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# CS355: Cryptography

Lecture 21: Biometrics.

# Authentication

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- ▶ Something that you know
- ▶ Something that you have
- ▶ Something that you are

# What Are Biometrics ?

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(ancient Greek: *bios* ="life", *metron* ="measure")

- ▶ **Biometrics are automated methods of recognizing a person based on a physical or behavioral characteristic.**
- ▶ Physical Features
  - ▶ Fingerprint or fingerscan
  - ▶ Hand geometry
  - ▶ Face recognition
  - ▶ Retinal scans
  - ▶ Iris scans
- ▶ Behavioral Characteristics
  - ▶ Handwritten signature
  - ▶ Voice recognition
  - ▶ Typing
  - ▶ Gait



# Biometric System

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## ▶ Registration:

- ▶ A person registers with the system when one or more of his physical and behavioral characteristics are obtained.
- ▶ Information registered in a database (digital template), based on some algorithm.

## ▶ Use of biometrics:

- ▶ Biometric of the user is captured and processed into a digital template
- ▶ **Verification:** Compare a sample against a single stored template
- ▶ **Identification:** Search a sample against a database of templates.

# Performance of Biometric Systems

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- ▶ **False accept rate (FAR)**: percent of invalid users who are incorrectly accepted as genuine users.
- ▶ **False non match or reject rate (FRR)**: percent of valid users who are rejected as impostors.
- ▶ FAR and FRR can typically be traded off against each other by changing some parameter.
- ▶ High degree of confidence, forensic DNA evidence and iris recognition technology (can discriminate between individuals with identical DNA, such as monozygotic twins)

# Applications of Biometric Technologies

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- ▶ **Secure identification and personal verification**
- ▶ WHERE: Federal, state and local governments, in the military, travel and transportation, financial, law enforcement, health and social services.
- ▶ Specific applications:
  - ▶ Civil and government ID
  - ▶ Network security infrastructures
  - ▶ Surveillance and screening
  - ▶ Retail/ATM/point of sale
  - ▶ Secure electronic banking
  - ▶ Telephony
  - ▶ Criminal ID

## More about Applications...

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- ▶ Biometrics can be used alone or integrated with other technologies such as smart cards, encryption keys and digital signatures
- ▶ Think about the number of passwords you must remember...Use of biometrics personal authentication: convenience, accuracy (?), provide audit trail
- ▶ Many countries started using biometrics

## Use of Biometrics...

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- ▶ Japan has been using retinal and/or iris scans for bank ID since 1997
- ▶ Malaysian airport uses face recognition for baggage claim
- ▶ USA started using it for airport security Dec. 2004
- ▶ UK airports
- ▶ European standard for biometric passports, US
- ▶ Identity cards including biometrics: UK, Oman, United Arab Emirates, Brazil

# Biometrics: the DARK SIDE ...

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- ▶ **Social acceptance:** Perceived as invasive; people liked facial scans less than fingerprints as a substitute for a PIN in ATM.
- ▶ **Easy to forge:** Biometric measurements are easy to forge. It is easy to steal a biometric after the measurement is taken.
- ▶ **Impossible to revoke:** What happens if a biometric is stolen? It can not be revoked... Once someone steals your biometric, it remains stolen for life.
- ▶ **Privacy:** issues... Biometrics are personal.



# Handwritten Signature

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- ▶ Handwritten signatures used a lot in the past to validate deals or identification
- ▶ Seals were mostly used in Europe
- ▶ How easy is to forge handwritten signatures? Depends who verifies, how trained the verifiers are
- ▶ **Experiment:** 105 professional document examiners, 144 pairwise comparisons, **mistake rate was 6.5%**
- ▶ Rules and conventions of accepting handwritten signatures differ from country to country



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# Handwritten Signature

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- ▶ Automated signature recognition/storage:  
signature tablet
  - ▶ Signature tablet: sensor surface on which the client signs
  - ▶ Uses shape, speed, stroke order, off-tablet motion, pen pressure and timing information captured during the act of signing.
- ▶ **Equal error rate (false accept = false reject) is about 0.01** for current commercial products, not acceptable for retail stores
- ▶ Used for financial document to prevent identity fraud



# Handwritten Signature

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- ▶ SMARTpen Biometric Authentication System (BiAS):
  - ▶ pen that uses sensors to authenticate individuals by the biometric characteristics of their signatures.
  - ▶ writes on regular paper
  - ▶ built-in sensors register the dynamics of writing, including the forces that are applied in 3D on paper, such as the speed, acceleration and angles of writing.
- ▶ **Equal error rate (false accept = false reject)** is about **0.01** for current commercial products, not acceptable for retail stores



# Face Recognition

- ▶ Human ability to recognize other people's facial features and expression is much better than any automatic system to date.
- ▶ Photo identification widely used.
- ▶ **Experiment:** Psychologists at University of Westminster, supermarket chain and bank
  - ▶ Recruited 44 students and issued them 4 credit cards with 4 different pictures with varied quality of the photos
  - ▶ **Optimal conditions:** experienced cashiers, enough time, students used any of the cards, several times'
  - ▶ Result: **cashiers could not tell the difference**



# Face Recognition

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- ▶ How well does the technology works?
- ▶ Methods not very robust, depends on lighting, viewpoint and expression. **Error rates were up to 20%.**
- ▶ Error rate very high when compared with other biometrics recognition (**less than 1%**)
- ▶ Many companies are providing face recognition products
- ▶ Several countries use face recognition for identification in airports



# Face Recognition

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- ▶ Interesting psychological aspect: technology has problems, but system seems to work
- ▶ Studies done by banks showed that fraud dropped substantially when credit cards with photo IDs were issued/used
- ▶ In a borough in London a computer system that was said to **scan faces in the crown for local criminals** got a significant decrease in burglary, shoplifting and street crime

# Fingerprint: Some History ...

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- ▶ First modern systematic use of fingerprints seems to be in India in mid 19th century: use of fingerprints to prevent rich people to pay poor people to serve in prison in their place
- ▶ Discovered independently by a medical missionary in Japan
- ▶ Mainstream use in 1900 when a former chief officer from Bengal becomes Commissioner of the Metropolitan Police in London



# Fingerprint: Applications

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- ▶ Finger print technology captures a representation of the finger; it involves storing the image of the finger and comparing
- ▶ Two main applications:
  - ▶ Government identification
  - ▶ Criminal identification: IAFIS “Integrated Automated Fingerprint Identification System” is the law enforcement tool used either to identify a fingerprint’s maker or to confirm prints



# IAFIS

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- ▶ Became operational in July 1999
- ▶ It is the national fingerprint and criminal history system maintained by the FBI
- ▶ It provides automated fingerprint search capabilities, latent searching capability, electronic image storage, and electronic exchange of fingerprints and responses.
- ▶ Answer received between 2 hours to 24 hours ( before the integration/digital it took days sometime months)
- ▶ Largest biometric database in the world, containing the fingerprints and corresponding criminal history information for more than 66 million subjects.

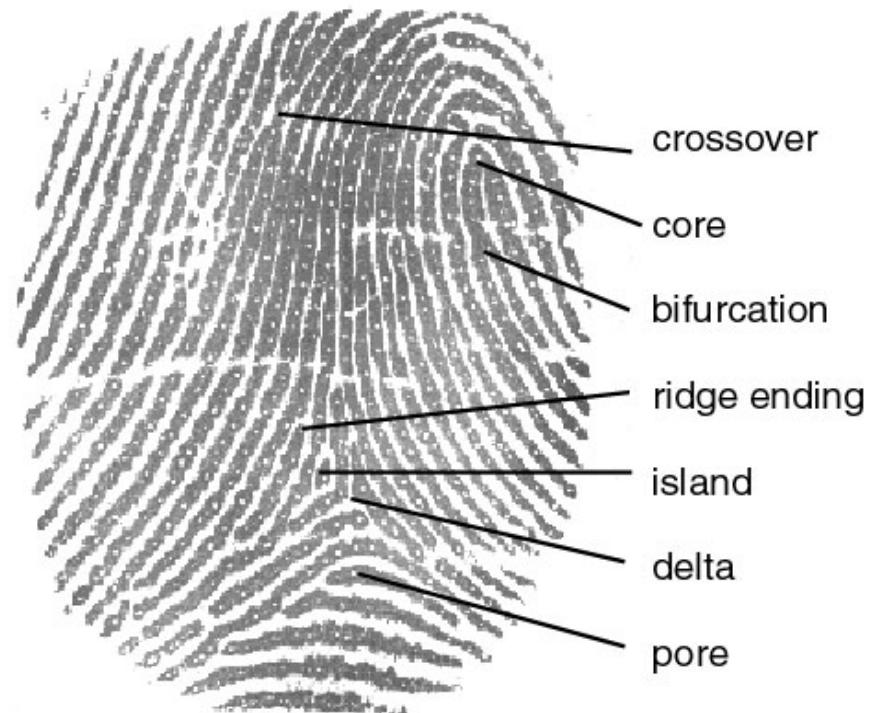
# Fingerprint: Storage



- ▶ Storage is an issue
- ▶ FBI and NIST developed an image coding standard for digitized fingerprints
- ▶ The standard is a discrete wavelet transform-based algorithm referred to as Wavelet/Scalar Quantization (WSQ).
- ▶ Storage requirements...500 dots per inch with 8 bits of grayscale resolution. Do the math ...

# Fingerprint Identification

- ▶ Fingerprint is made of a series of ridges and furrows
- ▶ Fingerprint uniqueness: determined by the pattern of ridges and furrows as well as the minutiae points
- ▶ **Minutiae points are local ridge characteristics that occur at either a ridge bifurcation or a ridge ending**



# Fingerprint Identification Accuracy

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- ▶ Error rate in forensic applications is very low, it depends on the quality and size of the image taken at the crime
- ▶ Fingerprints require a number of match points, different from country to country. UK requires 16 points

# Finger-scan

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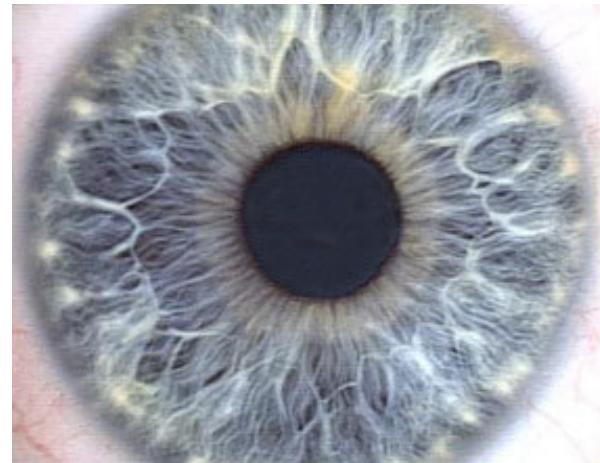
- ▶ A live acquisition of a person's fingerprint.
- ▶ Different type of devices:
  - ▶ Glass plate
  - ▶ Electronic
  - ▶ Ultrasound



# Iris Scan

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- ▶ Probability that two people have the same Iris Code is less than  $1/10^{52}$
- ▶ 512 byte Iris Code represents the visible characteristics of the eye
- ▶ Iris Code includes “266 spots” to distinguish between irises (claim is most other biometrics have between 10-60 distinguishing spots)
- ▶ Issues: obtain the information without being intrusive
- ▶ Other issues: blinking, eyelashes, sunglasses



# Retinal Scan

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- ▶ Analyses the layer of blood vessels at the back of the eye.
- ▶ Scanning involves using a low-intensity light source and an optical coupler
- ▶ Retina scan devices are probably the most accurate biometric available today.
- ▶ Retinal pattern changes very rarely, only from degenerative diseases, in case the person dies it deteriorates very quickly

# Retinal Scan: Disadvantages

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- ▶ Expensive
- ▶ Difficult to use
- ▶ Requires participant cooperation
- ▶ Psychological factor: consumer's thinking it is potentially harmful to the eye

# Attacks on Biometrics-Based Systems

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- ▶ Villain gives policeman fingerprinted fingers in the wrong order...
- ▶ Forensic biometrics: information can be planted, or not fresh; freshness is a critical aspect.
- ▶ Recordings attacks: on voice recognition systems, imprinted lens to fool iris scanners
- ▶ Collusions: handwriting systems, by giving childish samples, they can force the machine to accept a lower threshold than usual.
- ▶ Biometrics are not as accurate for all people. Biometrics referred to these people as goats.
- ▶ Political and religious issues