Biometrics Introduction

Daniel Novák

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Acknowledgments: Chang Jia, Andrzej Drygajlo

laboratory Gerstner

Podmínky předmětu

- Přednášející: Daniel Novák, místnost E225, xnovakd1@labe.felk.cvut.cz,
- Stránky předmětu
  - https://cw.felk.cvut.cz/doku.php/courses/a6m33bio/start
  - 3. laboratorní úlohy – každá za 20 bodů, celkem 60 bodů
  - Klasifikovaný zápočet – 20 otázek, každá za 2 body
- Podmínky předmětu
  - https://cw.felk.cvut.cz/doku.php/courses/a6m33bio/podminky

Body z předmětu	Stupeň ECTS	Známka
100–90	A	výborně
89–80	B	velmi dobře
79–70	C	dobře
69–60	D	uspokojivě
59–50	E	dostatečně
49 a méně	F	nedostatečně

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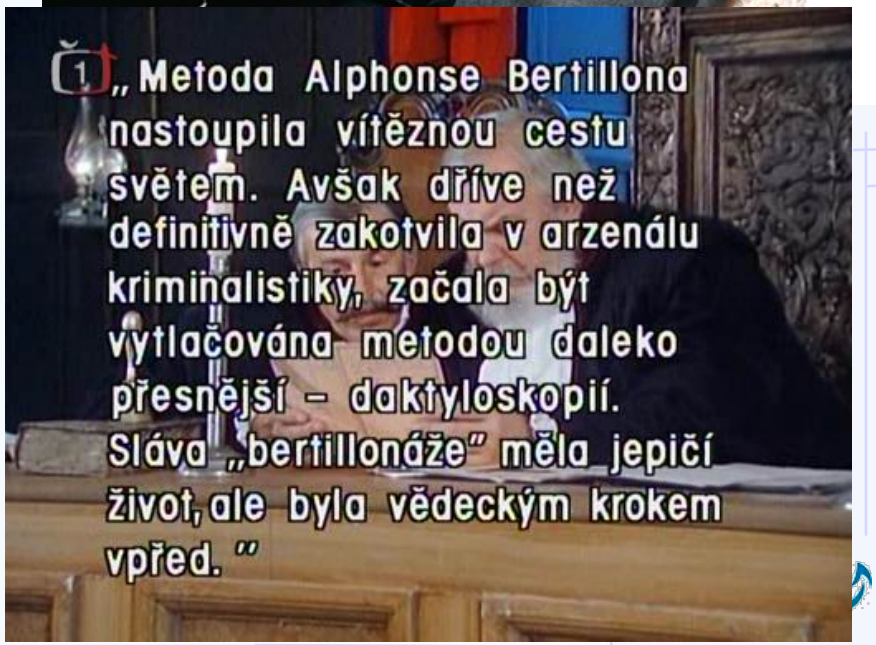
Alternativní úvod

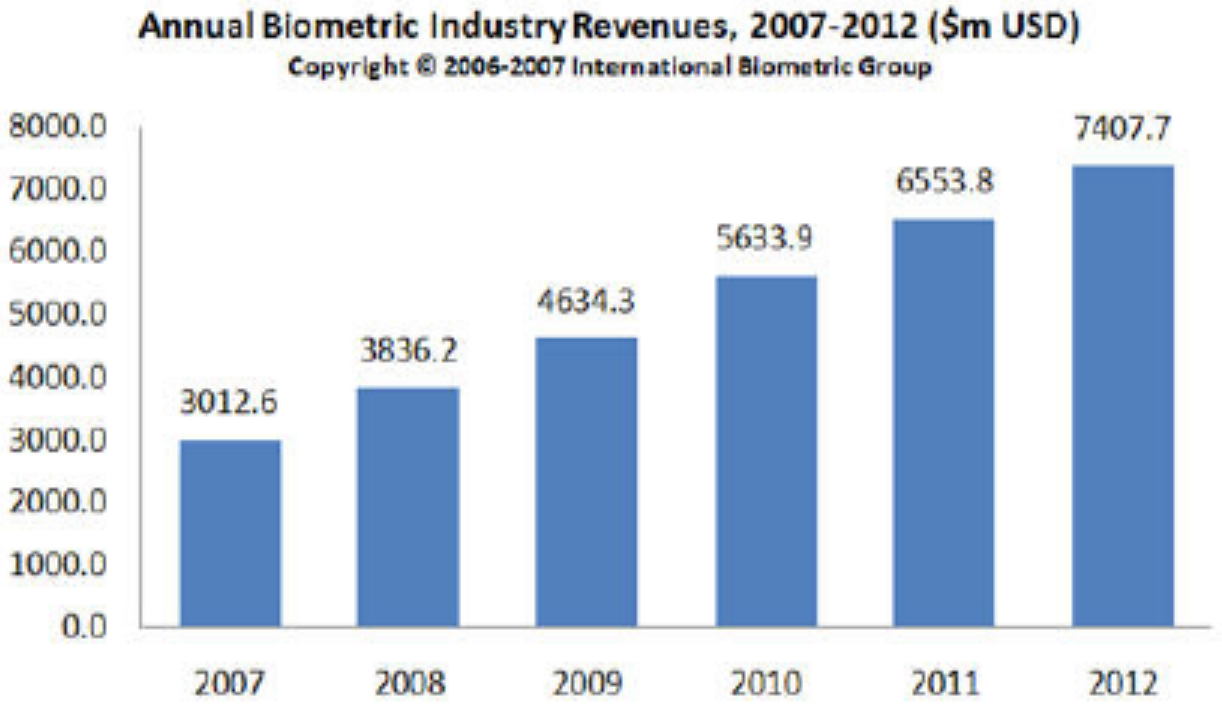
- Dobrodužství kriminalistiky na csfd
- Dobrodužství kriminalistiky na CT



Biometrics numbers

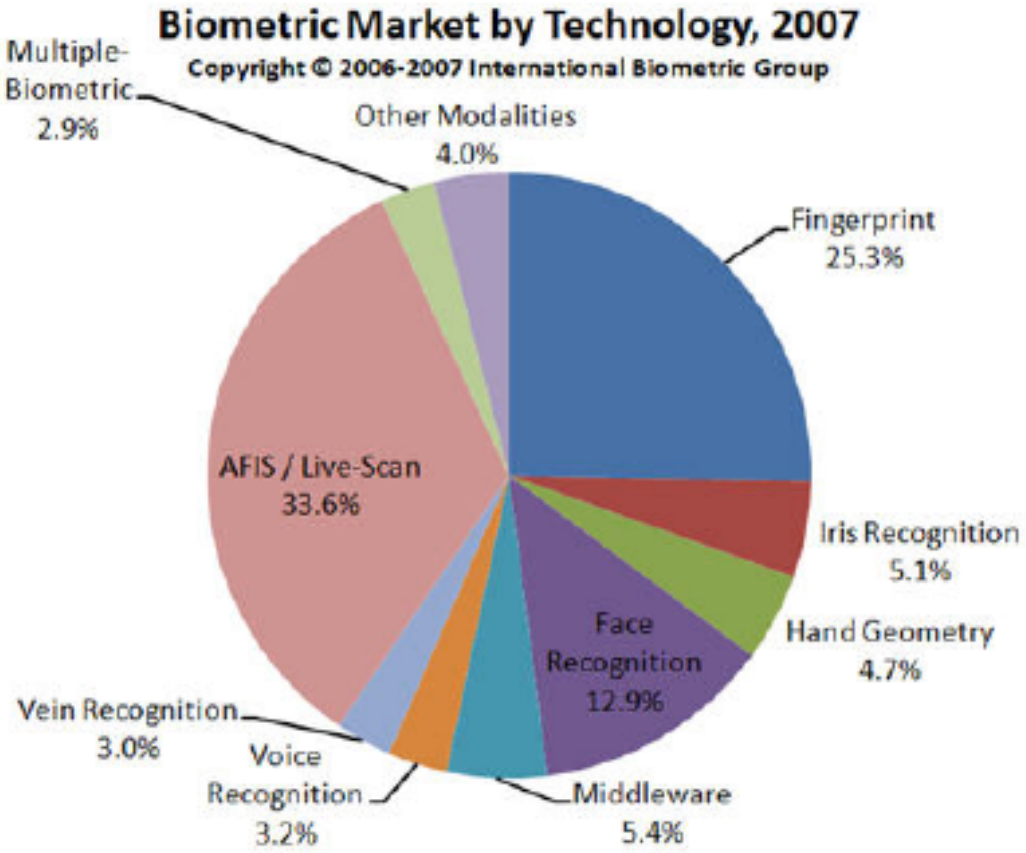
~ $3,000,000,000	→	Estimated value of biometrics market in 2007 (IBG)
> 75%	→	Market share of the 3 core technologies: face, iris and fingerprinting (IBG)
2009	→	Planned launch of 2nd generation passports (to include fingerprints)
> 50,000	→	Number of people caught since 2003 at UAE borders using iris recognition

Trend



"A Touch of Money"

Market Share



Today: eBordersin the United Arab Emirates (UAE)

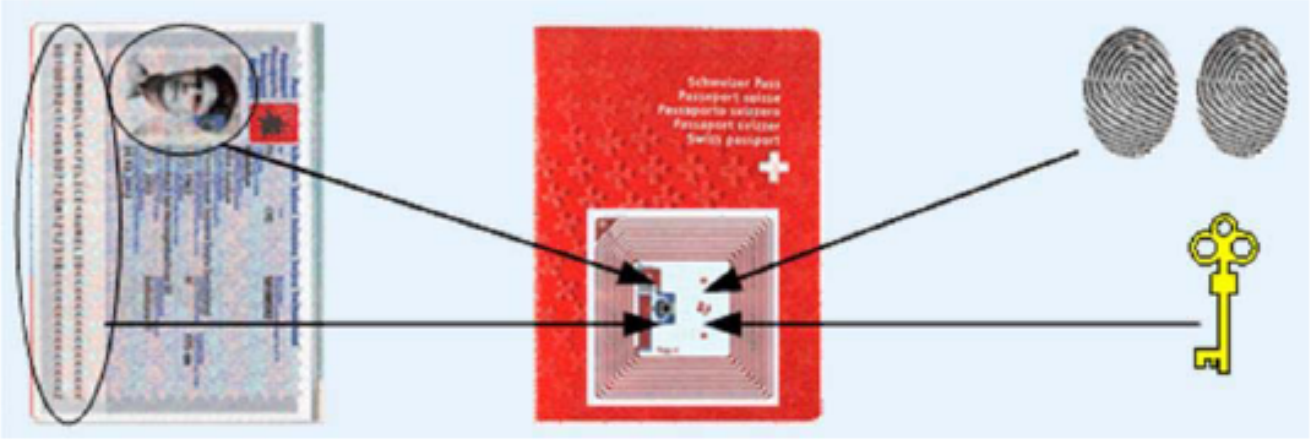
- Iris recognition system
- Fully operational since April 2003
- 36 land, air and sea ports
- 12,000 passengers each day

- 1 central database
  - Watchlist application
  - Fully networked
  - Enrolment centres: prisons and deportation centres
  - More than 1 million enrolments (150+ nationalities)
  - Exhaustive search takes <2 seconds

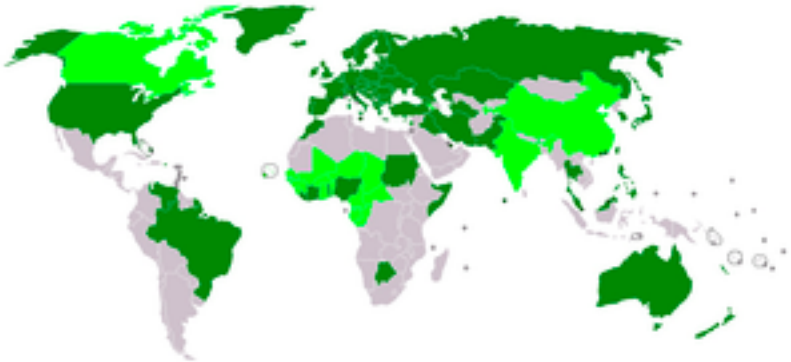
- 12 billion comparisons each day (12,000 passengers against 1 million enrolments)
- About 50,000 persons caught since launch

ePassport

In accordance with ICAO and EU specifications, the data of the machine readable zone, the facial image and two fingerprints plus electronic signatures will be stored in the chip.



Integration of Technologies: chip card (smart card), radio-frequency identification (RFID), electronic signatures and public key infrastructure (PKI), back-office systems (databases), biometrics



International Civil Aviation Organization

Some statistics of Mobile devices

- Some statistics:
  - 35,000 laptops reported stolen in the UK each year
    (Times Online's estimate: 110,000 stolen laptops/year)
  - only 3% ever retrieved

- Several million biometrically enabled phones, PDAs and peripherals now on the market

SecurePhone

What is Biometrics?

- **Biometrics** – automated recognition of individuals based on their biological and behavioral characteristics
  - *Scientific follow-on to Bertillon's body measurements of the late 1800s*
- **Biometry** – statistical and mathematical methods applicable to data analysis problems in the biological sciences
- **Biometric system** – essentially an automatic pattern recognition system that recognizes a person by determining the authenticity of a specific biological and/or behavioral characteristic (biometric modality) possessed by that person
- **Anthropometry** – measurement techniques of human body and its specific parts
  - ***Forensic (judicial) anthropometry*** – *identification of criminals by these measurement techniques*

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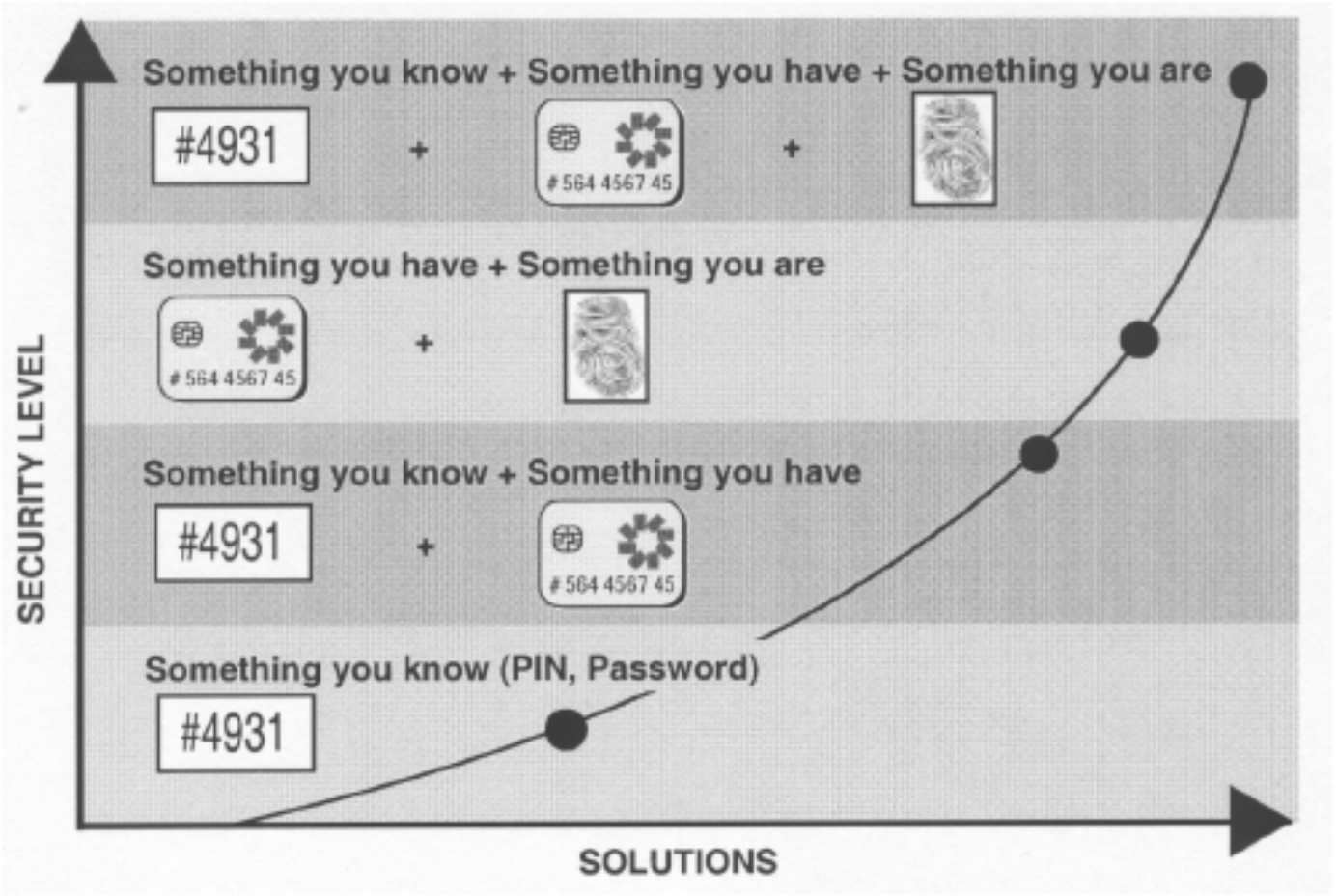
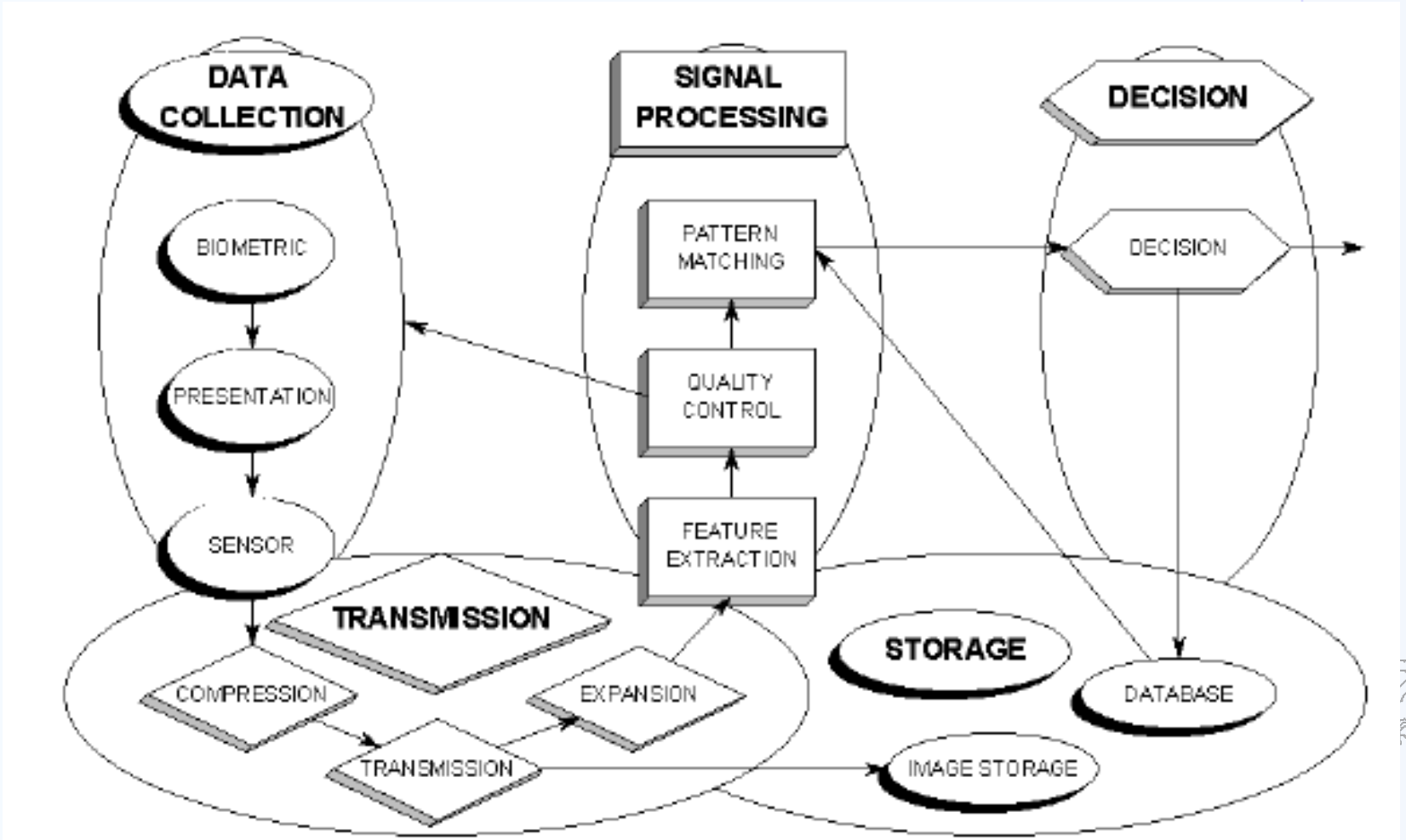
Three basic means



Generic Biometric System

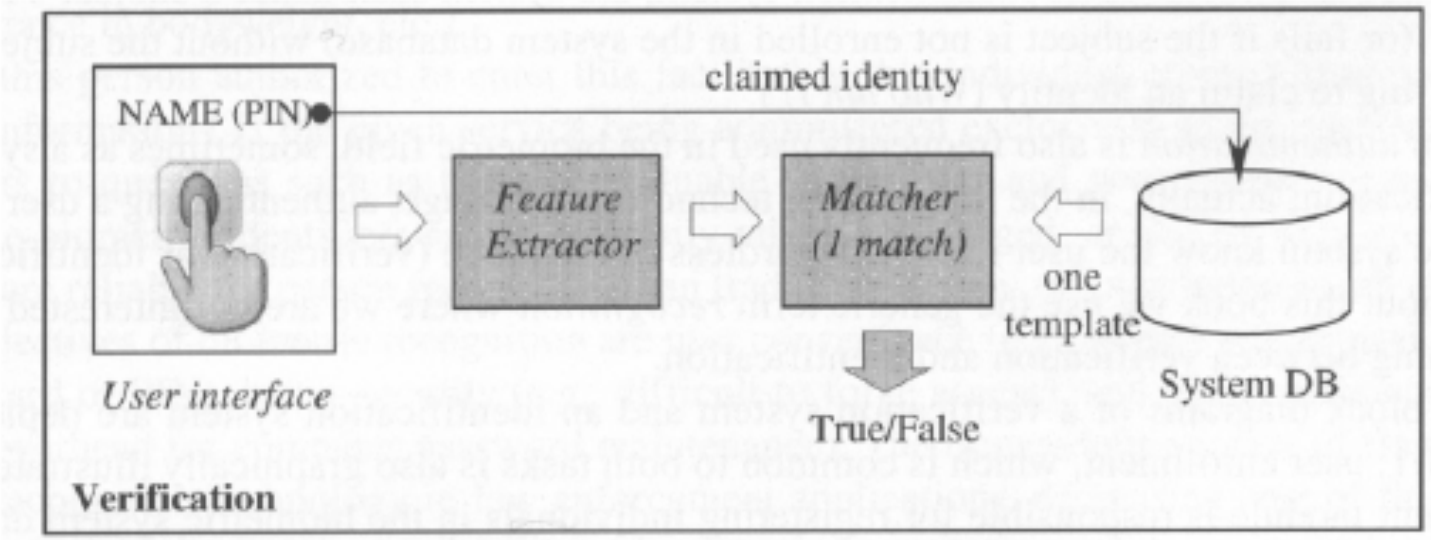


Pattern Recognition System

Two patterns are similar, if an appropriately defined distance measure between their feature vectors is small

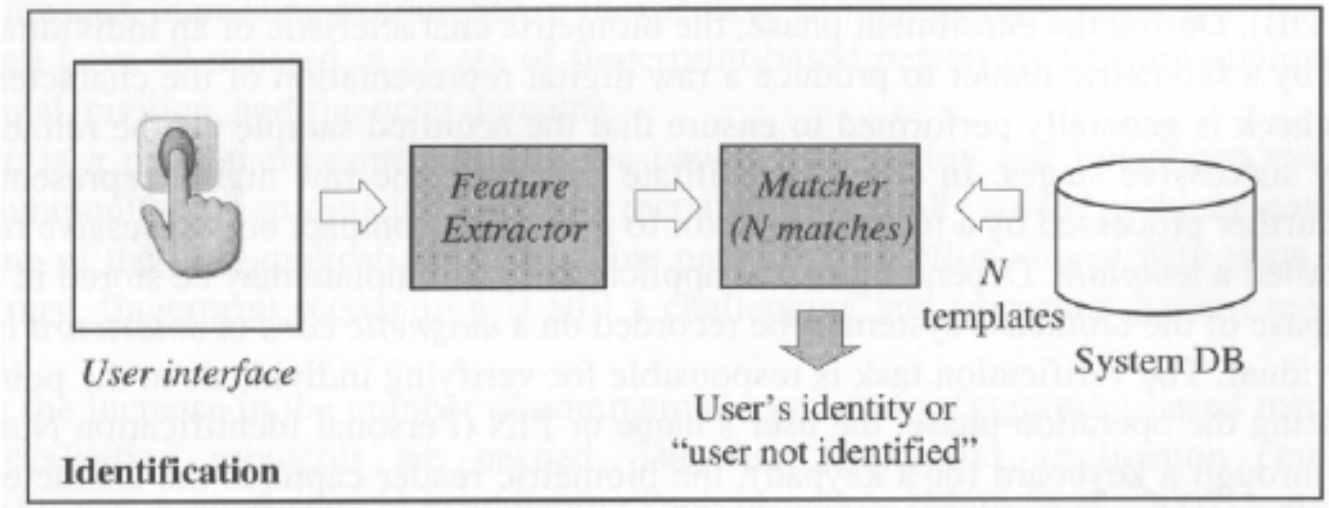
Person recognition

- Verification – biometric system function that performs a one-to-one comparison of a submitted biometric characteristic (sample) set against a specified stored biometric references, and returns the comparison score and decision.
- "Is this person who he claims to be?"

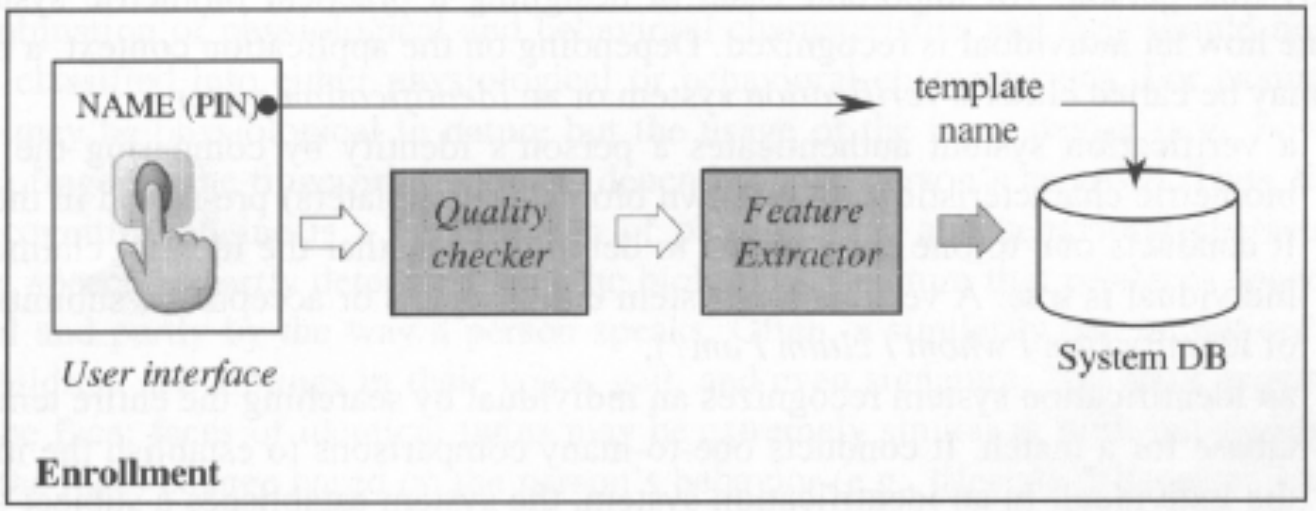


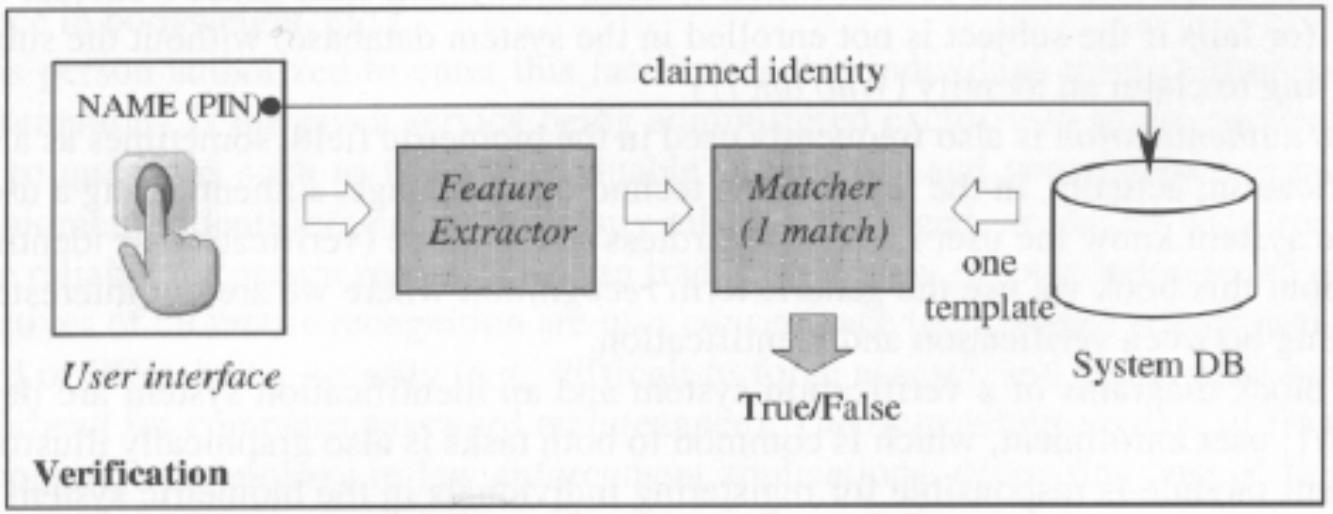
Identification

- Identification – biometric system function that performs a one-to-many comparison/search process in which a biometric characteristic set is compared against all or part of the database to find biometric references with a specified degree of similarity.
- "Who is this person?"



Enrollment


NAME (PIN)
template name
Quality checker
Feature Extractor
System DB
User interface
Enrollment


claimed identity
NAME (PIN)
Feature Extractor
Matcher (1 match)
one template
System DB
User interface
True/False
Verification

Main Sorting

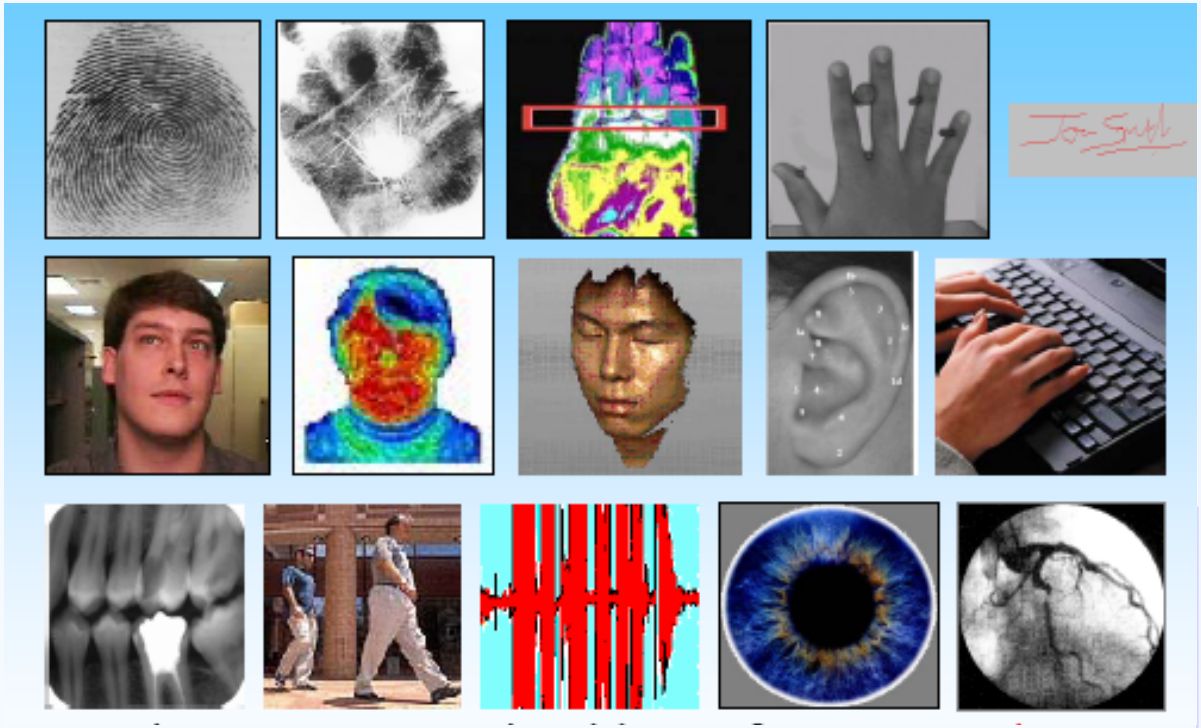
Biometrics can be sorted into two classes:

- Physiological

  Examples: ***face, fingerprint, hand geometry and iris recognition***

- Behavioral

  Examples: ***signature and voice***



Biometric Identifiers

Common:

- *Fingerprint Recognition*
- *Face Recognition*
- *Speaker Recognition*
- *Iris Recognition*
- *Hand Geometry*
- *Signature verification*

Others:

- DNA
- Retina recognition
- Thermograms
- Gait
- Keystroke
- Ear recognition
- Skin reflection
- Lip motion
- Body odor

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Some More* …

Vein Pattern
Sweat Pores
Fingernail Bed
Hand Grip
Brain Wave Pattern
Footprint and Foot Dynamics

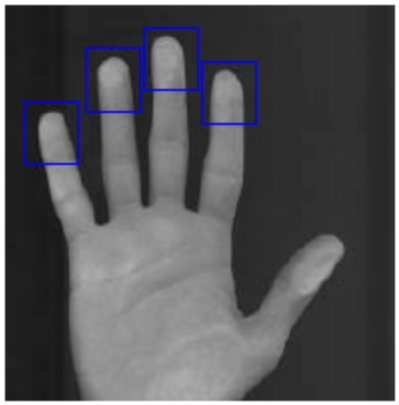
•*See details in ***Chapter 7 Esoteric Biometrics*** of ***Biometrics*** by John D. Woodward, Nicholas M. Orlans, Peter T. Higgins, New York : McGraw-Hill/ Osborne, c2003

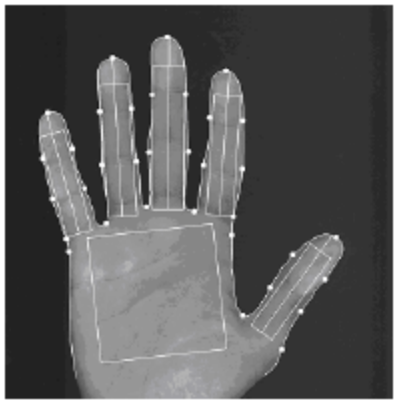
1. Fingerprint Recognition (D.Novak)

- An extremely useful biometrics technology since fingerprints have long been recognized as a primary and accurate identification method.

Hand shape

Fingerprints





Palm print

Finger strips
(digitprints)

Palmar veins

Acquisition Devices

- ✓ Ink & paper – the oldest way
- ✓ Ink-less Methods - sense the ridges on a finger

– "Livescan" fingerprint scanners

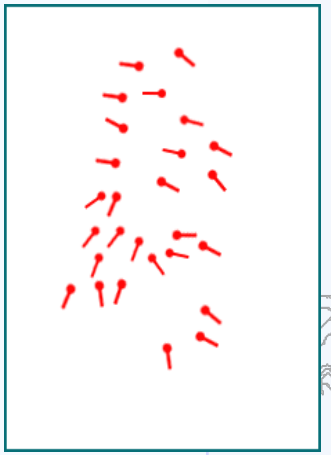
- ➢ Optical methods (FTIR)
- ➢ CMOS capacitance
- ➢ Thermal sensing
- ➢ Ultrasound sensing

Minutiae

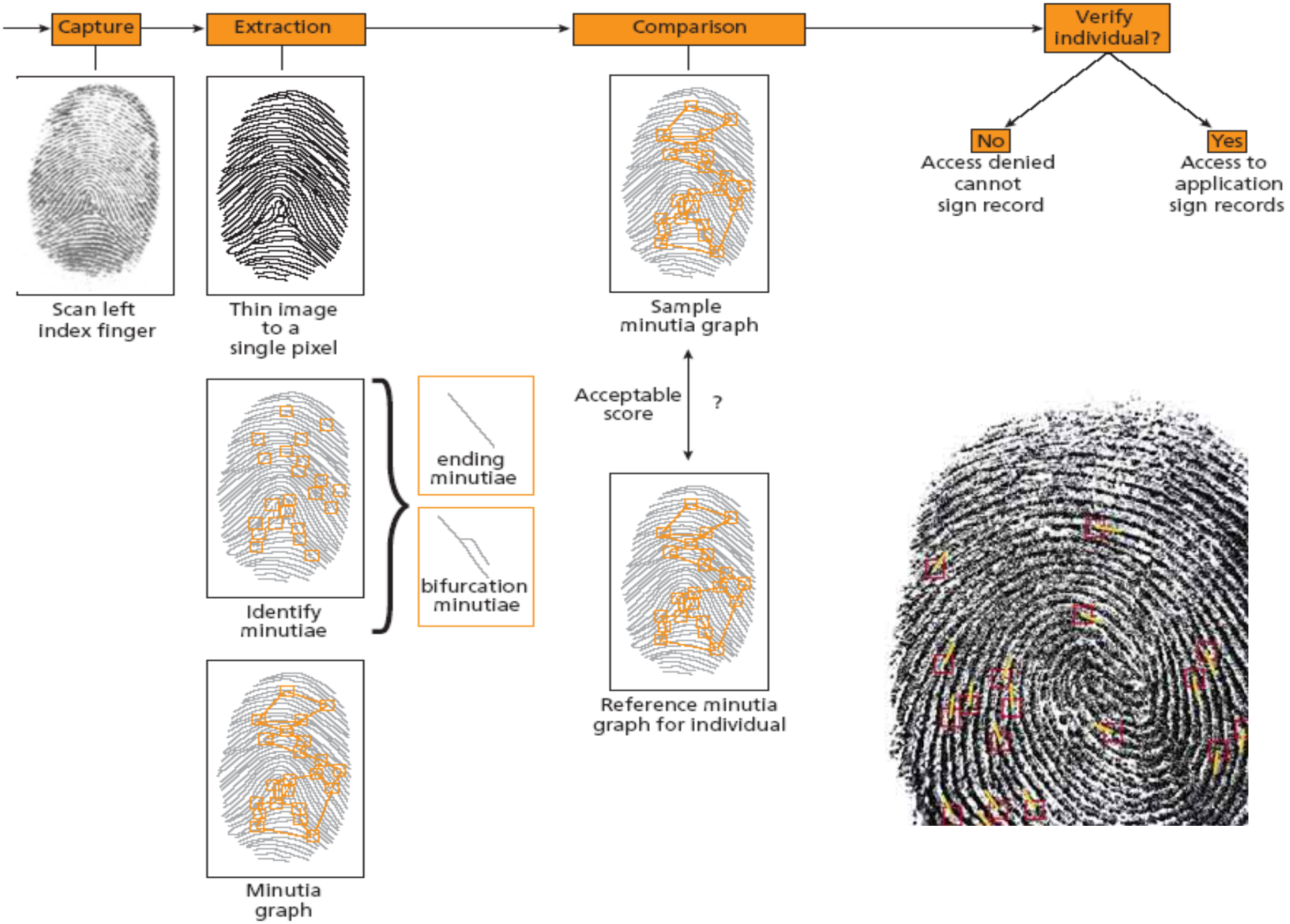
- Uses the ridge endings and bifurcation's on a persons finger to plot points known as Minutiae
- The number and locations of the minutiae vary from finger to finger in any particular person, and from person to person for any particular finger

•Finger Image

•Finger Image + Minutiae



•Minutiae


Capture
Extraction
Comparison
Verify individual?
No
Access denied cannot sign record
Yes
Access to application sign records
Scan left index finger
Thin image to a single pixel
Sample minutia graph
Acceptable score
?
ending minutiae
bifurcation minutiae
Identify minutiae
Reference minutia graph for individual
Minutia graph

2. Face Recognition (V. Franc)

- Uses an image or series of images either from a camera or photograph to recognize a person.
- Principle: analysis of the unique shape, pattern and positioning of facial features.

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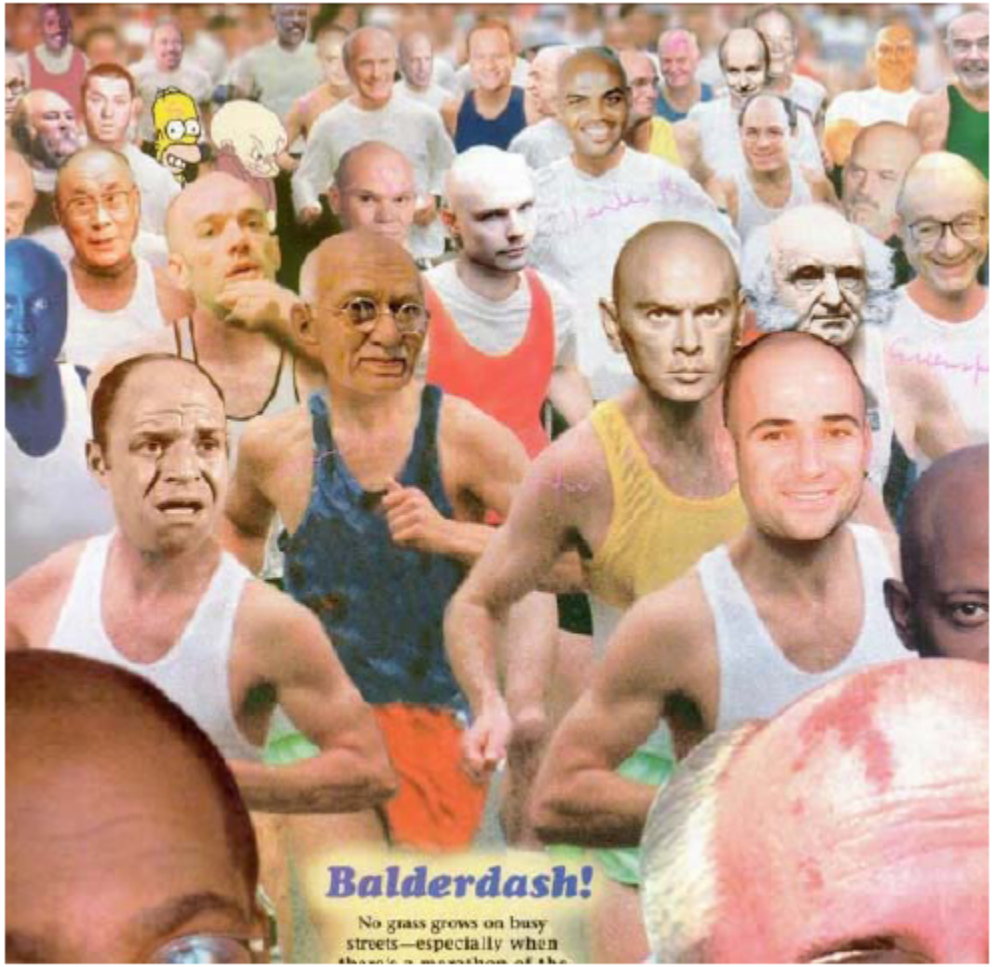
Who is there??



Games Magazine, September 2001

Why face?

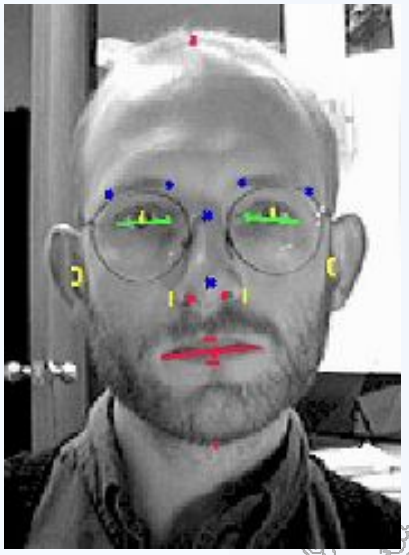
- Face is the most common biometric characteristic used by humans
- Sensing at a distance
- Easy to capture from low-cost cameras
- Non-contact data acquisition (free from contagious disease)

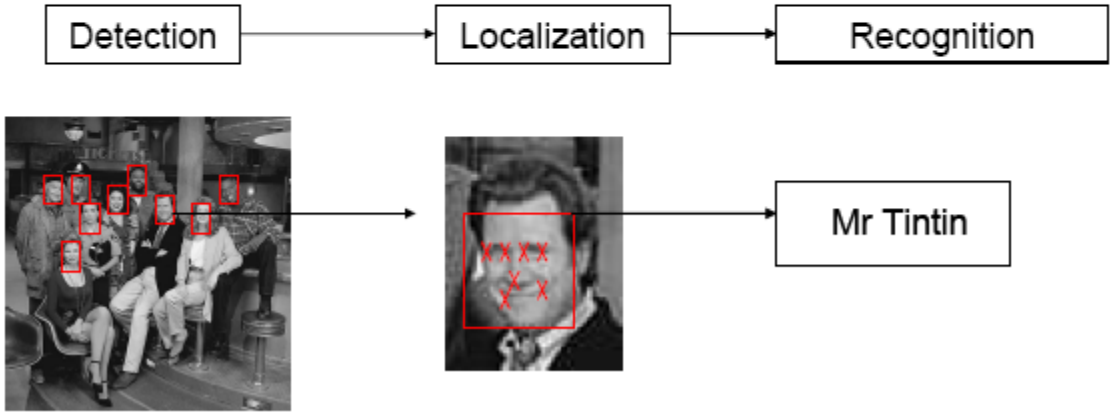
- Non-intrusive technique which people generally accept as biometric characteristic
- Overt (user aware) and covert (user unaware, e.g. ubiquitous surveillance cameras) applications
- Legacy databases (passport, visa and driver's license)

Details

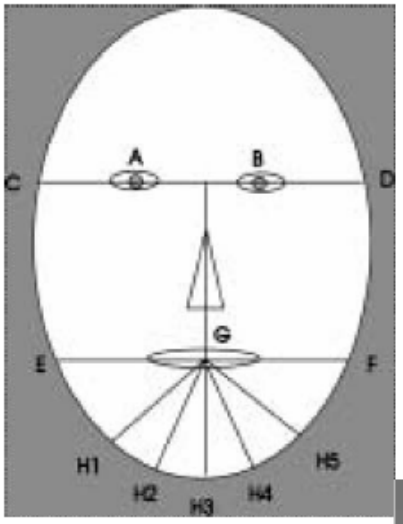
- Source of data: Single image, video sequence, 3D image and Near Infrared
- Models: weak models of the human face that model face shape in terms of facial texture

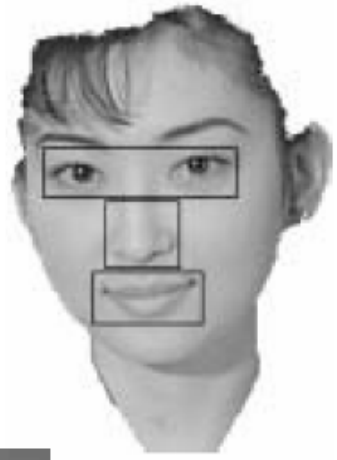
- **Face detection** – discriminating faces from all other possible images. This is 2-class classification task of assigning an image to the face class or the non-faces class.
- **Face localization** – finding precisely the position of one face, whose presence is already known in a single image

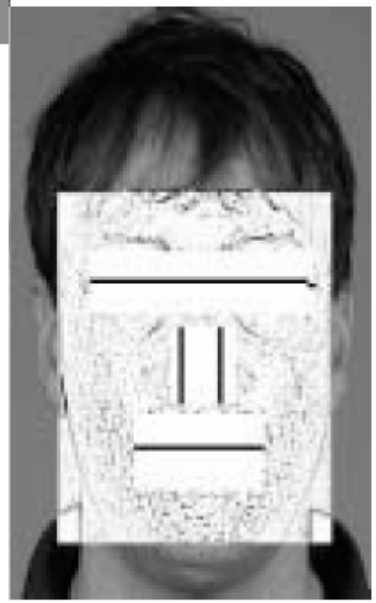


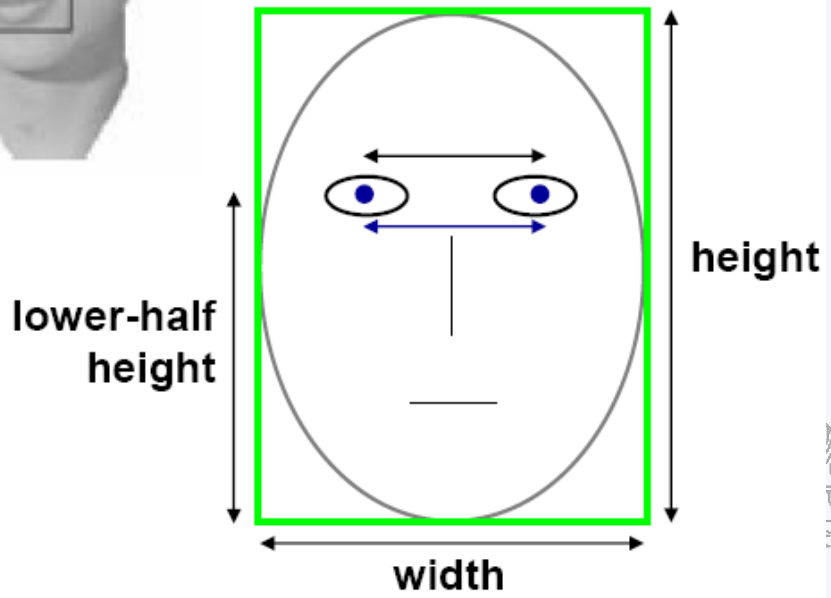


Feature based approach

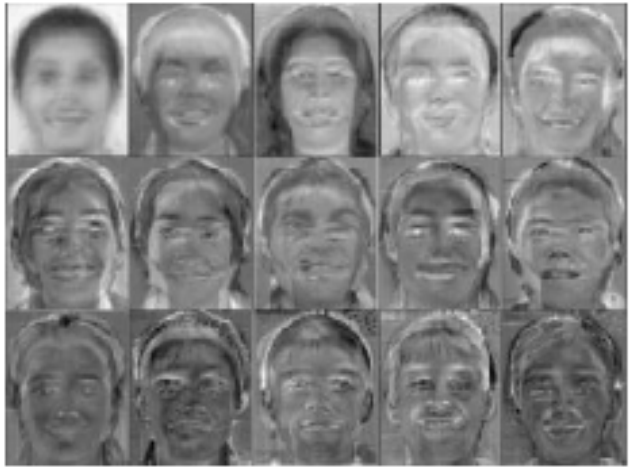








Example: Eigenfaces

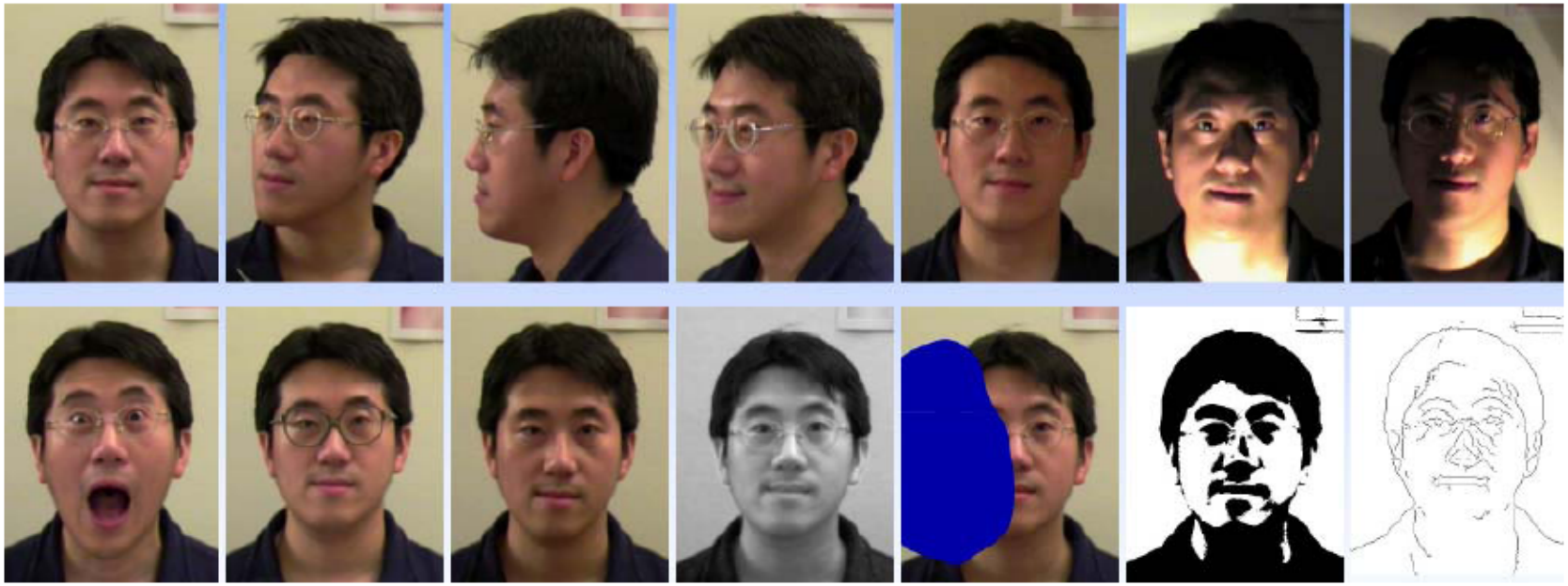


Perfect reconstruction with all eigenfaces

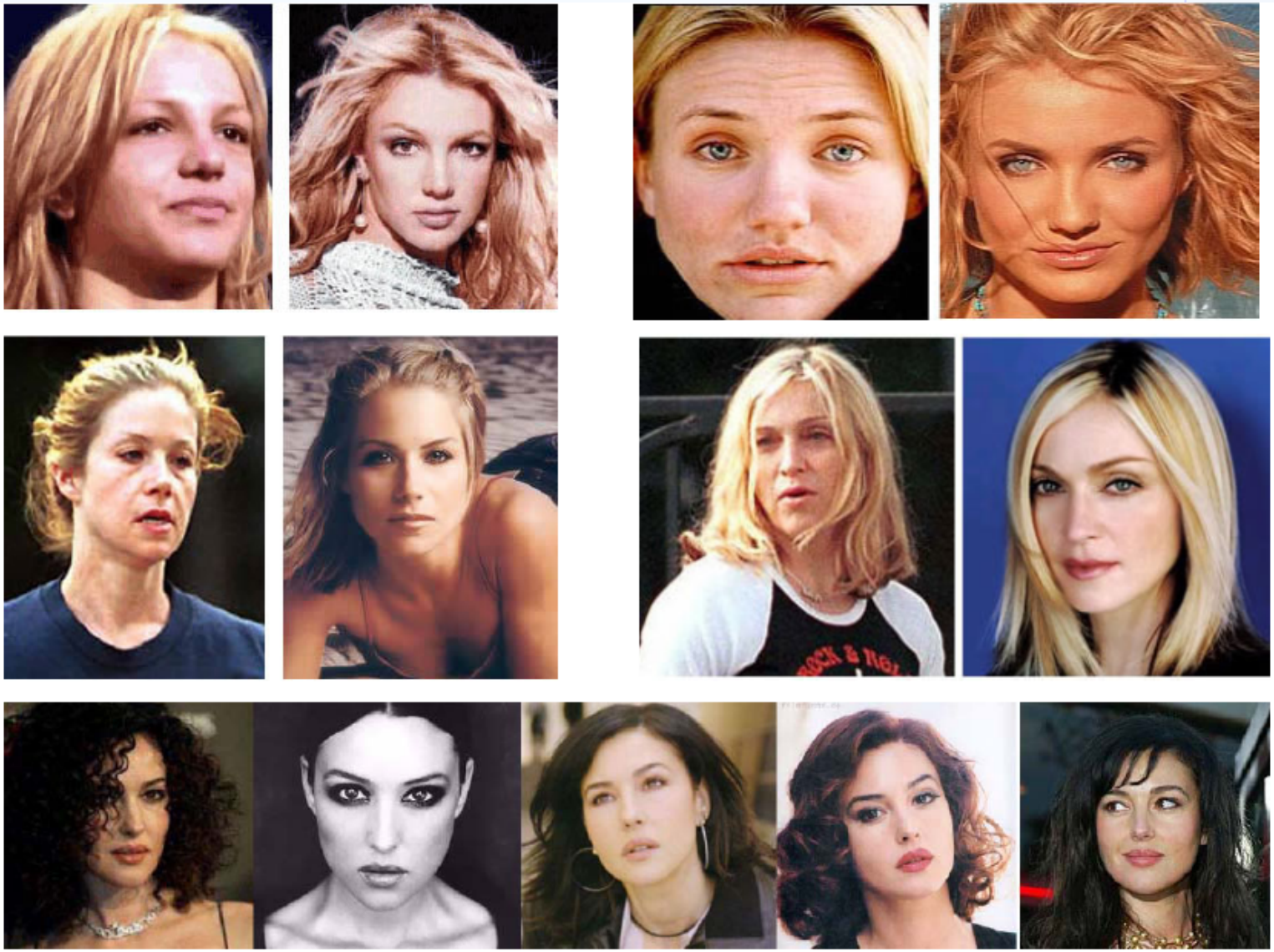
Reasonable reconstruction with just a few eigenfaces

Intra-class variability

- Faces with intra-subject variations in pose, illumination, expression, accessories, color, occlusions, and brightness

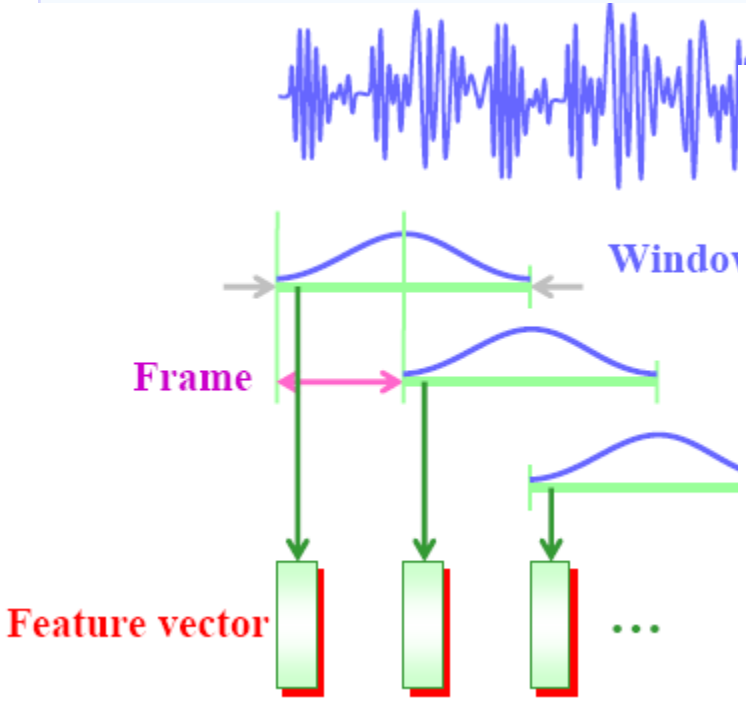


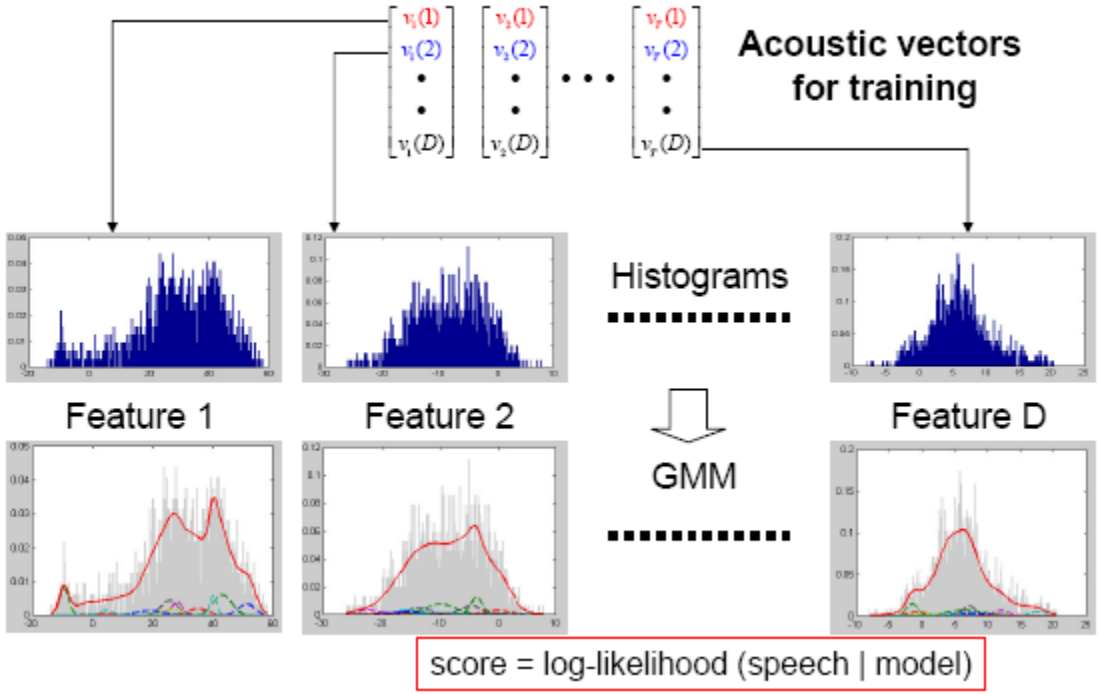
The power of make up



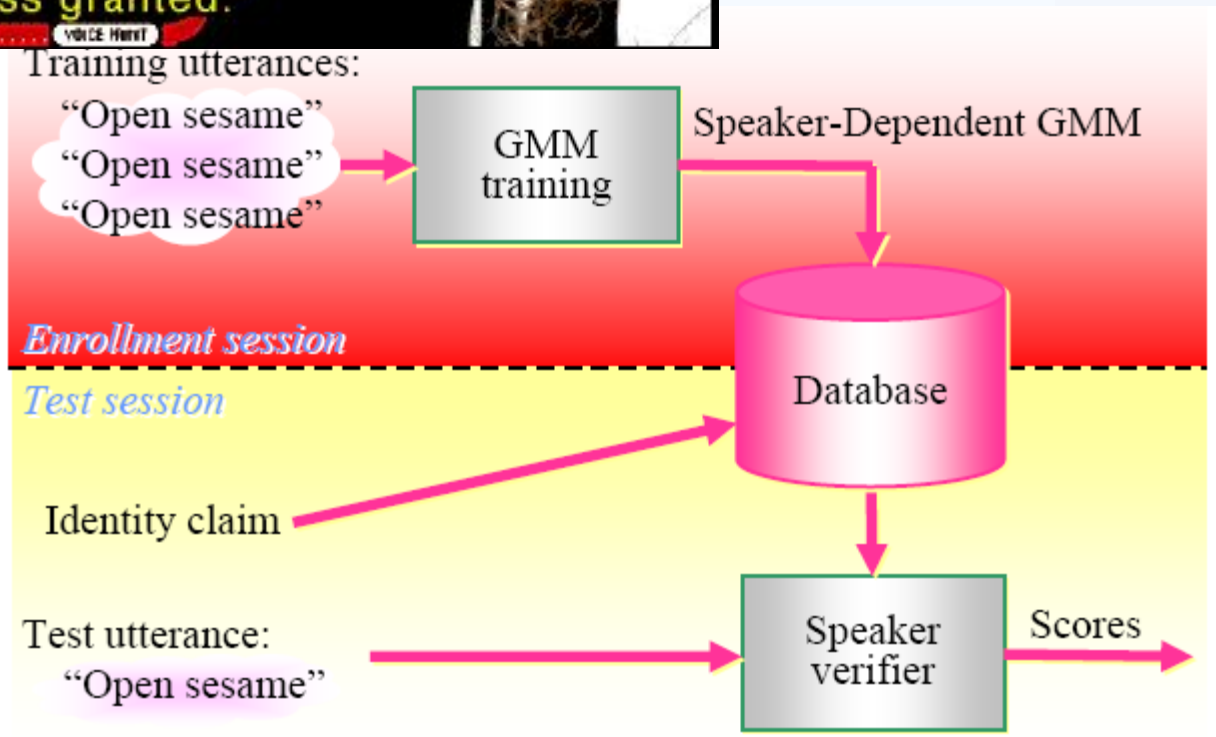
3. Voice Recognition (V. Hanzl)

- Voice recognition is not the same as speech recognition, it is speaker recognition
- Considered both physiological and behavioral
- Popular and low-cost, but less accurate and sometimes lengthy enrollment





Application categories



Features

- Advantage
  - Less requirements for users, such that they do not have to go through a separate process for verification
  - Very little hardware is required, and ideally suited to **telephone-based** system for a remote identification
  - **Zero client-side cost, no special reader needs to be installed**
- Disadvantage
  - Acoustic features : 1. Misspoken or misread phrases; 2. The human voice's tremendous variability, due to colds, aging, and simple tiredness
  - Can be captured surreptitiously by a third party and replayed

4. Iris recognition

- Analysis of the iris of the eye, which is the colored ring of tissue that surrounds the pupil of the eye.
- Based on visible features, i.e. rings, furrows, freckles and the corona. Features and their location are used to form the Iriscodes, which is the digital template.
- **Widely regarded as the most safe, accurate biometrics technology and capable of performing 1-to-many matches at extraordinarily high speeds, without sacrificing accuracy**.
- VIDEO: http://www.youtube.com/watch?v=QEQEht8zloQ

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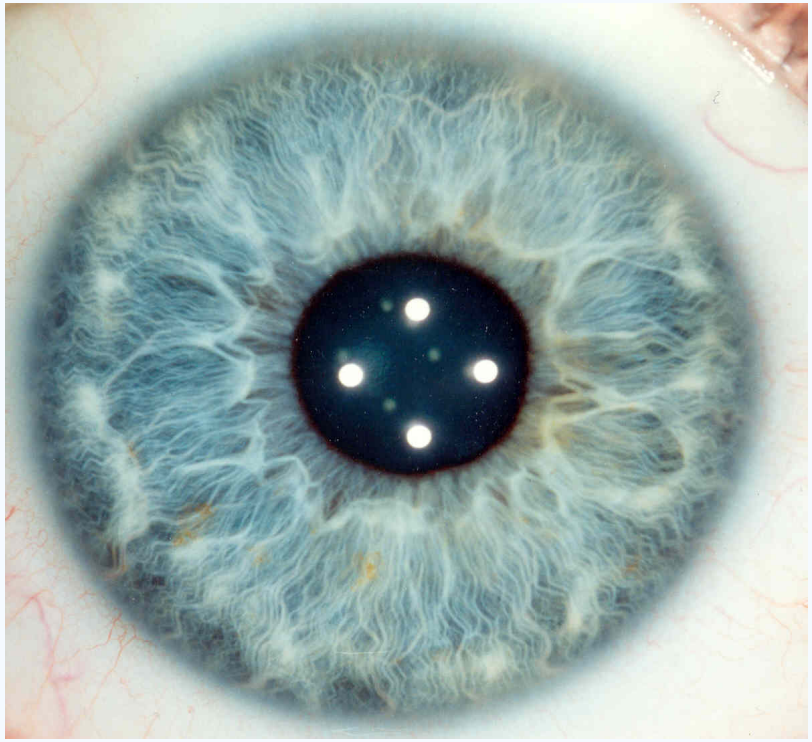
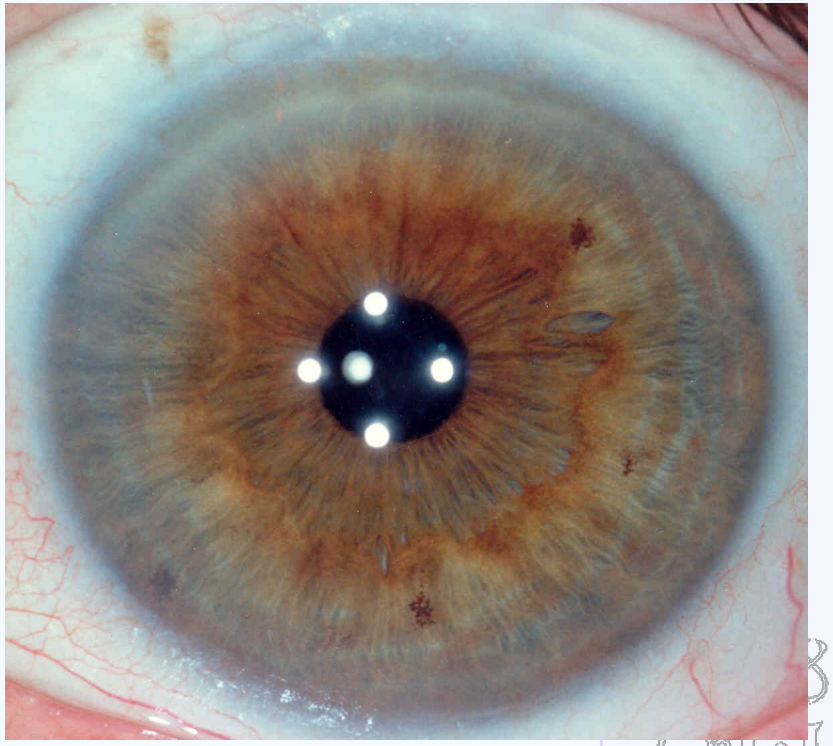
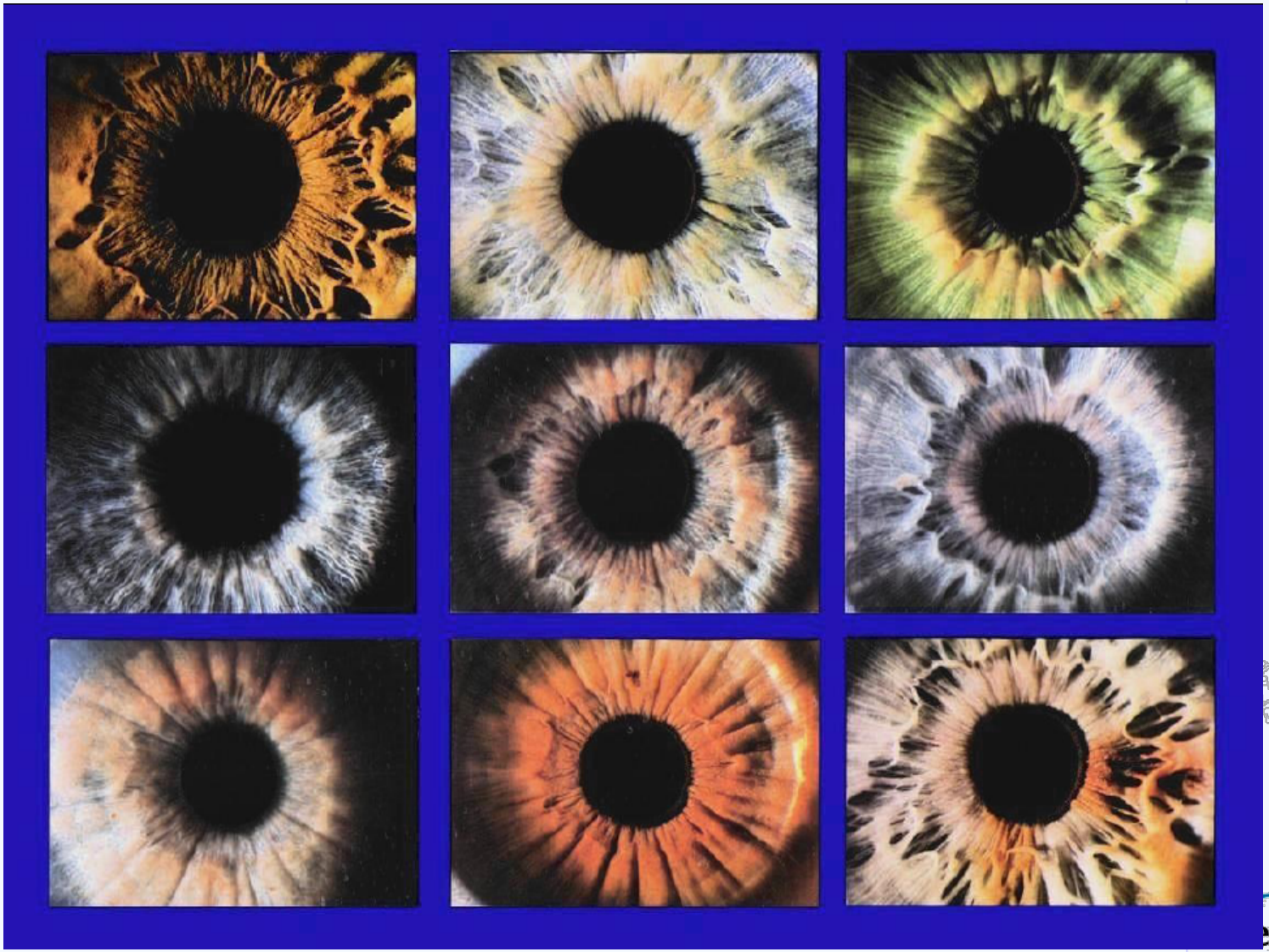
Example Iris Images

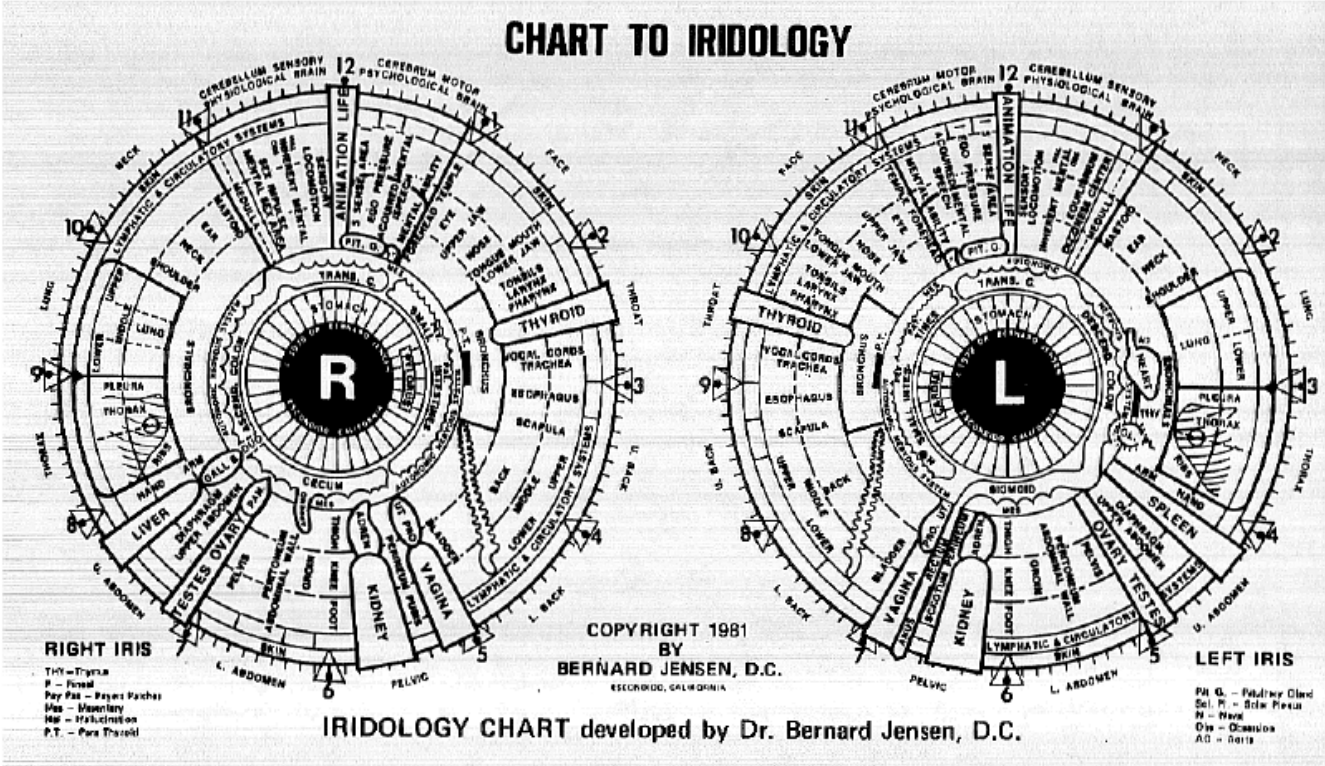




IRISES

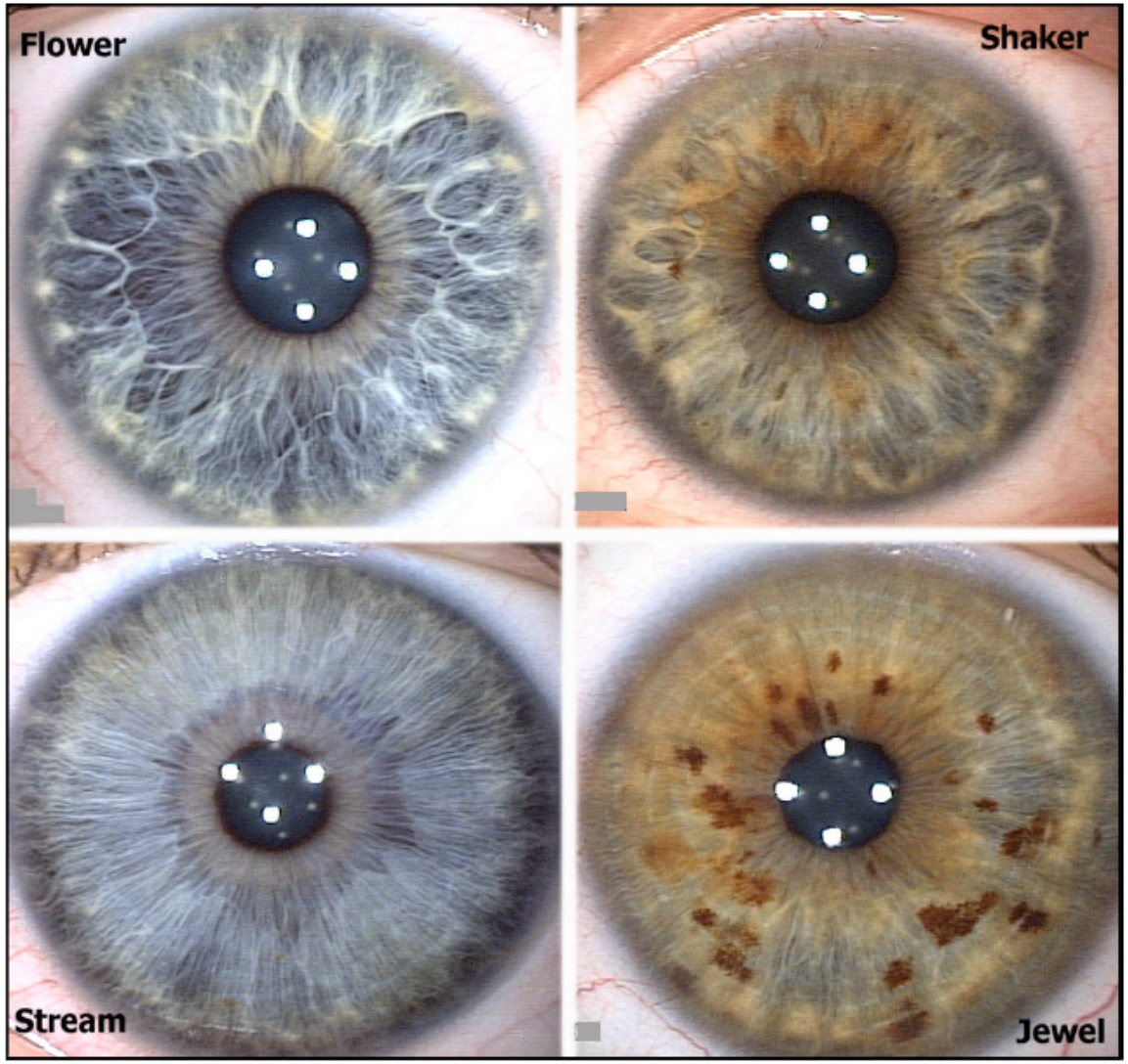


Iridology



"Throughout the ages, the eyes have been known as the windows to the soul, and modern behavioral research is proving this adage to be true. If you look closely at the iris of the eye, you will notice small, dark dots, light streaks or rounded openings in the fibers. These characteristics provide the key to unlocking the mysteries of the personality" (Rayid International).

Iridology



Iris code

Iris Code

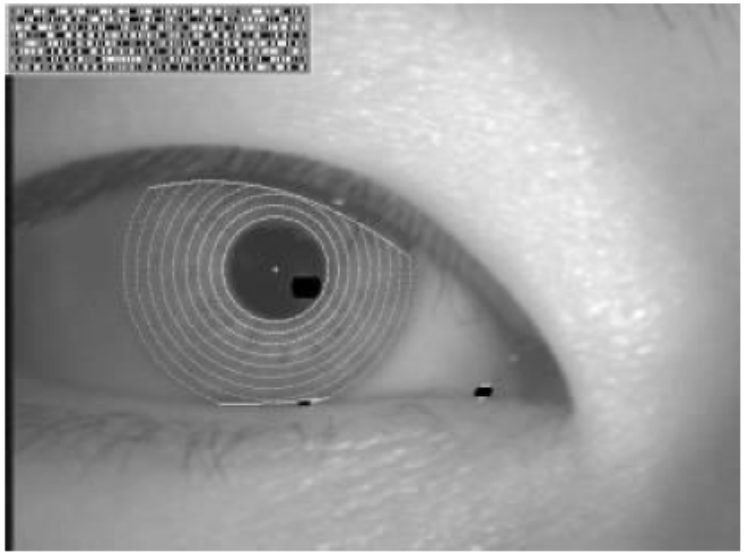
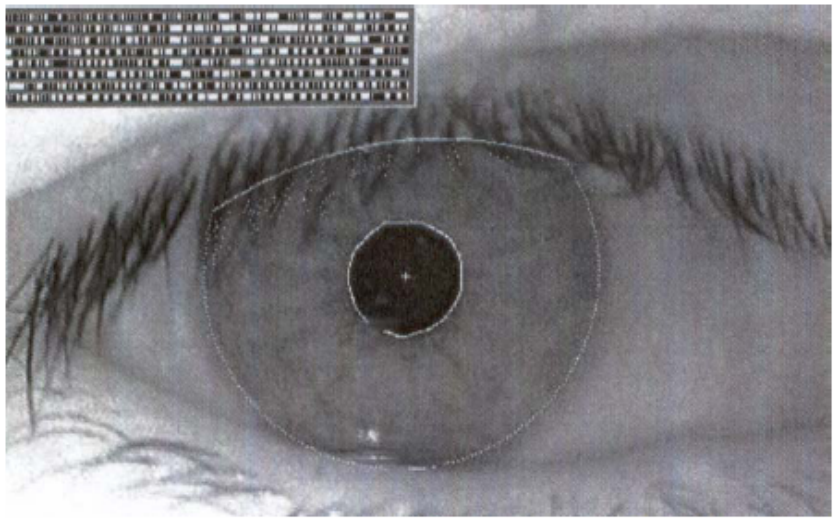
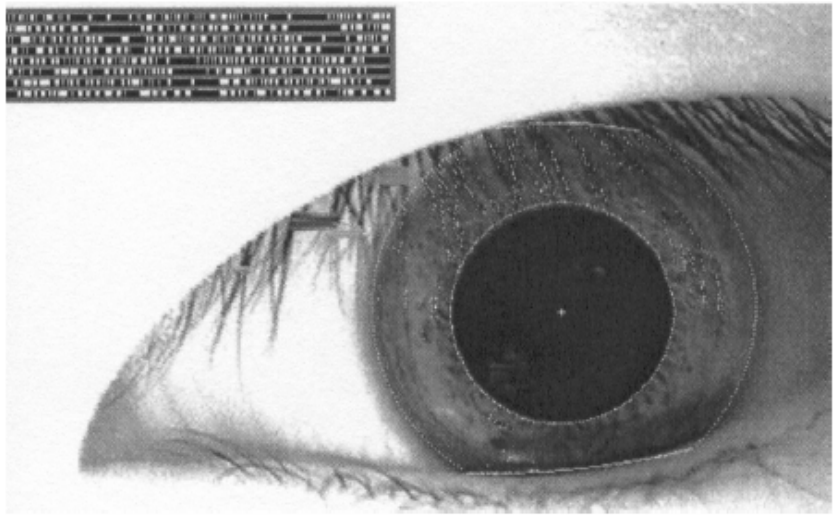
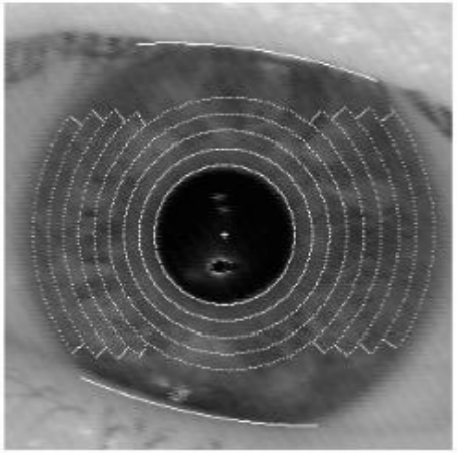


Image size is 64 x 256 bytes and the iris code is 8 x 32 bytes

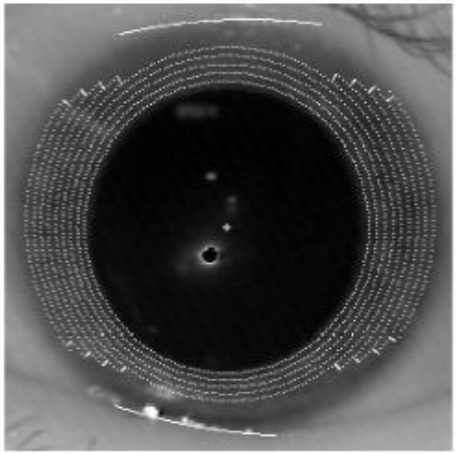
Iris mapping







Dilatation normale



Dilatation élevée

- The iris mapping has to be invariant to shift, distance, magnification, and pupillary dilation

5. Hand geometry

- Hand geometry systems are commonly available in two main forms. Full hand geometry systems take an image of the entire hand for comparison while Two Finger readers only image two fingers of the hand.
- Hand recognition technology is currently one of the most deployed biometrics disciplines world wide

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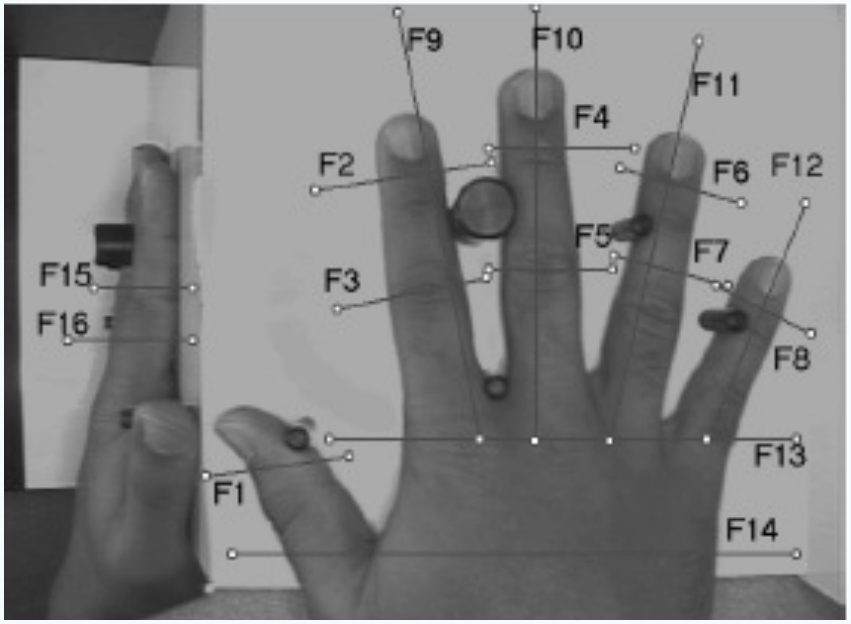
How does it work

- A camera capture an image of the hand, with the help of a mirror to get also the edge. The silhouette of the hand is extracted, and some geometrical characteristics stored.



$$\sum_{j=1}^{d} | y_j - f_j | < \epsilon_a, \quad (1)$$

$$\sum_{j=1}^{d} \frac{| y_j - f_j |}{\sigma_j} < \epsilon_{wa}, \quad (2)$$

$$\sqrt{\sum_{j=1}^{d} (y_j - f_j)^2} < \epsilon_e, and \quad (3)$$

$$\sqrt{\sum_{j=1}^{d} \frac{(y_j - f_j)^2}{\sigma_j^2}} < \epsilon_{we}, \quad (4)$$

where σ_j^2 is the feature variance of the jth feature and ϵ_a, ϵ_{wa}, ϵ_e, and ϵ_{we} are threshold values for each respective distance metric.

•(See Jain et al. A Prototype Hand Geometry-based Verification System)

Applications

BenGurion Airport – Tel-Aviv,
Hand Geometry

JFK International Airport

1998

INSPASS - Hand Geometry

6. Signature Verification

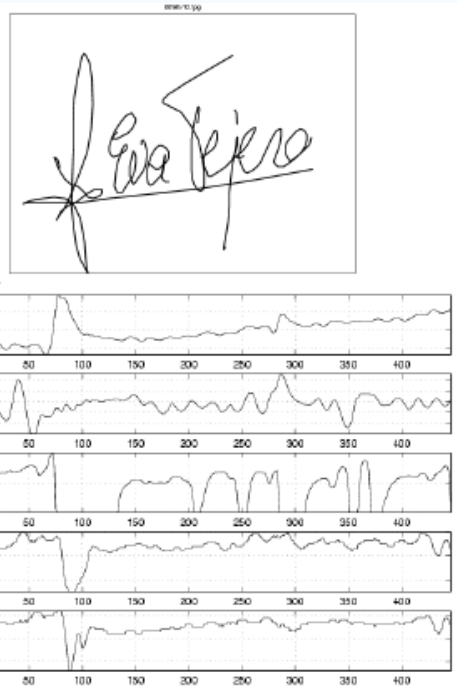
- Static/Off-line: the conventional way
- Dynamic/On-line: using electronically instrumented device

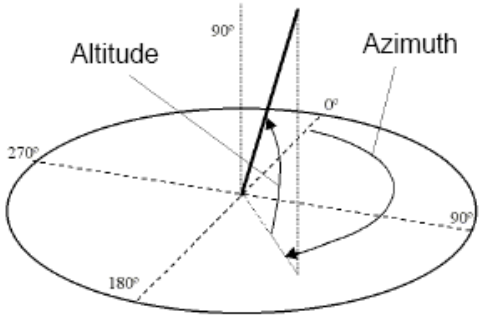
- Principle: the movement of the pen during the signing process rather than the static image of the signature.
- Many aspects of the signature in motion can be studied, such as pen pressure, the sound the pen makes

Static off-line technology – document authentication

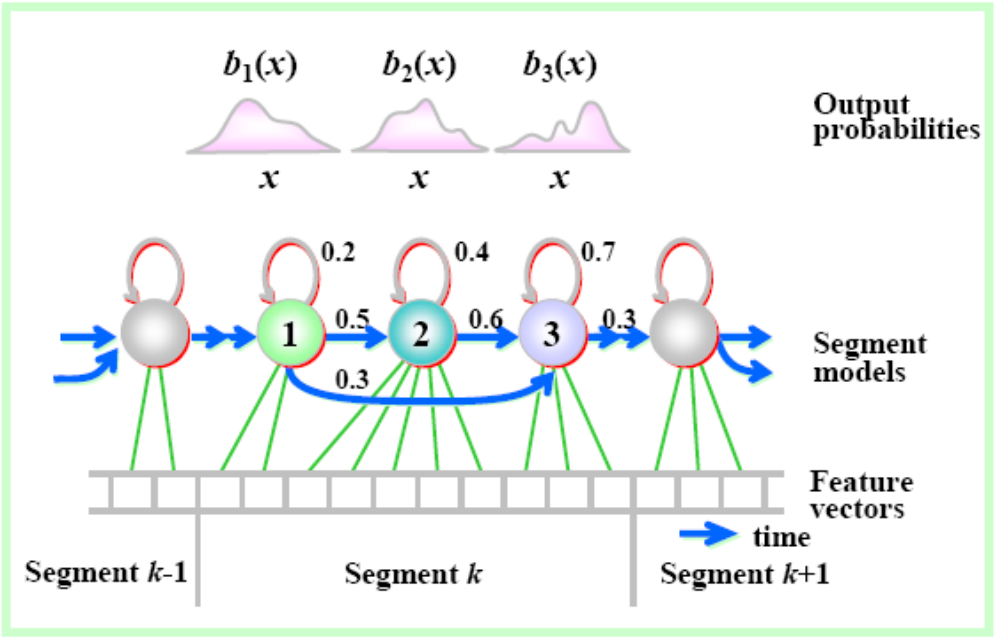
Dynamic on-line technology – signal processing and pattern recognition

Dynamic signature

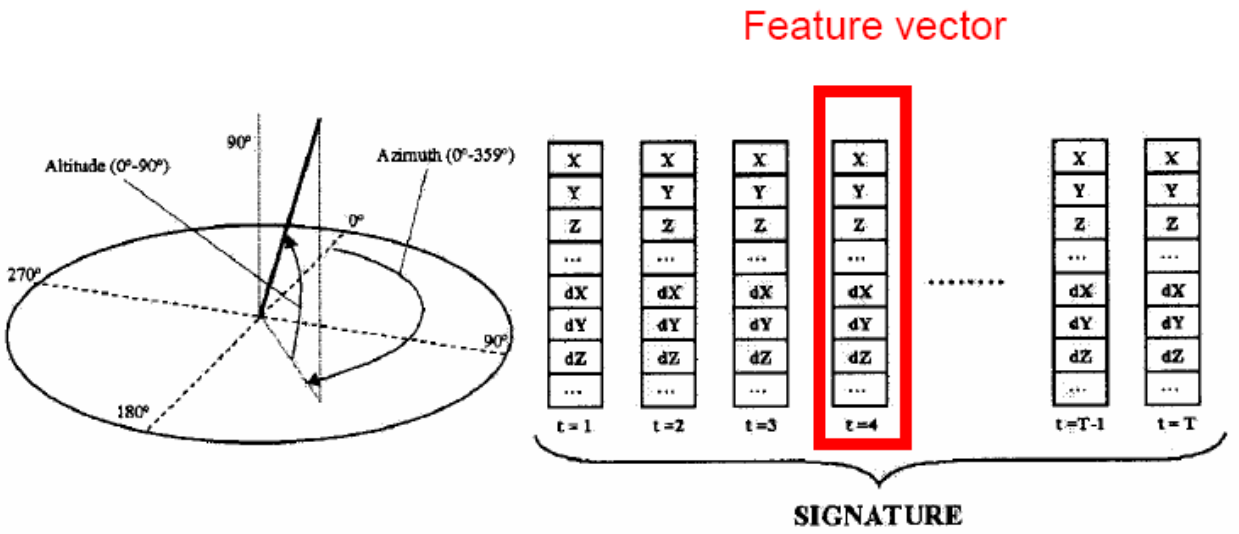




Features:
1. coordinate X
2. coordinate Y
3. pressure
4. pen azimuth (0° - 359°)
5. pen altitude (0° - 90°)



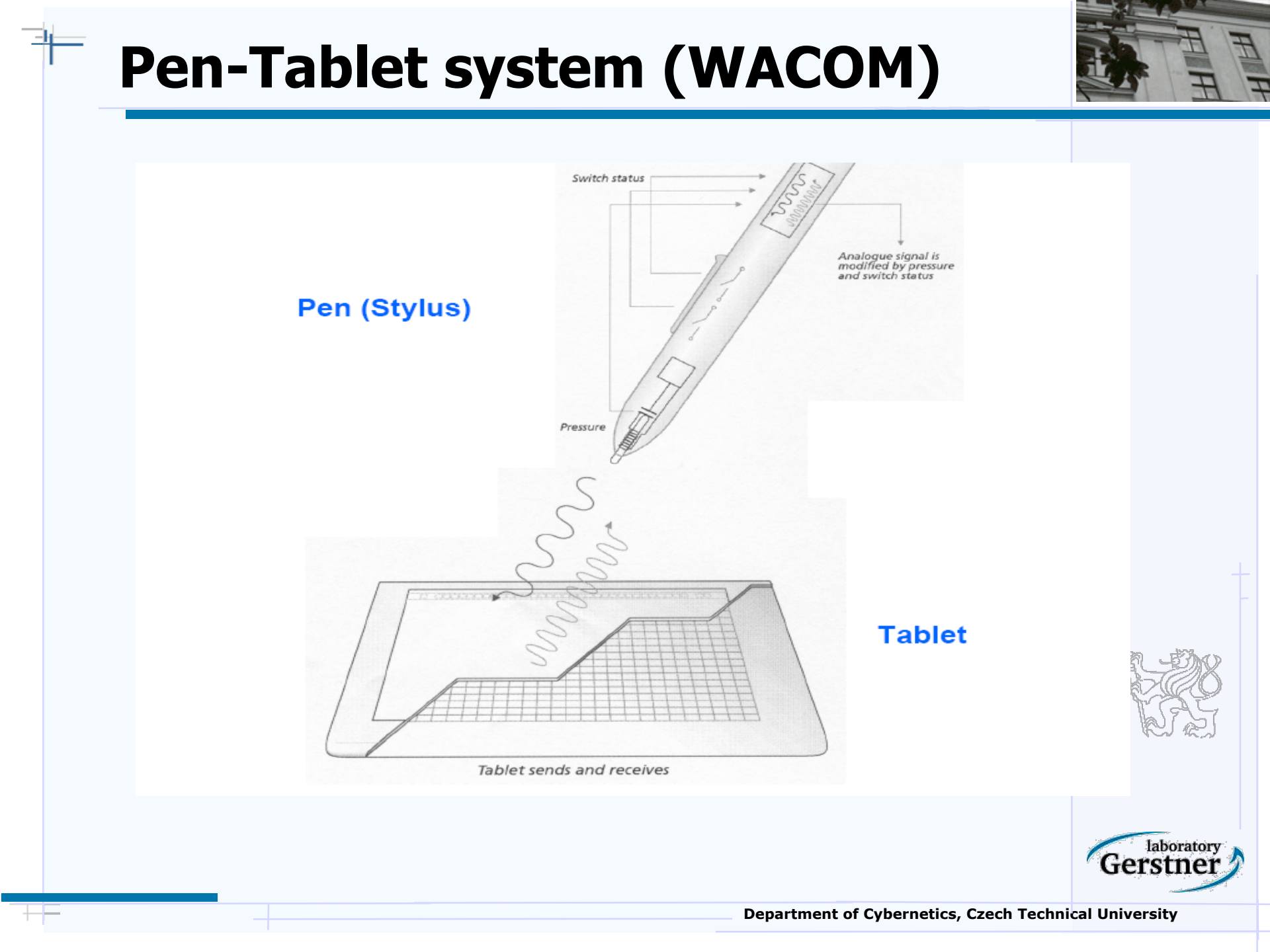
Dynamic signature



Acquisition:

-acquisition area: 127·106 mm
-pressure levels: 1024
-resolution: 2540 lines/inch (100 lines/mm)
-precision: +/- 0.25 mm
-detection height: 10 mm
-sampling frequency: 100 pps (points per s)

Pen-Tablet system (WACOM)



Pen (Stylus)

Tablet

WACOM – How it works?

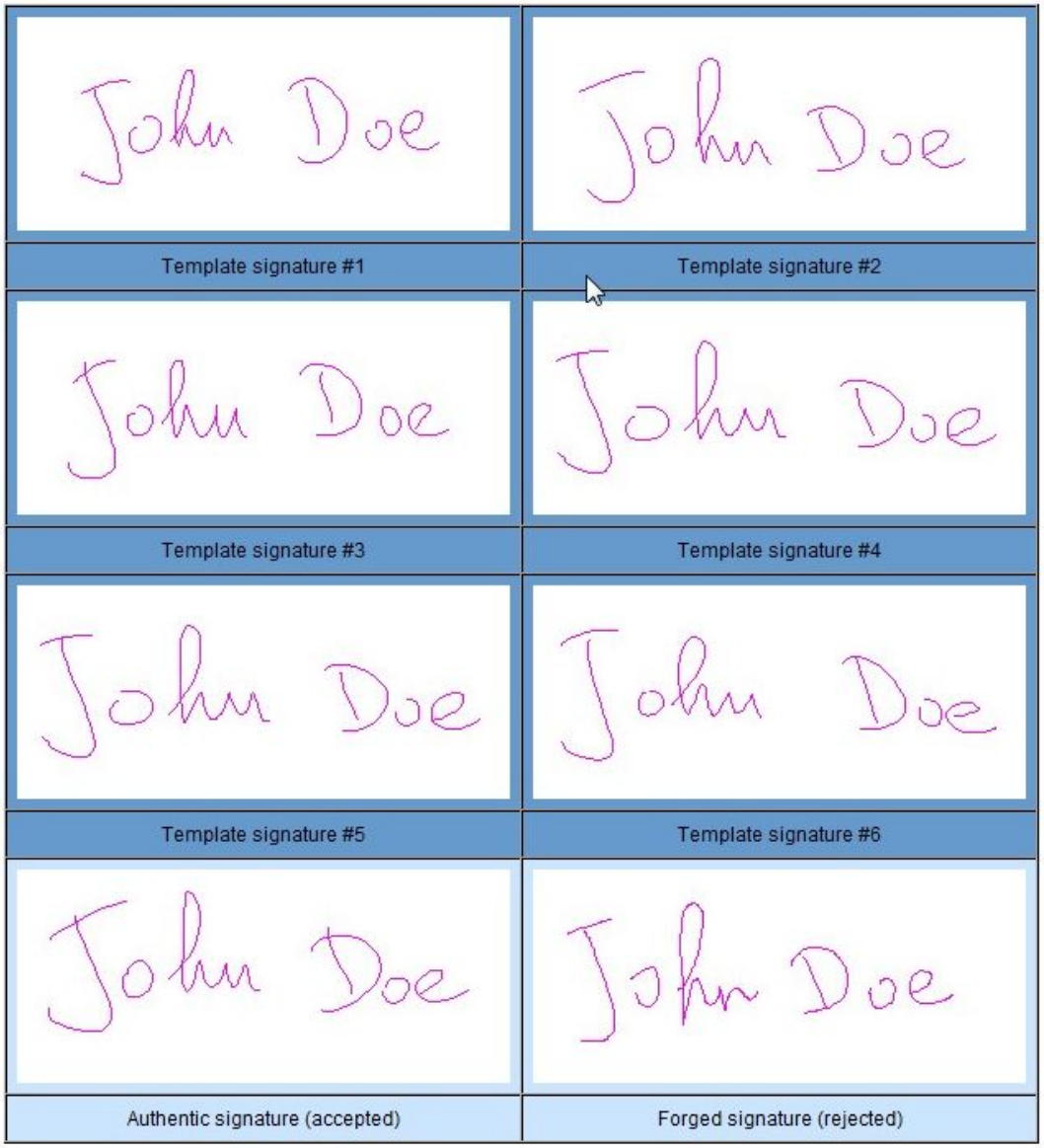
- The WACOM stylus looks and feels like a pen yet contains no batteries or magnets. Instead it takes advantage of electro-magnetic resonance technology in which radio waves are sent to the stylus and returned for position analysis.
- In operation, a grid of wires below the screen alternates between transmit and receive modes (about every 20 μs):
  - In **transmit mode**, the electro-magnetic signal stimulates oscillation in the coil-and capacitor resonant circuit in the pen
  - In **receive mode**, the energy of the resonant circuit oscillation in the pen is detected by the antenna grid. This is then analysed to determine position and other information including pressure
- Since the grid provides the power to the pen through resonant coupling, no batteries are required. Thus there are no consumables that will run down and need to be replaced or that would make the pen top-heavy.

Dynamic signature: companies

- On-line:
  - SOFTPRO (http://www.signplus.com/)
  - CYBERSIGN (http://www.cybersign.com/)
  - CIC (http://www.cic.com/)
- Off-line:
  - APP-DAVOS (http://www.app-davos.ch/)
  - NUMEDIA (http://www.sapura.com.my/NuMedia/check.htm)

IBM online verification

IBM online signature verification



Biometrics in Early Stages

DNA	Retina recognition	Thermograms
Gait	Keystroke	Ear recognition
Skin reflection	Lip motion	Body odor

I. DNA

- DNA has been called the “ultimate identifier”
- Identify information from every cell in the body in a digital form
- Not yet fully automated, not fast and expensive
- Theoretical limitation: Identical twins have the same DNA
- Privacy issue – DNA contains information about race, paternity, and medical conditions for certain disease

Comparison Chart: DNA

DNA	Conventional Biometrics
Requires an actual physical sample	Uses an impression, image, or recording
Not done in real-time; not all stages of comparison are automated	Done in real-time; “lights-out” automated process
Does a comparison of actual samples	Uses templates or feature extraction

II. Retina recognition

- The pattern of blood vessels that emanate from the optic nerve and disperse throughout the retina depends on individuals and never changes.
- **No two retinas are the same, even in identical twins.**
- Commercial products: Retinal Technologies

III. Thermograms

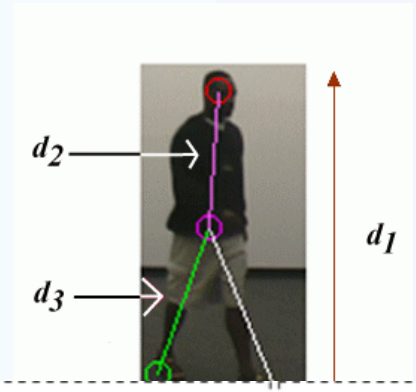
- Thermograms requires an infrared camera to detect the heat patterns of parts of the body that are unique to every human being (such as the face)

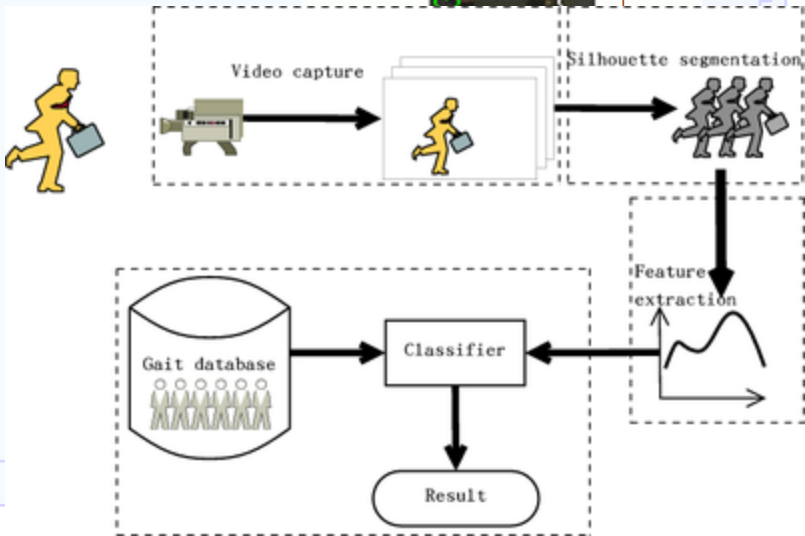
- Normally expensive because of the sensors

- Useful paper:
  Illumination Invariant Face Recognition Using Thermal Infrared Imagery (Solikinski & als)

IV. Gait

- The final objective: to recognize persons using standard cameras in any conditions.
- Gait recognition is particularly studied as it may enable identification at distance.
- Gait video





Češi vyhráli policejní olympiádu

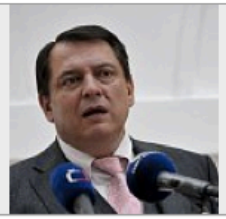
HNED.cz

ŠNÍ HN | FOTO & VIDEO | DATAROOM | KULTURNÍ TIPY | TV PROGRAM | POČASÍ | NAŠE TITULY

Vyhledat... Google

NED.cz HNZPRÁVY HNBYZNYS HNLIFE HNTECH HNSPORT HNDIALOG

OLITIKA ČESKO SVĚT LEHKÉ ZPRÁVY ON-LINE ROZHOVORY ZPRÁVY A-Z



Paroubek by mohl být šéfem ČSNS 28. října

Sněmovna: volba prezidenta i exekuce

10 nejznámějších korupčních kauz

Pospíš vysvětl Rampu odvolá

24. 9. 2010 | poslední aktualizace: 24. 9. 2010 19:34

0 +1 velikost písma

Čeští kriminalisté získali největší úspěch v historii. Za to, jak čtou chůzi

Dynamiku pohybu má každý člověk unikátní, podobně jako otisky prstů.

Čtěte více o: kriminalistika | policie

Zuzana Keményová
redaktor

REKLAMA

Hlásíme plně naloženo.

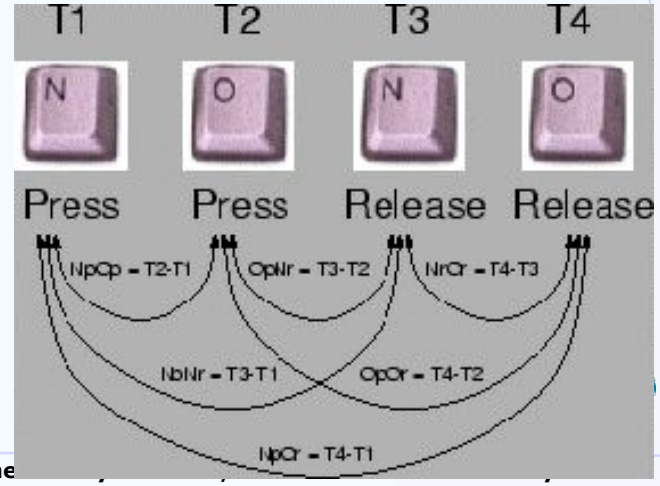
S tarifem Podnikatel Plus 1100 získát

- ✓ volání ve firmě zdarma
- ✓ volání do sousedních zemí za cenu jako v ČR
- ✓ nejrychlejší 3G internet

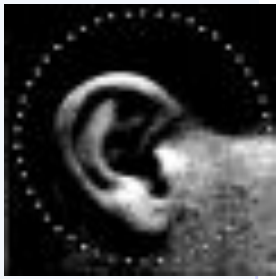
oratory Gerstner

V. Keystroke

- The rhythms with which one types at a keyboard are sufficiently distinctive to form the basis of the biometric technology known as keystroke dynamics
- 100% software-based, requiring no sensor more sophisticated than a home computer
- VIDEO



VI. Ear recognition



- Ear geometry recognition uses the shape of the ear to perform identification
- Suggestions have been made that the shapes and characteristics of the human ear are widely different
- **An infrared image can be used to eliminate hair**
- Might be recognized at a distance

Example

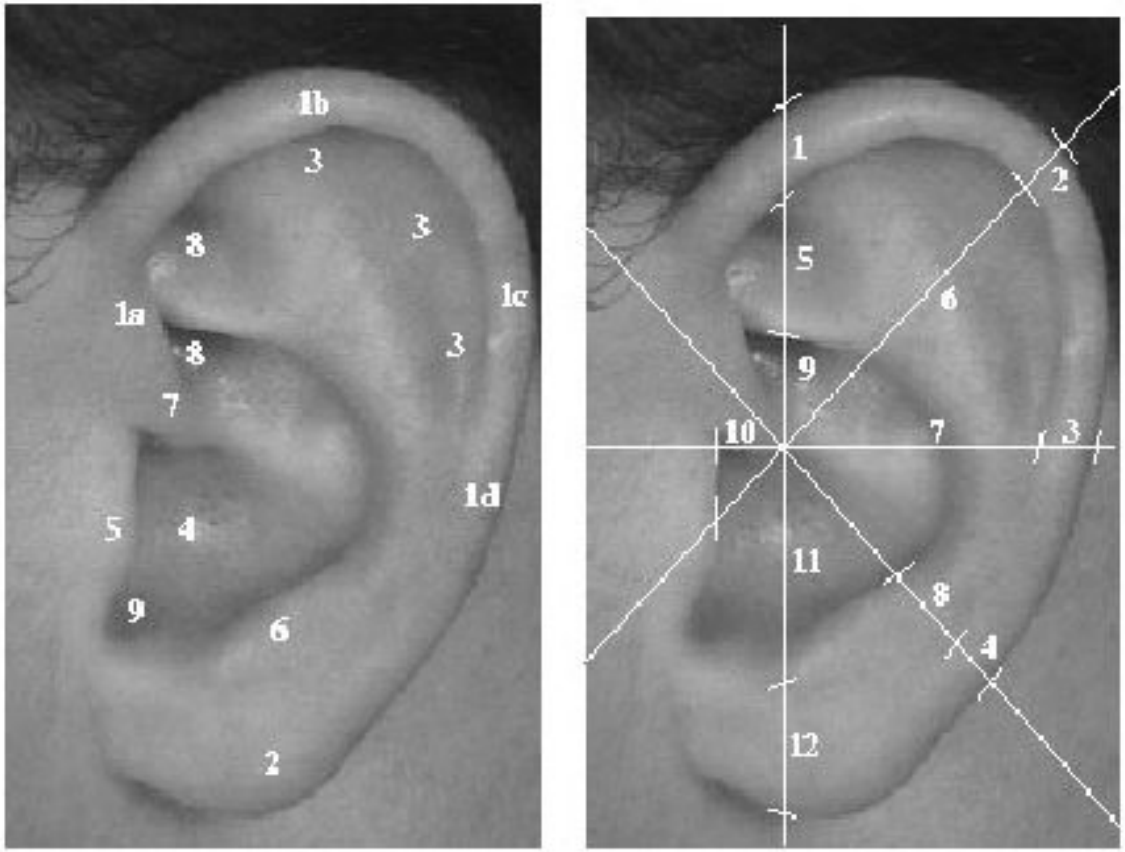
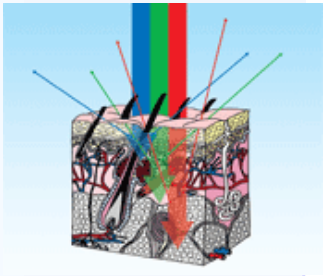


Fig. 2. (a) Anatomy, (b) Measurements. (a) 1 Helix Rim, 2 Lobule, 3 Antihelix, 4 Concha, 5 Tragus, 6 Antitragus, 7 Crus of Helix, 8 Triangular Fossa, 9 Incisure Intertragica. (b) The locations of the anthropometric measurements used in the "Iannarelli System". (Burge et al., 1998)

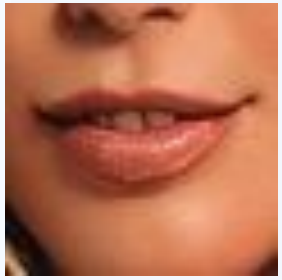
VII. Skin reflection

- Lumidigm Inc. has established that the absorption spectrum of the skin depends on the individuals.



- In a range of wavelengths over 6mm patch, several LEDs send light into the skin, and photodiodes read the scattered light, which is analyzed to perform the authentication.

VIII. Lip motion

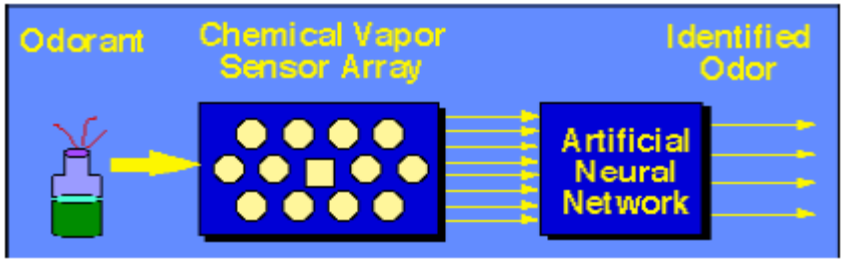


- Compares the characteristic lip motions of people while they speak.
- **Helps identification associated with speaker recognition**.
- Different imaging conditions: Infrared (high security & cost) and Near Infrared (cheap, normally used for active sensing)

IX. Body odor

It's absolutely clear that people with differing immunity genes produce different body odors

Electronic/artificial noses: developed as a system for the automated detection and classification of odors, vapors, gases.

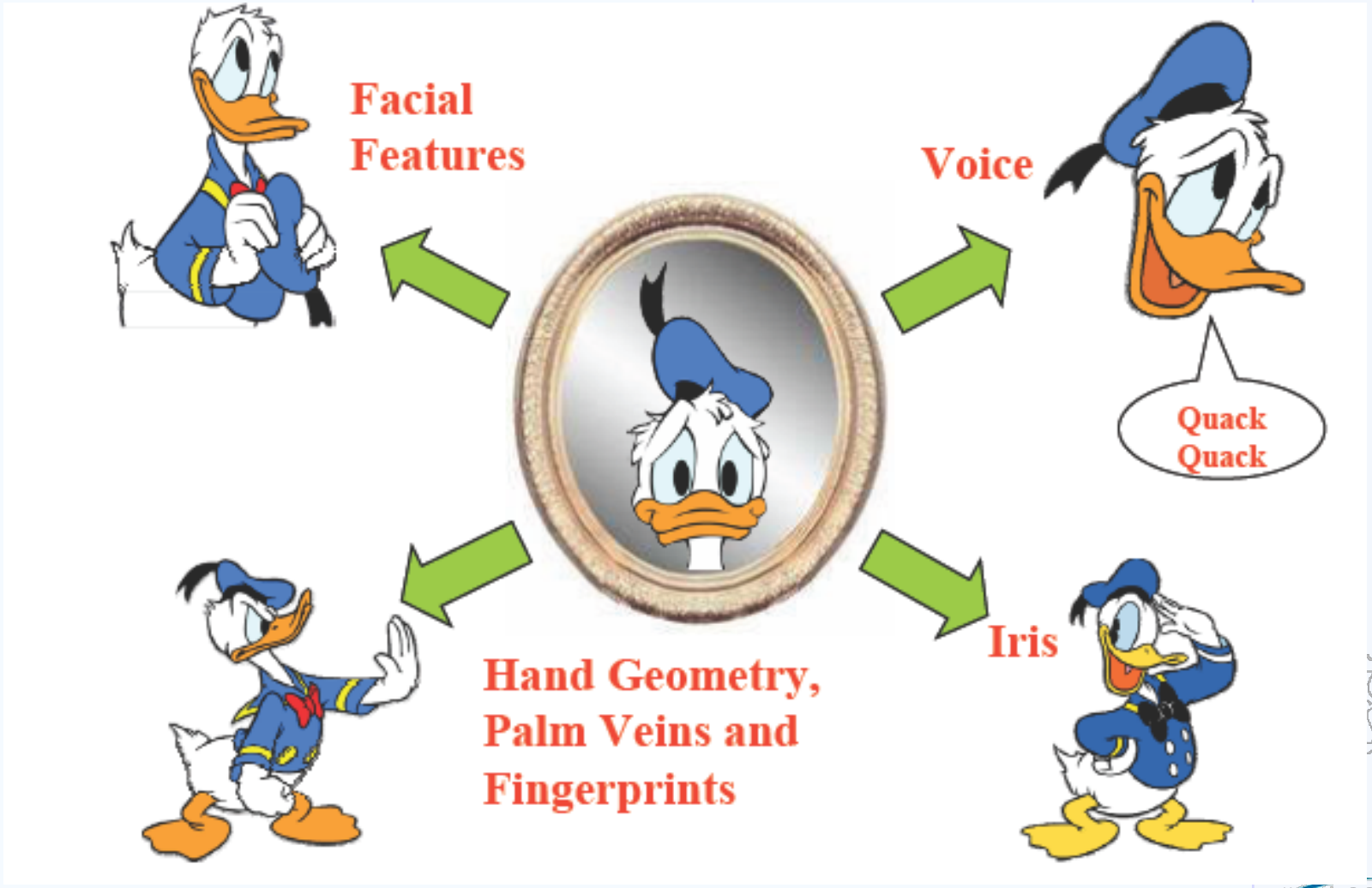


Schematic Diagram of Artificial nose

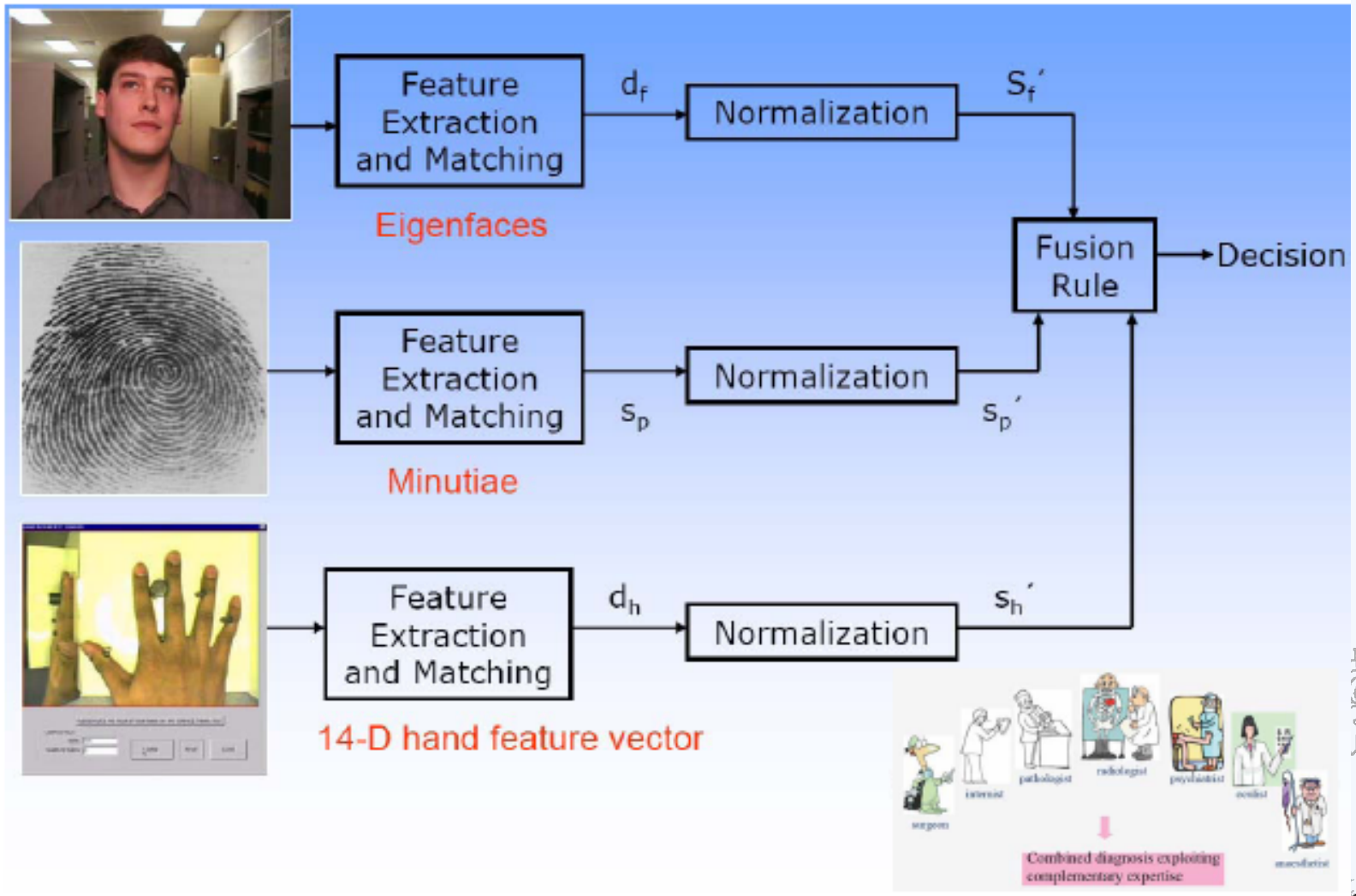
- Prometheus (Alpha Mos) ,
- an example of electronic nose

Artificial noses are not yet sophisticated enough to do all the job

Multimodal Biometrics



Fusion after normalization



Comparision of Biometric Technologies

Characteristic	Fingerprints	Hand Geometry	Retina	Iris	Face	Signature	Voice
Ease of Use	High	High	Low	Medium	Medium	High	High
Error Incidence	Dryness, dirt, age	Hand injury, age	Glasses	Lighting	Lighting, age, glasses, hair	Changing signatures	Noise, colds
Accuracy	High	High	Very High	Very High	High	High	High
User Acceptance	Medium	Medium	Medium	Medium	Medium	High	High
Long-Term Stability	High	Medium	High	High	Medium	Medium	Medium

Possible Future Events

Why news about iris recognition triggered an alien invasion