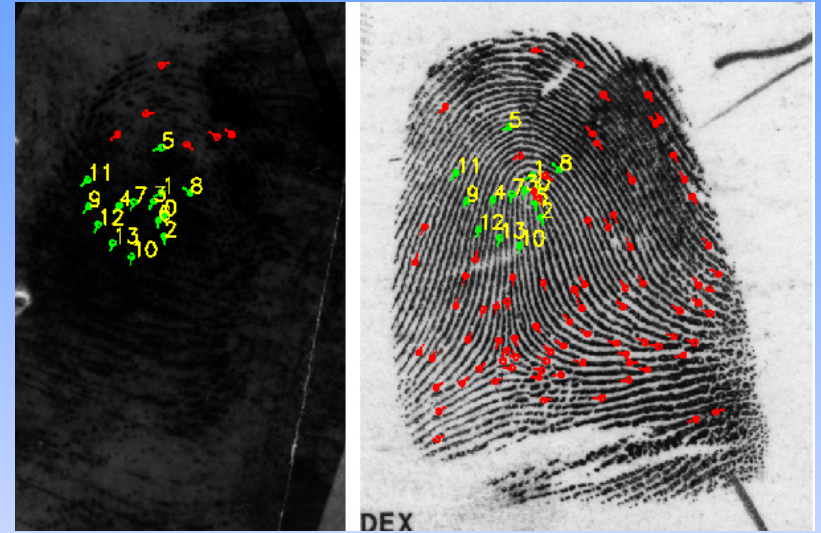
Bad
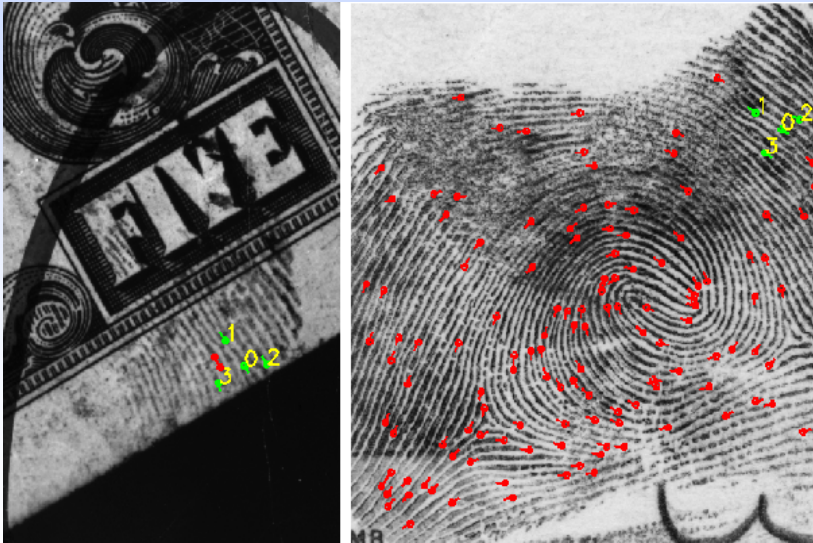
Ugly

Matching minutiae (green); index of matching minutiae (yellow); unmatched minutiae (red)

Latent Palmprint Matching

~30% of latents at the crime scenes are of palms
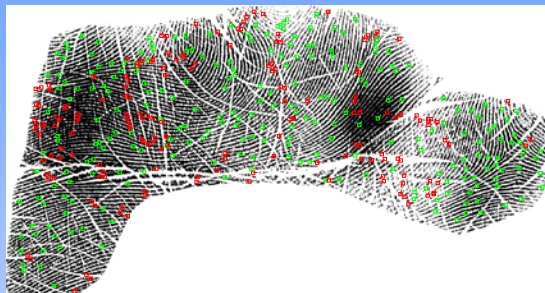
Latent with minutiae (green: good quality)

Mated full print
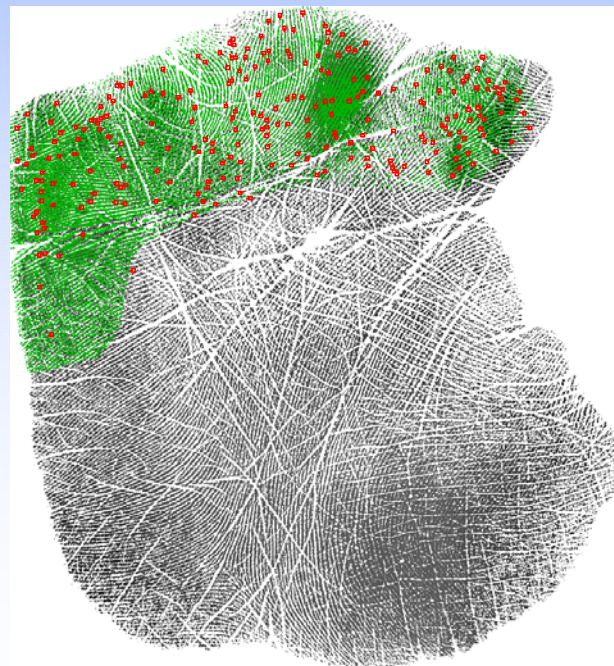
Latent overlaid on the full print

Template Aging
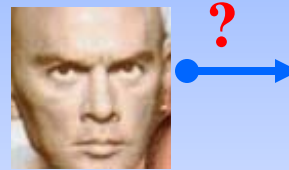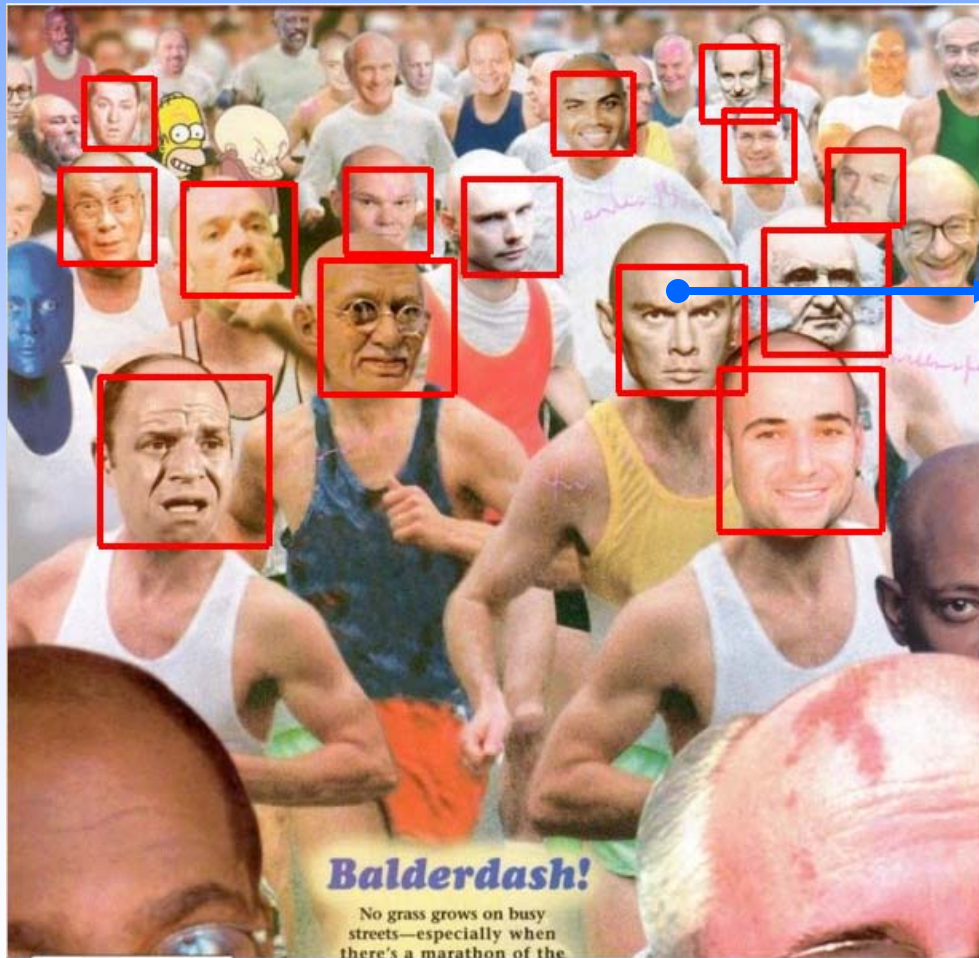
1959

1960
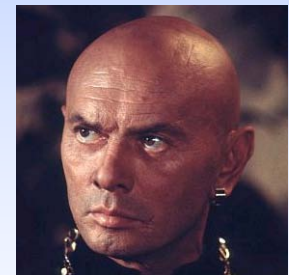
1972

1973

Brown Sisters

Rank-one accuracy of FaceVACS improved by 12%

1975 (age: 23, 15, 25, 21)

2007 (age: 56, 48, 58, 54)

Park, Tong and Jain, PAMI, 2010
Nixon and Galassi, The Brown Sisters, Thirty-three Years, 2007, The Museum of Modern Art

User Profiling (IPTV)

Technology

Identify the audience and categorize them (alone, family, friends); determine viewer sentiment

Applications

Content recommendation, targeted advertisements, secure TV commerce, real-time audience measurement

Video Surveillance Trial
Mainz Railway Station

Conducted by German Federal Police (Oct 06 to Jan 07);
60% identification at a FAR of 0.1% (gallery size of 200)

Protect video privacy

Face Recognition At a Distance

Data: UTK-LRHM DB (Indoor session)

Training: 110 images of 55 subjects

Probe: 275 far-distance face images

Gallery: 55 near-distance images
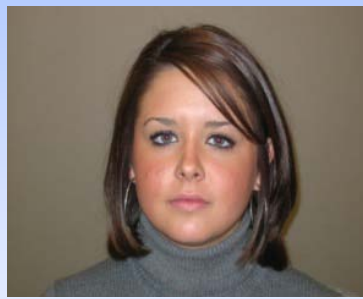
Gallery (0.5 meter)

Probe (16 meters)

Cumulative matching scores by adding more gallery mug shot images (0, 1k, 5k, 10k)
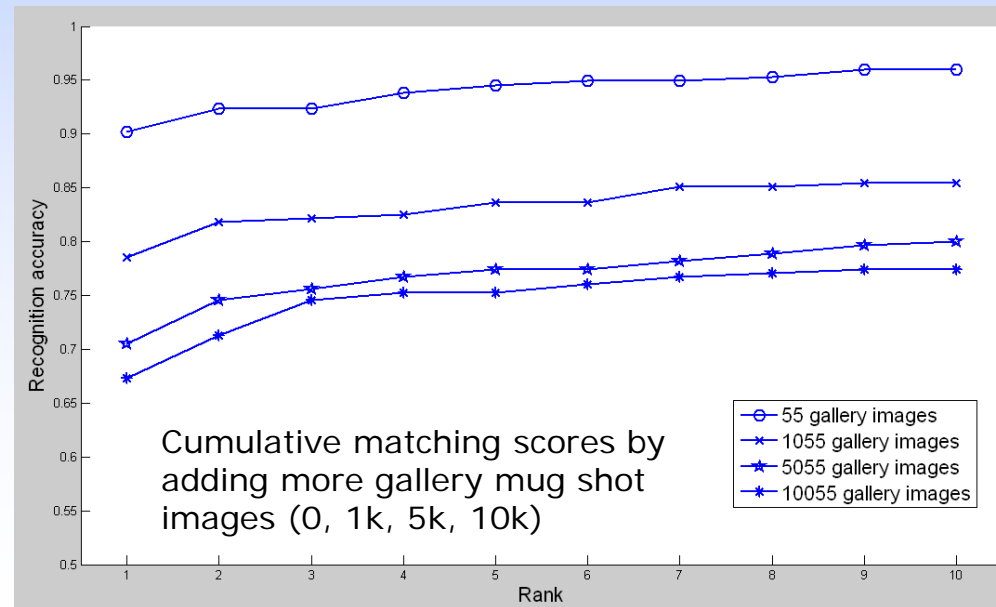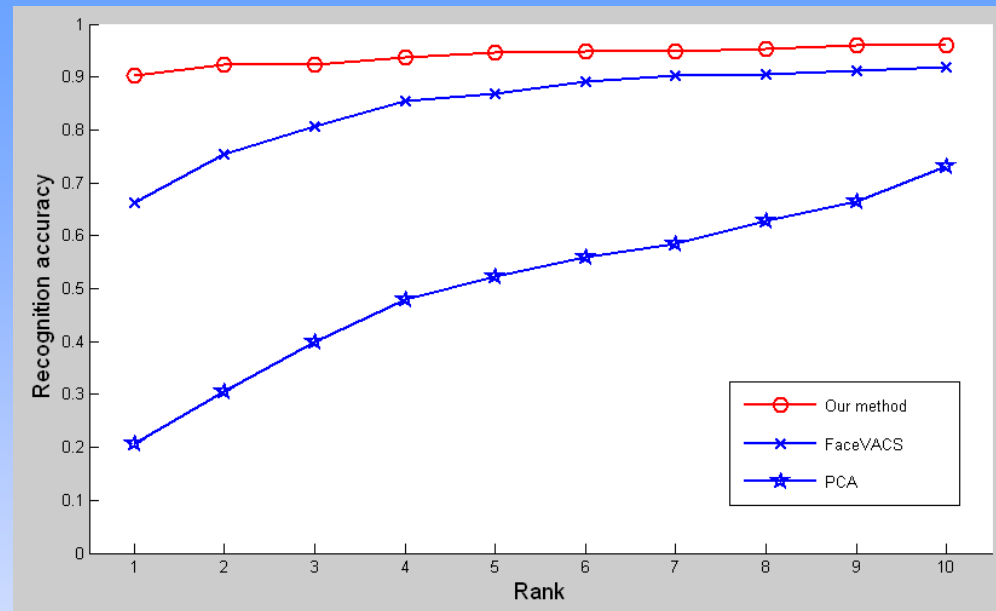
Sketch To Photo Matching
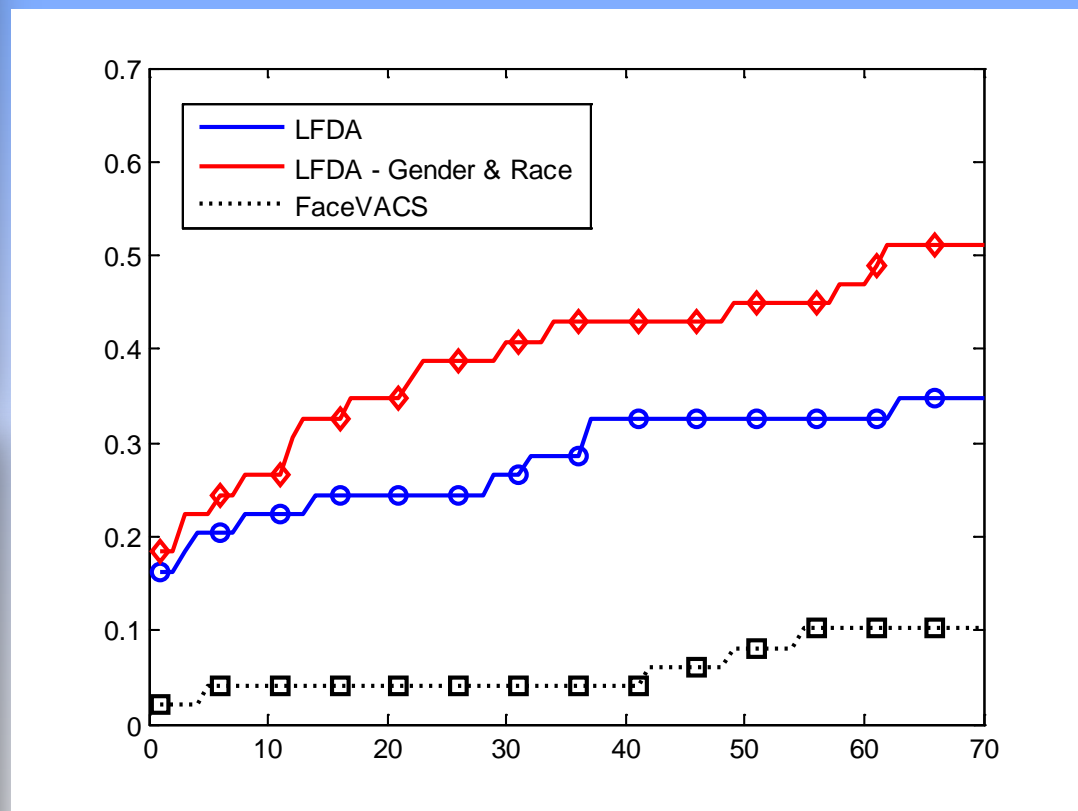
49 forensic sketch probes; 10K gallery images

Brendan Klare and A. K. Jain, SPIE Biometrics Conf., April 2010

Retrieval Example

Query Sketch:

Rank 1 Rank 2 Rank 3 (Correct) Rank 4

Continuous Authentication

Koichiro Niinuma and A. K. Jain, SPIE Biometrics Conf., April 2010

Soft Biometrics

Soft biometrics provide some information about the individual, but lack the distinctiveness and permanence to sufficiently differentiate them

Ethnicity, Skin Color, Hair color
(Sub-Saharan African, Indian, Southern European, and Northwest European)

http://anthro.palomar.edu/adapt/adapt_4.htm
© Corel Corporation, Ottawa, Canada

Height

http://www.altonweb.com/history/wadlow/p2.html
© Alton Museum of History and Art

Weight

http://www.laurel-and-hardy.com/
goodies/home6.html © CCA
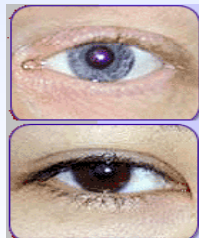
Eye color
http://ology.amnh.org/genetics/longdefinition/index3.html
© American Museum of Natural History, 2001

Periocular Biometric

- Augment iris or face recognition ability
- Iris captured in infrared; periocular (shape and texture) measured in visible spectrum

Face

overall appearance

Periocular

detailed information around the eye

Iris

texture pattern

Park, Ross & Jain, "Periocular Biometrics in the Visible Spectrum: A Feasibility Study", BTAS 2009
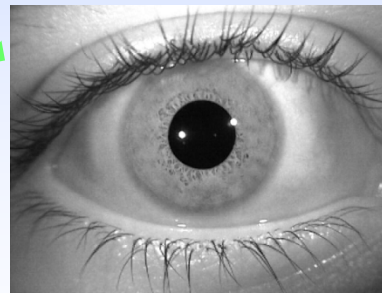
Ethnic Gangs Make Growing Presence Felt

(The Korea Times, Sept 5-6, 2009)

Gangs prey on people of the same ethnic background, commit extortion & run illegal gambling pits

Former members of 'Hanoi Gang' are rounded up — with some showing their clan tattoos — at Seoul Suseo Police Station last week. They were arrested for kidnapping a Vietnamese woman in Korea and trying to get a ransom from her family back in Vietnam.

Yonhap

Image Matching & Retrieval

Query1	163	157	111	27	26	26	26
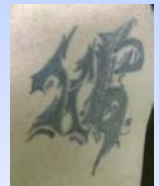
Query2	168	92	69	64	63	62	61

Jain, Lee and Jin, ICIP, Nov 2009
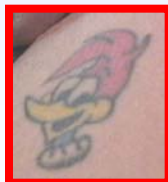
Fingerprint Forgery

- Many companies have installed fingerprint-based time and attendance systems
- Crafty companies help people forge their fingerprints
- Employees distribute multiple fake fingerprints of their own to their colleagues
- Fine for being late > $30; price of fake print < $15

http://www.dailystar.co.uk/playlist/view/107571/Give-your-boss-the-finger/

Biometric Obfuscation

- Hundreds of asylum-seekers (in Sweden and France) are cutting or burning their fingertips to evade identification by Eurodac, an EU fingerprint ID system for asylum-seekers

- A Chinese woman arrested in Japan for illegal entry had altered her fingerprints through surgery (Dec 8)

J. Feng, A.K. Jain, A. Ross, "Fingerprint Alteration", submitted to IEEE TIFS, 2009

http://www.dailymail.co.uk/news/worldnews/article-1201126/Calais-migrants-mutilate-fingertips-hide-true-identity.html#
http://news.bbc.co.uk/2/hi/europe/3593895.stm

Template Security

Minutiae

Spiral phase

Reconstructed fingerprint

Orientation field

Gradient of continuous phase

Continuous phase

J. Feng and A.K. Jain, "Fingerprint reconstruction: From minutiae to phase", ICB 2009
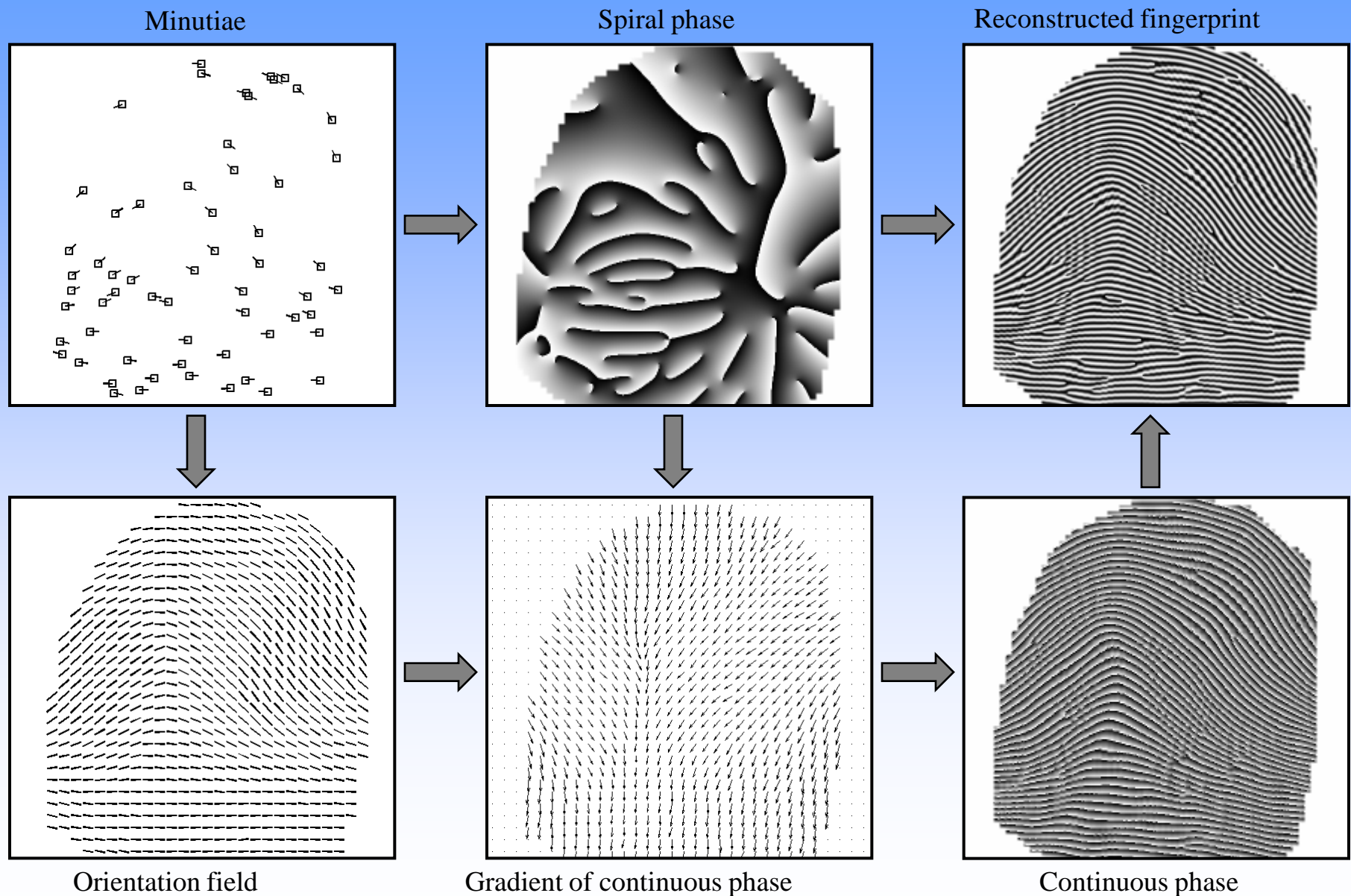
Biometric Traits of Identical Twins

• Can biometric system distinguish identical twins?

• Identical twins pose a real challenge to face recognition; multimodal systems give best results
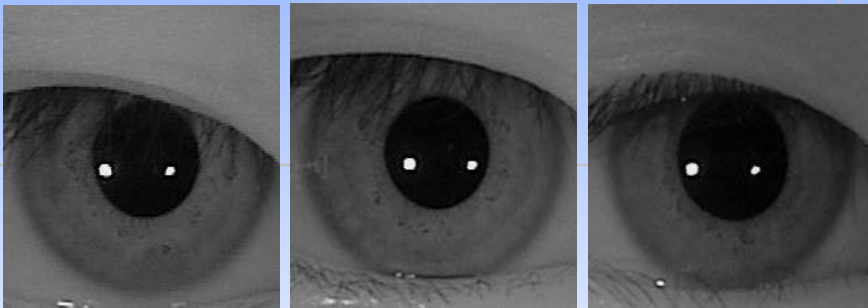

Face

Image of a person's trait, followed by his identical twin's trait, followed by an unrelated person's trait

Z. Sun, A. Paulino, T. Tan and A. K. Jain, SPIE Biometrics, April 2010

Summary

- Biometric recognition is a part of the security solution not a solution in itself

- Indispensable in many applications: forensics, border crossing, travel & ID documents,...

- Commercial market for biometrics will grow, but slowly (ATM, transaction based accountability)

- Biometric systems are not likely to be perfect; what is the acceptable error for an application?

- For biometrics to be pervasive, we need to: understand application requirements & expectations, user concerns & integration issues