

BIOMETRIC SYSTEMS

“Artificial Intelligence” Course
University of Naples Federico II
May 13, 2010

outline

- 1 Introduction to Biometrics
- 2 Fingerprint Recognition
- 3 Face Recognition
- 4 Iris Recognition
- 5 Multimodal Biometric Systems
- 6 Liveness Detection in Fingerprint Scanners

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1 Introduction to Biometrics

Traditional method of Authentication

- Knowledge-based mechanisms: based on passwords, Pin, etc...
“WHAT YOU KNOW”
- Possession-based mechanisms: based on badges, passports, keys..
“WHAT YOU HAVE”

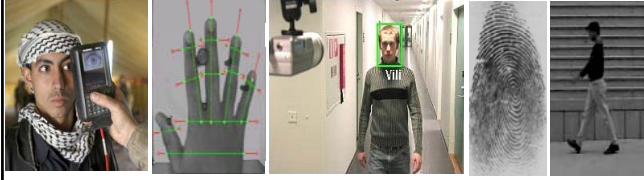



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1 Introduction to Biometrics

Biometric Authentication

It is possible to establish an identity based on **“Who you are”**
Biometric is a *measure* of a part of our body



Iris Hand-geometry Face Fingerprint Gait

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1 Introduction to Biometrics

Different traits, different properties

Biometrics	Universality	Uniqueness	Permanence	Collectability	Performance	Acceptability	Circumvention
Face	High	Low	Medium	High	Low	High	Low
Fingerprint	Medium	High	High	Medium	High	Medium	Low
Hand geometry	Medium	Medium	Medium	High	Medium	Medium	Medium
Iris	High	High	High	Medium	High	Low	High
Signature	Low	Low	Low	High	Low	High	Low
Voice	Medium	Low	Low	Medium	Low	High	Low

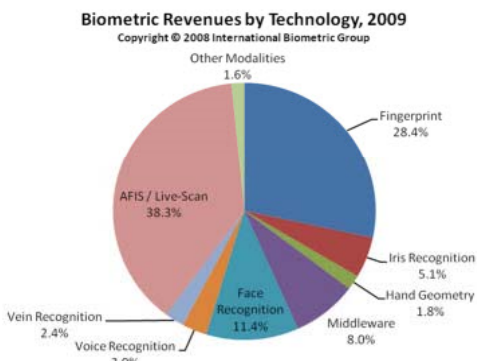
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1 Introduction to Biometrics

Biometric Market

Biometric Revenues by Technology, 2009

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Technology	Revenue Percentage
AFIS / Live-Scan	38.3%
Fingerprint	28.4%
Face Recognition	11.4%
Middleware	8.0%
Voice Recognition	3.0%
Vein Recognition	2.4%
Hand Geometry	1.8%
Iris Recognition	5.1%
Other Modalities	1.6%

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1 Introduction to Biometrics

Biometric Applications

Forensic	Government	Commercial
Corpse Identification	Border Crossing	Access Control




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1 Introduction to Biometrics

Biometric Applications



IRIS: Frankfurt Airport

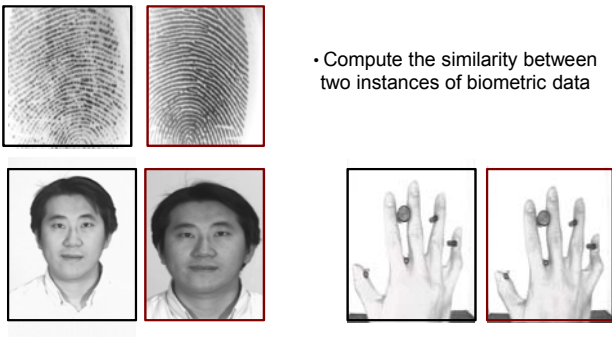
FACE: Surveillance Applications

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1 Introduction to Biometrics

Biometric Recognition



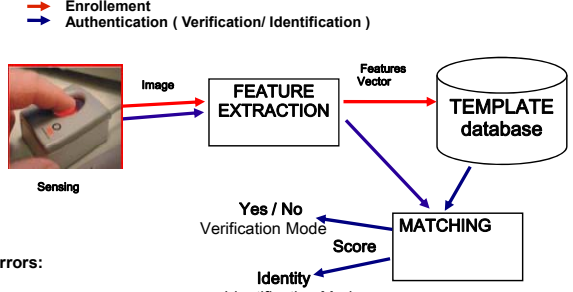
- Compute the similarity between two instances of biometric data

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1 Introduction to Biometrics

Biometric Recognition Process



Enrollement (red arrow)
Authentication (Verification/ Identification) (blue arrow)

Sensing → Image → FEATURE EXTRACTION → Features Vector → TEMPLATE database

Yes / No Verification Mode
Score
Identity Identification Mode

Errors:
FAR: False Acceptance Rate
FRR: False Rejection Rate

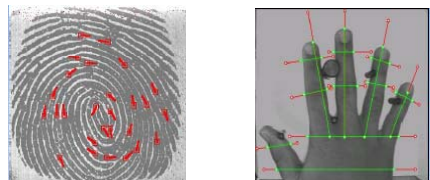
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1 Introduction to Biometrics

Template

A set of features extracted from the raw biometric data of an individual: a **prototype** of an individual's biometric.



Fingerprint Features:
minutiae coordinates and local Ridge orientation

Hand Features:
Length and width of fingers, width of palm


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1 Introduction to Biometrics

Biometric Functionalities

- **Verification**



“ I am Emanuela “

• Am I who I claim I am?

“ Does this biometric data belong to Emanuela? “

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

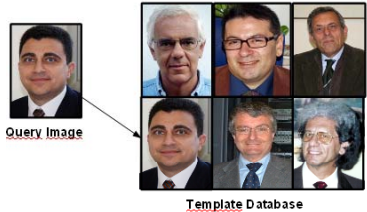
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1 Introduction to Biometrics

Biometric Functionalities

- **Identification**
- Who am I?



Query Image

Template Database

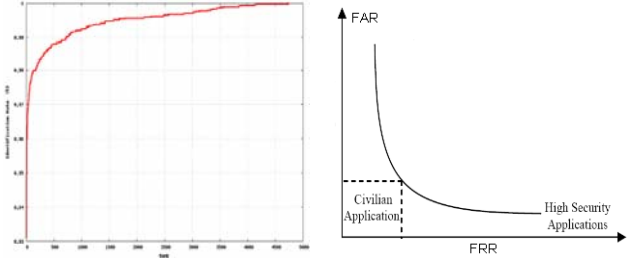
- User presents her biometric
- Features are extracted
- Features are compared against all records in the db (1:N match)
- Output: User's Identity or Reject

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1 Introduction to Biometrics

Biometric Performance Measures

- **Verification (one-to-one)**: Receiver Operating Characteristic (ROC)
- **Identification (one-to-many)**: Cumulative histogram of genuine ranks is plotted on linear scale (CMC) Curve



Cumulative Match Curve (CMC)

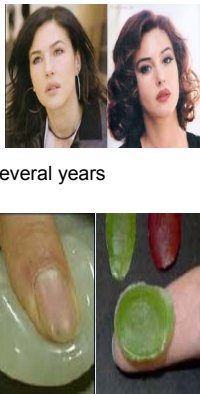
Receiver Operating Curve (ROC)

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1 Introduction to Biometrics

Challenges in Biometric Systems Design

- Large number of classes (e.g., millions of faces)
- Error rates (e.g., faces look similar)
- Noise in the data
- Temporal Variations: aging of the person after several years
- Segmentation
- Intra-class variability and Inter-class variability
- Individuality of biometric characteristics
- Spoofing of Biometric



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1 Introduction to Biometrics


References

- A. Jain, A. Ross and S. Prabhakar, "An Introduction to Biometric Recognition", IEEE Transactions on Circuits and Systems for Video Technology, Special Issue on Image and Video-Based Biometrics, Vol. 14, No. 1, pp. 4-20, January 2004.

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2 Fingerprint Recognition

Fingerprints

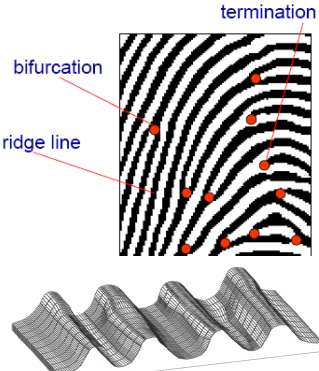


- **Description**: graphical flow-like ridges present in human fingers.
- **Formation**: during embryonic development.
- **Uniqueness**: believed to be unique to each person and each finger.
- **Permanence**: minute details do not change over time.
- **History**: used in forensics for criminal investigations.

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2 Fingerprint Recognition

Fingerprint Representation



bifurcation

ridge line

termination

A fingerprint is composed of a set of lines (**Ridge lines**) which mainly flow parallel, making a pattern (**Ridge pattern**)

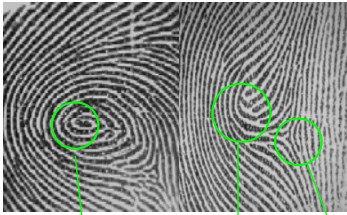
Local ridge characteristics (**Minutiae**):

- Ridge ending
- Ridge bifurcation

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Fingerprint Recognition

Fingerprint Representation

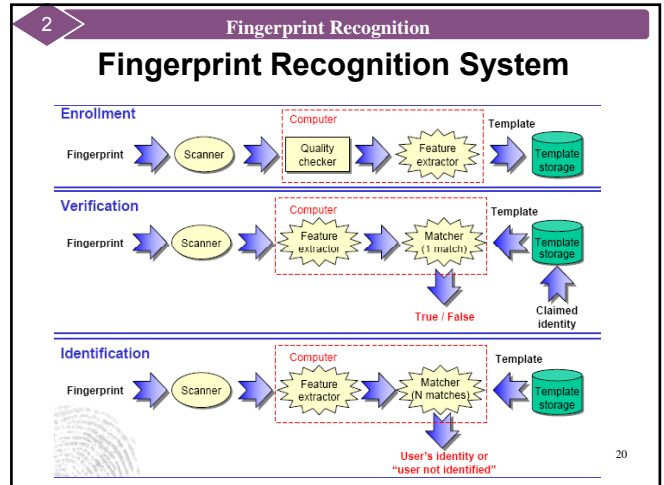


Sometimes the ridge lines produce local Macro-singularities called

- Whorl (O)
- Loop (U)
- Delta (Δ)

whorl loop delta

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Fingerprint Recognition


Fingerprint Acquisition

Off-line acquisition:

- Ink technique
- Latent fingerprint

On-line acquisition:

- Optical sensor
- Solid-state



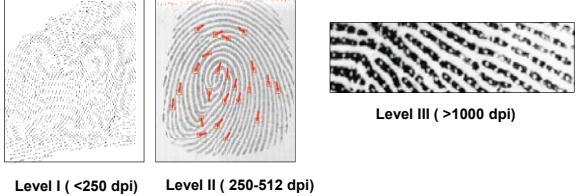
□ Fingerprint images of the same finger acquired by different commercial scanners: *

- a) Biometrika FX2000,
- b) Digital Persona UareU2000,
- c) Identix DFR200,
- d) Ethentica TactiSense TFPm,
- e) STMicroelectronics TouchChip TCS1AD,
- f) Veridicom FPS110,
- g) Atmel FingerChip AT77C101B,
- h) Authentec AES4000

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Fingerprint Recognition

Image Resolution



Level I (<250 dpi) Level II (250-512 dpi) Level III (>1000 dpi)

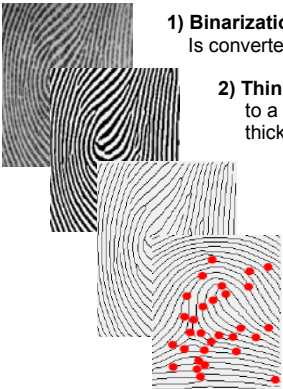
Increasing Resolution →

Increasing the resolution of the scanner shows biometric details that can enhance the "uniqueness" of the trait, but this leads to an increase in noise content.

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Fingerprint Recognition

Feature extraction: Minutiae detection

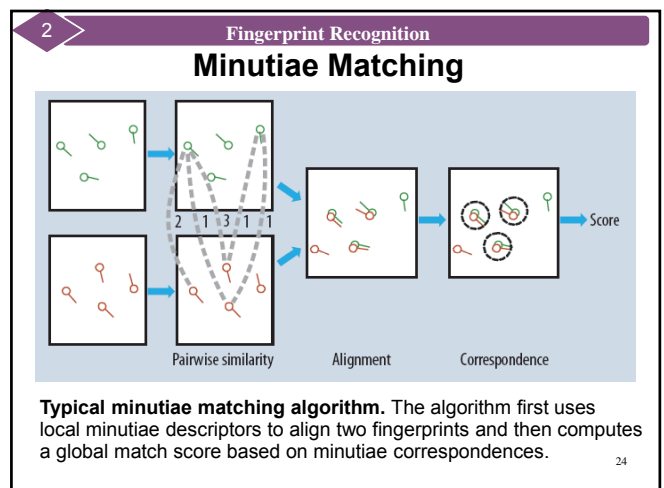


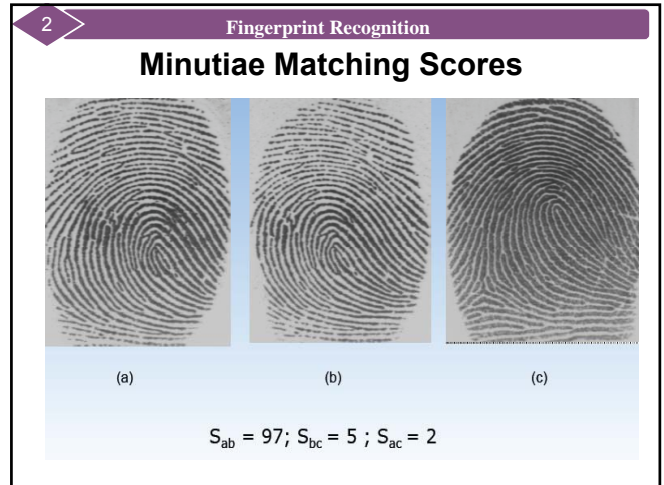
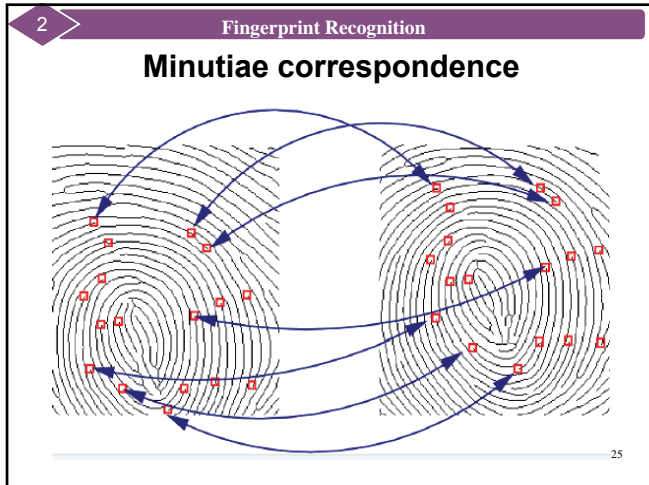
- 1) Binarization:** the fingerprint gray-scale image is converted into a binary image.
- 2) Thinning:** the binary image is submitted to a thinning stage (the ridge line thickness is reduced to one pixel).
- 3) Detection:** a simple image Scan allows to detect the pixels that correspond to Minutiae.

Some problems:

- The technique is not robust in presence of low-quality images.
- A significant amount of information may be lost during binarization process.

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2 Fingerprint Recognition

Main Challenges in Fingerprint Recognition

- Noise in sensed data: residual deposits, cuts on fingers, dry fingers, ...
- High rotation
- Non-linear distortion
- Different pressure and skin conditions
- Features extraction errors
- Fake fingerprint
- Non-universality of fingerprints

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2 Fingerprint Recognition

References

D. Maltoni, D. Maio, A. Jain and S. Prabhakar, "Handbook of Fingerprint Recognition", Second Edition, Springer, 2009.

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3 Face Recognition

Detecting Face in Images

It is natural to recognize a person from his face.
Face perception is a routine task for human.

What do humans do with faces?

Identify:	Categorize:
<ul style="list-style-type: none"> • Recognize (familiar/unfamiliar) • Label (name, context,...) 	<ul style="list-style-type: none"> • Sex, race, age

Variables: Viewpoint, illumination, resolution

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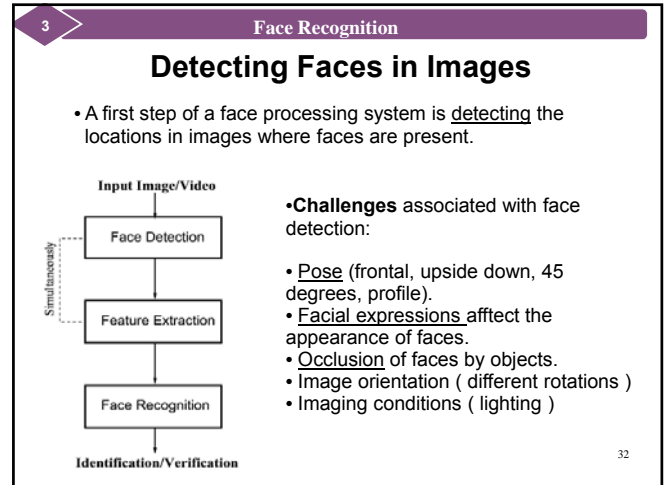
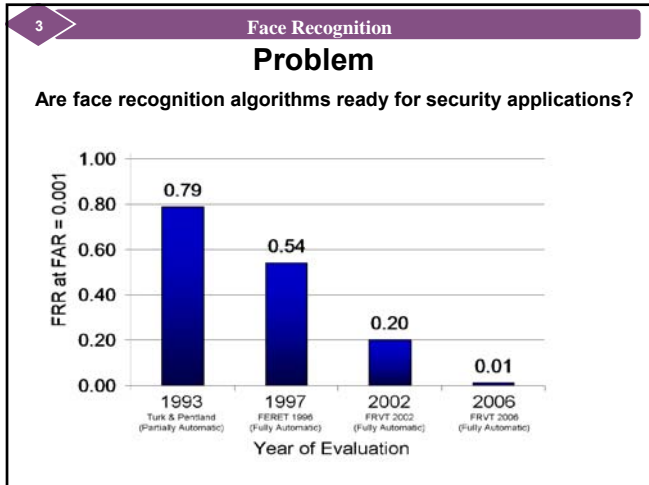
3 Face Recognition

Same or different person?

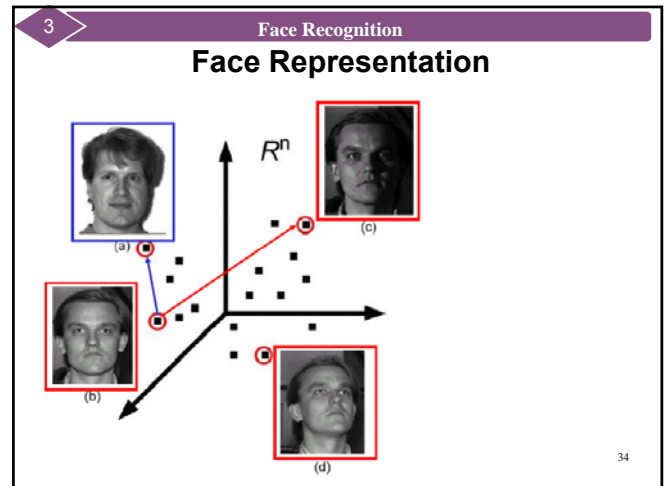
Response:

1. sure they are the same person
2. think they are the same person
3. not sure
4. think they are not the same person
5. sure they are not the same person

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- 3 Face Recognition
- ### Approaches for Detection in a single image
- Knowledge-based**
 - Feature invariant**
 - Facial features
 - Texture
 - Skin color
 - Multiple features
 - Template matching**
 - Predefined face templates
 - Deformable templates
 - Appearance-based method**
 - Eigenface
 - Distribution-based
 - Neural network
 - Support vector machine
 - Naive Bayes classifier
 - Hidden Markov model
 - Information-theoretical
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- 3 Face Recognition
- ### References
- M. Yang, D. Kriegman and N. Ahuja, "Detecting Faces in Images: A Survey", IEEE Transactions on Pattern Analysis And Machine Intelligence (PAMI), vol. 24, no. 1, pp. 34-58, 2002.
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