



Introduction

Biometrics
CSE 190-a
Lecture 1

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Who are you??

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How are people identified?

- People are identified by three basic means:
 - Something they **have** (identity document or token)
 - Something they **know** (password, PIN)
 - Something they **are** (human body)

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Person Identification

- Identifying fellow human beings has been crucial to the fabric of human society
- In the early days of civilization, people lived in small communities and everyone knew each other
- With the population growth and increase in mobility, we started relying on **documents** and **secrets** to establish identity
- Person identification is now an integral part of the infrastructure needed for diverse business sectors such as banking, border control, law enforcement.

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Automatic Identification

Different means of automatic identification:

- **Possession-based** (credit card, smart card)
 - "something that you have"
- **Knowledge-based** (password, PIN)
 - "something that you know"
- **Biometrics-based** (biometric identifier)
 - "something about or produced by your physical make-up"

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Problems with Possession- or Knowledge-based Approaches

- Card may be lost, stolen or forgotten
 - Password or PIN may be forgotten or guessed by the imposters
- ~25% of people seem to write their PIN on their ATM card
- Estimates of annual identity fraud damages:
 - \$56.6 billion in credit card transactions in U.S. alone in 2005*
 - 0.25% of internet transactions revenues, 0.08% of off-line revenues
 - \$1 billion in fraudulent cellular phone use
 - \$3 billion in ATM withdrawals
- The traditional approaches are unable to differentiate between an authorized person and an impostor

* Spectrum July, 2006

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Identification Problems




Identity Theft: Identity thieves steal PIN (e.g., date of birth) to open credit card accounts, withdraw money from accounts and take out loans

3.3 million identity thefts in U.S. in 2002; 6.7 million victims of credit card fraud

Surrogate representations of identity such as passwords and ID cards no longer suffice

Too Many Passwords to Remember!



Copyright 1996 Ready Garbagen. www.garbasen.com

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

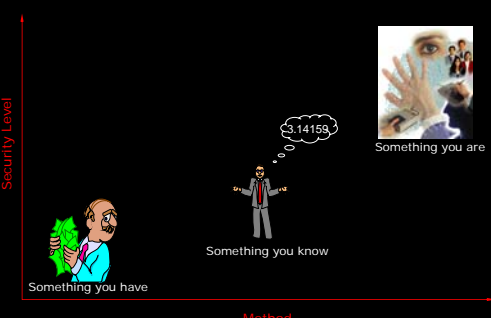
- Heavy web users have an **average of 21 passwords**; 81% of users select a common password and 30% write their passwords down or store them in a file. (2002 NTA Monitor Password Survey)

What are Biometrics?

- Biometrics** – science, which deals with the automated recognition of individuals (or plants/animals) based on biological and behavioral characteristics
 - Scientific follow-on to Bertillon's body measurements of the late 1800s
- Biometry** – mathematical and statistical analysis of biological data
- Biometric system** – a pattern recognition system that recognizes a person by determining the authenticity of a specific biological and/or behavioral characteristic (biometric)
- Anthropometry**–measurement techniques of human body and its specific parts
 - Forensic (judicial) anthropometry**–identification of criminals by these measurement techniques

Why Biometrics?

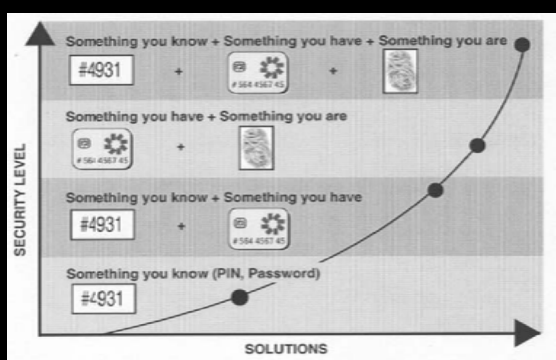
Security Level



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Mentioning the Obvious

SECURITY LEVEL



Requirements for an Ideal Biometric Identifier

- Universality**
 - Every person should have the biometric characteristic
- Uniqueness**
 - No two persons should be the same in terms of the biometric characteristic
- Permanence**
 - The biometric characteristic should be invariant over time
- Collectability**
 - The biometric characteristic should be measurable with some (practical) sensing device
- Acceptability**
 - One would want to minimize the objections of the users to the measuring/collection of the biometric

What are possible biometrics?

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Identifiable Biometric Characteristics

- **Biological traces**
 - DNA (DeoxyriboNucleic Acid), blood, saliva, etc.
- **Biological (physiological) characteristics**
 - fingerprints, eye irises and retinas, hand palms and geometry, and facial geometry
- **Behavioral characteristics**
 - dynamic signature, gait, keystroke dynamics, lip motion
- **Combined**
 - voice

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Biometrics is Not New!

- Bertillon system (1882) took a subject's photograph, and recorded height, the length of one foot, an arm and index finger
- Galton/Henry system of fingerprint classification adopted by Scotland Yard in 1900
- FBI set up a fingerprint identification division in 1924
- AFIS installed in 1965 with a database of 810,000 fingerprints
- First face recognition paper published in 1971 (Goldstein et al.)
- FBI installed IAFIS in ~2000 with a database of **47 million 10 prints**; average of 50,000 searches per day; ~15% of searches are in **lights out** mode; 2 hour response time for criminal search

Emphasis now is to **automatically** perform **reliable** person identification in **unattended** mode, often **remotely** (or at a distance)

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Bertillon System



The Bertillon system (1882) entailed photographing the subject looking directly at the camera, then in profile, with the camera centred upon the right ear. Besides the two photographs, the subject's height was recorded, together with the length of one foot, an arm and index finger.



<http://www.tld.tcu.edu.au/hist/stats/bert/>

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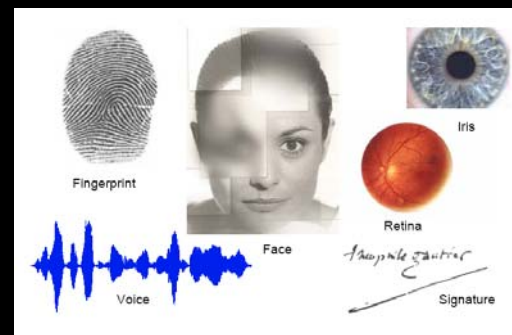
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Alphonse Bertillon: Forensic Anthropometry



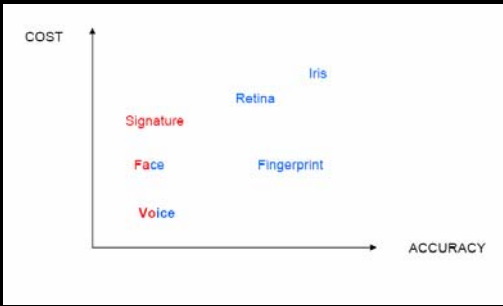
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Popular Biometric Characteristics (modalities) (Details later)



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Comparison of Biometric Techniques



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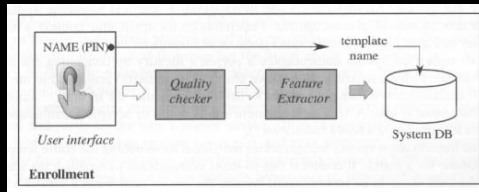
Using Biometrics

Enrollment, Verification
Recognition

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Enrollment

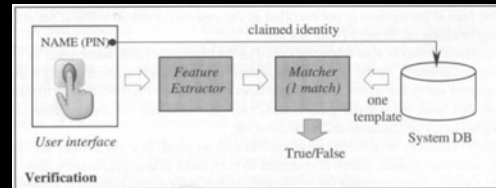
- **Enrollment**
 - Person entered into the database



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Verification

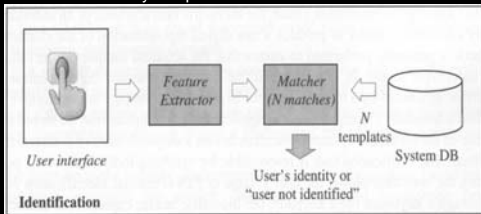
- **Verification: Am I who I claim to be?**
 - One to one comparison



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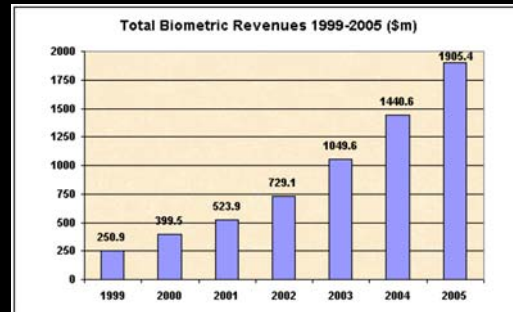
Identification

- **Identification: Who am I?**
 - One to many comparison



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Total Biometrics Market



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Different Biometrics

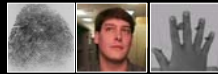
DNA (Deoxyribo Nucleic Acid) The Ultimate Biometric

- One-dimensional unique code for one's individuality, but identical twins have identical DNA patterns
- Issues limiting the utility of DNA
 - Contamination
 - Access
 - Automatic real-time recognition issues
 - Privacy issues: information about susceptibilities of a person to certain diseases could be gained from the DNA pattern

Behavioral vs Physical Traits

Physical Characteristics

- Iris
- Retina
- Vein Pattern
- Hand Geometry
- Face
- Fingerprint
- Ear shape



Behavioral Characteristics

- Keystroke dynamics
- Signature dynamics
- Walking Gait
- Voice

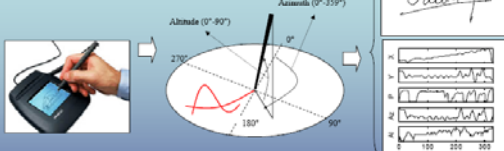


A Brief Look at Different Biometrics

- **Dynamic Signature**
- Fingerprints
- Iris
- Retina
- Face
- Speaker Recognition
- Others
- Multimodal Biometrics

On-line and Off-line Signature

On-Line:



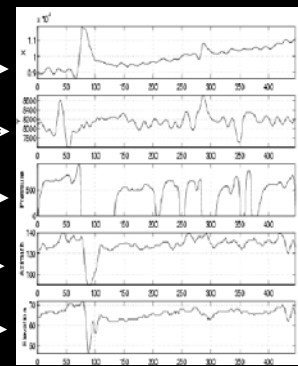
Off-Line



Dynamic Signature

Features:

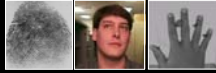
1. X coordinate
2. Y coordinate
3. Pressure
4. Pen azimuth (0°-359°)
5. Pen altitude (0°-90°)



Behavioral vs Physical Traits

Physical Characteristics

- Iris
- Retina
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- Face
- Fingerprint
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Behavioral Characteristics

- Keystroke dynamics
- Signature dynamics
- Walking Gait
- Voice



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Fingerprints: A Brief History

- 1750 B.C. - In ancient Babylon, fingerprints were used on clay tablets for business transactions.
- 300 B.C. - Emperors of China used personalized clay seals
- 220 A.D. - The first time ink prints were used was in China



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Fingerprints: A Brief History

- 1858 - Sir William Herschel, Chief Magistrate of the Hooghly district in Jungipoor, India, first used fingerprints on native contracts.
- 1880 - Dr. Henry Faulds published an article in the Scientific Journal, "Nautre" (nature), discussing fingerprints as a means of personal identification, and the use of printer's ink as a way of obtaining them.
- 1892 - Sir Francis Galton published his book, "Fingerprints", establishing the individuality and permanence of fingerprints. The book included the first classification system for fingerprints.
- More to come later in the course....

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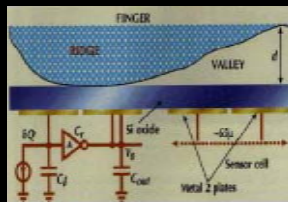
Fingerprints



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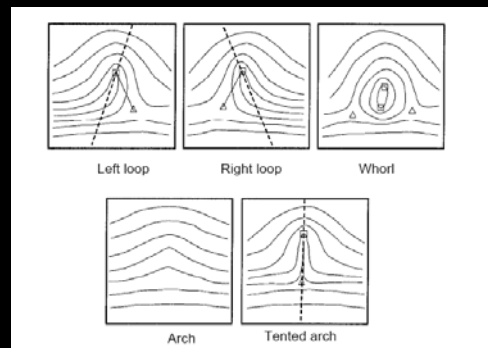
Fingerprint Systems

- Thermic systems :
- Tactile systems :
- Capacitive systems :



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Fingerprint Features: Level 1



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A Brief Look at Different Biometrics

- Dynamic Signature
- Fingerprints
- **Iris**
- Retina
- Face
- Speaker Recognition
- Others
- Multimodal Biometrics

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Iris Recognition: Eye



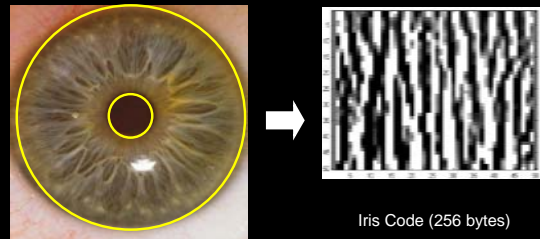
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Iris



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Iris Code



Iris Code (256 bytes)

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Comparing Irises



- Different IrisCodes are compared Exclusive-OR'ing them in order to detect the bits that disagree.
- Occluded parts of the iris are masked.

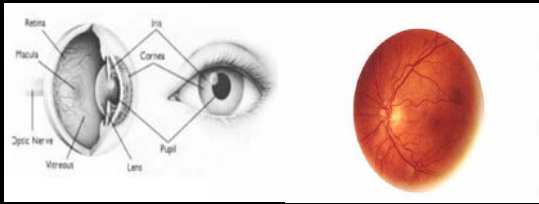
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National Geographic 1984 and 2002



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Retina



Every eye has its own totally unique pattern of blood vessels.

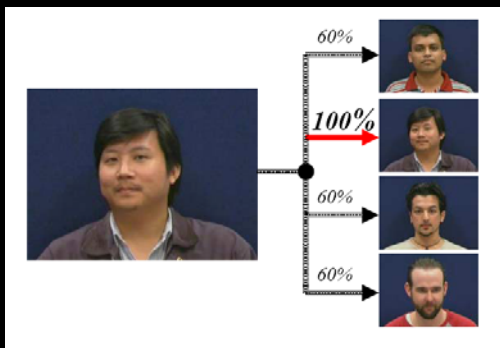
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Face Recognition: Who are these people?



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Face Recognition: Correlation



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Lighting Variability: Yikes!



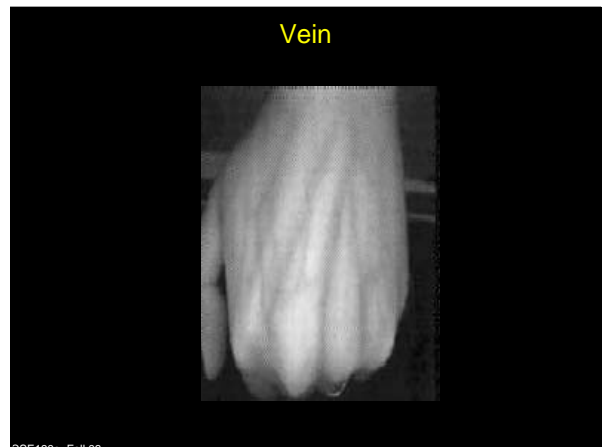
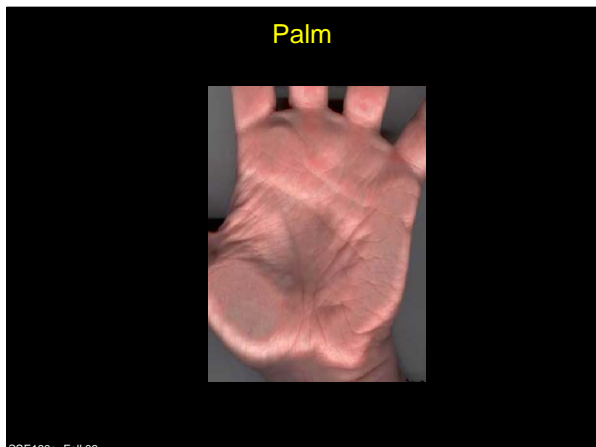
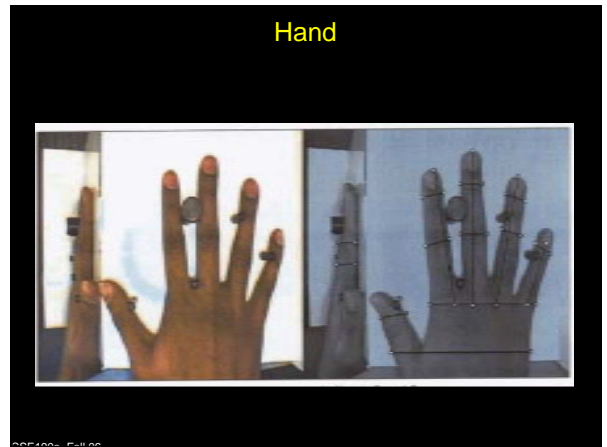
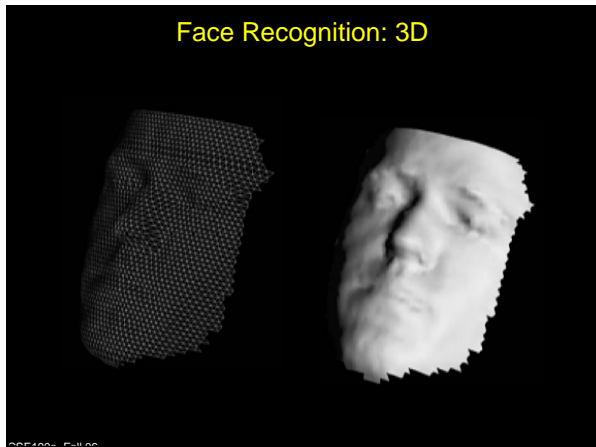
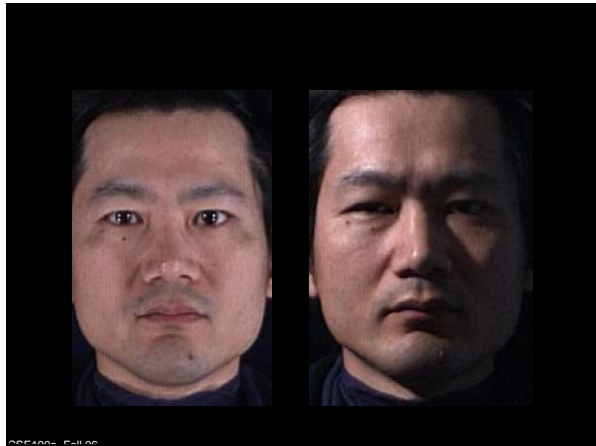
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Same Person or Different People



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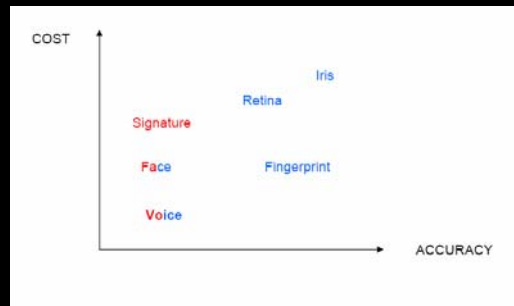


Ear



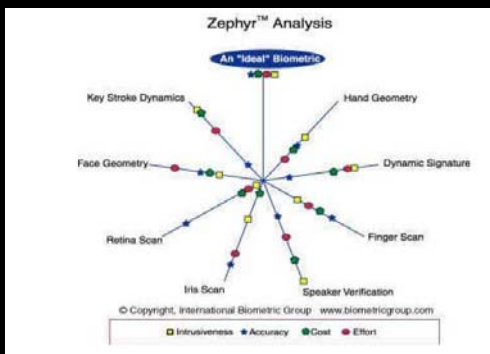
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Comparison of Biometric Techniques



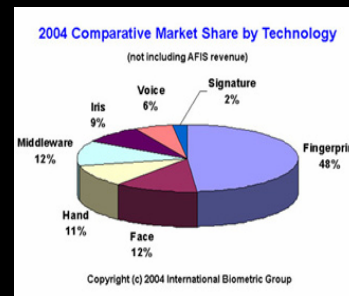
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Comparison of Biometric Techniques



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Market Share



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About this Class

- See Syllabus
- Special thanks to
 - Peter Belhumeur
 - Anil Jain

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Biometric Applications

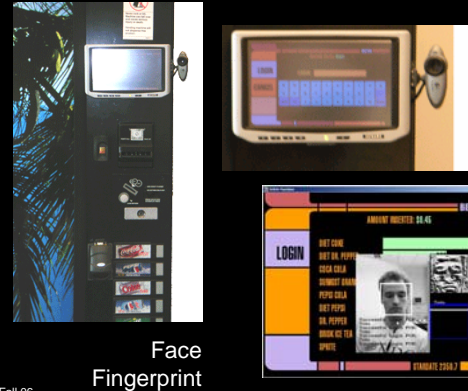
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Applications

Forensic	Government	Commercial
Corpse Identification, Criminal Investigation, Terrorist Identification, Parenthood Determination, Missing Children, etc.	National ID card, Correctional Facility, Driver's License, Social Security, Welfare Disbursement, Border Control, Passport Control, etc.	Computer Network Logon, Electronic Data Security, E-Commerce, Internet Access, ATM, Credit Card, Physical Access Control, Cellular Phones, Personal Digital Assistant, Medical Records Management Distance Learning, etc.

* There are ~500 million border crossings/year in the U.S.

UCSD Biometric Soda Machine



Face
Fingerprint



* As part of the enhanced procedures, most visitors traveling on visas will have two fingerprints scanned by an inkless device and a digital photograph taken. All of the data and information is then used to assist the border inspector in determining whether or not to admit the traveler. These enhanced procedures will add only seconds to the visitor's overall processing time.



The electronic fingerprint scanner allows inspectors to check identities of visitors against those on terrorist watch lists.
By Stephen J. Boitano, AP

*From the DHS US-VISIT web-site



National Biometric ID Cards

U.K. to consider national biometric ID cards, database

By Laura Rohde, COMPUTERWORLD (Nov 29, 2003)-

The U.K. government is set to consider legislation next year for the establishment of compulsory biometric identity cards and a central database of all U.K. subjects, it was announced by the government this week.

The information that the government is considering for inclusion on the card includes personal details such as a person's home address and telephone number, his National Insurance number (the equivalent of the U.S. Social Security number), medical information and criminal convictions, as well as the biometric information, most likely in the form of an iris, fingerprint or palm print scan.

Biometric Applications



Hajj pilgrims in Saudi Arabia



Fingerprint at check-out counter



Disney World



Ben Gurion Airport



Cell Phone with Fingerprint Sensor



Smart gun

Access Control

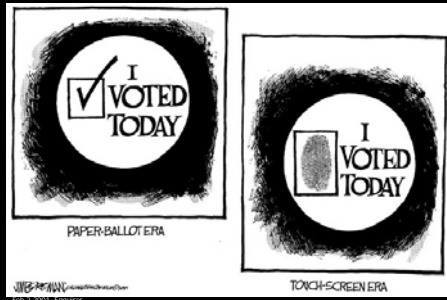


<http://www.livegrip.com>



<http://www.livegrip.com>

Did You Vote?



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Applications

- Video Surveillance (On-line or off-line)



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Fingerprint System at Gas Stations

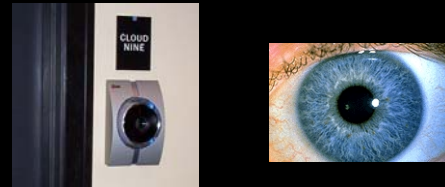
"Galp Energia SGPS SA of Lisbon won the technology innovation award for developing a payment system in which gasoline-station customers can settle their bills simply by pressing a thumb against a glass pad. Scanning technology identifies the thumbprint and sends the customer's identification information into Galp's back-office system for payment authorization."
THE WALL STREET JOURNAL, November 15, 2004



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Using Iris Scans to Unlock Hotel Rooms



The **Nine Zero** hotel in Boston just installed a new system which uses digital photos of the **irises** of employees, vendors and VIP guests to admit them to certain areas, the same system used in high-security areas at airports such as New York's JFK.

USA TODAY 7/22/2004

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Fingerprint System at Border Crossings

"Foreigners entering the United State in three cities, including Port Huron, were fingerprinted, photographed and subjected to background checks on Monday in a test of a program that will eventually be extended to every land border crossing nationwide."

Lansing State Journal, Nov. 16, 2004



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New Passports

"ICAO TAG-MRTD/NTWG RESOLUTION N001 - Berlin, 28 June 2002

ICAO TAG-MRTD/NTWG endorses the use of **face recognition** as the **globally interoperable biometric** for machine assisted identity confirmation with machine readable travel documents.

ICAO TAG-MRTD/NTWG further recognizes that Member States may elect to use fingerprint and/or iris recognition as additional biometric technologies in support of machine assisted identity confirmation.

Endorsement: Unanimous"

<http://www.icao.int>



The new passports have an embedded contactless (ISO 14443) "smart-card" chip that stores personal information and a biometric template. Two problems: **reliability and privacy**

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Want to Charge It? You'll Have to Talk to Your Credit Card



Beepcard, a company in California, has designed a credit card that works only when it recognizes the voice of its rightful owner. Enclosed in the card is a tiny microphone, a loudspeaker and a speech recognition chip that compares the spoken password with a recorded sample. If the voices match, the card emits a set of beeps that authorize a transaction over the telephone or the Internet. If the voices do not match, the card will not beep.

The system tolerates some variations in voice to accommodate cold or background noise. But it might not work if there is a blaring music in the background.

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Biometrics for Personalization

- Automatic personalization of vehicle settings:
 - Seat position
 - Steering wheel position
 - Mirror positions
 - Lighting
 - Radio station preferences
 - Climate control settings
- URLs at your fingertips



<http://www.vision.com>



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Amsterdam Schiphol Airport



Frequent flyers can sign up for the so-called Privium club which not only allows members to bypass the lengthy line at passport control, but also lets them park closer to the departure hall and use fast check-in counters.

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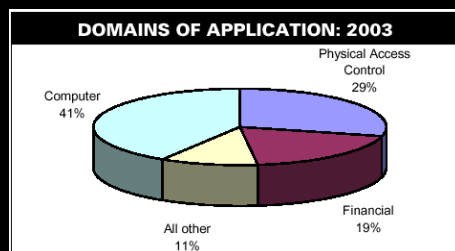
Application Characteristics

- Overt vs Covert
- Attended vs Unattended
- Cooperative vs Non-cooperative
- Scalable vs Non-scalable
- Habituated vs Non-habituated
- Private vs Public
- Closed vs Open
- Reduce vs Eliminate fraud

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Domains of Application



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References

- A. Jain, R. M. Bolle, S. Pankanti, "Biometrics: Personal Identification in Networked Society," Kluwer Academic Press, 1998.
- R.M. Bolle, J.H. Connell, S. Pankanti, N.K. Ratha, A.W. Senior, "Guide to Biometrics," Springer-Verlag, New York, 2004
- D. Maltoni, D. Maio, A.K. Jain, S. Prabhakar, "Handbook of Fingerprint Recognition," Springer-Verlag, New York, 2003.

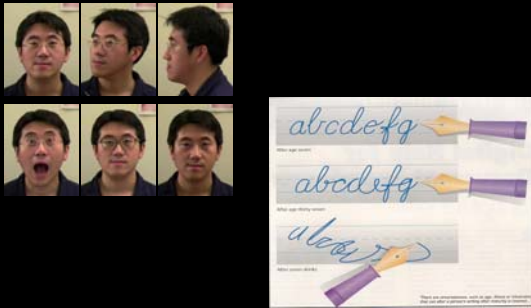
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What makes using biometrics difficult?

Why is Biometric Recognition Difficult?

- Large number of classes (e.g., millions of faces)
- Intra-class variability and inter-class similarity
- Segmentation
- Noisy and distorted images
- Population coverage & scalability
- System performance (error rate, speed, throughput, cost)
- Attacks on the biometric system
- Template ageing
- Non-uniqueness of biometric characteristics
- Addressing privacy concerns

Intra-class variability



Inter-class Similarity

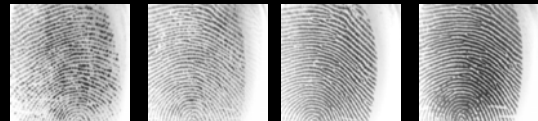


Identical Twins



Temporal Variations

Time duration: 6 months



Time duration: 2 years

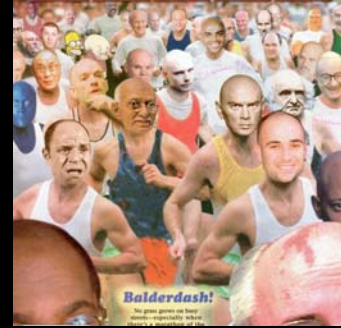


Segmentation: Face Detection



*Theo Pavlidis, <http://home.att.net/~t.pavlidis/comphumans/comphuman.htm>

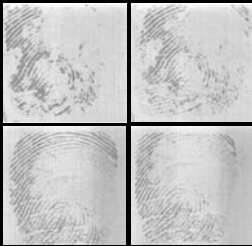
Locating Faces in a Crowd



Games Magazine, September 2001

Noisy Images

- ~ 3% of the population has poor quality fingerprint images



Four impressions of a user's fingerprint

Faded fingerprints cost former welder a job

Associated Press **ridges on his fingerprints**

DECATUR — The years Chuck Strickler spent as a welder provided him with the experience he needed as a welding inspector at power plants across the nation.

But the welding also has left Strickler, 40, of Decatur, lacking a full set of intact fingerprints required under some stringent security regulations at nuclear plants. Since the U.S. Department of Homeland Security issued the new rules in the wake of Sept. 11, the owner of documents Strickler has attached to his identity no longer are sufficient.

"I first ran into a problem with it three or four years ago," Strickler said. "They said my fingerprints weren't valid. But at the time they accepted a picture ID as proof of identity."

Earlier this year, when he tried to get a job supporting the 21-Cent Nuclear Power Station near Brigham, where he had worked before, his application was turned down because of the worn-down

ridges on his fingerprints. Strickler said adding that the application process included a comprehensive psychological examination and criminal background check.

The plant sent the fingerprints to the FBI, and they said it's outside the realm of the Homeland Security's guidelines (the what is needed). It was a little frustrating.

A person has about 100 identification marks on his or her fingerprints, and most adults have about 80 that can be used to identify them.

But because of his welding work, Strickler has only about 40 of the identification points.

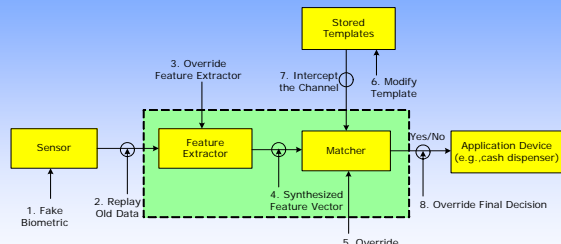
Strickler is free to work at non-nuclear plants. But he says he prefers to have the option of working for the nuclear facilities.

"This cuts my income in half," he said.

- Some problems plague all identification technologies: possession, knowledge or biometrics
- Different types of fraud
 - Loopholes: illegitimate access not envisaged by the designers
 - Inherent in the means and mechanisms of identification used by the system that cannot be completely eliminated
 - Collusion; misuse of super operator status
 - Coercion; forcibly extract biometric from a user
 - Denial; user denies access after gaining the access
 - Covert Acquisition; "video snooping"

Security of Biometric System

Like any security system, biometric systems are **not foolproof**



Attacks on Biometric Systems

- Spooing a biometric trait



Dummy finger created from a lifted impression



Artificial skin/fingers (<http://www.livingskin.com/>)

Sensor Interoperability

- Sensors used during enrollment and verification may be different



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Sensor Interoperability



A rolled inked fingerprint



Digital Biometrics optical sensor
(508x480)



Veridicom capacitive sensor
(300x300)



Fidelica pressure sensor
(256x256)

Sensors used during enrollment and verification may be different

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