CSE 741C: Emerging Biometrics and Internet of Things Security

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Agenda

- Administration & Logistics
- Introduction to IoT Security
- Introduction to (traditional) Biometrics

Course Information

- Class time: 10 – 11:30am Friday
- Location: 113 Davis
- Office hour: 10-12 Wednesday (Davis 330)
- Email: wenyaoxu@buffalo.edu
- Course Website: https://www.cse.buffalo.edu//~wenyaoxu/courses/fall2017/cse741c

About the course

- This seminar course will discuss emerging biometrics and IOT security.
- Each student will present 1 research papers and review 2 research papers.
- (HW: each student need to send me 3 paper candidates to present; 4 paper candidates to review by *TODAY*)
  - Each presentation will be about 25 minute.
    - Discuss with me before Wednesday.
  - Each reviewer need to write a review comment.

Paper Presentation

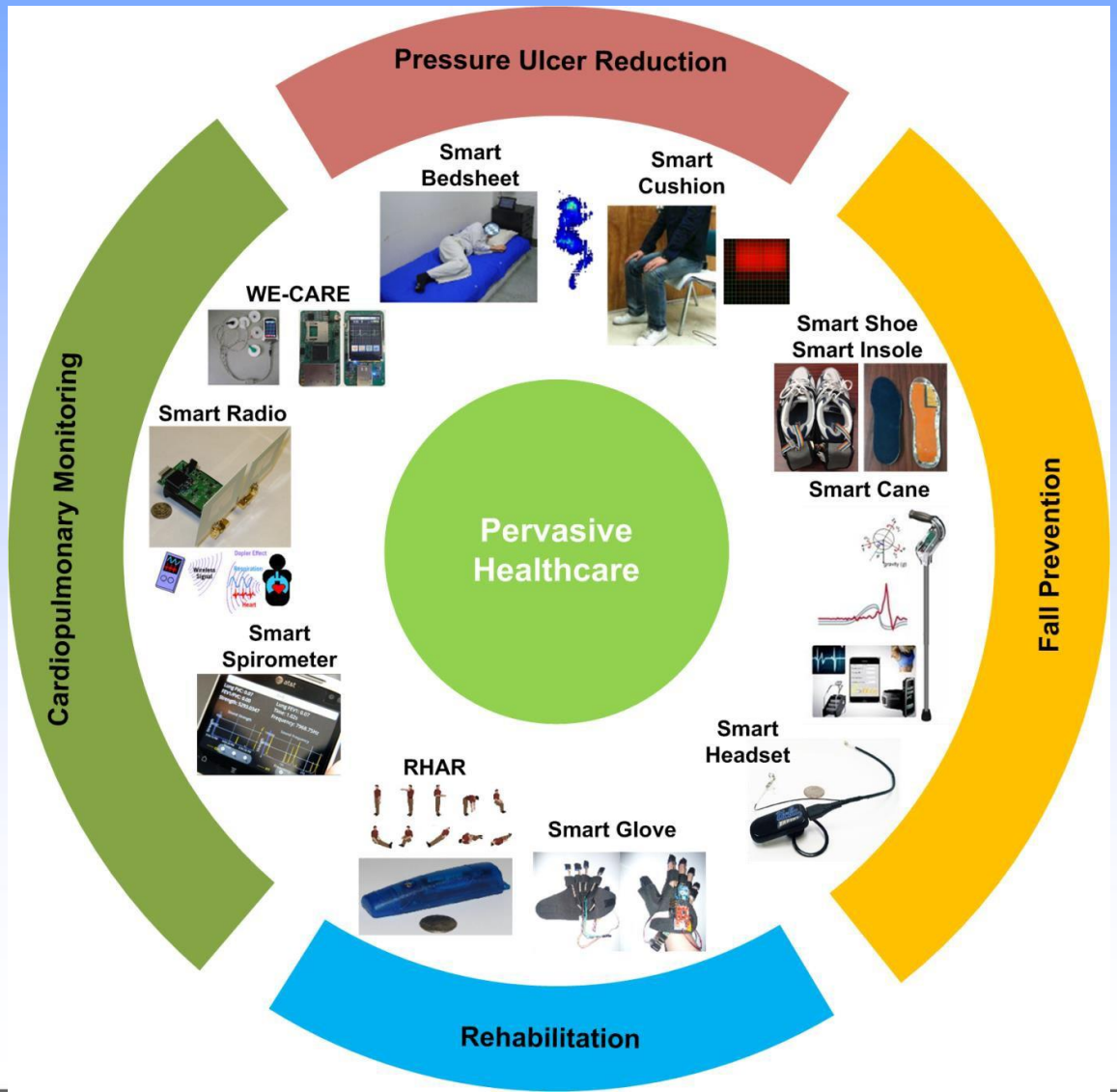
- Each research paper presents a research direction.
  - Don’t just present the paper content. Do expand your thought on this topic.
  - For example, in face recognition, can we
    - Distinguish twins?
    - Can we recognize lineage relation?
    - Can we recognize incomplete face image?
    - Can we match with aging effect or plastic surgery?
    - Spoofing and Anti-spoofing

Paper Review: Q7

- Q1: Contributions (novelty, creativity, and technical depth of the paper.)
- Q2: Briefly summarize the main ideas/the approach to the solution.
- Q3: What are the paper's strengths? Be brief.
- Q4: What are the paper's weaknesses? Be brief.
- Q5: Comment on the paper's evaluation methodology.
- Q6: Are there any issues/directions this work left open? List a few possible extensions of this work.
- Q7: Any other comments/questions.

Date	Topic	Required Readings	Presenters	Reviewers
Week 1 (9/1)	Overview and Logistics	N/A [CSE741C.pdf]	Wenyao Xu	
Week 2 (9/8)	Pulse-Response Biometrics and Hacking	[1] Authentication Using Pulse-Response Biometrics [pdf] [slides] [2] Broken Hearted: How to Attack ECG Biometrics [pdf] [slides]		
Week 3 (9/15)	Eye Movement Biometrics/ Key stroke Dynamics	[3] Biometric Identification via Eye Movement Scanpaths in Readings [pdf] [4] Keystroke Dynamics as a Biometric for Authentication [pdf]		
Week 4 (9/22)	Authenticating Internet of mobile things	[5] Towards Implicit Visual Memory-based Authentication [pdf] [6] KEH-Gait: Towards a Mobile Healthcare User Authentication System by Kinetic Energy Harvesting [pdf]		
Week 5 (9/29)	EEG (Brainwave) Biometrics	[7] Brainprint: Assessing the uniqueness, collectability, and permanence of a novel method for ERP biometrics [pdf] [8] EEG Biometrics for Individual Recognition in resting state with closed eyes [pdf]		
Week 6 (10/6)	Social Authentication Answering a call? Mobile is in danger	[9] It's not what you know, but who you know [pdf] [10] Mind How You Answer Me! [pdf]		
Week 7 (10/13)	Language Biometrics/ Posture Biometrics Multi-modal Biometrics: Finger Vein&Print&Shape	[11] Use of language as a cognitive biometric trait [pdf] [12] The value of Posture, Build and Dynamics in Gesture-based user Authentication [pdf]		
Week 8 (10/20)	Multi-mode Authentication	[13] A Low-cost multimodal biometric sensors to capture Finger Vein and Fingerprint [pdf] [14] Multimodal biometric method that combines veins, prints and shape of a finger [pdf]		
Week 9 (10/27)	Daily Activity as a biometrics/ Daily memory as a biometrics	[15] Activ'Pass: Your Daily Activity is Your Password [pdf] [16] Exploring capturable every memory for autobiographical authentication [pdf]		
Week 10 (11/3)	Know your devices	[17] Fingerprinting Electronic Control Units for Vehicle Intrusion Detection [pdf] [18] Blind Recognition of Touched Keys on Mobile Devices [pdf]		
Week 11 (11/10)	**No class**			
Week 12 (11/17)	Mobile User Authentication Miscellaneous	[19] A graphical-based password keystroke dynamic authentication system for touch screen handheld mobile devices [pdf] [20] Your love is public [pdf]		
Week 14 (11/24)	**No Class (holidays)**			
Week 15 (12/1)	TBD			
Week 16 (12/8)	TBD			

My Research Work: Internet of Medical Things



IoT?

Embedded systems (1980)

Wireless Sensor Networks (2000)

Internet of Things (2010)

What is IoT?

The **Internet of Things (IoT)** is the network of physical objects—devices, vehicles, buildings and other items embedded with electronics, software, sensors, and network connectivity—that enables these objects to collect and exchange data.

Where is IoT?

It’s everywhere!

The Smart *Internet of Things* School

Personalized learning with adaptive eTextbooks

Digital classroom white boards and display

iBeacons

Complete coverage with high performance Wi-Fi

Wearables for athletics and attendance tracking

Video recorders for lecture capture

International Collaboration and social exchange

Online testing

Sensors on trash receptacles

Supplies and inventory tracking by sensor with auto-reorder

Student devices & eTextbooks

- Notebooks
- Tablets
- Smartphones

Robot cleaning

Augmented and virtual reality

Makerspaces with 3D printers and laser trimmers

Robotics for STEM and remote presence

Internet of Things-based HVAC

Monitor and display of air quality throughout school

File and program storage, local or cloud-based

- Demographics, academics, behavior, interests
- LMS, CMS, SIS
- Educational programs and applications
- Video files: lectures and recorded lab experiments

Surveillance security cameras

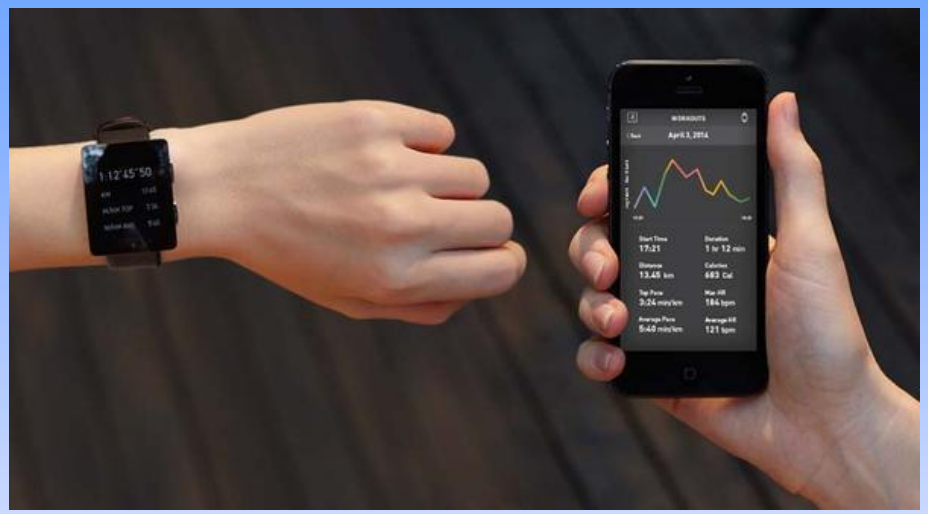
Wi-Fi sensors and locks

- Entrances and exits
- Classroom doors

Sensors track buses and verify student passengers

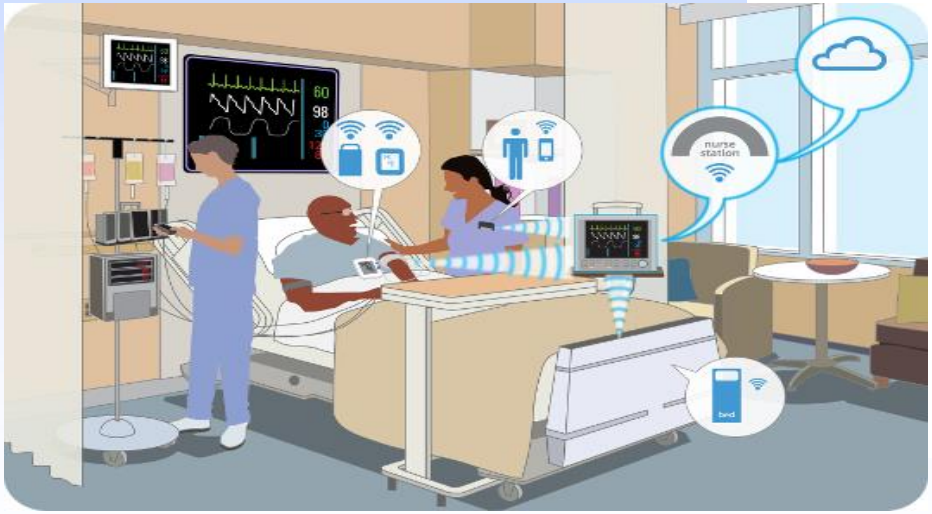
Network application analytics to monitor devices and network behavior

Sensors in parking lot and driveways

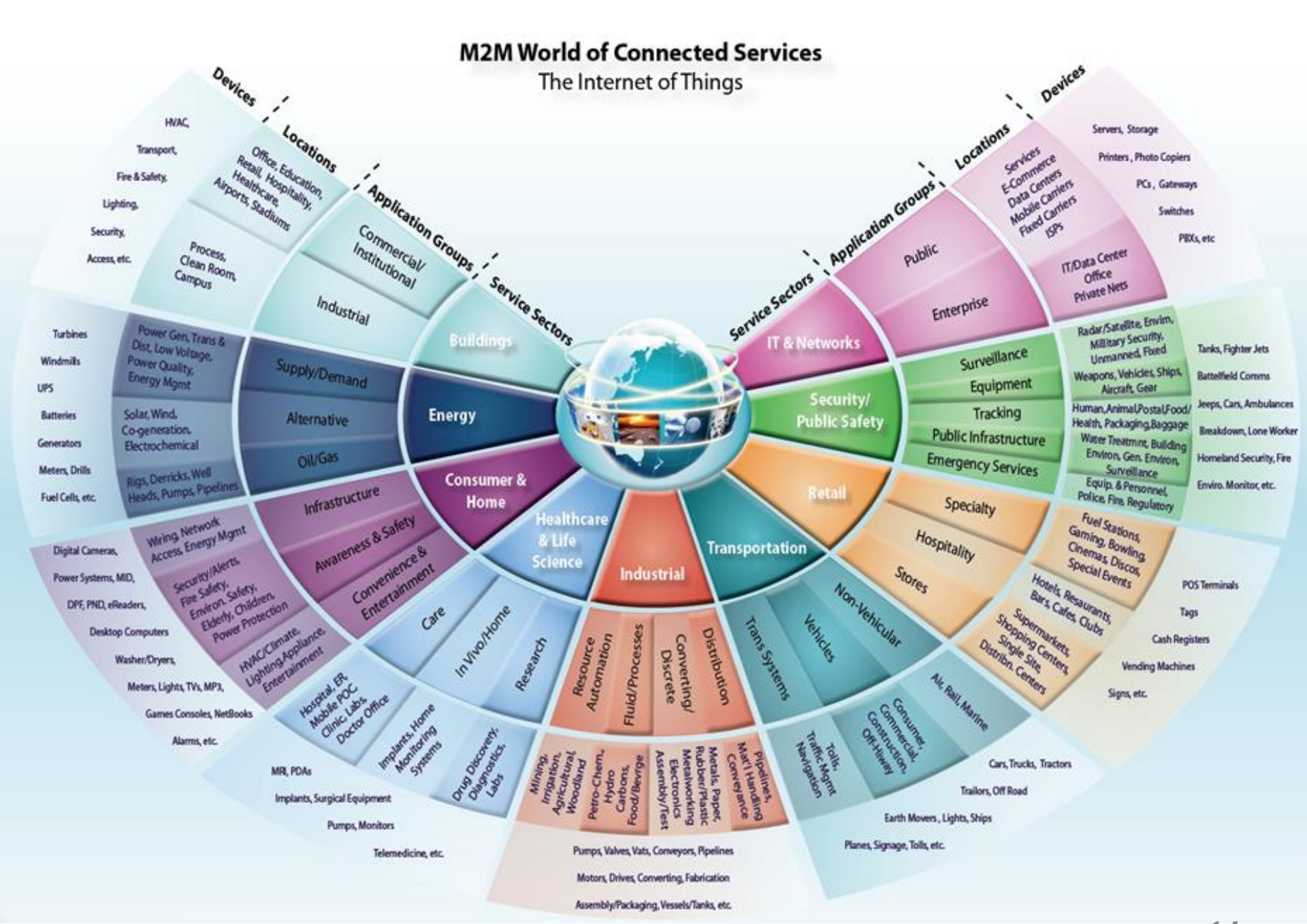


Wearable Tech

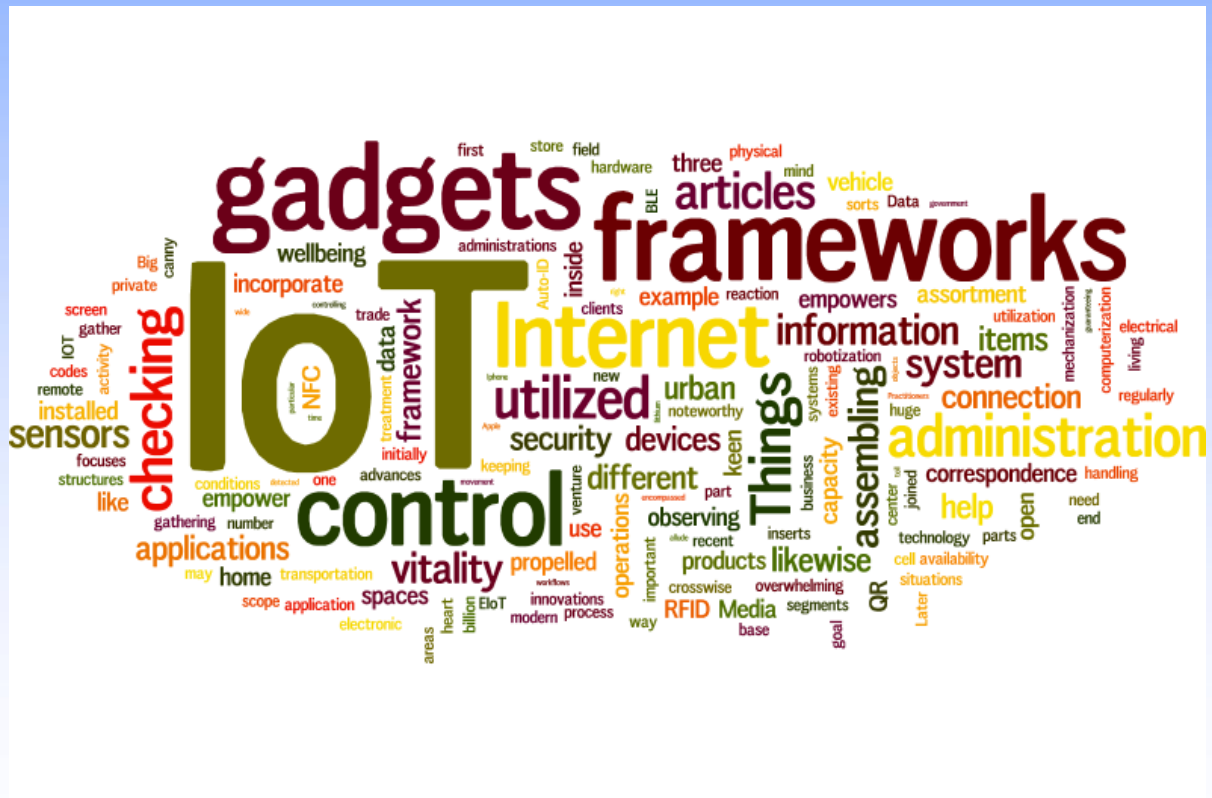
Smart Appliances



Healthcare

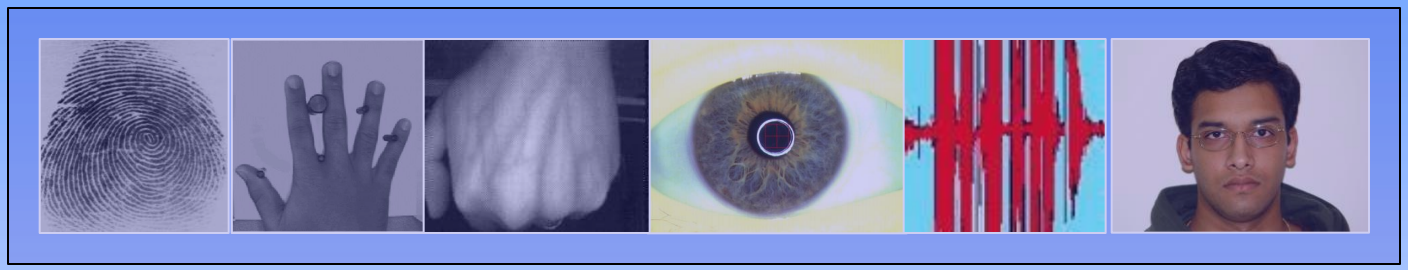

M2M World of Connected Services
The Internet of Things
Devices
Locations
Application Groups
Service Sectors
HVAC,
Transport,
Fire & Safety,
Lighting,
Security,
Access, etc.
Office, Education, Retail, Hospitality, Healthcare, Airports, Stadiums
Process, Clean Room, Campus
Commercial/ Institutional
Industrial
Buildings
Energy
Supply/Demand
Alternative
Oil/Gas
Power Gen, Trans & Dist, Low Voltage, Power Quality, Energy Mgmt
Solar, Wind, Co-generation, Electrochemical
Rigs, Derricks, Well Heads, Pumps, Pipelines
Turbines
Windmills
UPS
Batteries
Generators
Meters, Drills
Fuel Cells, etc.
Consumer & Home
Infrastructure
Awareness & Safety
Convenience & Entertainment
Wiring, Network Access, Energy Mgmt
Security/Alerts, Fire Safety, Environ. Safety, Elderly, Children, Power Protection
HVAC/Climate, Lighting,Appliance, Entertainment
Digital Cameras,
Power Systems, MID,
DPF, PND, eReaders,
Desktop Computers
Washer/Dryers,
Meters, Lights, TVs, MP3,
Games Consoles, NetBooks
Alarms, etc.
Healthcare & Life Science
Care
In Vivo/Home
Research
Hospital, ER, Mobile POC, Clinic, Labs, Doctor Office
Implants, Home Monitoring Systems
Drug Discovery, Diagnostics, Labs
MR, PDAs
Implants, Surgical Equipment
Pumps, Monitors
Telemedicine, etc.
Industrial
Resource Automation
Fluid/Processes
Converting/ Discrete
Distribution
Mining, Irrigation, Agricultural, Woodland
Petro-Chem, Hydro Carbons, Food/Bevrge
Assembly/Test Electronics Metalworking Rubber/Plastic Metals, Paper
Pipelines, Mat'l Handling Conveyance
Pumps, Valves, Vats, Conveyors, Pipelines
Motors, Drives, Converting, Fabrication
Assembly/Packaging, Vessels/Tanks, etc.
Transportation
Trans Systems
Vehicles
Non-Vehicular
Tolls, Traffic Mgmt, Navigation
Consumer, Commercial, Construction, Off-Hiway
Air, Rail, Marine
Cars, Trucks, Tractors
Trailors, Off Road
Earth Movers , Lights, Ships
Planes, Signage, Tolls, etc.
Retail
Specialty
Hospitality
Stores
Hotels, Resaurants, Bars, Cafes, Clubs
Supermarkets, Shopping Centers, Single Site, Distribn. Centers
Fuel Stations, Gaming, Bowling, Cinemas, Discos, Special Events
POS Terminals
Tags
Cash Registers
Vending Machines
Signs, etc.
Security/ Public Safety
Surveillance
Equipment
Tracking
Public Infrastructure
Emergency Services
Radar/Satellite, Envirn, Military Security, Unmanned, Fixed Weapons, Vehicles, Ships, Aircraft, Gear
Human,Animal/Postal/Food/ Health, Packaging,Baggage
Water Treatmnt, Building Environ, Gen. Environ, Surveillance
Equip. & Personnel, Police, Fire, Regulatory
Tanks, Fighter Jets
Battelfield Comms
Jeeps, Cars, Ambulances
Breakdown, Lone Worker
Homeland Security, Fire
Enviro. Monitor, etc.
IT & Networks
Public
Enterprise
Services
E-Commerce
Data Centers
Mobile Carriers
Fixed Carriers
ISPs
IT/Data Center
Office
Private Nets
Servers, Storage
Printers , Photo Copiers
PCs , Gateways
Switches
PBXs, etc

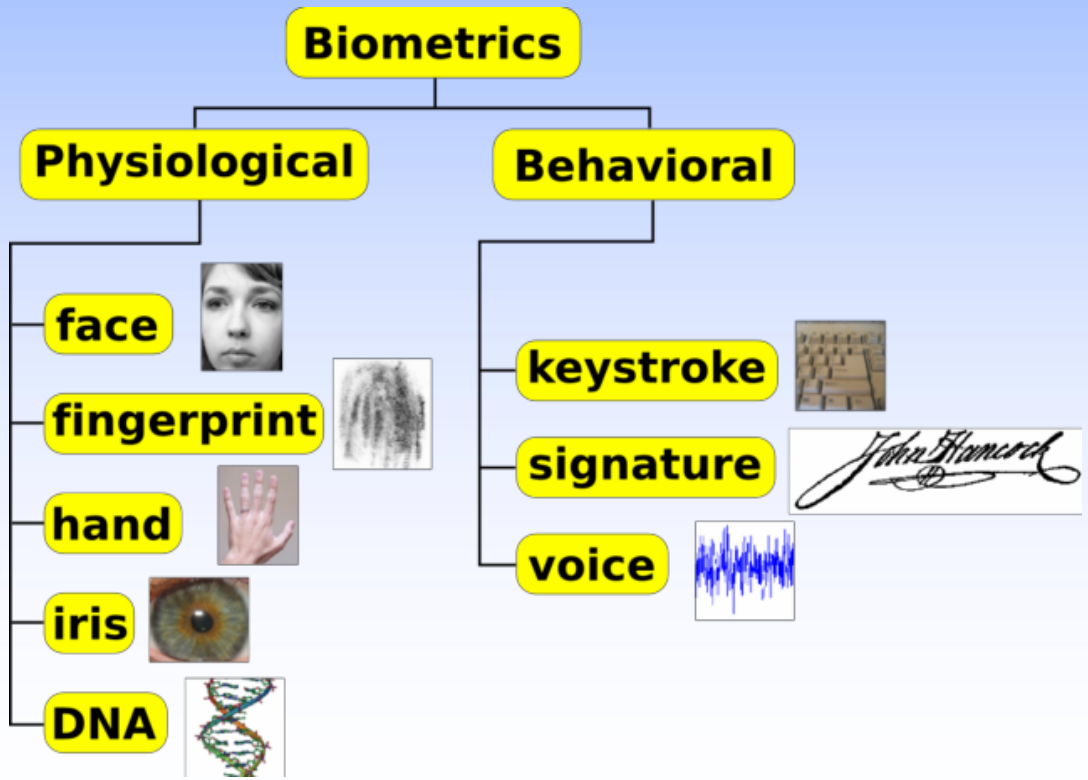
The Internet of Things (IoT)
Security Considerations for Higher Education



Who are they?
Who are authenticated?
Who are safe?
…..

Introduction to Biometrics





Overview of Biometrics

Proving one's identity

Face-to-face interactions

Remote interactions

Human-machine interactions

Traditional modes of authentication

- Possession-based schemes

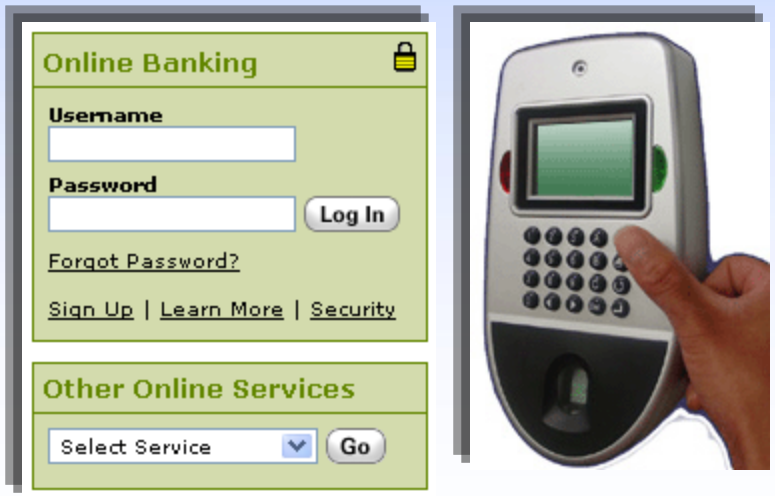
  Based on ID cards, tokens, keys, etc.

  WHAT YOU HAVE

- Knowledge-based schemes

  Based on passwords, PINs, etc.

  WHAT YOU KNOW



Identity Theft

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

Something "Phishy"

"A recent survey found 70% of those asked said that they would reveal their computer passwords for a bar of chocolate. Sweet!" (Technology Review, March 2005, p. 78)

Security Threats

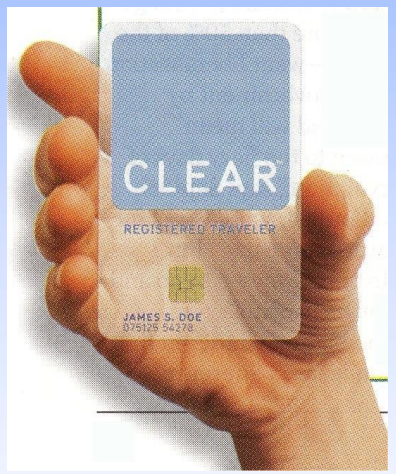
- Dealing with individuals whose claimed identity cannot be trusted solely based on their identification documents

Surrogate representations of identity based on credentials (passwords, ID cards) no longer suffice

What is Biometrics?

Biometric Recognition

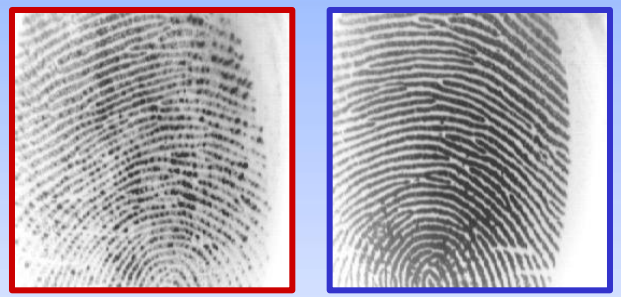
Personal recognition based on "who you are" as opposed to "what you know" (PIN) or "what you possess" (ID card)

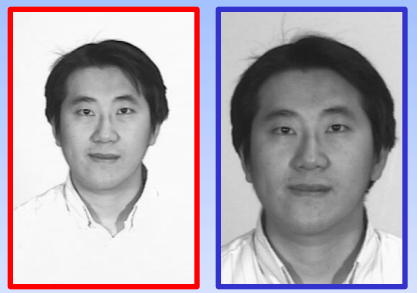


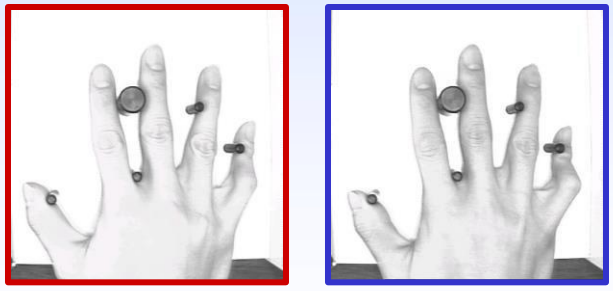
Recognition of a person by his body, then linking that body to an externally established "identity", forms a very powerful tool for identity management

Biometric recognition

- Compute the similarity between two instances of biometric data







Biometric Functionalities

- Verification

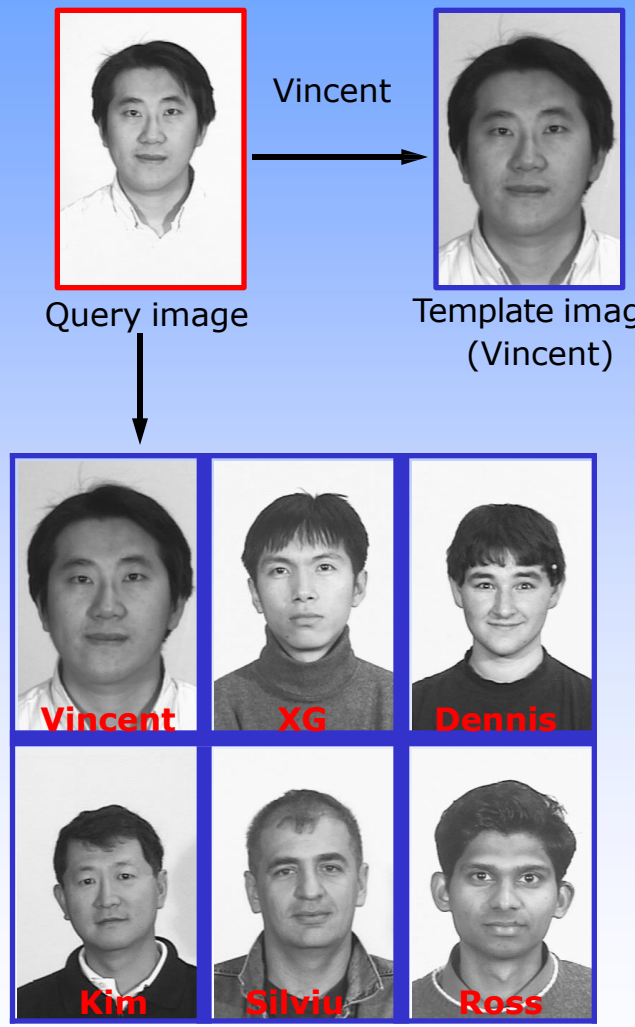
  Are you who you say you are? (1:1 match)

- Identification

  Who is this person? (1:N match)

- Watch List

  Is this a wanted person?



Only biometrics can provide negative identification (i.e., I am not he) capability. It can search for multiple enrollments by the same individual

Verification

- User presents her biometric trait and claims an identity
- Features extracted
- Features compared against record associated with claimed identity (1:1)
- Output: Genuine or Impostor

Identification

- User presents her biometric trait
- Features extracted
- Features compared against all records in database (1:N)
- Output: User's identity or Reject

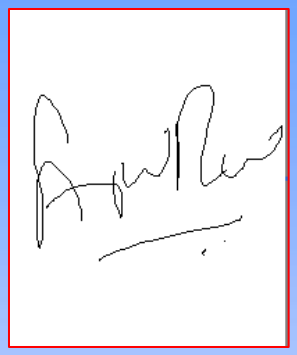
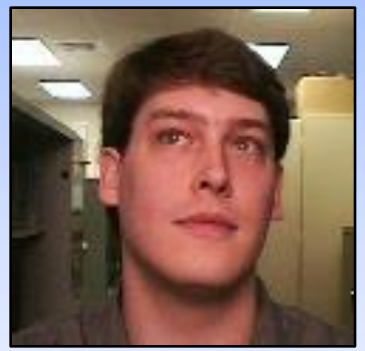
- Recognition/Authentication: Verification or Identification

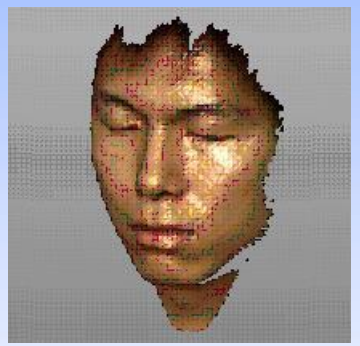
Biometric Traits

Biometric Characteristics



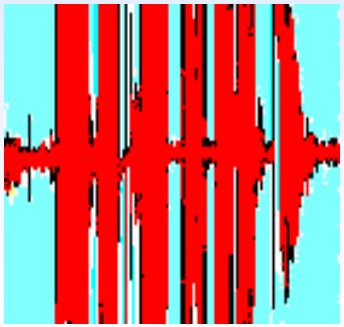
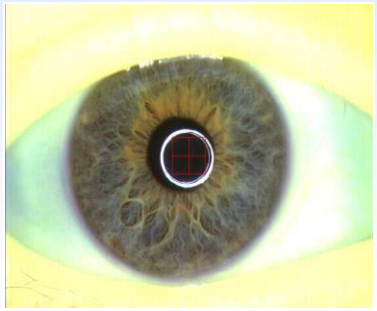
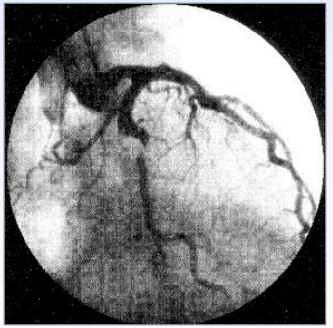






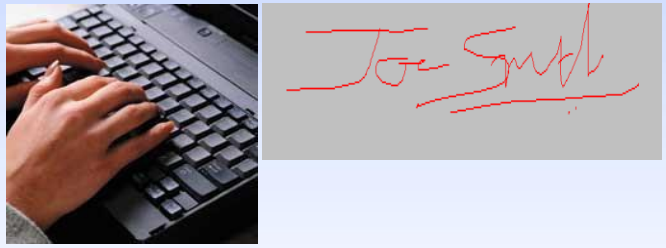


Physical vs Behavioral Traits

- Physical Characteristics:
  - Iris
  - Retina
  - Vein Pattern
  - Hand Geometry
  - Face
  - Fingerprint

- Behavioral Characteristics:
  - Keystroke dynamics
  - Signature dynamics
  - Gait



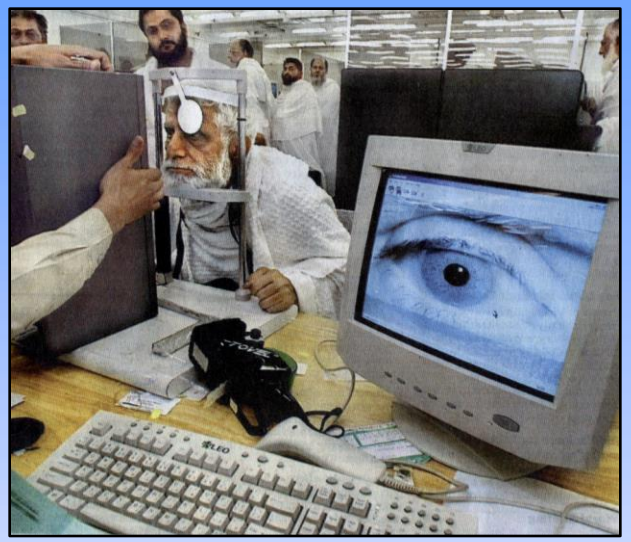
Voice biometric has a strong "biological" *and* "behavioral" component

Properties of a Biometric Trait

- Universality (all users possess this biometric)
- Uniqueness (varies across users)
- Permanence (does not change over time)
- Measurability (can be acquired and measured quantitatively)
- Performance (low error rates and processing time)
- Acceptability (is it acceptable to the users?)
- Circumvention (can it be easily spoofed?)

Biometric Applications

Biometric Applications

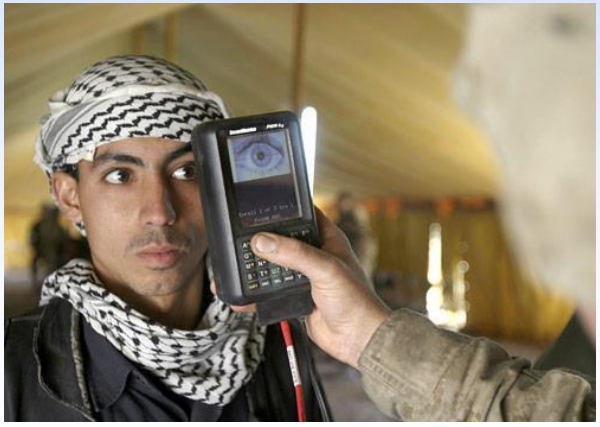


Iris: Haj pilgrims in Saudi Arabia

Fingerprint: Point of sale

AP/Rob Griffith

Fingerprint, Face, Iris: Australia airport security



Iris: Identifying insurgents

Fingerprint: Mobile phone

Palm Vein: Japan ATM

Biometric Applications

Iris: Frankfurt Airport

Face: Surveillance Applications

Keyless ignition: Audi A8

Hand Geometry: Ben Gurion Airport

Fingerprint: US-VISIT program

Finger Vein: Accessing ATMs in Japan

Retail Banking

Offers services to poor population of Mexico

- Extend credit to people who do not have verifiable identities (like drivers licenses, etc)

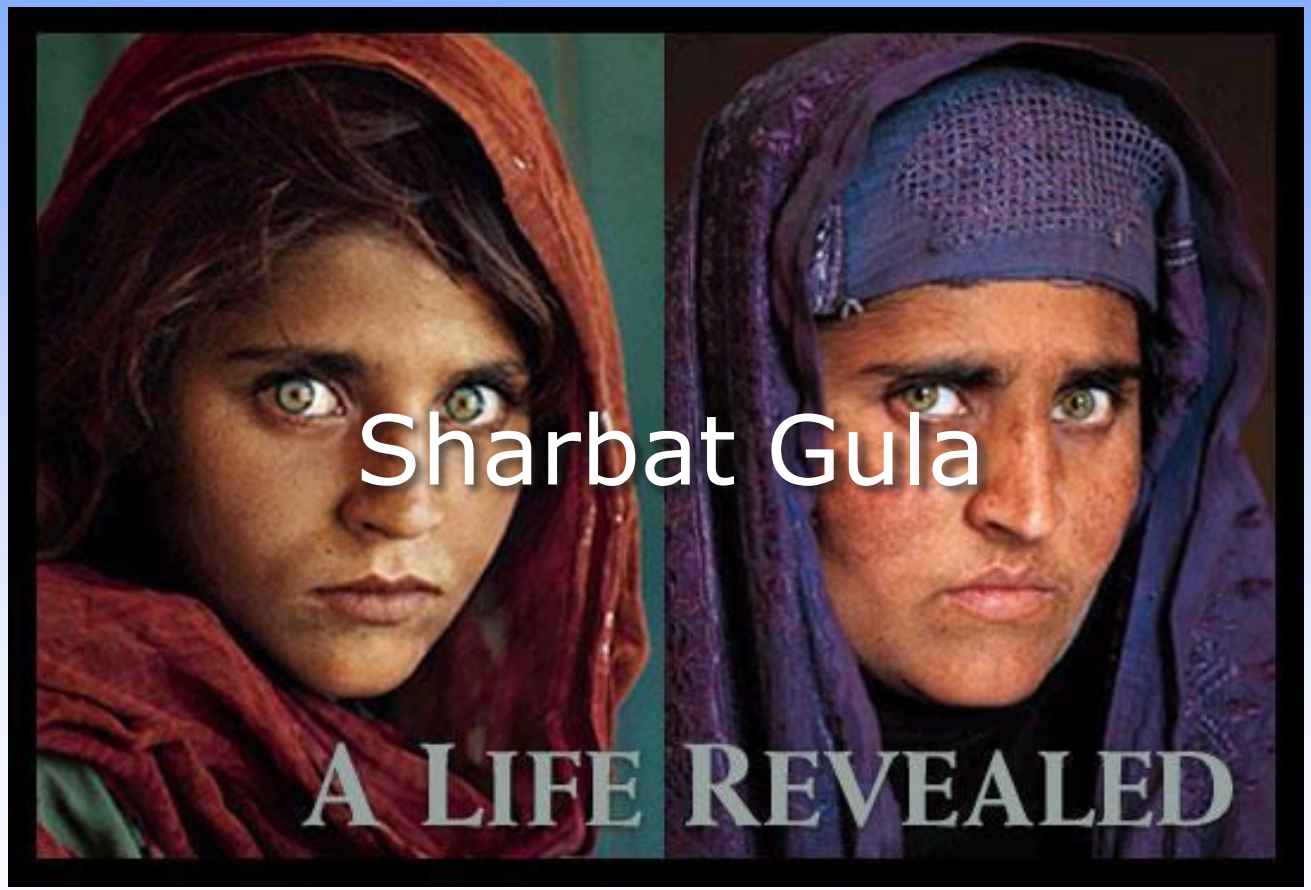
Adopted fingerprint authentication:

- Registered over 8M users for access to accounts at bank tellers and point of sale
- Conducts over 500k transactions per day with fingerprint
- Access w/ fingerprint into Internet banking

Courtesy DigitalPersona

Who is She?

- The Afghan girl identified via iris (and facial scar) match

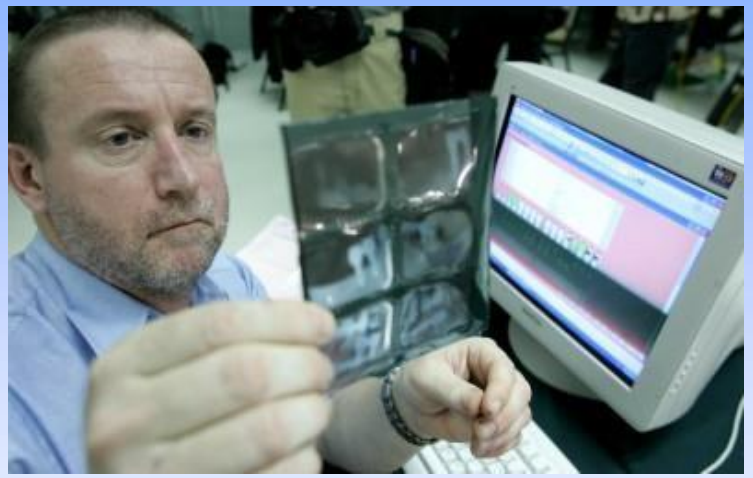


http://magma.nationalgeographic.com/ngm/afghangirl/

1984 and 2002

Identifying Disaster Victims

- When bodies are decomposed (due to fire, water), common biometric methods (fingerprint, face) cannot be used
- At ground zero, among victims identified in the first year, ~20% were identified using dental records
- By mid-March, 2005, 90% of the identified victims of Asian tsunami were done so by dental records



A forensic expert examines a film of the teeth of a tsunami victim in Phuket, Thailand, on Jan. 11, 2005.

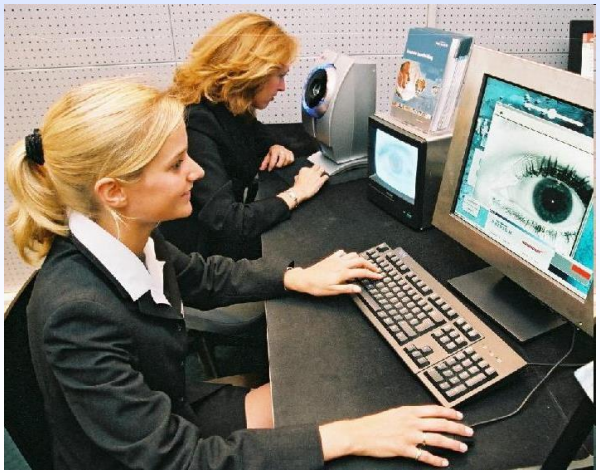
Design and Performance Evaluation

Operation of a Biometric System

- The sensor acquires the raw biometric data
- The feature extractor processes the biometric data to extract a compact feature set that represents the identity of the individual
  - When this feature set is placed in the database it is known as a template
- The matcher compares two such feature sets and generates a match score
- The decision module uses the match scores to determine the identity or verify the claimed identity

Enrollment

- The process of creating and including an identity in a database
- An individual's biometric traits are extracted and stored in a database (possibly) along with some biographic information
- Database can be centralized or decentralized



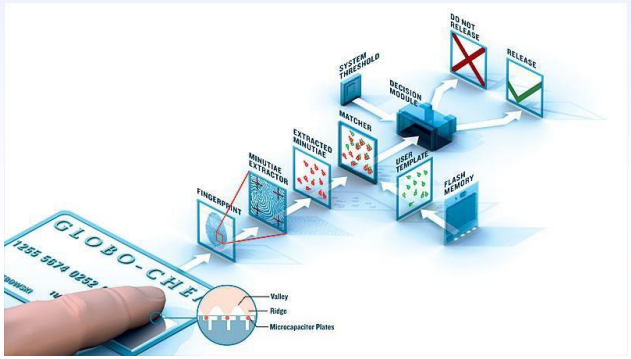
http://www.cl.cam.ac.uk/~jgd1000/SchipholEnrollment.jpg

Smart card

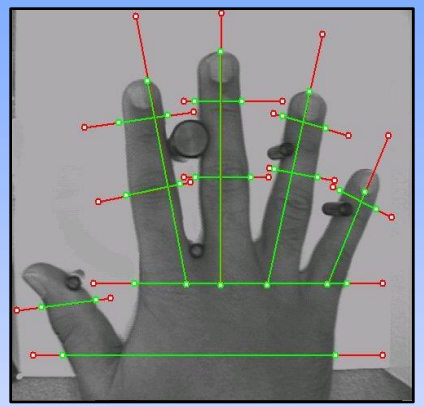
- To ensure total personal privacy of employees' fingerprint database, fingerprint templates can now be stored on a Smart Card

- With Smart Cards, the biometric fingerprint template is stored on the card's internal memory only. The scanned fingerprint is compared with the template stored within the card

Taken from http://www.smesolutions.com.au/index.php?action=ProductsAndServices/IDCards



Example of Templates

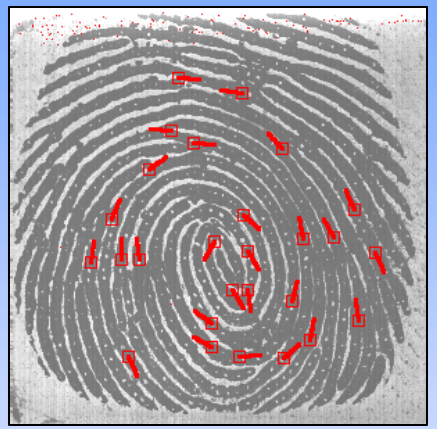


Hand features:

Length & width of fingers, width of palm

Face features:

(a) PCA-coefficients (b) LDA-coefficients



Fingerprint features:

Minutiae coordinates and local ridge orientation

Fingerprint Recognition

Fingerprints

- Description: graphical flow like ridges present in human fingers
- Formation: during embryonic development
- Permanence: minute details do not change over time
- Uniqueness: believed to be unique to each finger
- History: used in forensics and is well studied

Fingerprint Matching

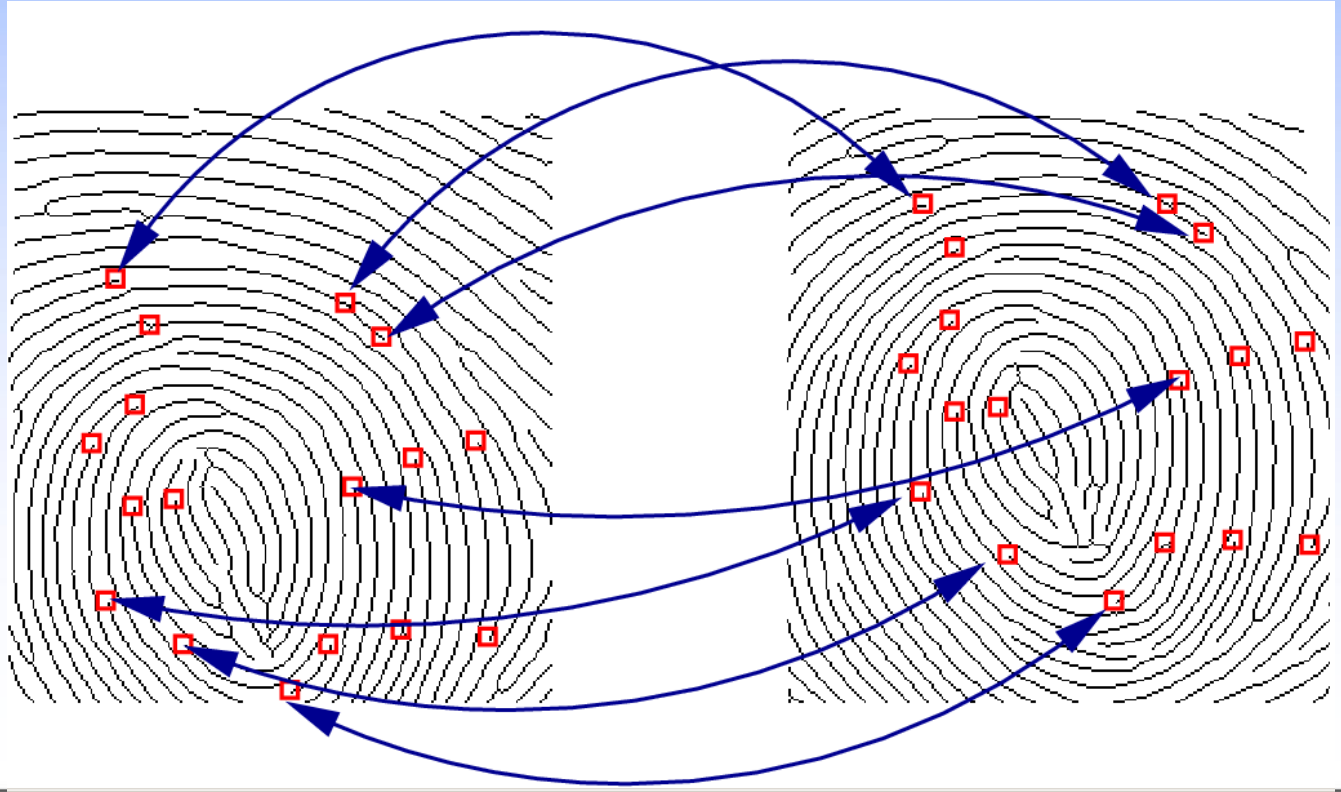
- Find the similarity between two fingerprints

Fingerprints from the same finger

Fingerprints from two different fingers

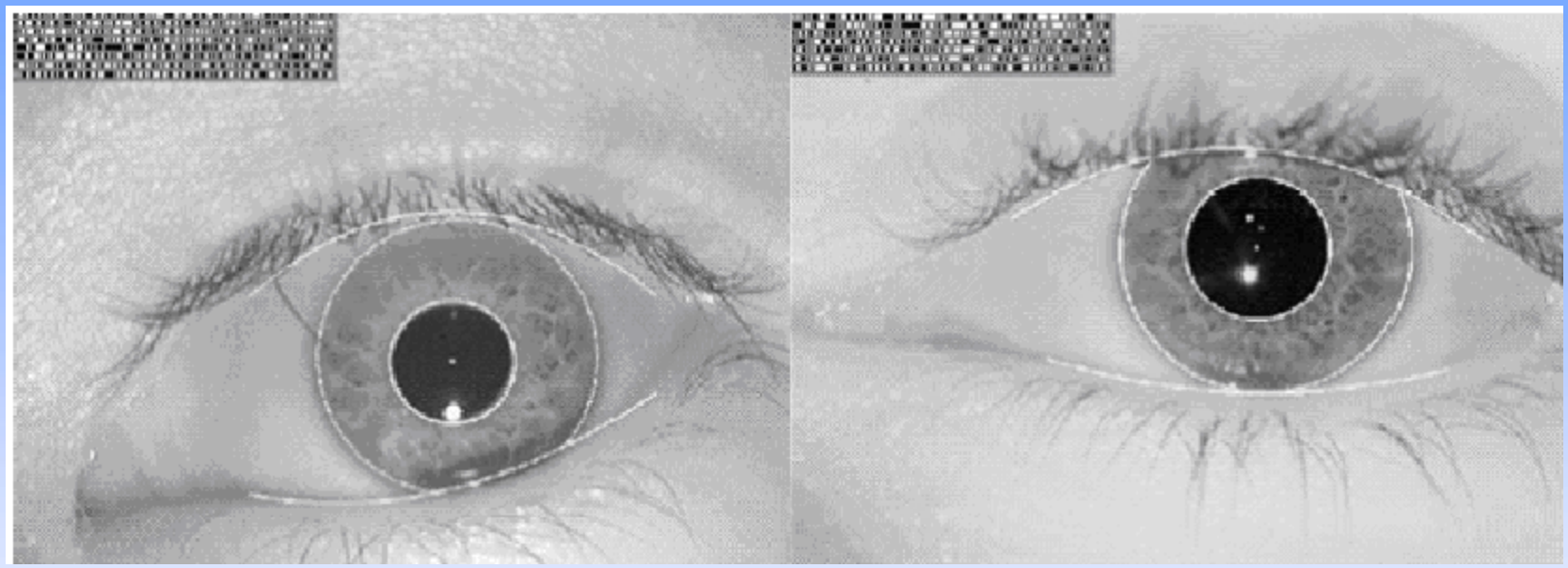
Fingerprint Matching

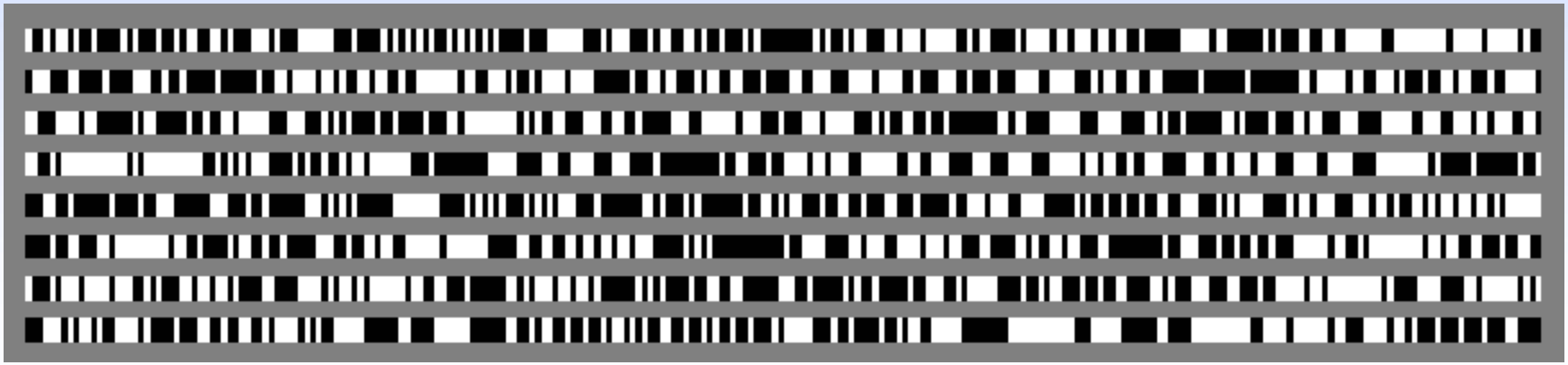
- Determine the number of corresponding minutiae in two fingerprint images:
  - String matching
  - Graph matching
  - Hough transforms



Iris Recognition

Iris Matching using Iriscodes



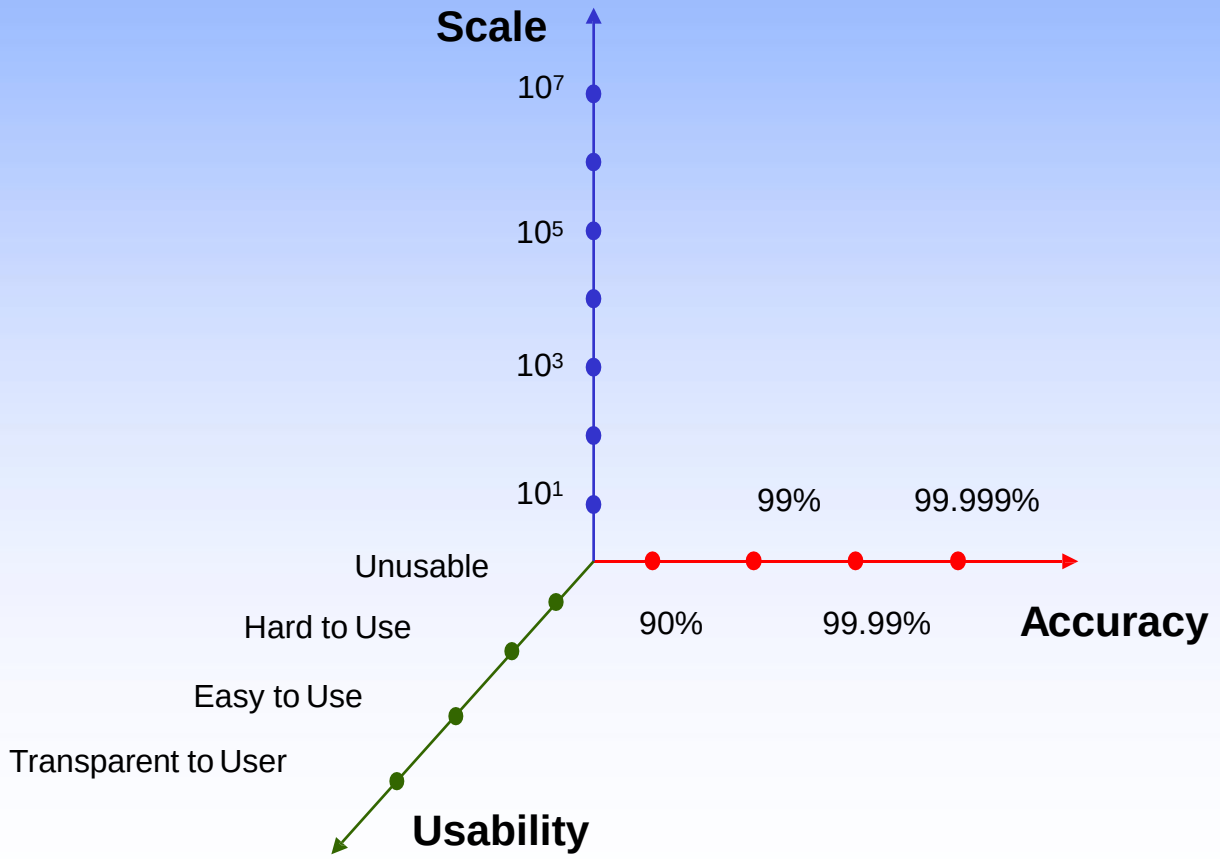


http://www.cl.cam.ac.uk/~jgd1000/

Challenges in Biometric System Design

A Grand Challenge

- A number of identity management systems now need a highly accurate, scalable, real-time, low cost, user-friendly biometric recognition system



Challenges in Biometric Systems Design

- 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 requirements (error rate, speed, cost)
- Attacks on the biometric system
- Individuality of biometric characteristics

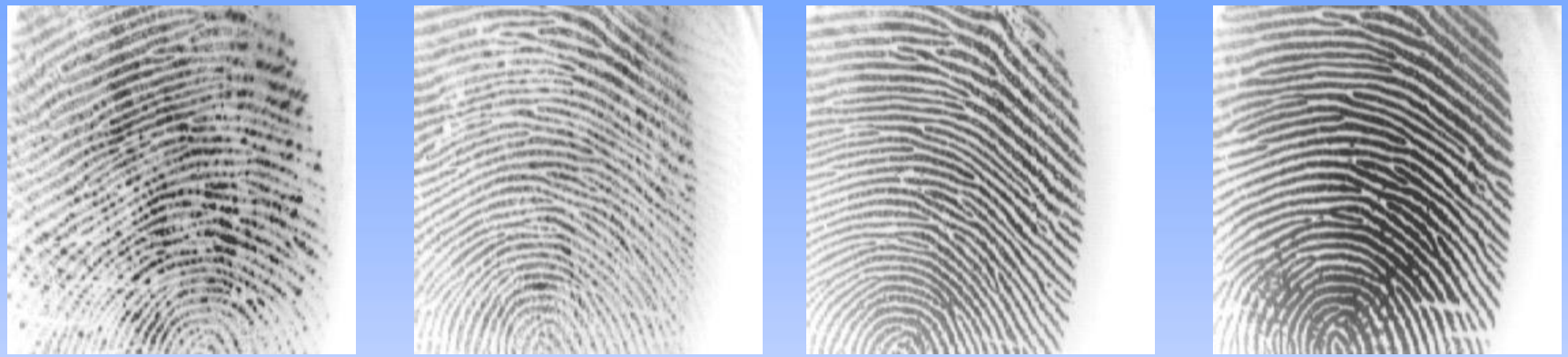
High throughput: Disney World, Orlando

Throughput: order of 1000's

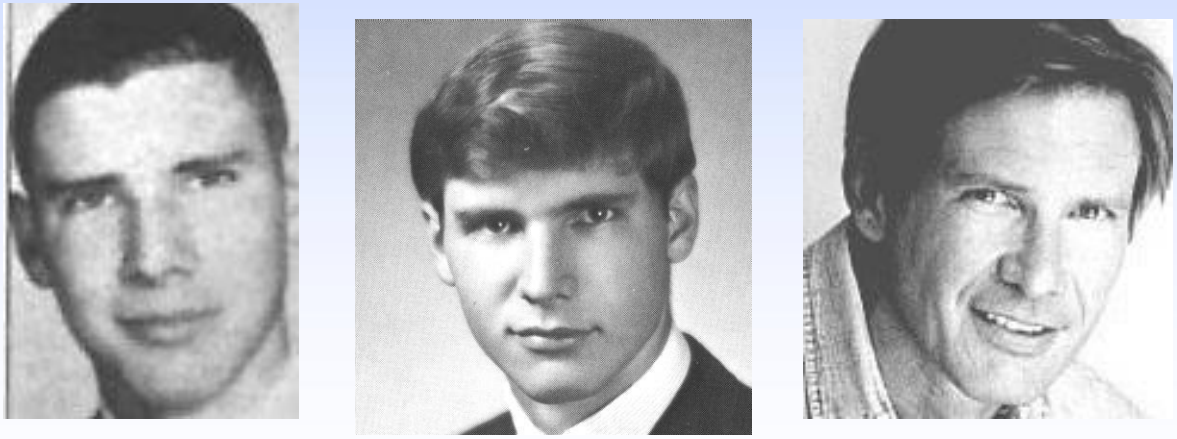
Temporal Variations

Uludag, Ross, Jain, "Biometric Template Selection and Update: A Case Study in Fingerprints", Pattern Recognition, 2004.

Time duration: 6 months



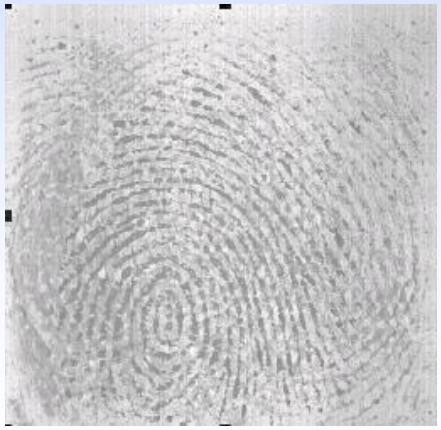
Time duration: several years



Noise in sensed data

During enrolment

During authentication



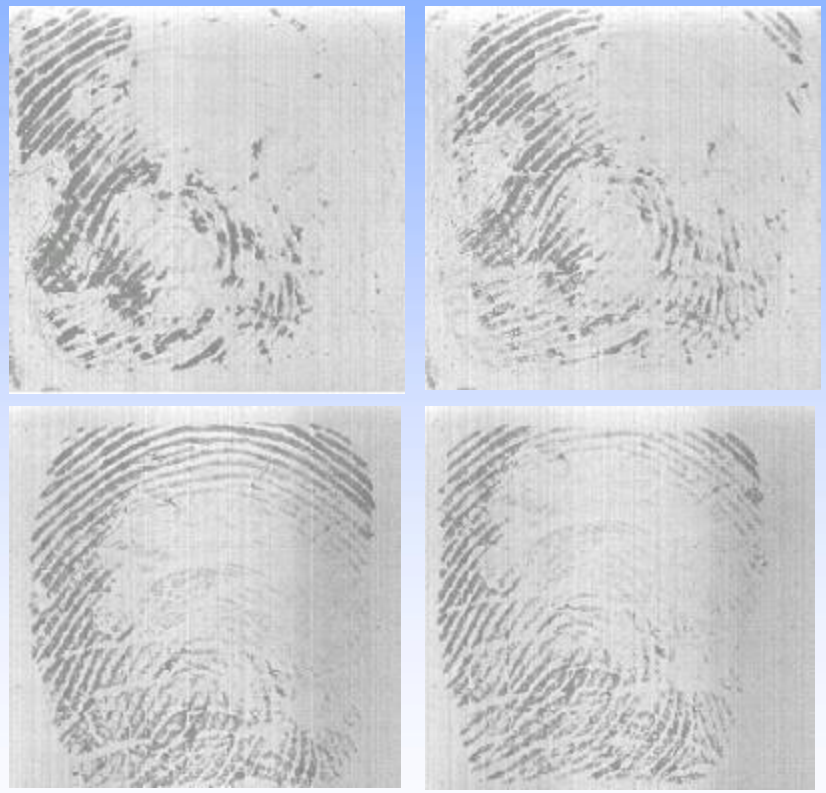
Noise due to smearing, residual deposits, cuts and folds, etc

Rotation and Translation

Non-linear Deformation

Failure to Enroll

- A fraction of the population has poor quality fingerprint images



Four impressions of a user's fingerprint

Jan 2, 2004

Faded fingerprints cost former welder a job

ASSOCIATED PRESS

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, 60, of Decatur, lacking a full set of intact fingerprints required under new, stepped-up security regulations at nuclear plants. Since the U.S. Department of Homeland Security issued the new rules in the wake of Sept. 11, the reams of documents Strickler has attesting 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 inspecting the D.C. Cook Nuclear Power Station near Bridgman, where he had worked before, his application was turned down because of the worn-down ridges on his fingertips.

"I passed everything except for the fingerprints," Strickler said adding that the application process included a comprehensive psychological examination and criminal background check.

Strickler

"The plant sent the fingerprints to the FBI, and they said it's outside the realm of the Homeland Security's guidelines (for 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 30 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.

Sensor Interoperability

- There is a degradation in matching accuracy when the sensors used for enrollment and recognition are different

- Fingerprint images of the same finger acquired by different commercial scanners:*

  a)Biometrika FX2000,

  b) Digital Persona UareU2000,

  c) Identix DFR200,

  d) Ethentica TactilSense T-FPM,

  e)STMicroelectronics TouchChip TCS1AD,

  f) Veridicom FPS110,

  g)Atmel FingerChip AT77C101B,

  h) Authentec AES4000

*Maio, Maltoni, Jain, Prabhakar, "Handbook of fingerprint recognition", Springer 2003

Spoofing a Biometric Trait

Dummy finger created from a lifted impression

Artificial skin/fingers

Emerging Biometrics

If these challenges in existing biometrics cannot be addressed, we need to explore alternatives!

We start to learn how to explore new biometrics.