Technical University of Lodz
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Biometrics

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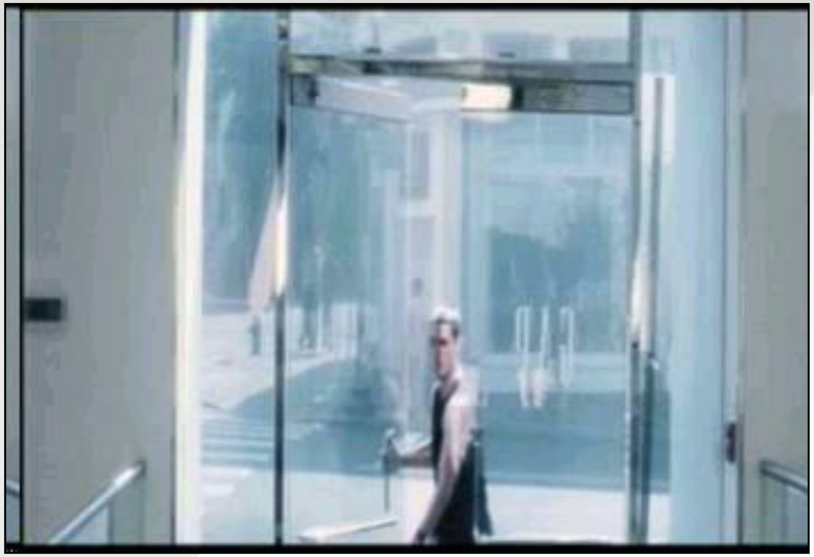
Identification of people by measuring some aspect of individual anatomy or physiology, or other behavioral characteristic, or something that is a combination of the two

www.primode.com/glossary.html



Unattended retinal scans, *Minority Report*

Presentation outline

- Basics
- A review of the state-of-art
- Applications and recent advances

Introduction

Strategies of identity assessment

- A possession - **something that we have** (keys, badges, tokens, smart cards, ...)
- Knowledge - **something that we know** (secret information, like passwords, PIN numbers, ...)
- An individual property of a person - **something we are** - biometrics

Personal identity resolution tasks

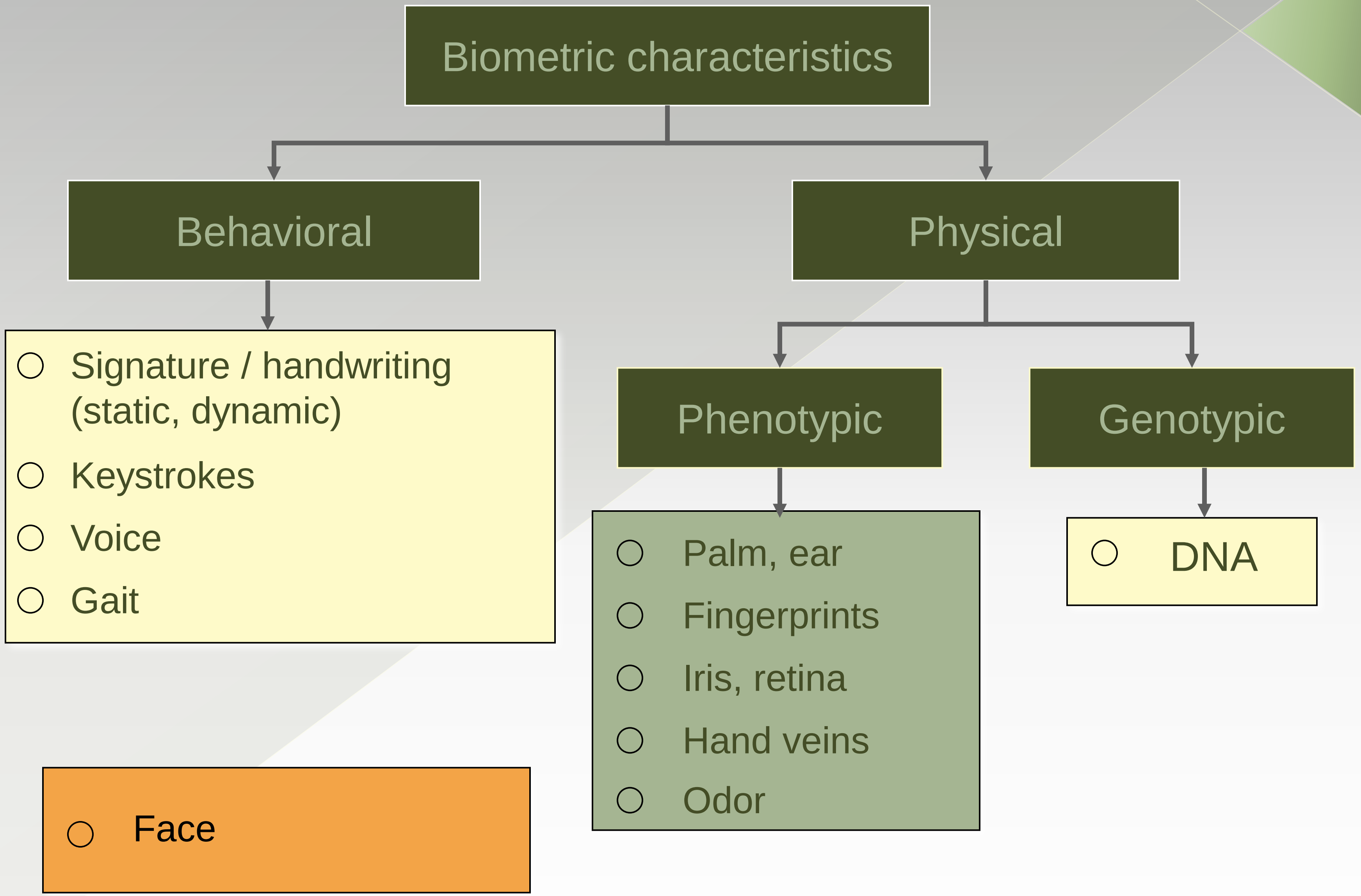
- **Verification (authentication)** - confirmation or denial of the claimed identity (Am I who I claim I am?)
- **Recognition (identification)** - establishing of subject’s identity (Who am I?)

Personal characteristics for biometrics

Basic requirements

- **Uniqueness** - a property must be distinct for different individuals (not a blood group etc.)
- **Permanence** - a property cannot change over time
- **Universality** - everyone (almost) must possess such a property
- **Collectability** - it has to be possible to measure (easily) a property
- **Immunity to circumvention** - it has to be hard to fool the system
- **Acceptability** - physical contact considerations, privacy considerations, religious issues, ...

Personal characteristics for biometrics



Biometric characteristics

Behavioral

- ○ Signature / handwriting (static, dynamic)
- ○ Keystrokes
- ○ Voice
- ○ Gait

Physical

Phenotypic

- ○ Palm, ear
- ○ Fingerprints
- ○ Iris, retina
- ○ Hand veins
- ○ Odor

Genotypic

- ○ DNA

- ○ Face

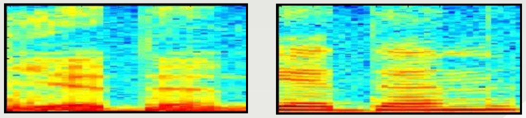
Why biometrics is difficult?

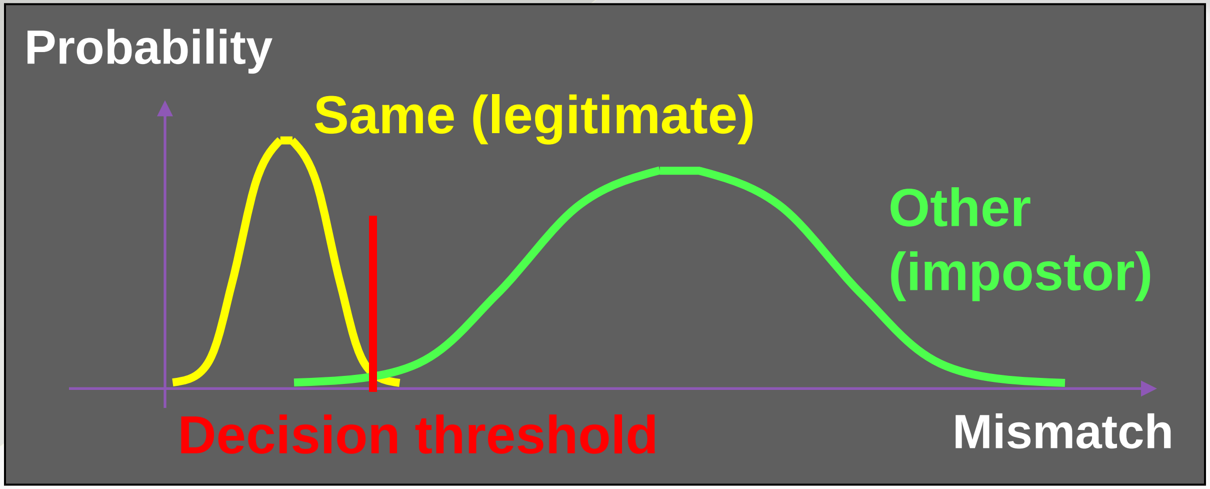
Expectations – fast and reliable recognition

- Samples are never exactly the same

Same face

Same speaker

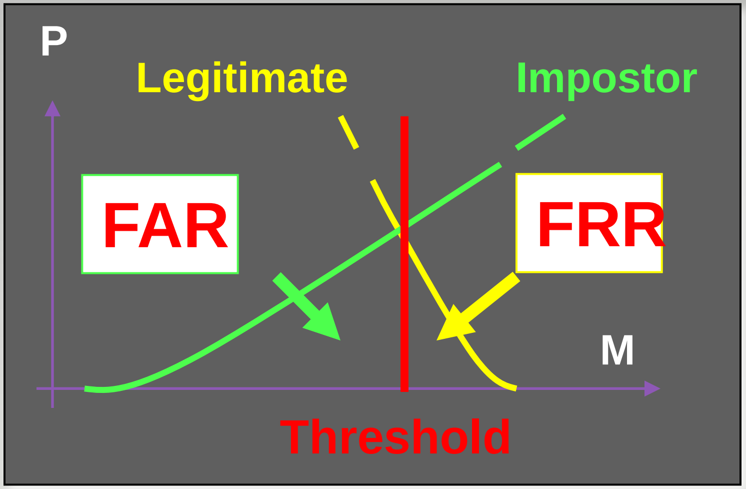


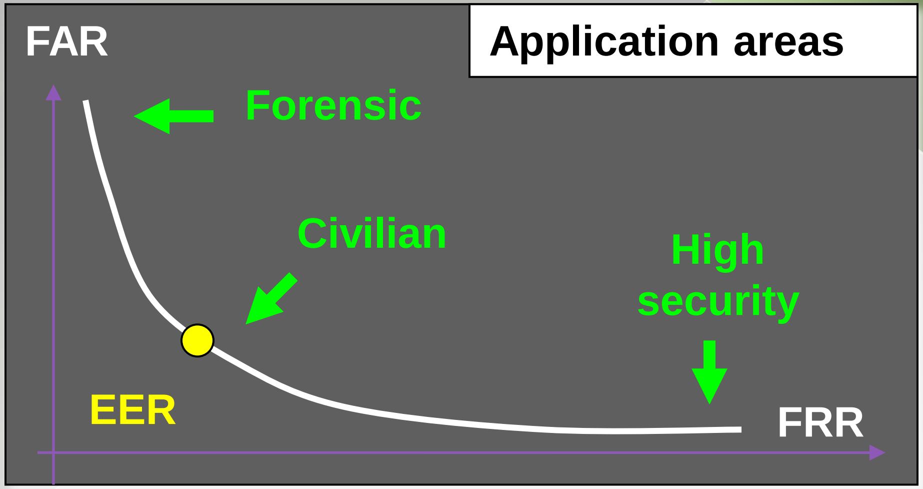


Quantitative performance measures

- FAR - False Acceptance Rate – impostor acceptance
- FRR - False Rejection Rate – legitimate user rejection

Performance measures



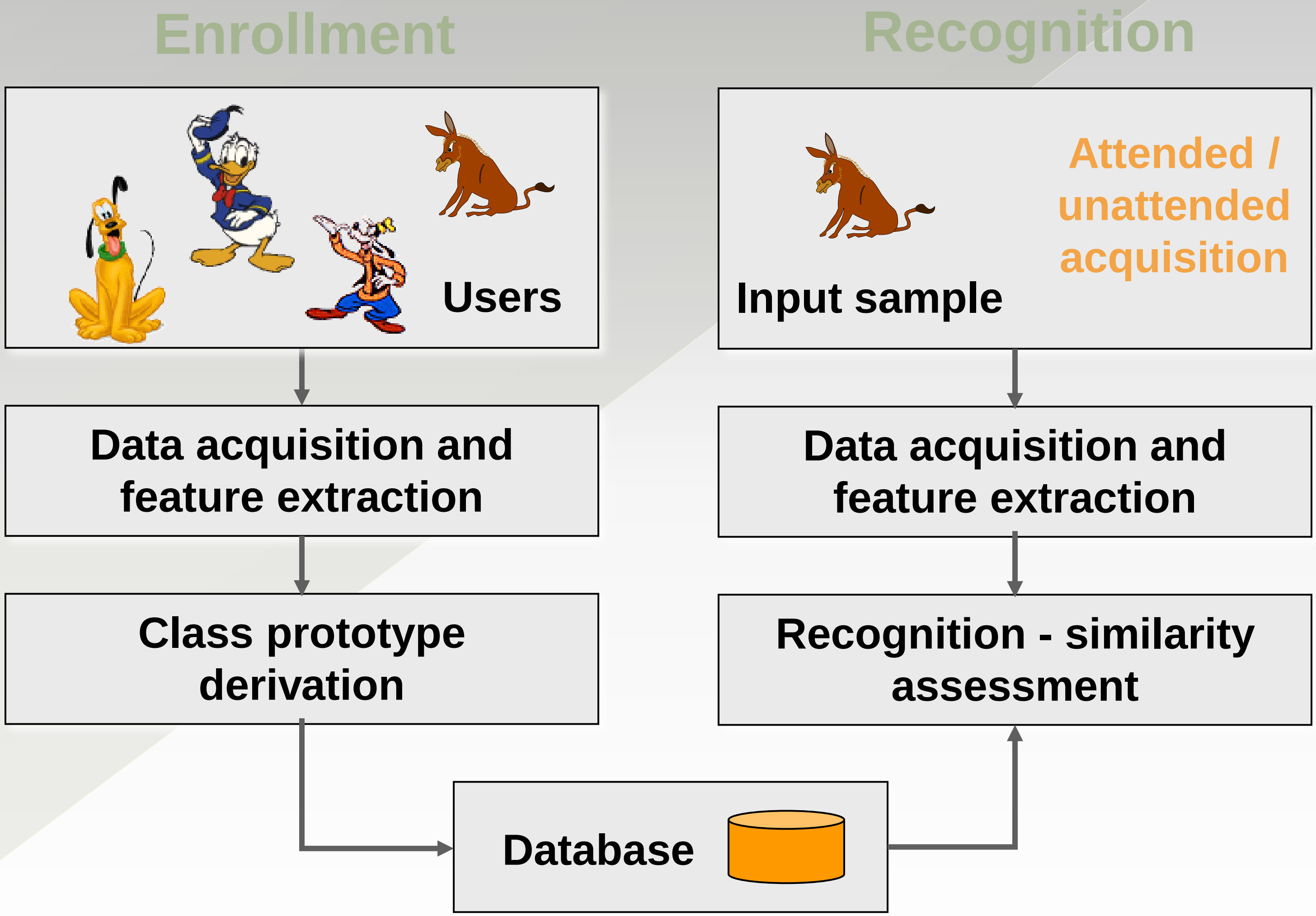


Biometric system design considerations

- Security requirements – **liveness test**
- Objective - verification or identification
- Operation mode - attended or unattended, covert or overt
- Resources - storage requirements, analysis time

Biometric system operation

Enrollment (training) – Execution (recognition)



Enrollment

Users

Data acquisition and feature extraction

Class prototype derivation

Recognition

Input sample

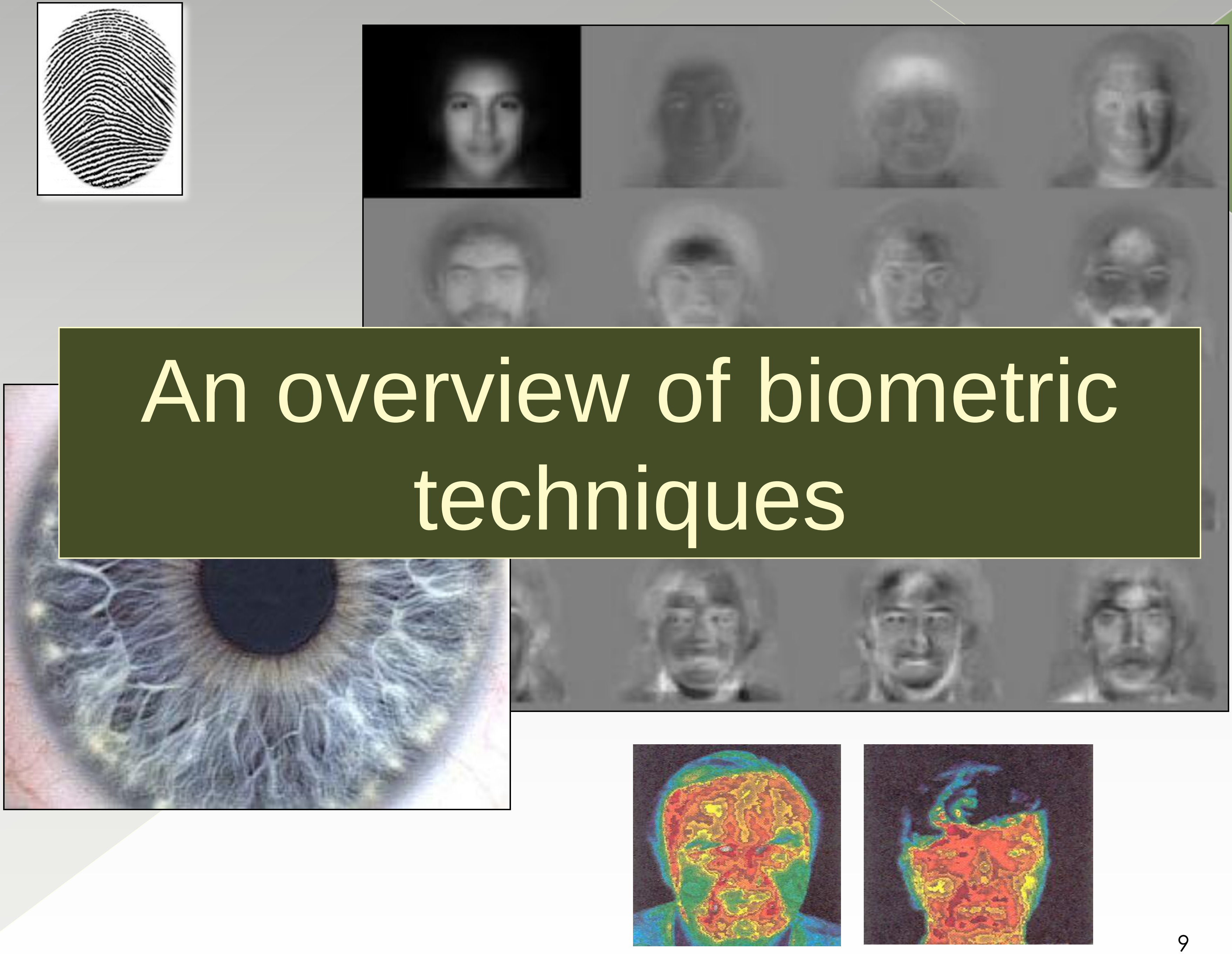
Attended / unattended acquisition

Data acquisition and feature extraction

Recognition - similarity assessment

Database

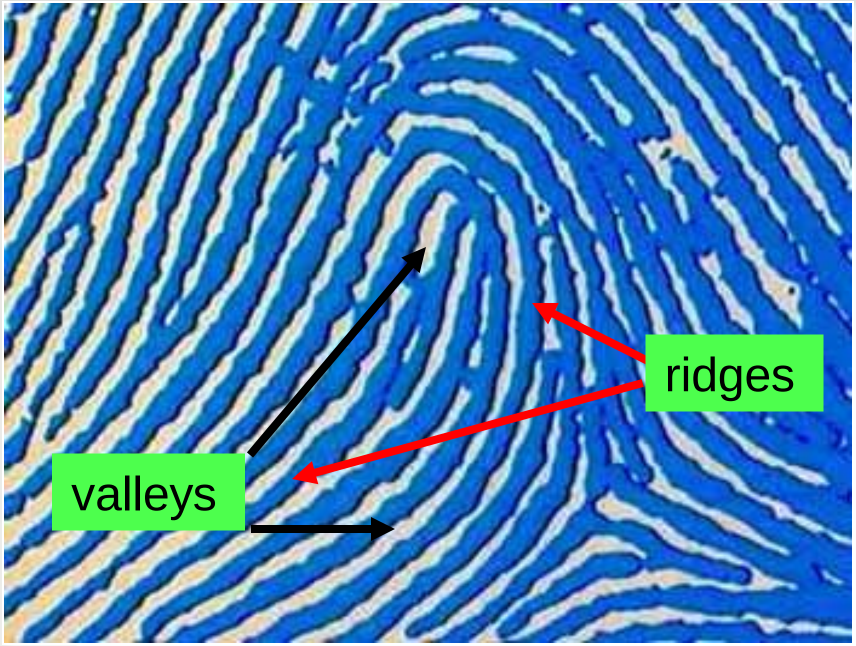
An overview of biometric techniques



Fingerprint-based recognition

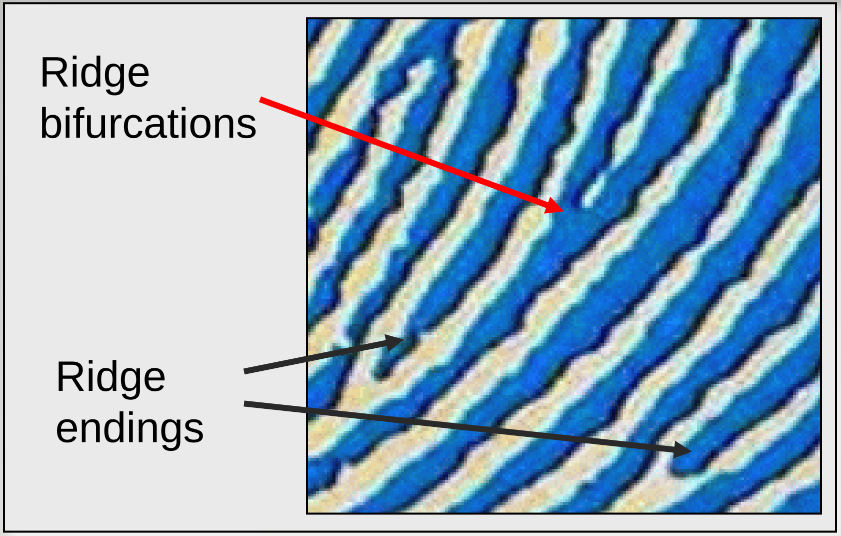
Major current biometric technology

- Earliest records - authentication imprints on clay tables - Babylon, 1700 B.C.
- Approved to be a forensic method in Great Britain in 1901



- No identical fingerprints found among recorded hundreds of millions - **uniqueness**
- Completely forms in early natal period and remains unaltered - **permanence**
- Most of us have it - **universality**
- Easy to **collect** in an **acceptable** way (subject’s cooperation)

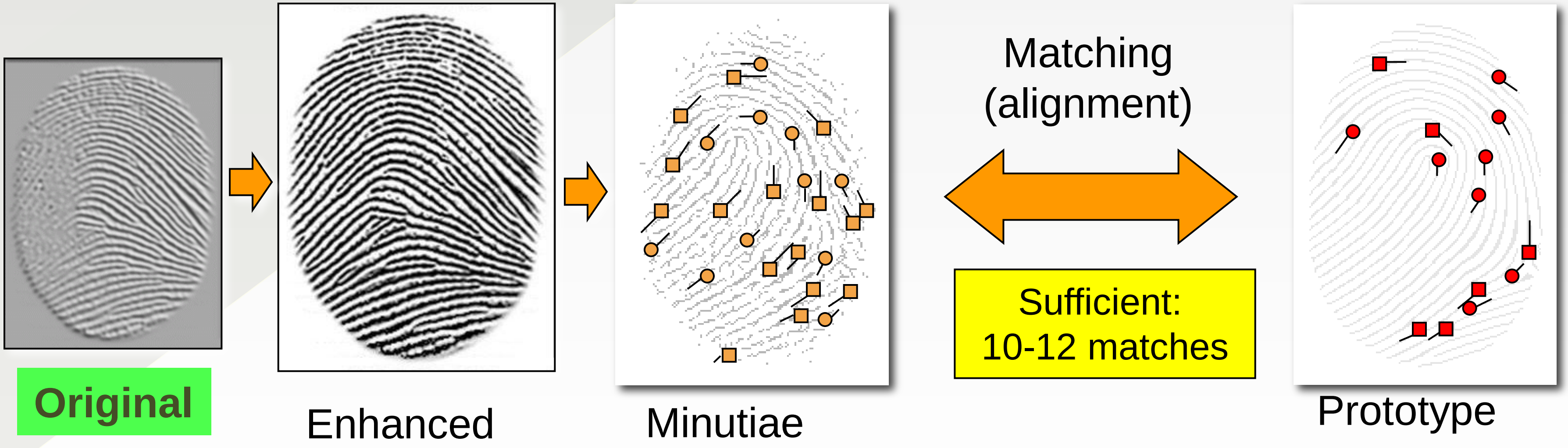
Automated fingerprint recognition



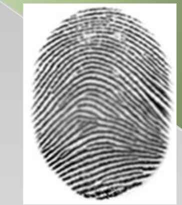
Minutiae-based

- Features: ridge endings and ridge bifurcations
- Typically 40-60 minutiae per fingerprint

Main steps of the minutiae-based recognition

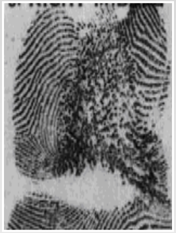


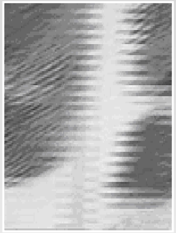
Fingerprint acquisition



Optical readers

- Inexpensive
- Easy to fool (not all types) - photos etc.
- Image quality can become low due to dirt (reader or finger), residual imprints etc.
- Low-cost, low-security systems – PC access





Ultrasound readers

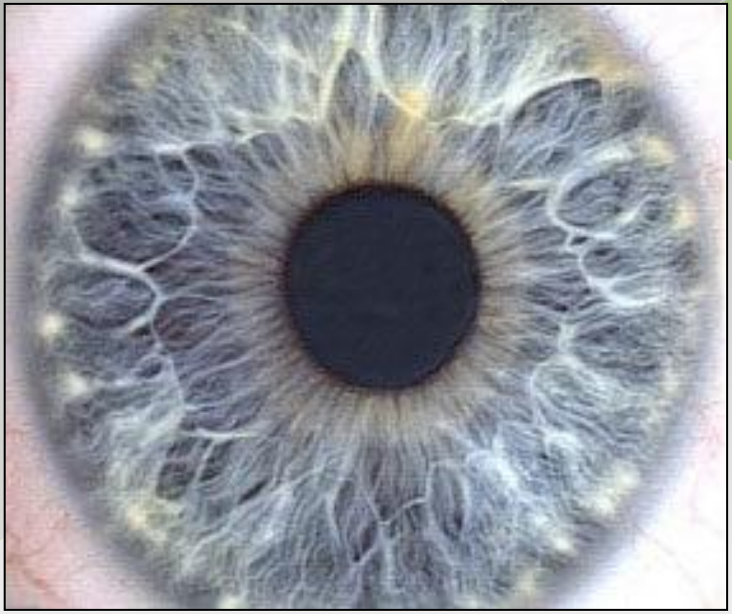
- Inner layers of skin are subject to scanning
- Very expensive
- Considered to be the most difficult (impossible) to circumvent

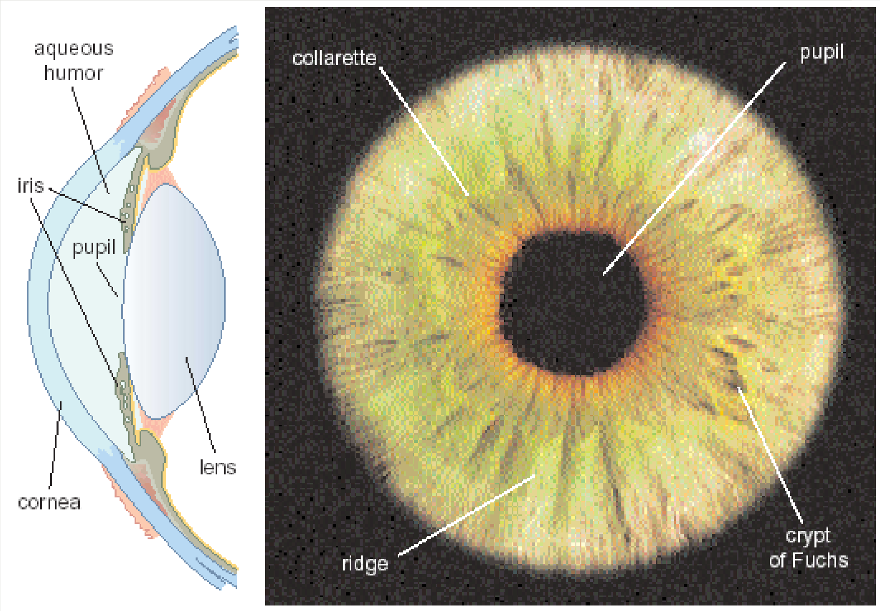
Thermal readers, capacitive readers

Iris-based recognition

Major prospective technology

- No identical irises found among recorded hundreds of millions - **uniqueness**
- Completely forms in early natal period - **permanence**

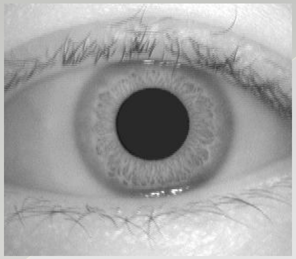




- Most of us have it - **universality**
- Easy to get - **collectabilty**
- No physical contact nor cooperation required - **acceptability**
- Hard to circumvent

Iris image analysis - J. Daugman's algorithm (preprocessing, localization, segmentation, code extraction, classification)

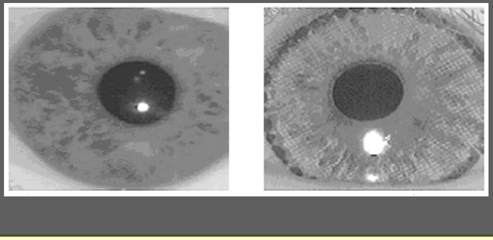
Visible light



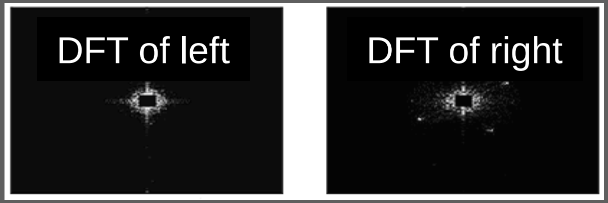
Near infrared

- Perfect (no false matches reported) if sufficient image quality
- Extremely difficult to circumvent

Original



With contact lenses

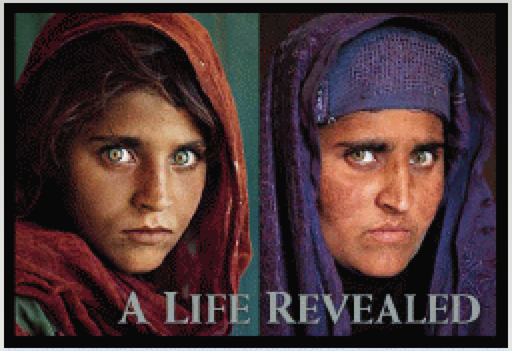


Simple liveness test – variable illumination

Face-based recognition

The most acceptable

- Surveillance and monitoring systems
- Permanence ☹: aging, diseases



Sharbat Gula in 1985, 1992

- Uniqueness ☹: twins, beard, facial expressions, make-up ...

Other challenges

- Face localization (detection)
- Acquisition errors - illumination, background

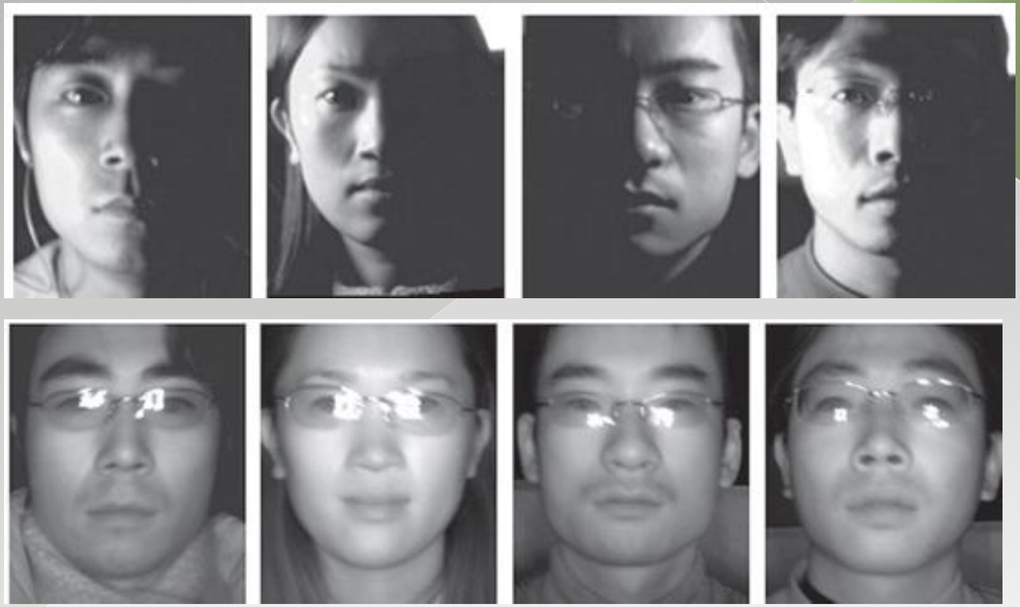
Huge security market

- Massive deployments in airports

Performance in access-control systems

Poor (10% EER if uncontrolled acquisition, otherwise – 1%)

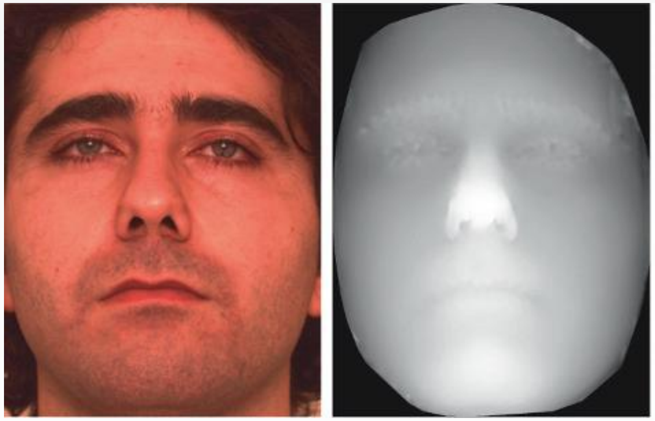
Recent advances in face-based recognition



Near infrared face recognition

- Minimizing lighting from other sources
- No color variation

3D Face Recognition



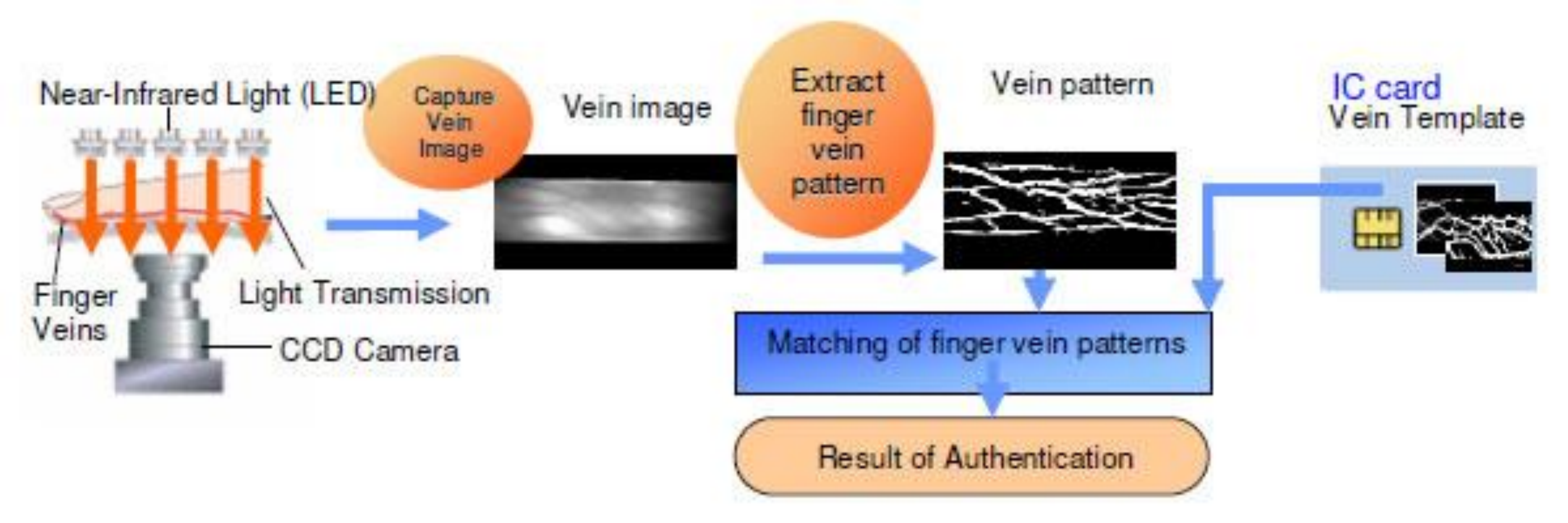
- Stereovision or laser active sensing to obtain depth information
- Access to shape and texture information
- Recognition algorithms less sensitive to variable or poor illumination and pose change -> better performance

Finger vein recognition

- Unique shape and distribution of human vessel tree
- Pattern-recognition techniques for images of human finger vein patterns beneath the skin's surface
- Easy and non-invasive image acquisition based on near-infrared radiation
- High acceptance

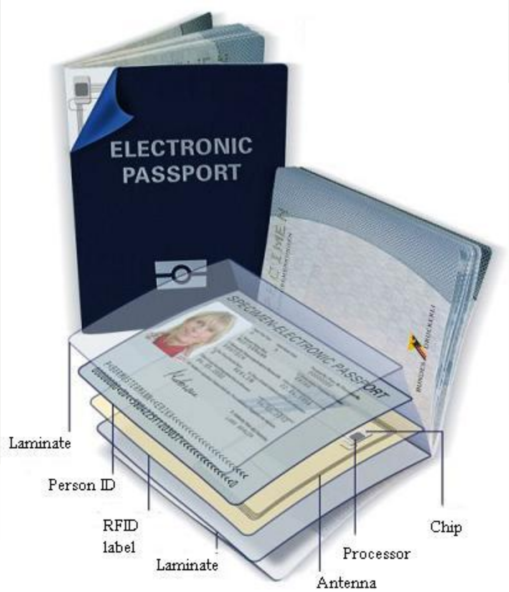
Finger vein recognition

- Developed by Hitachi, 2005
- Analysis time < 2s
- FAR < 0,0001%, FRR < 0.01%
- Applications: ATM, employee time and attendance tracking, computer and network authentication



Biometrics and smart cards

- Biometric data included in card microchips
- Finger print, face and iris templates
  (or their combination – multimodal biometrics)
- Biometric processing: match-off-card vs. match-on-card
- Threats: template decoding by reverse engineering
- Countermeasure: advanced data coding algorithms (fuzzy extractors)

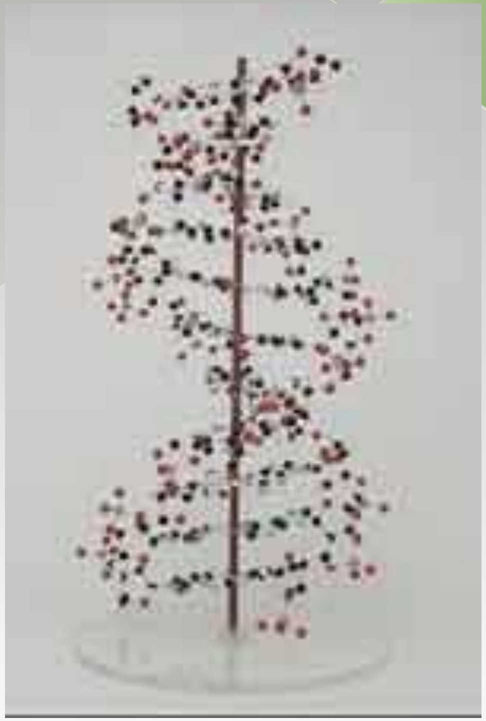


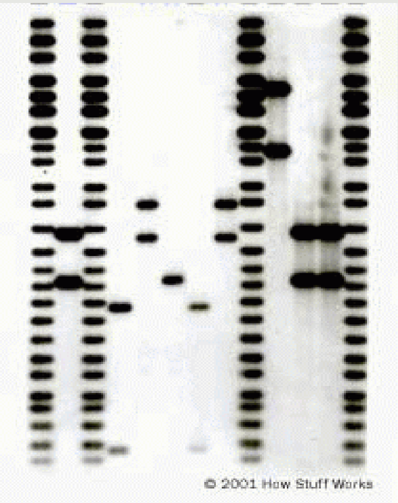
Microchips are also implemented
in biometric passports

DNA-based recognition

Highlights

- Approximately 3 million DNA base pairs (0.1% of a genome) vary from person to person (except twins)
- DNA evidence analyzes identical particle sequences in non-coding DNA - Variable Number Tandem Repeats - VNTR
- DNA individual profile: a number of VNTRs





Major drawbacks

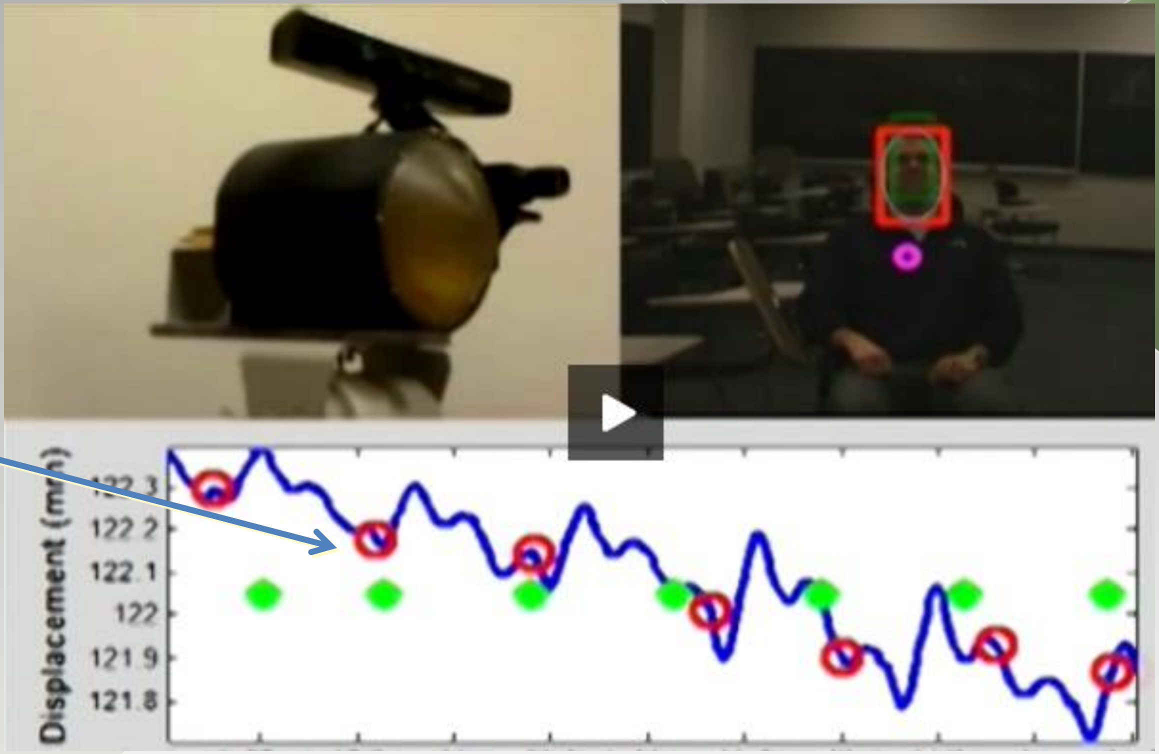
- Low acceptability - a rich pool of additional information unrelated to identity determination
- Samples are easy to steal and plant
- Time consuming procedure, high costs

New DNA analysis system by NetBio, USA (2013)

- Analysis of repeated DNA sequences of the human genome (short tandem repeats, STR)
- Odds of two unrelated people having the same STR profile are 1 in 575 trillion
- STR profile generated based on 16 STR regions (this type of DNA data is widely accepted in the criminal justice systems in Japan, the United States, and Western Europe)
- Cotton swabs (RFID tagged) to collect cheek cells from inside a person’s mouth
- Analysis time < 90 min, easy to use

Biometrics future

- Biomedical signals as biometrics (e.g. ECG)

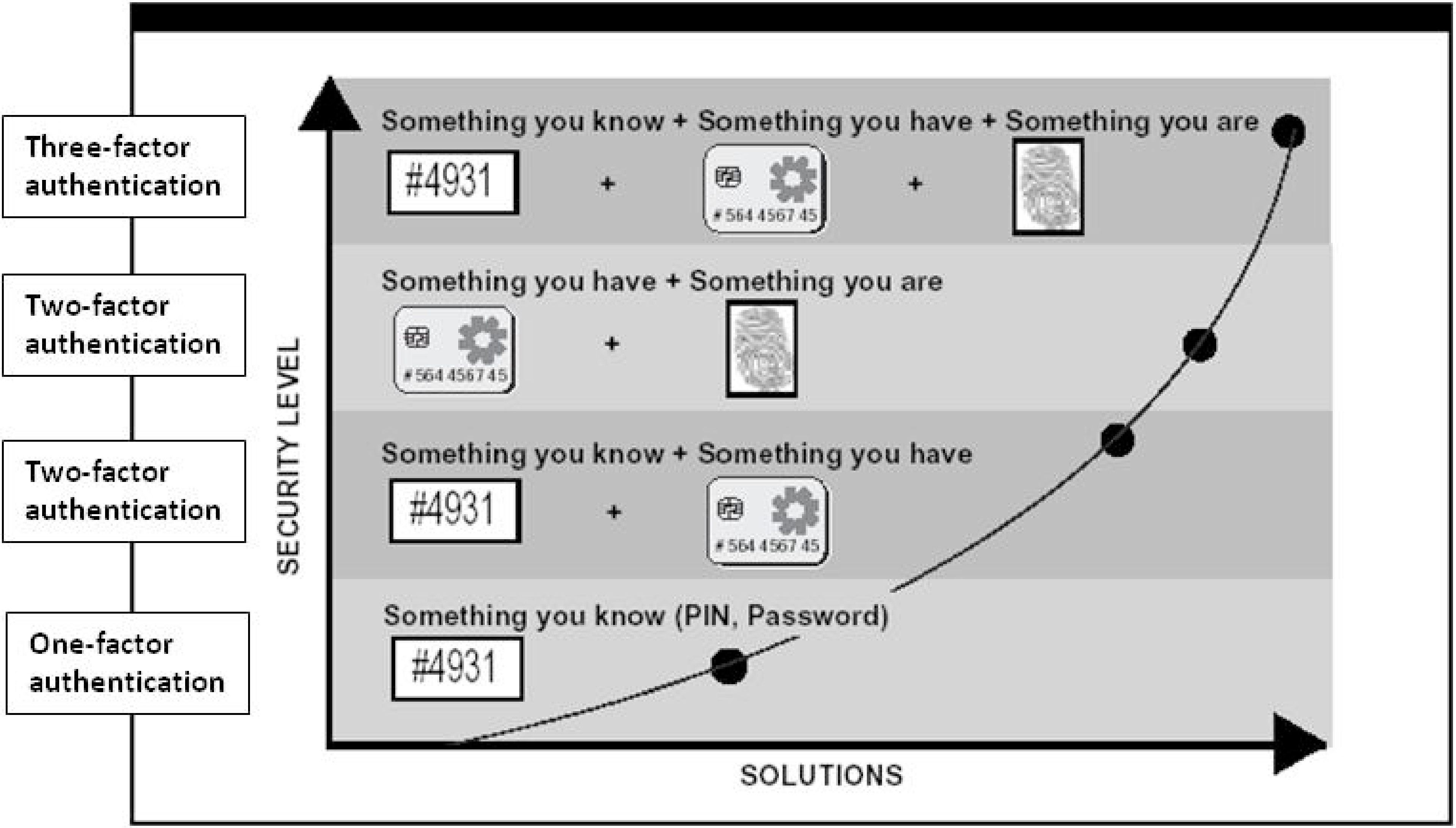


Argonne Nat. Lab., USA

- Remote biometrics (mobile device performs template matching)

3M Cogent, USA

Biometrics + SC improve security

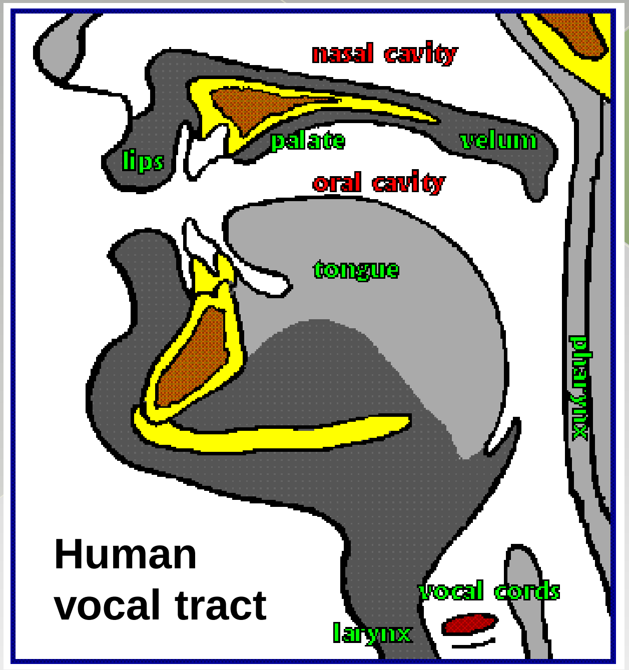

Three-factor authentication
Two-factor authentication
Two-factor authentication
One-factor authentication
SECURITY LEVEL
Something you know + Something you have + Something you are
#4931
+
# 564 4567 45
+
Something you have + Something you are
# 564 4567 45
+
Something you know + Something you have
#4931
+
# 564 4567 45
Something you know (PIN, Password)
#4931
SOLUTIONS

Thank you for your attention

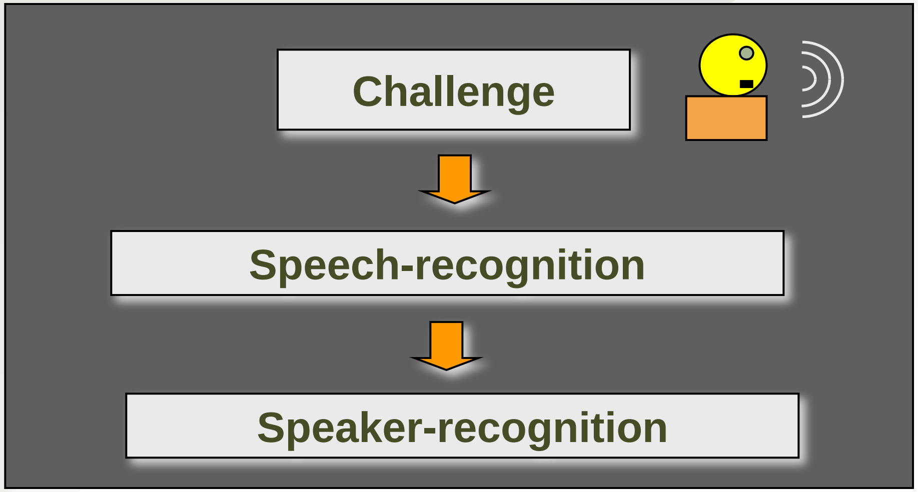
Voice-based recognition

Highlights

- Most of us have it - **universality**
- Easy to acquire (no cooperation)
- Gets changed (aging, health…) ☹
- Uniqueness hard to be proved ☹



- Combination of individual physical properties and learned elements



Challenge

Speech-recognition

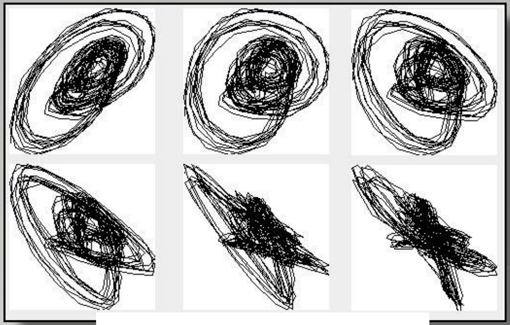
Speaker-recognition

The only means for remote applications

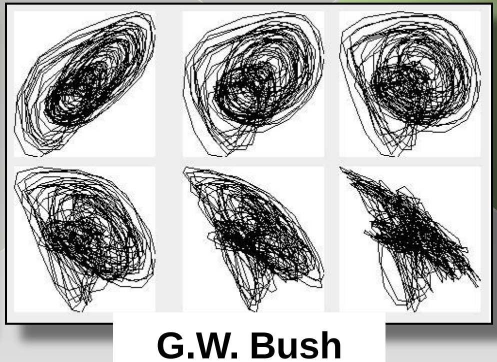
Successive increase in recognition confidence level

(nr)

Voice-based recognition



Impersonator



G.W. Bush

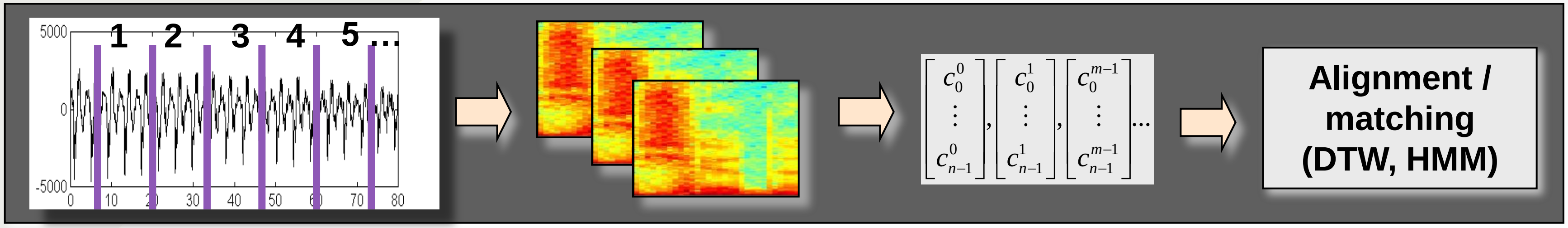
Other challenges

- Deliberate imitation
- Noise

Features

- Adopted from speech recognition (LPC, Mel …)
- Specific (e.g. pronunciation variability)

Recognition procedure



$$\begin{bmatrix} c_0^0 \\ \vdots \\ c_{n-1}^0 \end{bmatrix}, \begin{bmatrix} c_0^1 \\ \vdots \\ c_{n-1}^1 \end{bmatrix}, \begin{bmatrix} c_0^{m-1} \\ \vdots \\ c_{n-1}^{m-1} \end{bmatrix} \ldots$$

Alignment / matching (DTW, HMM)

- Poor recognition rates 1:50, 1:100

(nr)

Basics