



Introduction

Biometrics
CSE 190-D00
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"

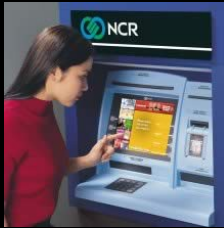
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Problems with Possession- or Knowledge-based Approaches

- 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
 - In 2009, Identity fraud losses estimated at \$54 billion, up 12.5% and affecting 11.1 million adults.
- The traditional approaches are unable to differentiate between an authorized person and an impostor

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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

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Too Many Passwords to Remember!



- 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)

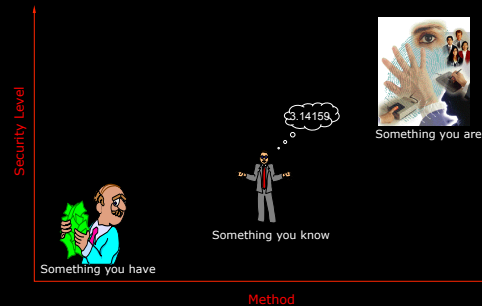
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What are Biometrics?

- 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

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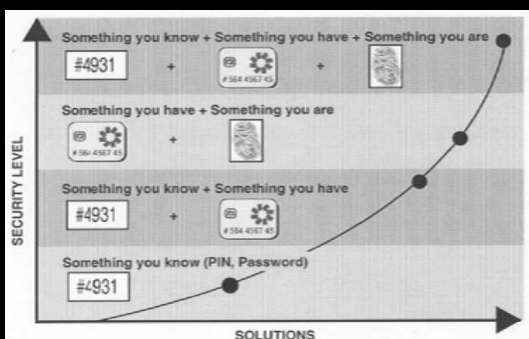
Why Biometrics?



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(c) Jain04

Mentioning the Obvious



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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

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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, ears, and facial geometry
- **Behavioral characteristics**
 - dynamic signature, gait, keystroke dynamics, lip motion, voice
- **Combined**

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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 circa 2000 with a database of **47 million 10 prints**; average of 50,000 searches per day; 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.



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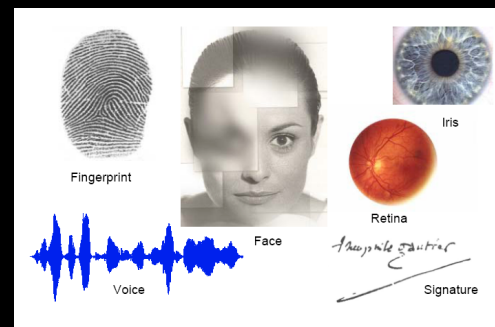
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Alphonse Bertillon: Forensic Anthropometry



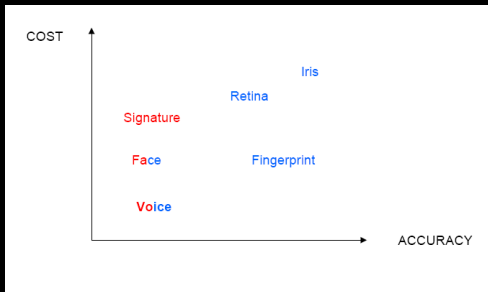
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Popular Biometric Characteristics (modalities) (Details later)



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Comparison of Biometric Techniques



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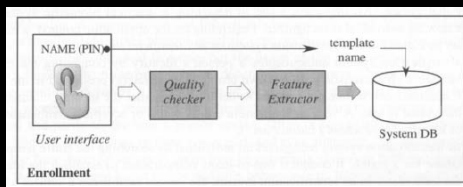
Using Biometrics

Enrollment, Verification
Recognition

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Enrollment

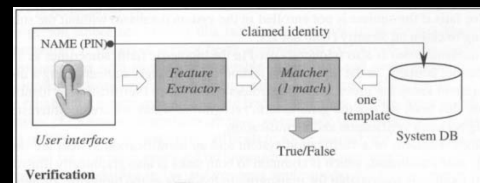
- **Enrollment**
 - Person entered into the database



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Verification

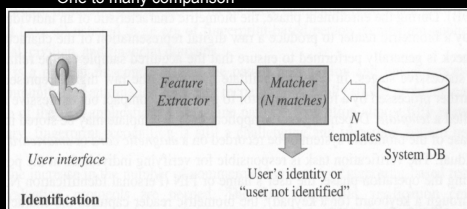
- **Verification**: Am I who I claim to be?
 - One to one comparison



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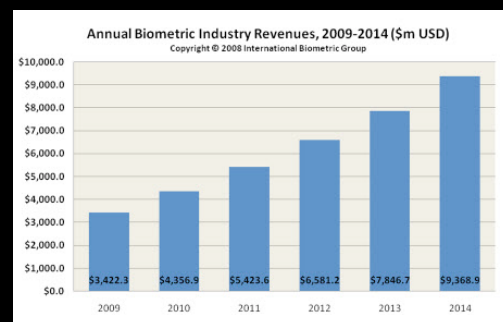
Identification

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



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Total Biometrics Market



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Different Biometrics

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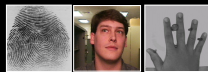
DNA (Deoxyribo Nucleic Acid) The Ultimate Biometric

- 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

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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



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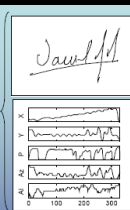
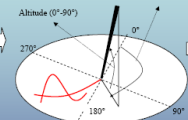
A Brief Look at Different Biometrics

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

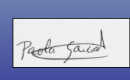
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On-line and Off-line Signature

On-Line:



Off-Line

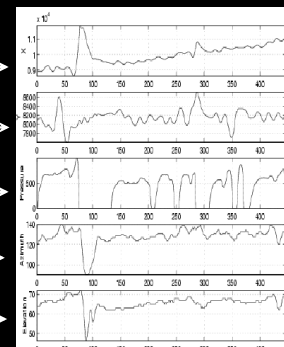


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Dynamic Signature

Features:

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

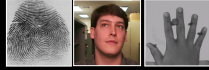


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Behavioral vs Physical Traits

Physical Characteristics

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



Behavioral Characteristics

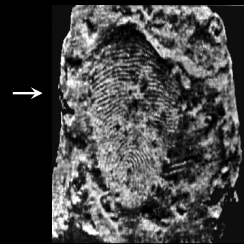
- Keystroke dynamics
- Signature dynamics
- Walking Gait
- Voice



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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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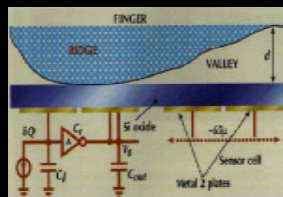
Fingerprints



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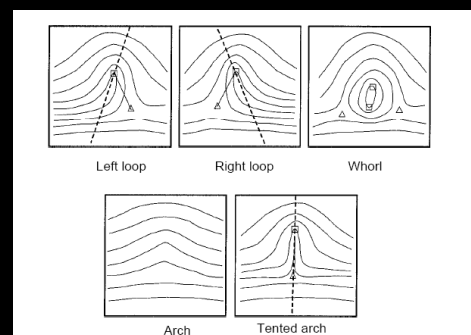
Fingerprint Systems

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



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Fingerprint Features: Level 1



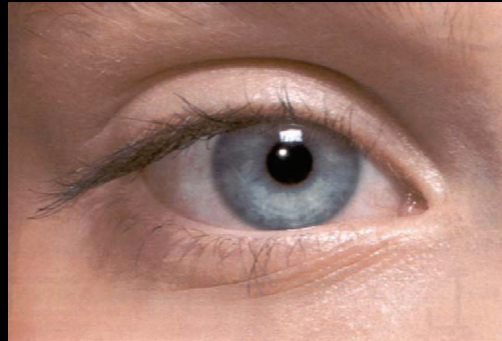
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A Brief Look at Different Biometrics

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

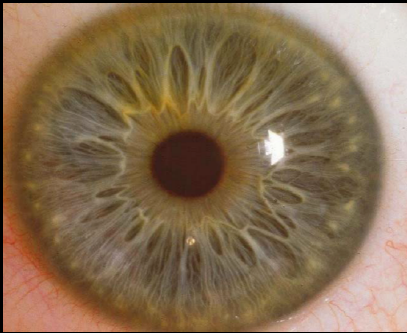
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Iris Recognition: Eye



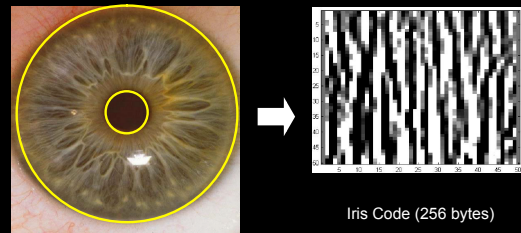
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Iris



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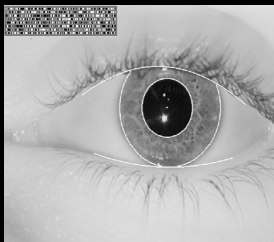
Iris Code



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.

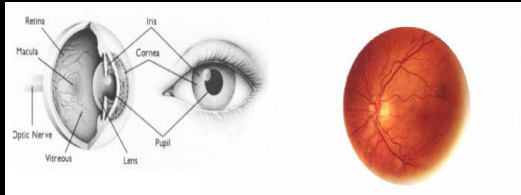
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National Geographic 1984 and 2002



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Retina



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

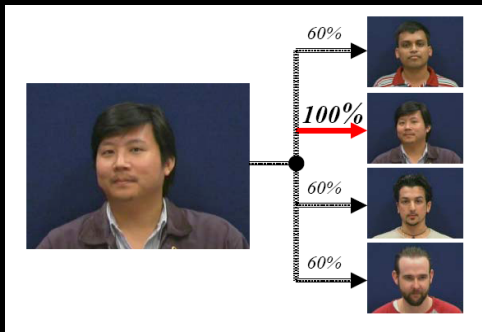
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Face Recognition: Who are these people?



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Face Recognition: Correlation



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Lighting Variability: Yikes!



Indoor

Outdoor

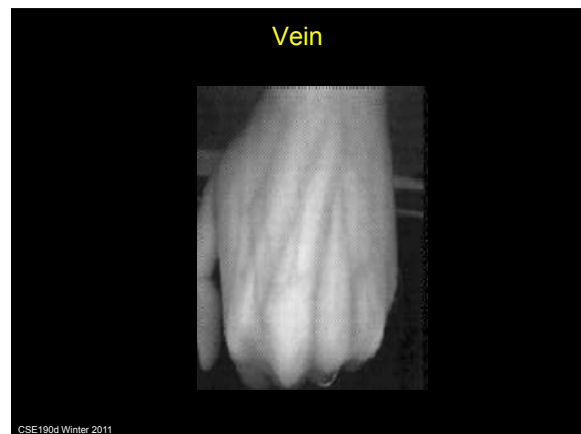
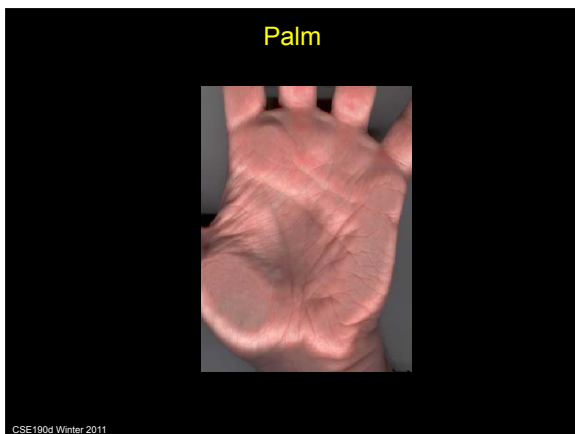
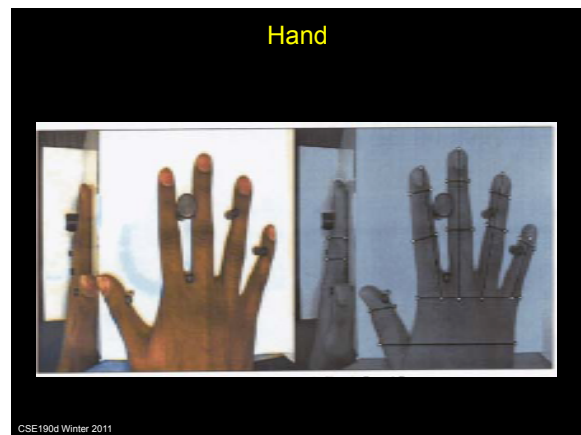
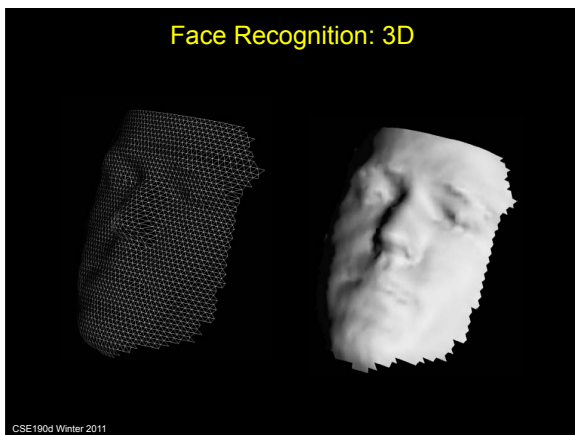
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Same Person or Different People



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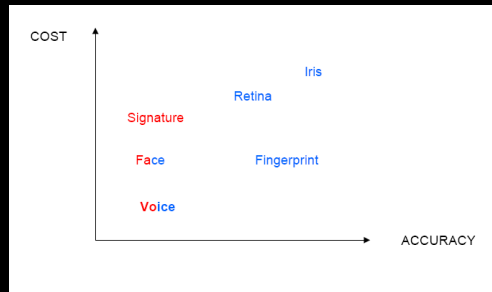


Ear



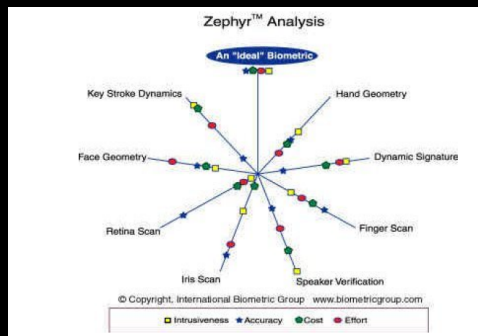
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Comparison of Biometric Techniques



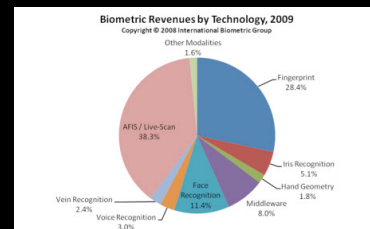
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Comparison of Biometric Techniques



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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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