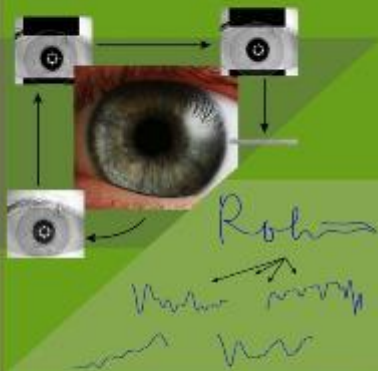


Nový předmět katedry kybernetiky, FEL ČVUT

BIOMETRIE (A6M33BIO)



Předmět je zaměřen na výklad nepoužívanějších metod v biometrii. Sami si naimplementujete dynamické rozpoznávání podpisu, detekce vlastního otisku prstu či duhovky!

Disponujeme profesionálním vybavením, pracujeme v Matlabu s předpřipravenými skripty, neztrácíte zbytečně čas na cvičeních. Soustředíme se na bezpečnostní rizika biometrických systémů. Pro každý biometrický systém je provedeno vyhodnocení z hlediska rychlosti, ceny a přesnosti.

Předmět doporučujeme zejména studentům oborů Otevřená informatika, Kybernetika a robotika a Biomedicínská informatika & inženýrství.

? Jak funguje snímač otisku prstů?

? Proč se neujalo rozpoznávání hlasu?

? Lze jednoduše prolomit biometrický systém?

? Proč je detekce duhovky nejpřesnější metodou?



! www.predmet-biometrie.cz

Kontakt:
Ing. Daniel Novák, Ph.D.
Katedra kybernetiky, ČVUT FEL
Technická 2, 166 27 Praha 6
Tel.: 22435 7314
xnovako1@fel.cvut.cz

Biometrics Introduction

**Daniel Novák
(+ Eduard Bakštein)**

24.9. 2013, Prague

**Acknowledgments:
Chang Jia, [Andrzej Drygajlo](#)**



Outline



1. About the course
 - course logistics, contacts, syllabus, conditions
2. Biometrics: general introduction
 - Short history, what is biometrics
3. Basic statistical concepts in biometrics
 - Hypothesis testing, Type I and II error, FAR, FRR
4. Overview of biometric techniques
 - Fingerprint, signature, iris, face, pace...





1 – ABOUT THE COURSE





Podmínky předmětu

- Garant předmětu: Daniel Novák, místnost E116, 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 (celkem 40)
- 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



Program přednášek



1. Úvod
- 2.-3. Dynamický podpis v biometrii – Jakub Schneider
- 4.-5. Duhovka (iris) – Eduard Bakštein
- 6.-7. Otisk prstu
- 8.-9. Tváře – Vojtěch Franc
- 10.-11. Řeč – Petr Pollák
12. Klasifikace a indexování v biometrických systémech
13. Závěrečný test, udělení klas. zápočtu





Program cvičení

- Členění do 3 bloků (+ úvod)
- 3 úlohy: práce na cvičení, popř. doma dokončit

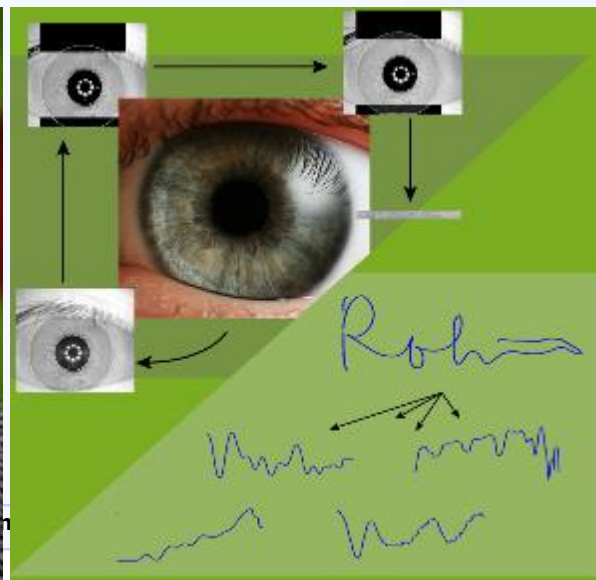
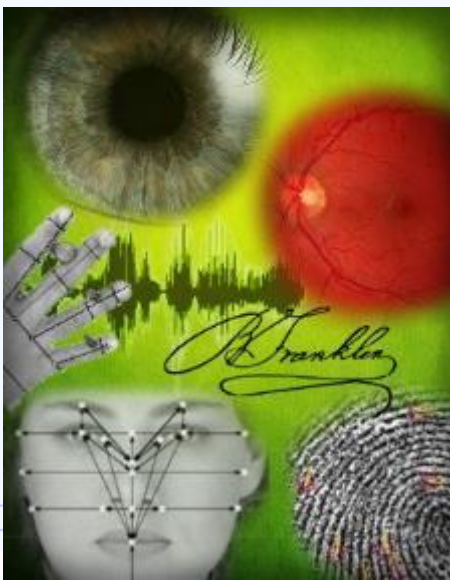
1. Matlab intro, statistika
2. Statistika - dokončení
- 3.-5. **Dynamický podpis** – Jakub Schneider
- 7.-10. **Duhovka** – Eduard Bakštein
- 11.-13. **Otisk prstu** – Jakub Schneider



Facebook, Twitter, Web



- **Prispivejte zejmena vy!!!!**
- Facebook (zalikujte, pokud se vam predmet bude libit:)
 - <http://www.facebook.com/biometrieCVUT>
- Twitter
 - <http://www.facebook.com/biometrieCVUT>
- Webove stranky
 - <http://www.predmet-biometrie.cz/>





2 - BIOMETRICS: GENERAL INTRODUCTION



Biometrics: what for?



"I'm sorry, but someone else with that identity is already here."



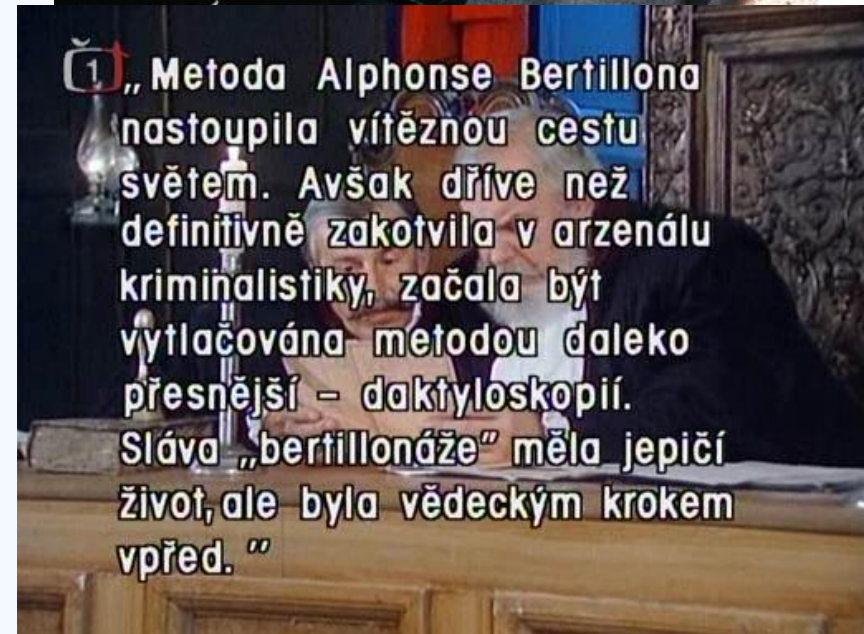
laboratory
Gerstner

Technical University

Alternative introduction



- [Dobrodužství kriminalistiky](#) na csfd
- [Dobrodužství kriminalistiky](#) na CT



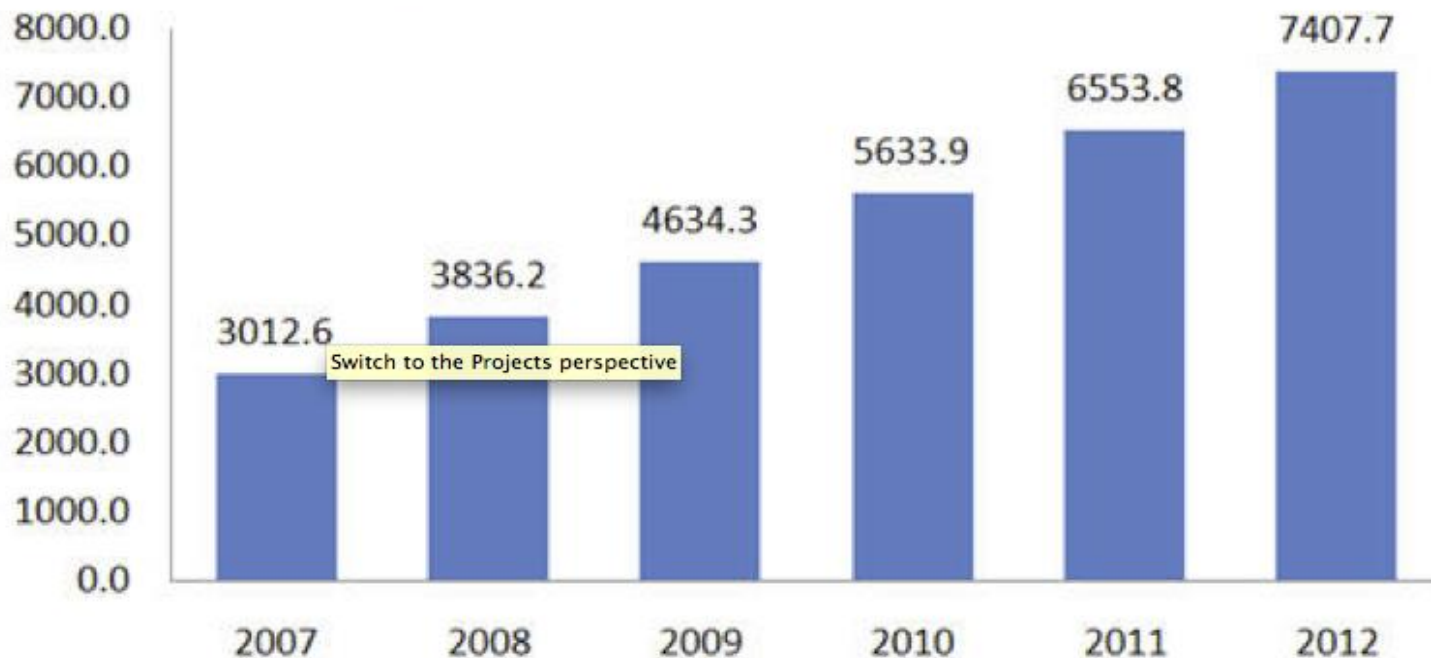


Trend: revenue of the field



Annual Biometric Industry Revenues, 2007-2012 (\$m USD)

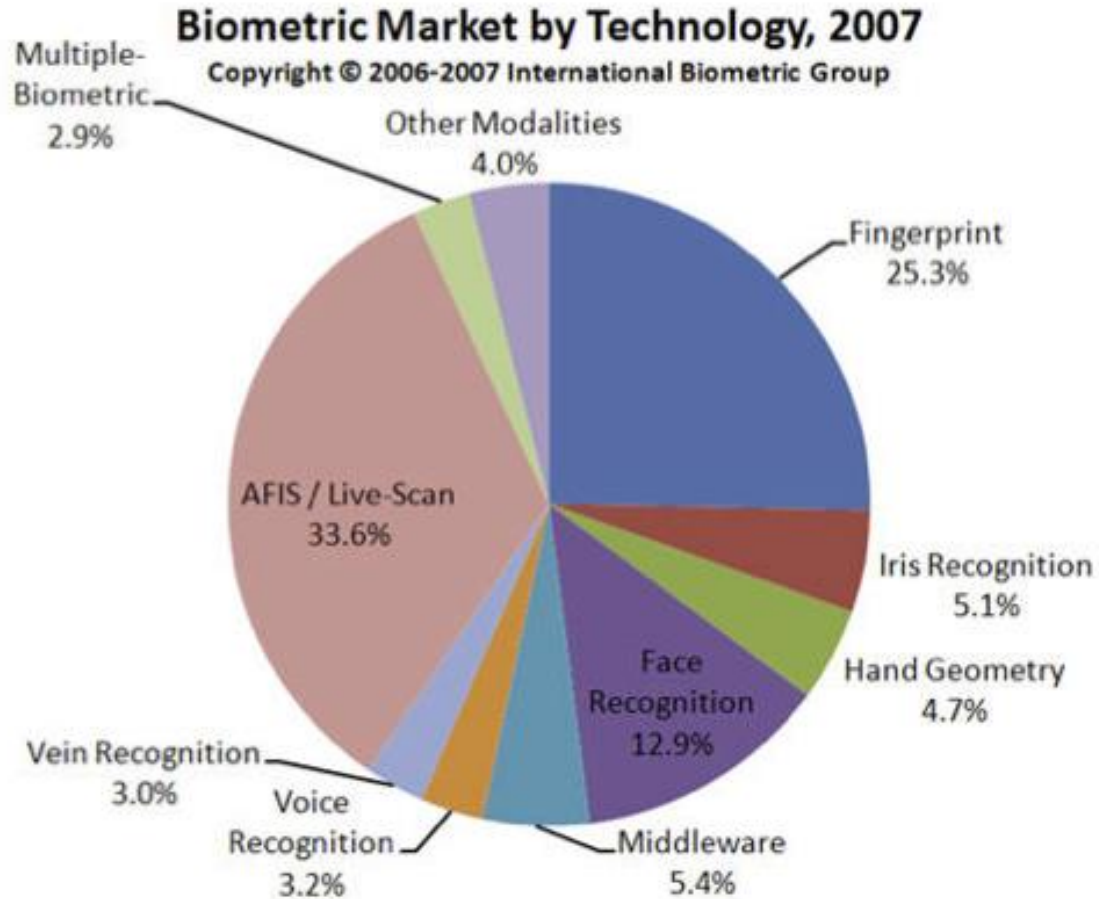
Copyright © 2006-2007 International Biometric Group



"A Touch of Money"



Market Share



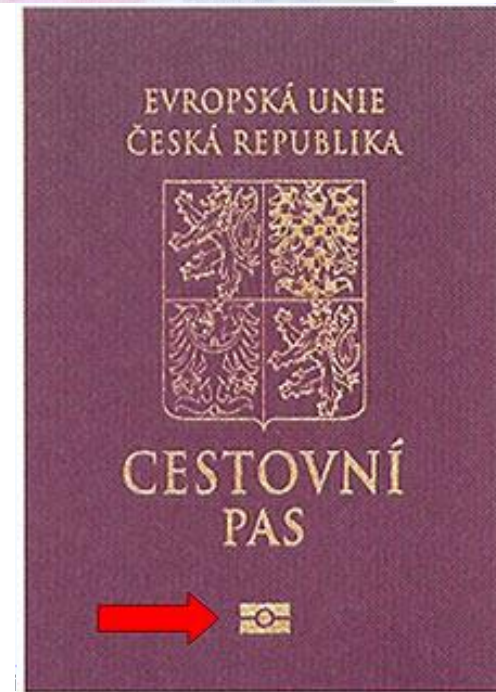
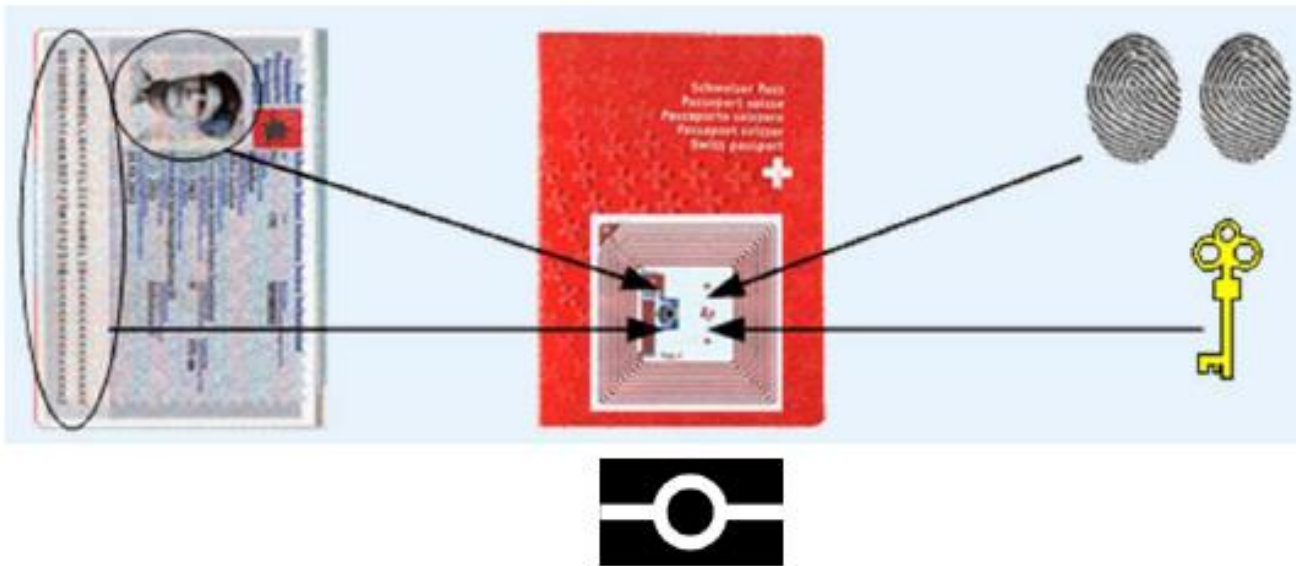
ePassport – Biometric passport

Necessary condition for travel to USA+ESTA. In ČR since 2006, since April 2009 - 2 fingerprints included

http://czech.prague.usembassy.gov/biometricky_pas.html

http://www.youtube.com/watch?v=ptb_nxCpgYQ

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

Today: eBorders in 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



Stolen identity



Article in [NY times](#) and [Telegraph](#), Hamas was responsible



- **February 2010:** Dubai Hamas murder: Fraudulent foreign passports were used by the alleged killers of a Hamas commander in Dubai



- One of the victims of the identity theft was British-Israeli Paul John Keeley (picture right). The passport used by one of the suspected assassins bore his name, but featured a photograph of another man (pictured left)



Another stolen identity



- HW - [Unknown](#) watch and rate at CSFD (71%)





What is Biometrics?

The term "biometrics" is derived from the Greek words bio (life) and metric (to measure)

- **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*

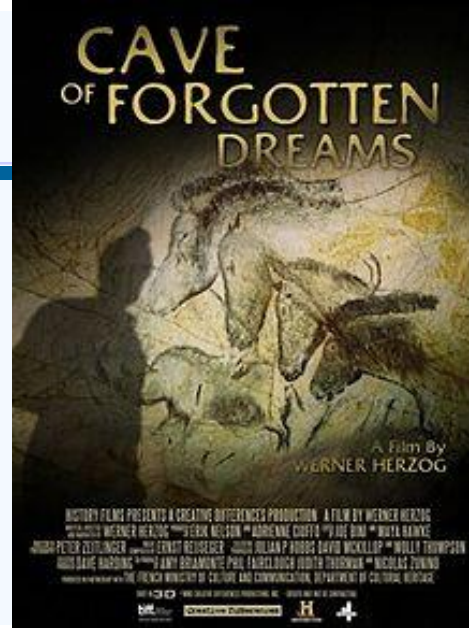


History of biometrics

- **Well-done summary:**

<http://www.biometrics.gov/documents/biohistory.pdf>

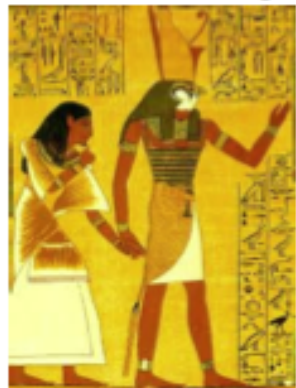
- **Oldest paintings in Chauvet cave, palm prints: I painted it! (documentary by Herzog)**



- **Ancient civilisations practised biometric techniques routinely.**



Sumerians considered a **hand print** and **outline of a hand** on a clay tablet a good identifier.



- **Egyptians** brought the concept of biometric identity verification into the **mainstream**, in many various ways:
 - **From discrete anatomical** measurements, e.g., distance between the individuals outstretched thumb and the tip of the elbow
 - **To more general notification of individual features**, e.g., Nechutes, son of Asos, aged 40, of middle size, sallow complexion, cheerful countenance, long face with straight nose and a scar upon the middle of his forehead.

Identity Verification by Animals - Examples

- **Penguins** - by **voice** recognition to locate their offspring within a population sometimes numbering hundreds of thousands
- **Frogs** – discriminate between neighbours and strangers by **voice** recognition
- **Hawks** and other **birds** – by using **visual** information
- **Wolves** – by **voice** at a distance and corroborate this information by **visual cues** and **scent** at shorter distances
- **Insects** (bees, wasps, ants, etc.) – practice identity verification routinely

- Possession-based schemes
Based on ID cards, tokens, keys, etc.

WHAT YOU HAVE



- Knowledge-based schemes
Based on passwords, PINs, etc.

WHAT YOU KNOW

Online Banking 

Username

Password

[Forgot Password?](#)

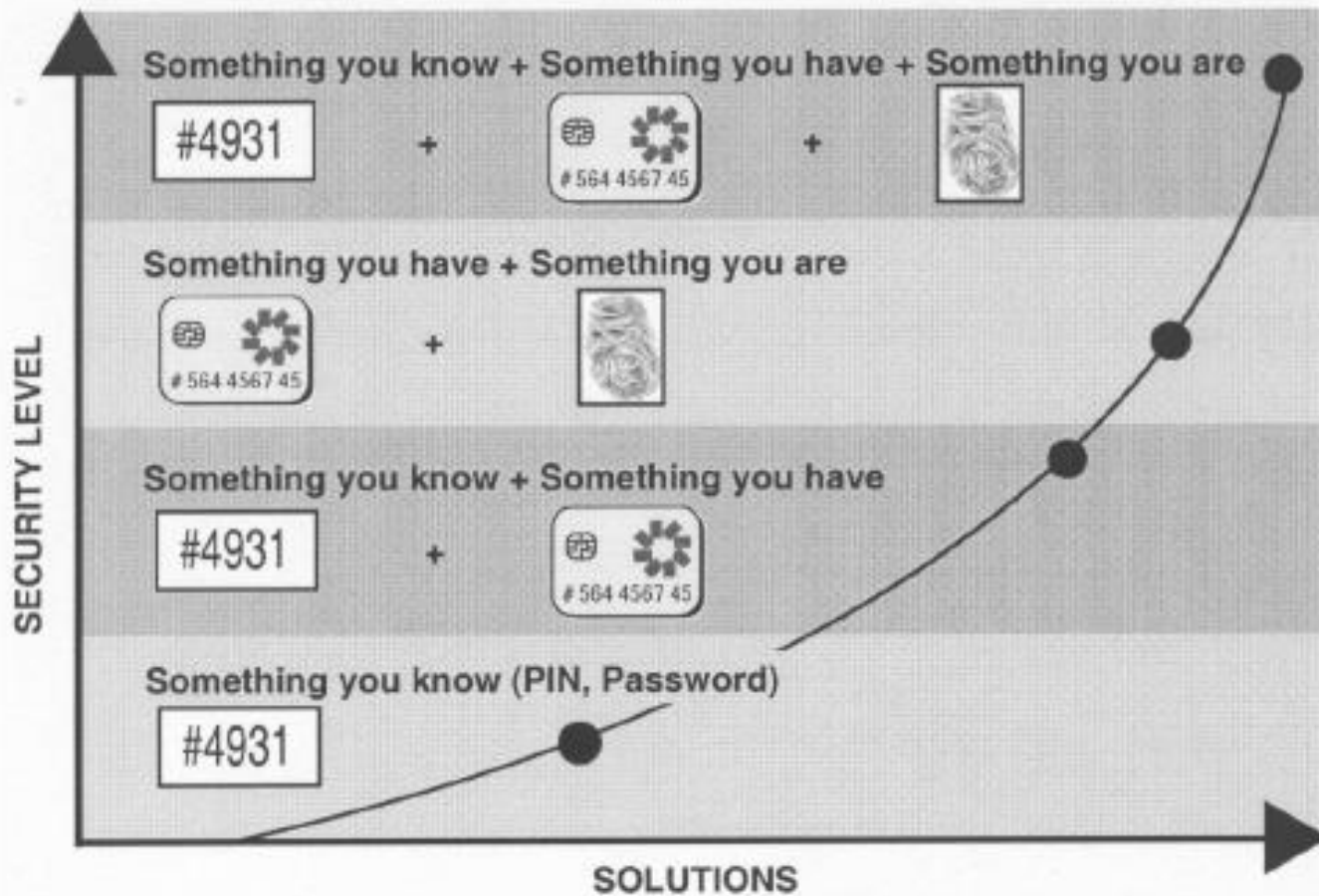
[Sign Up](#) | [Learn More](#) | [Security](#)

Other Online Services

Select Service

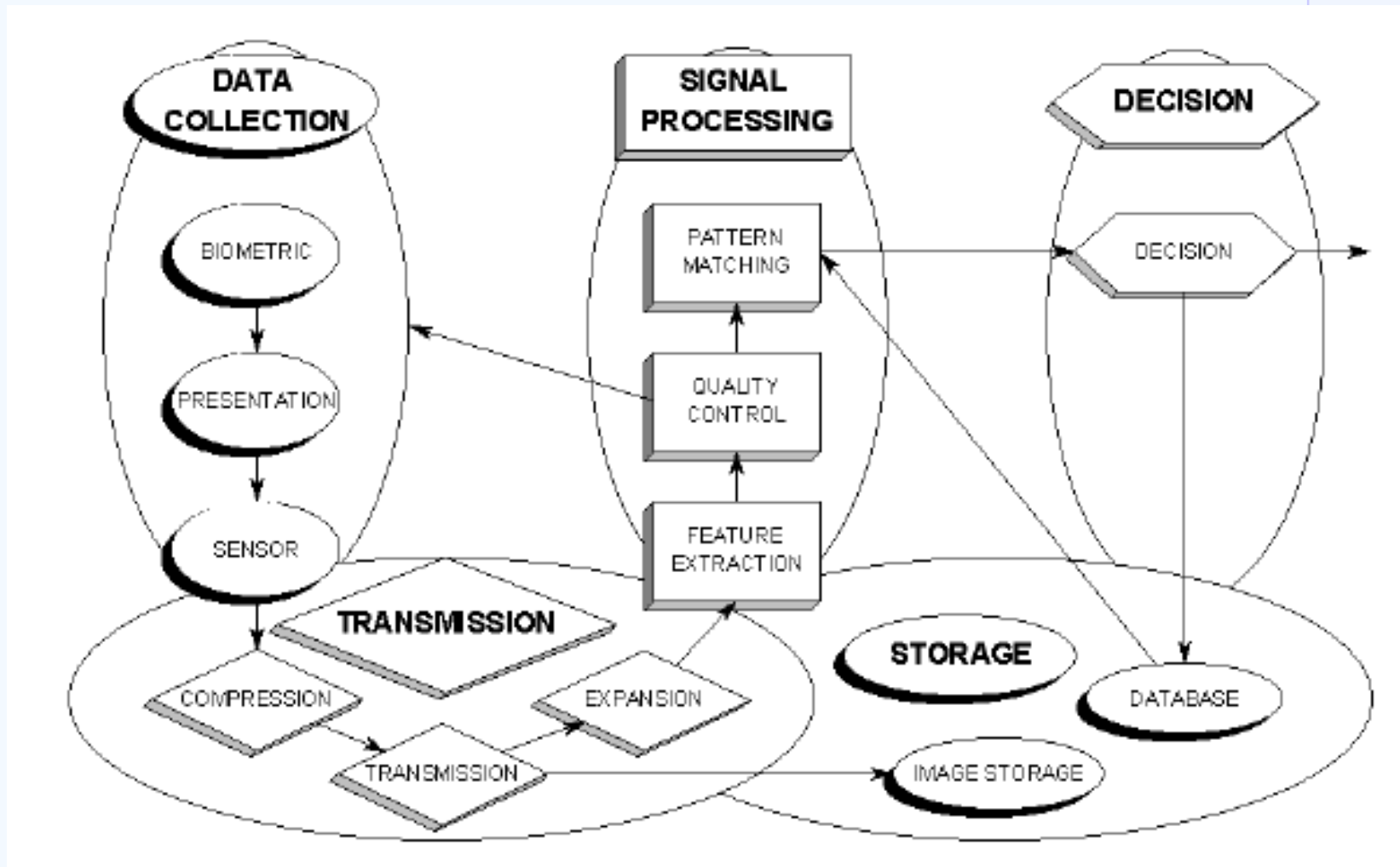


Three basic means





Generic Biometric System





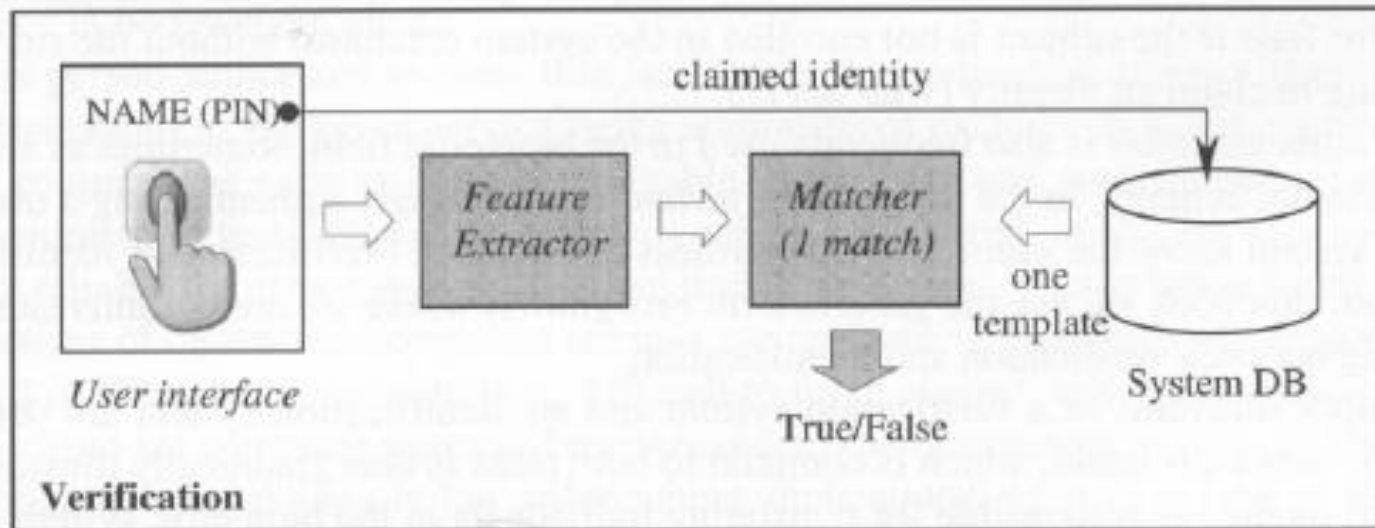
Pattern Recognition System

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



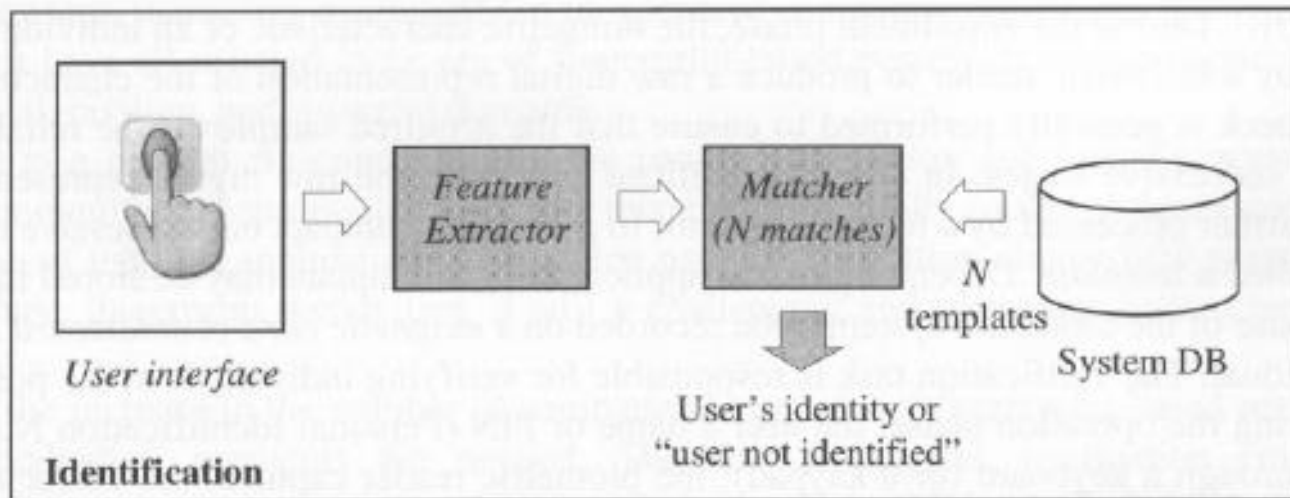
Person recognition

- **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?”

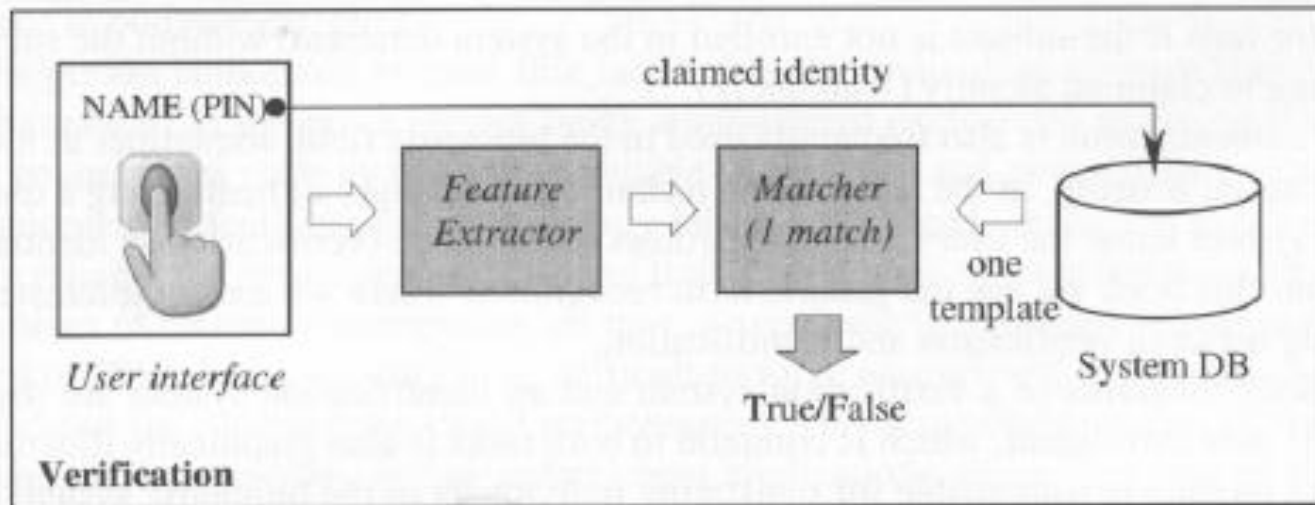
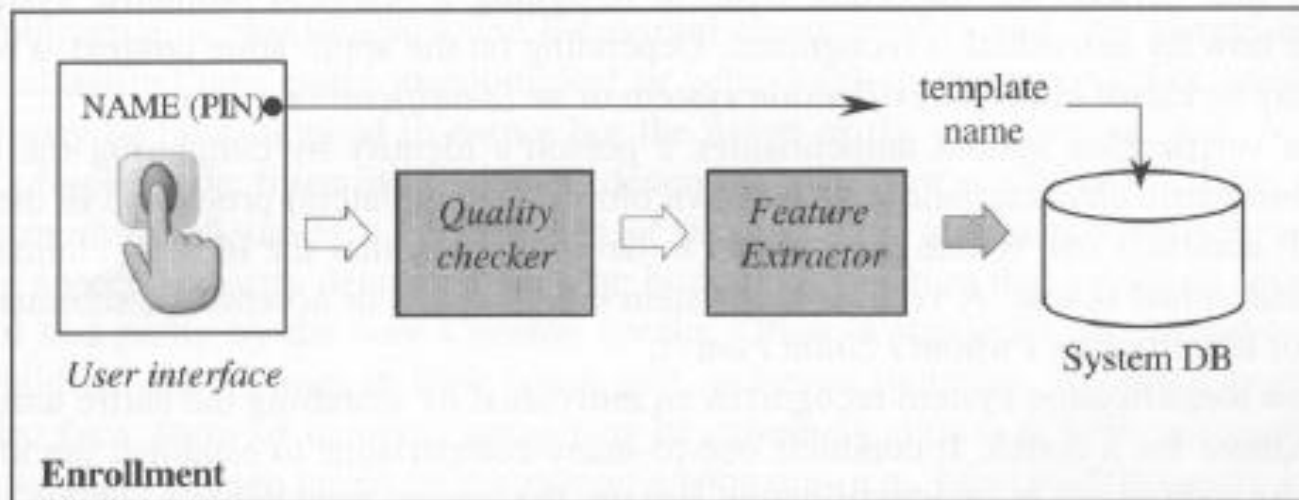


Identification

- **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





Some statistics of Mobile devices

Nice example – Motorola Atrix 4G using swipe fingerprint AuthenTec sensor

Company was [bought](#) by Apple in July 2012 for 356\$ mil (8\$ for share – current value: 5\$)

- 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





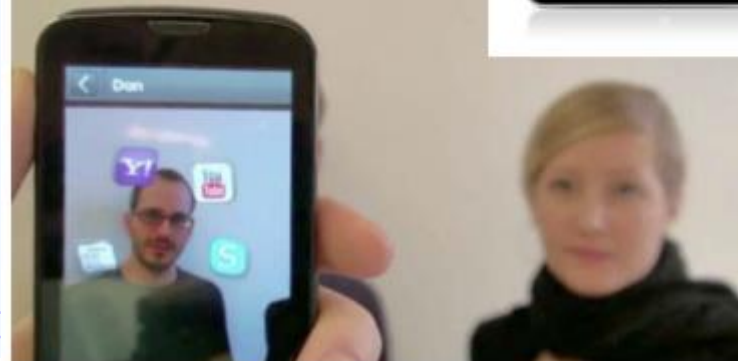
Mobile phone apps

- HW: try out and paste to fb or twitter
- [BioLock](#), youtube video:



Biometrics on iPhone and iPad (eye and face)

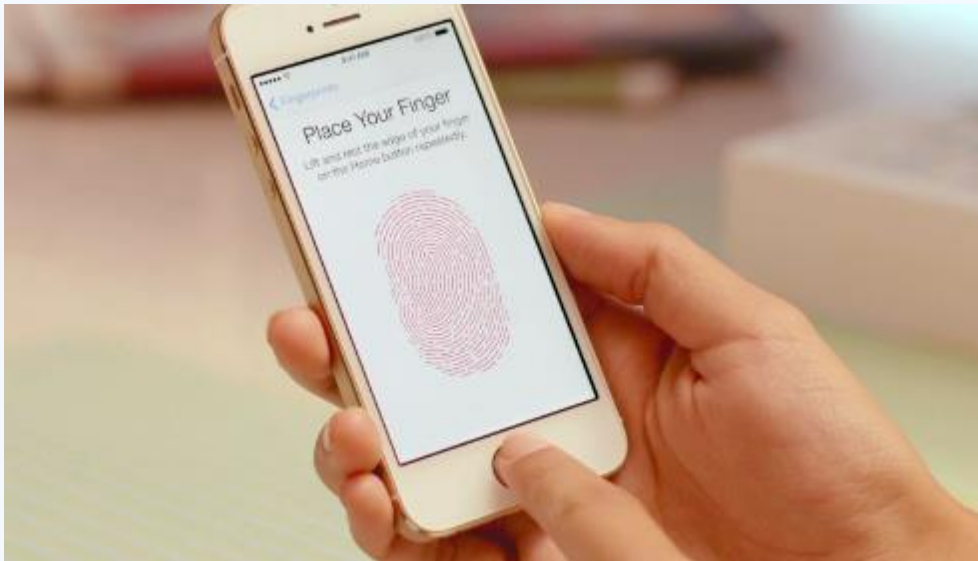
26





Mobile biometrics: future development?

- Iphone 5s (release 09/2013) has fingerprint sensor for authentication
- First mainstream smartphone with hw biometric sensor
- Massive spread of biometric identification in mobile devices?



2013

atory
er

Example Iris & Speech



- Example
 - Assume 10'000 customers are signed up for biometric authentication and 1'000 transactions are done weekly
 - Assume best-case biometric verification error of **1 in 1 million (iris)**
 - Assume best-case speaker verification error of **1 in 1 hundred**
 - How often are customers falsely billed?
- Answer
 - On average **10 people are falsely billed each week**
 - On average **100 000 people are falsely billed each week**

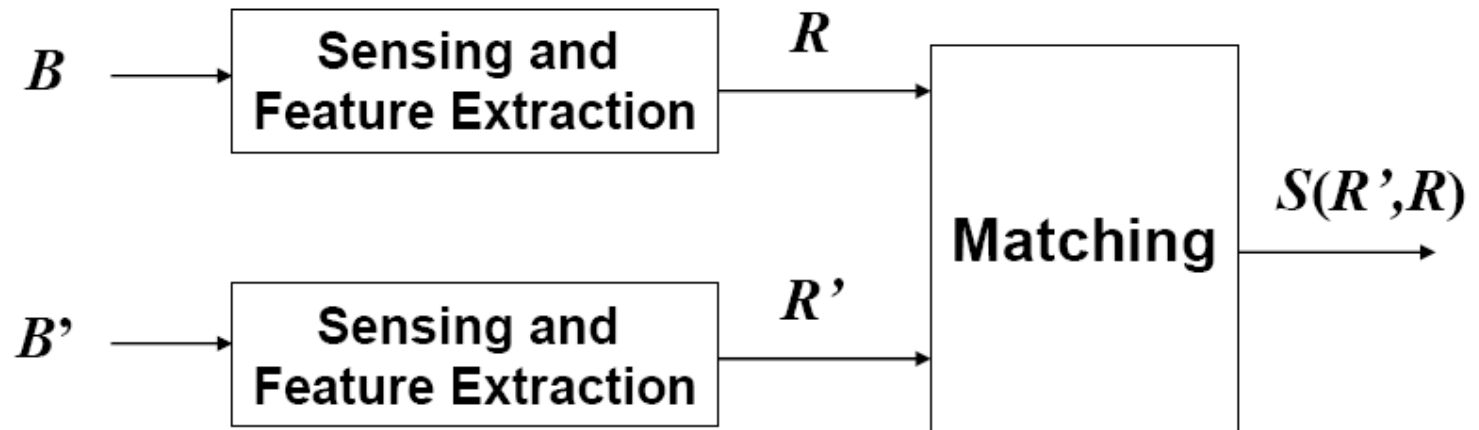




Matching

Real-world
biometrics

Features



$$s(R', R) = s(f_{t'}(B'(t')), f_t(B(t)))$$

Biometric matching makes a decision by computing a measure of the likelihood that the two input samples from two persons are the « same » and hence that the subjects are the same real-world identity.



3 - BASIC STATISTICS FOR BIOMETRICS



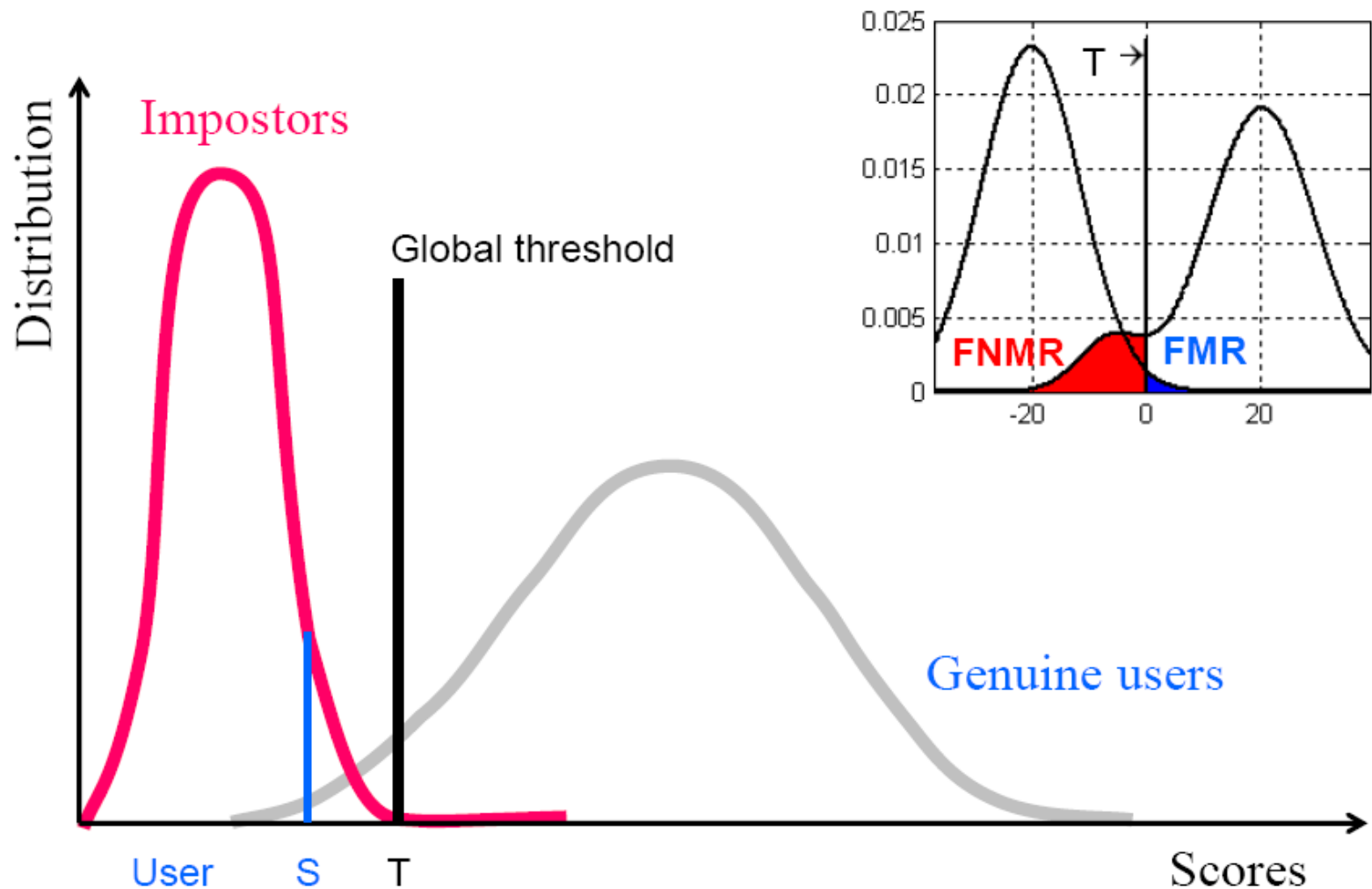


FA & FR

- **False Accept (FA):** Deciding that a (claimed) identity is a legitimate one while in reality it is an imposter; False Accept Rate (FAR)
- **False Reject (FR):** Deciding that a (claimed) identity is not legitimate when in reality the person is genuine; False Reject Rate (FRR)
- A **FA** results in **security** breaches, with an unauthorized person being admitted
- A **FR** results in **convenience** problems, since genuinely enrolled identities are denied access to the application

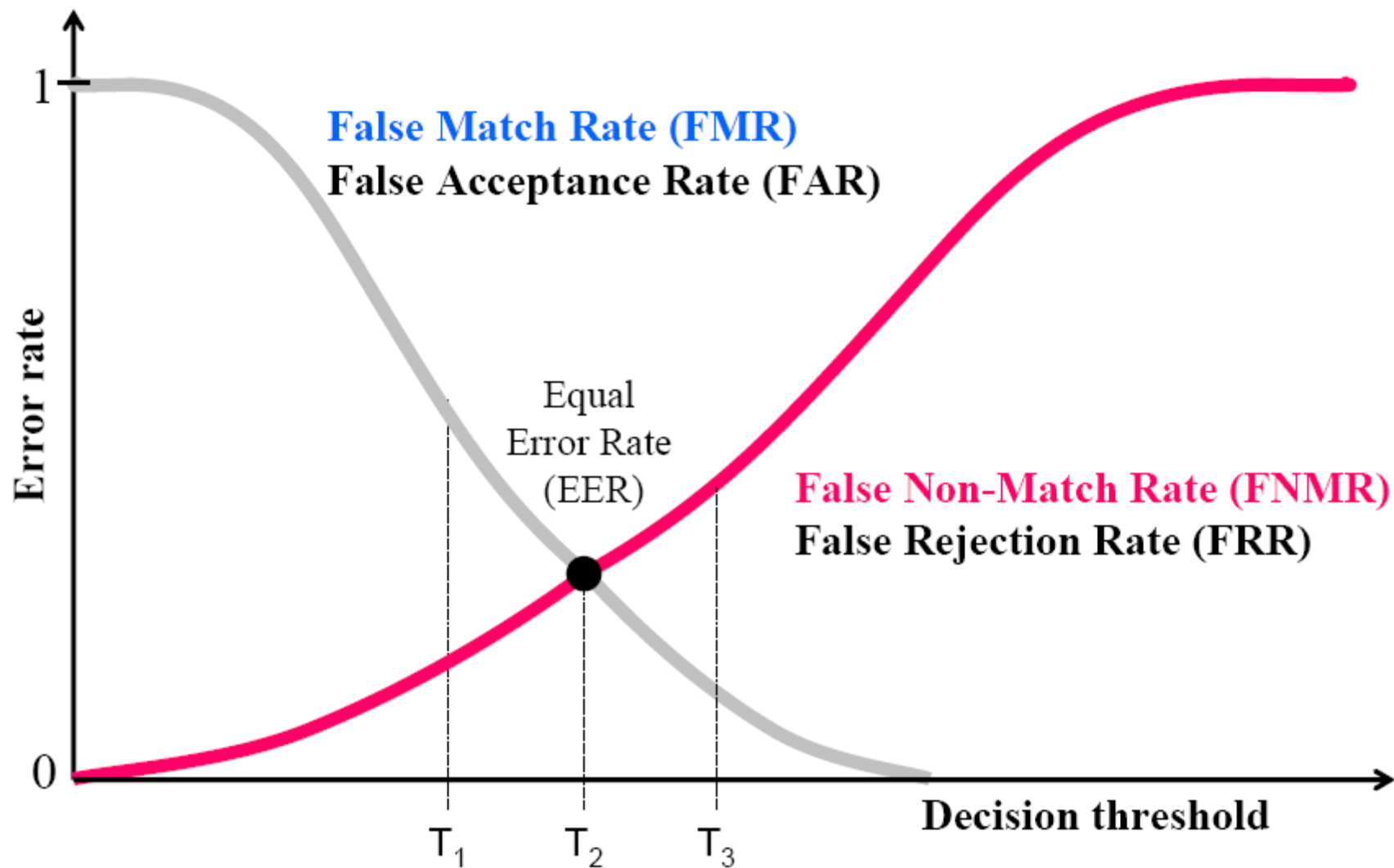


Performance evaluation





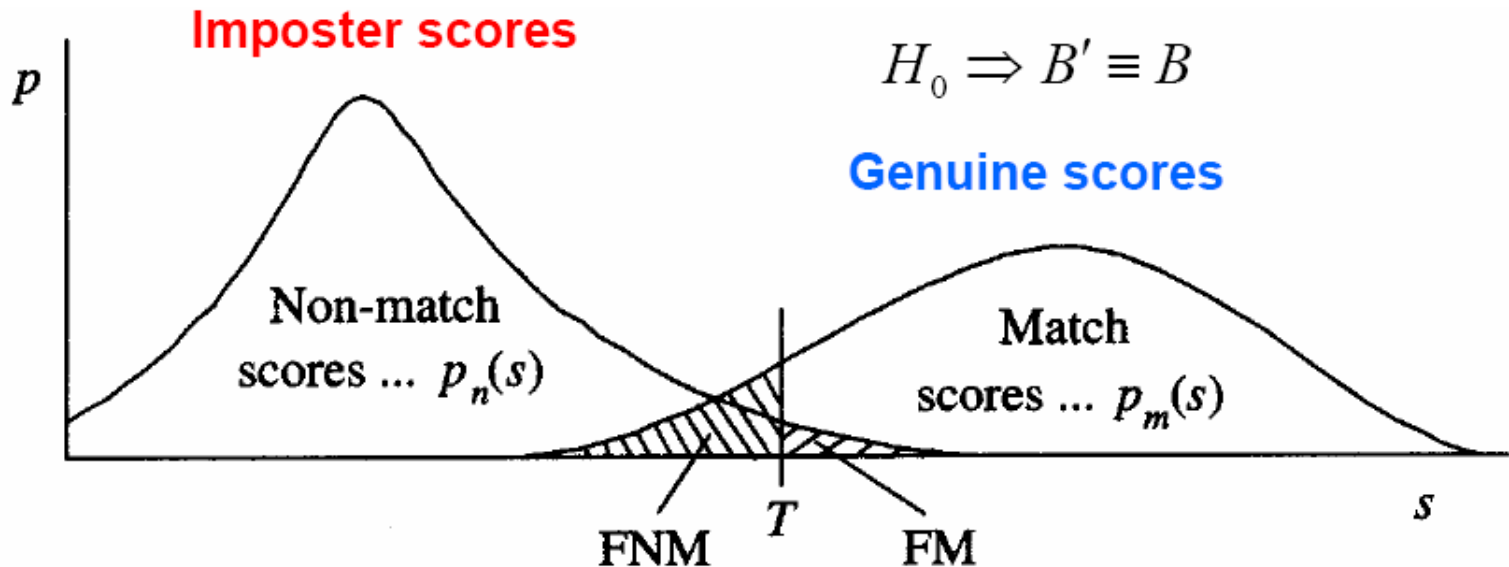
FMR and FNMR





Scores distribution

$$H_a \Rightarrow B' \neq B$$



Given two biometric samples, we can construct two possible hypotheses:

The null hypothesis: $H_0 \Rightarrow$ the two samples match

The alternate hypothesis: $H_a \Rightarrow$ the two samples do not match



Two kinds of error

- Verification:

Decide H_0 is true: if $s > T$,

Decide H_a is true: if $s \leq T$.

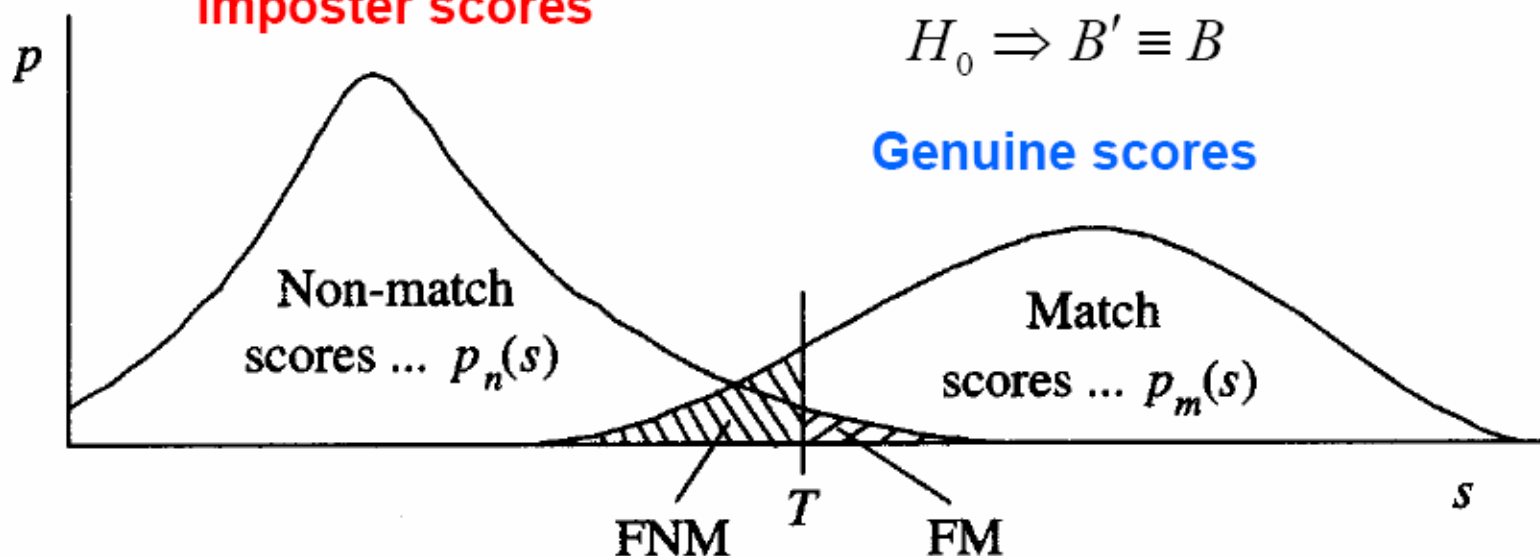
- Type II error **False Match (FM)**: Deciding that two biometrics are from the same identity, while in reality they are from different identities; the frequency with which this occurs is called the False Match Rate (FMR)
- Type I error – **False Non-Match (FNM)**: Deciding that two biometrics are not from the same identity, while in reality they are from the same identity: the frequency with which this occurs is called the False Non-Match Rate (FNMR)
- **Correct Match**: correctly deciding that two biometric samples match
- **Correct Non-Match**: correctly deciding that the samples do not match



Two kinds of error

$$H_a \Rightarrow B' \neq B$$

Imposter scores



$$H_0 \Rightarrow B' \equiv B$$

Genuine scores

Non-match
scores ... $p_n(s)$

Match
scores ... $p_m(s)$

FNM

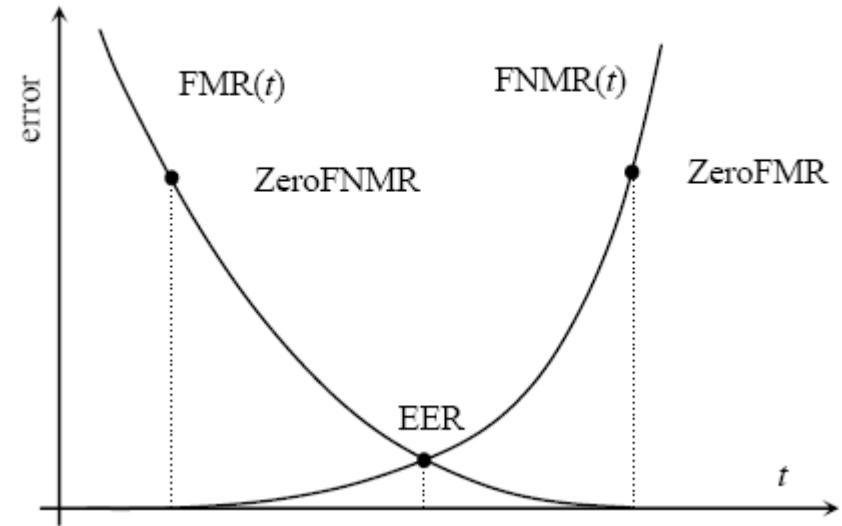
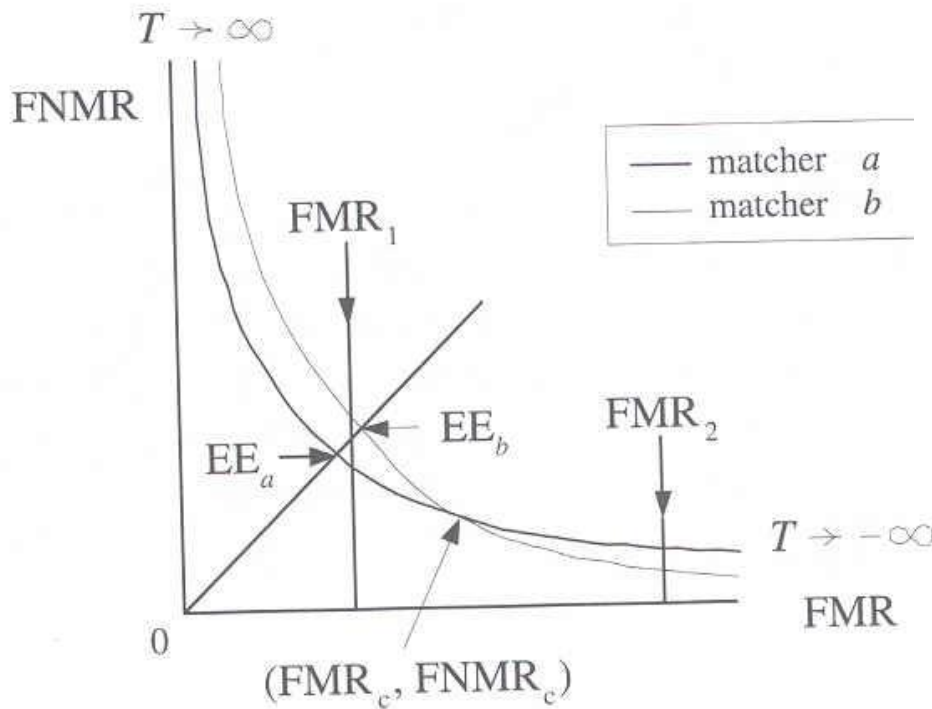
FM

$$\text{FNMR}(T) = \int_{s=-\infty}^T p_m(s) ds$$

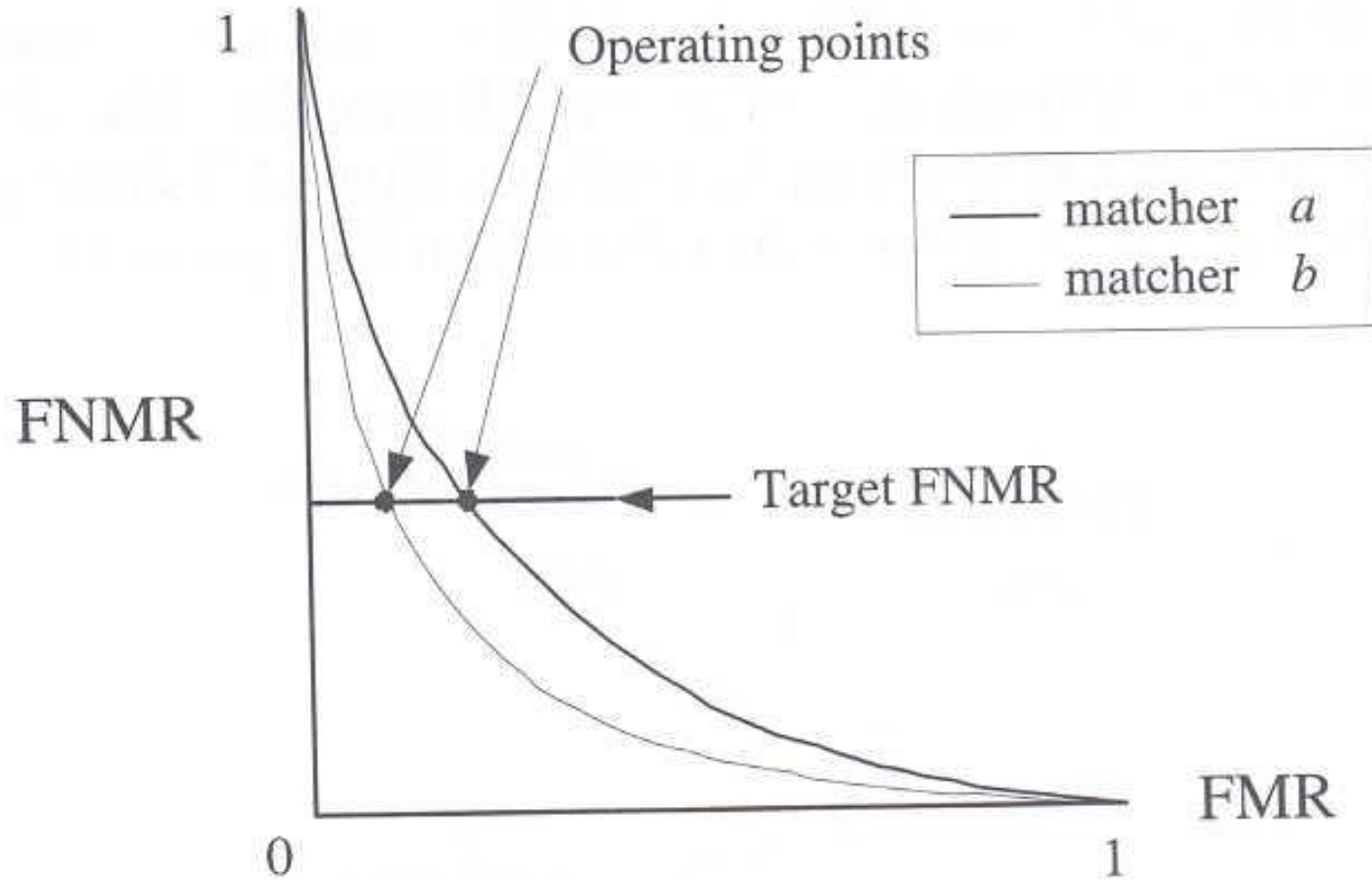
$$\text{FMR}(T) = \int_{s=T}^{\infty} p_n(s) ds$$

The Equal Error Rate

-ROC:



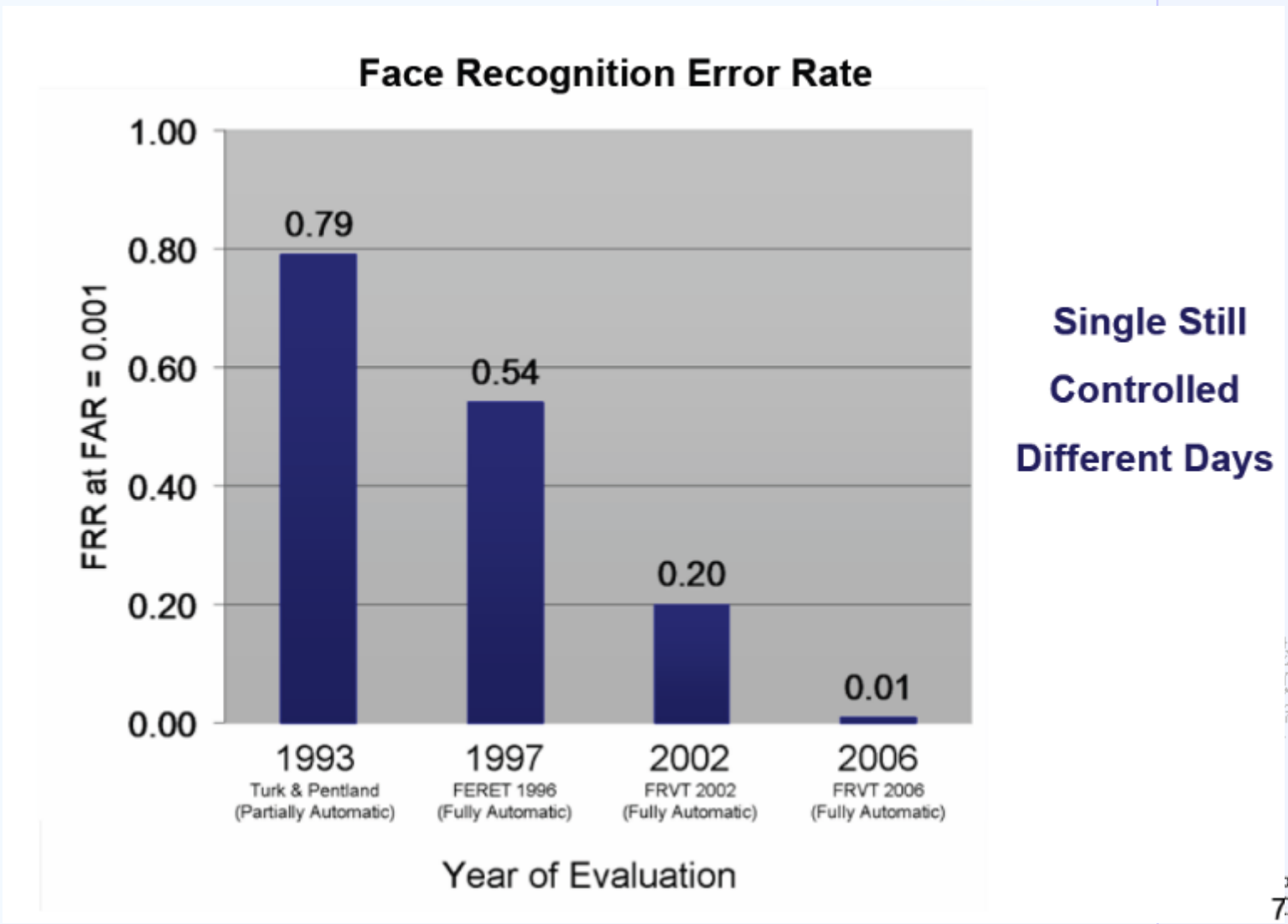
Using the ROC Curve



Matcher *b* is always better than matcher *a* since for every possible FNMR, its FMR is lower



Face recognition FRR & FAR





4 - OVERVIEW OF BIOMETRICS TECHNIQUES



Main Sorting

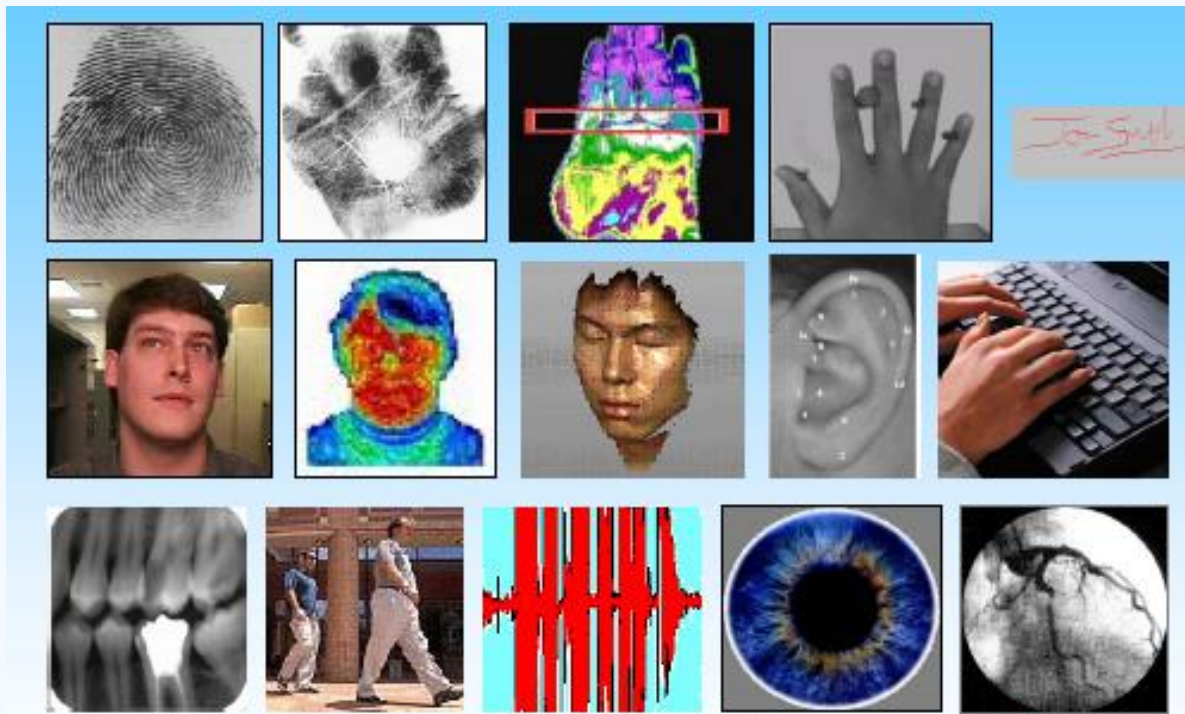
Biometrics can be sorted into two classes:

- 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



More biometric identifiers



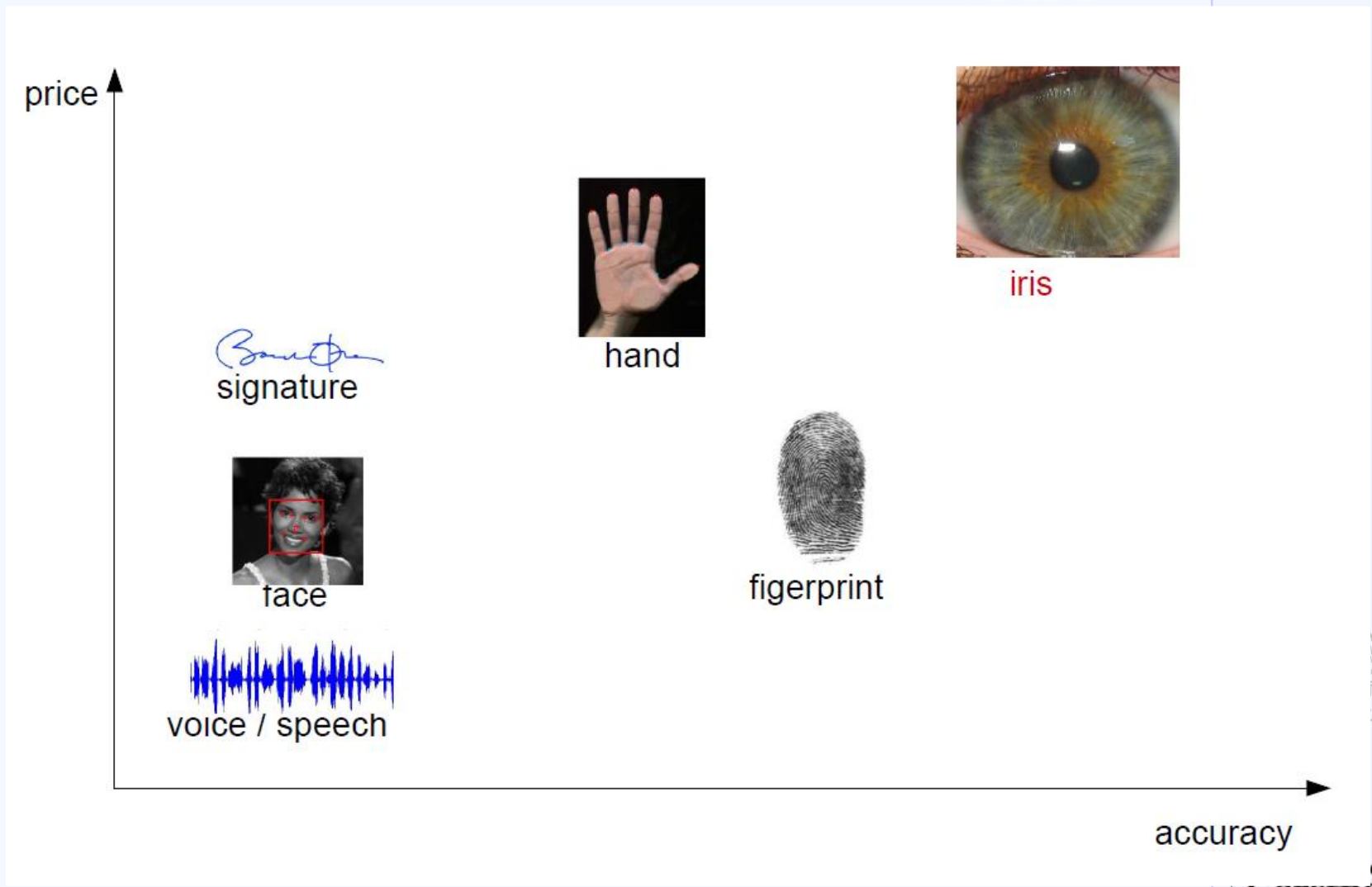
Vein Pattern
Sweat Pores
Fingernail Bed
Hand Grip
Brain Wave Pattern
Footprint and Foot Dynamics

•*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





Price vs accuracy





Biometric techniques overview

- Fingerprint recognition
- Face recognition
- Voice recognition
- Iris Recognition
- Dynamic signature



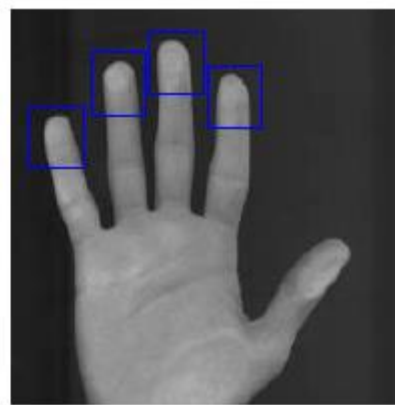
1. Fingerprint Recognition (D.Novak)



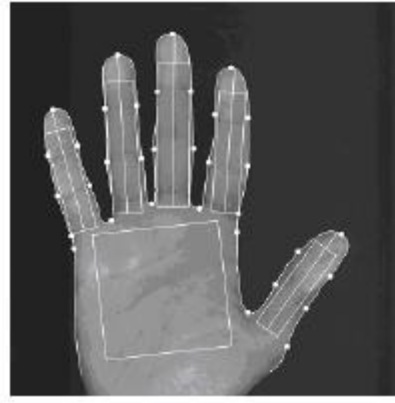
- An extremely useful biometrics technology since fingerprints have long been recognized as a primary and accurate identification method.



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

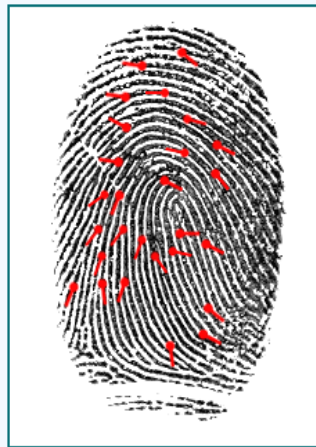


Minutiae

- 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?



Scan left index finger



Thin image to a single pixel



Sample minutia graph



Identify minutiae



ending minutiae



bifurcation minutiae



Minutia graph

Acceptable score ?



Reference minutia graph for individual



No
Access denied
cannot sign record

Yes
Access to application
sign records



Face recognition

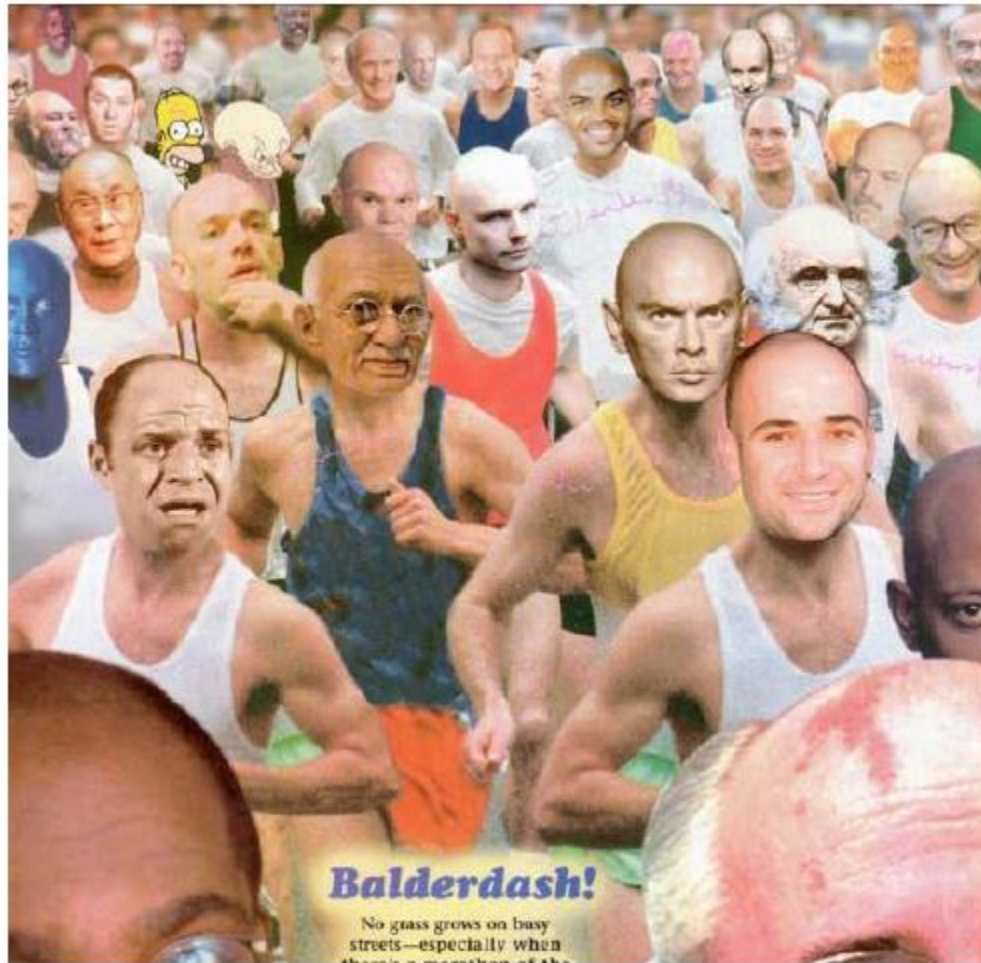


2. Face Recognition (V. Franc)

- 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.



Who is there??



Games Magazine, September 2001



laboratory
Gerstner

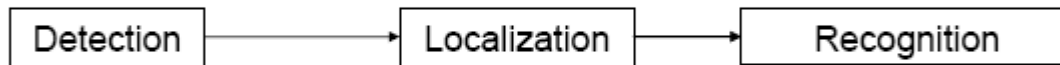
Why face?

- 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)

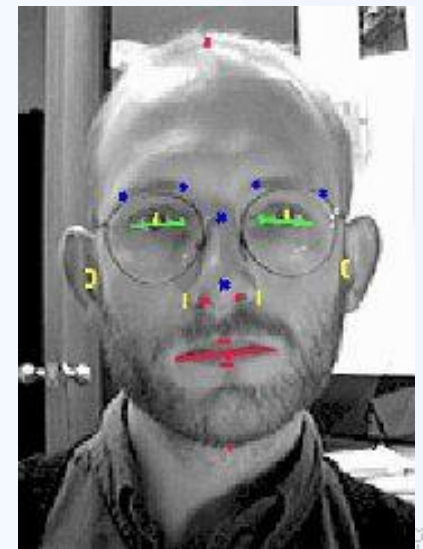


Details

- 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

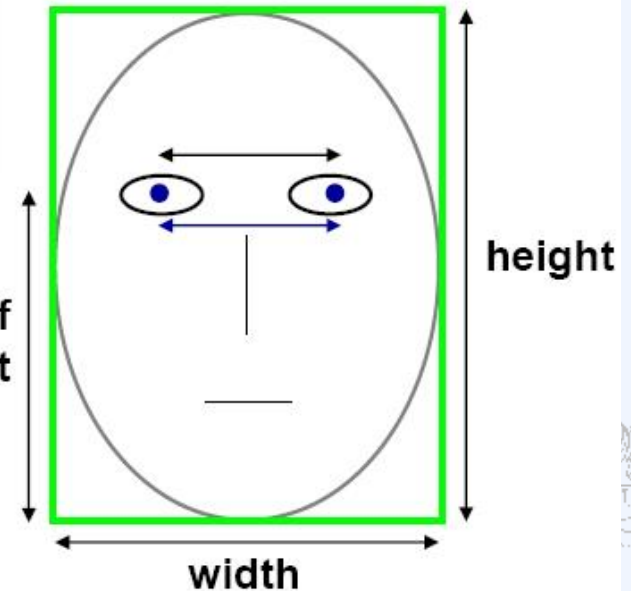
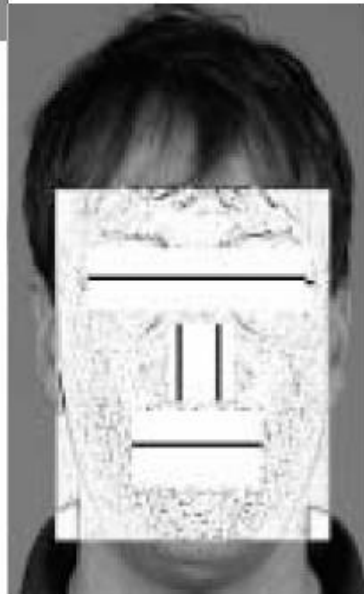
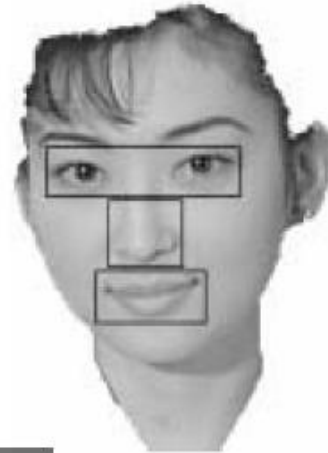
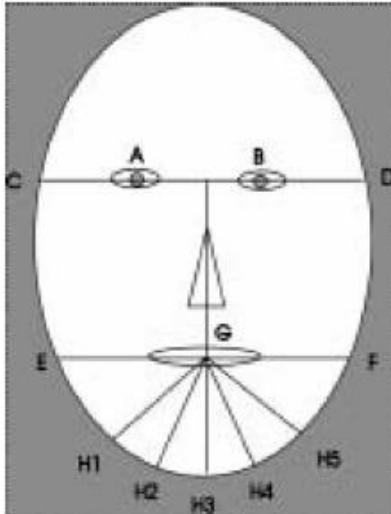


Mr Tintin

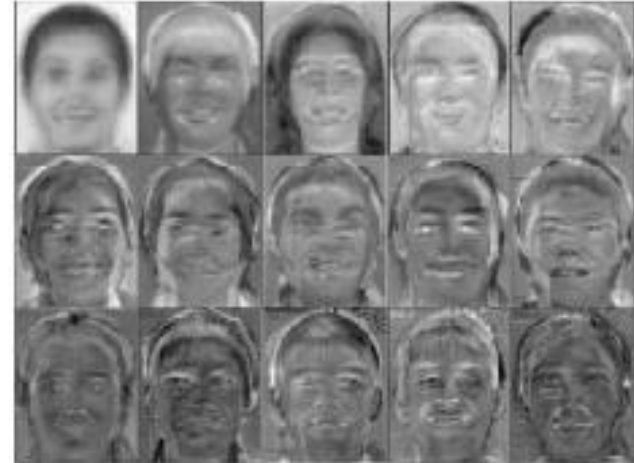




Feature based approach



Example: Eigenfaces



Perfect reconstruction with all eigenfaces

$$\text{Target Face} = 0.4 \text{ Eigenface 1} + 0.2 \text{ Eigenface 2} + \dots + 0.6 \text{ Eigenface N}$$

Reasonable reconstruction with just a few eigenfaces

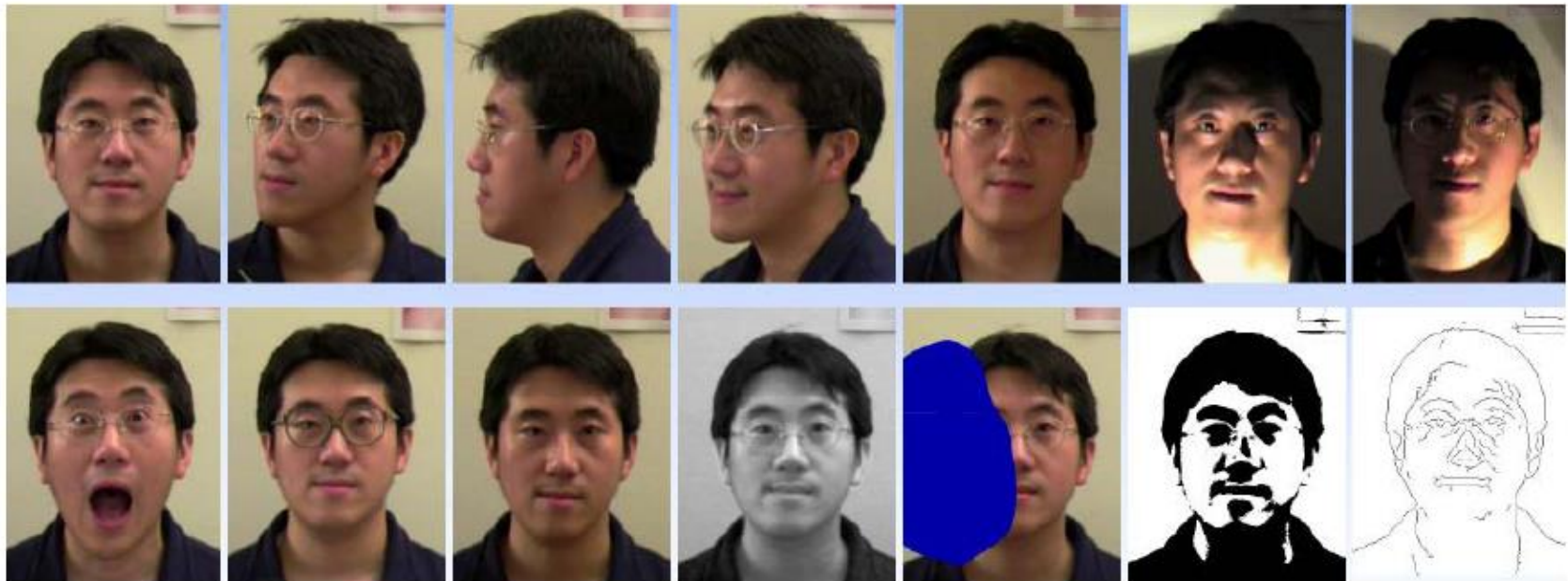
$$\text{Target Face} = 0.4 \text{ Eigenface 1} + 0.2 \text{ Eigenface 2}$$



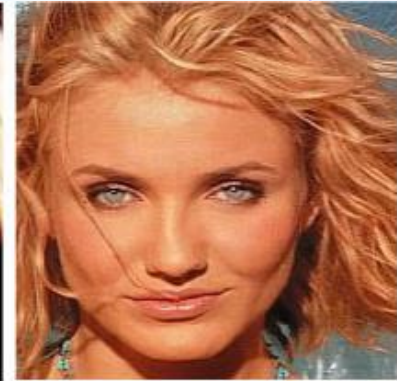
Intra-class variability



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



The power of make up



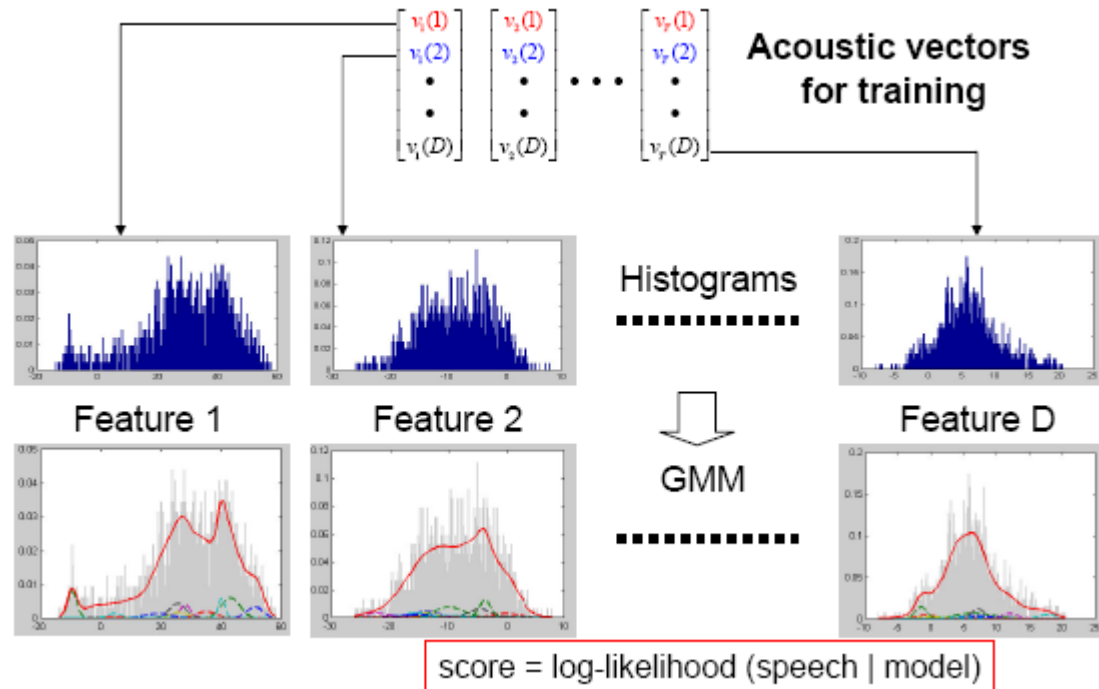
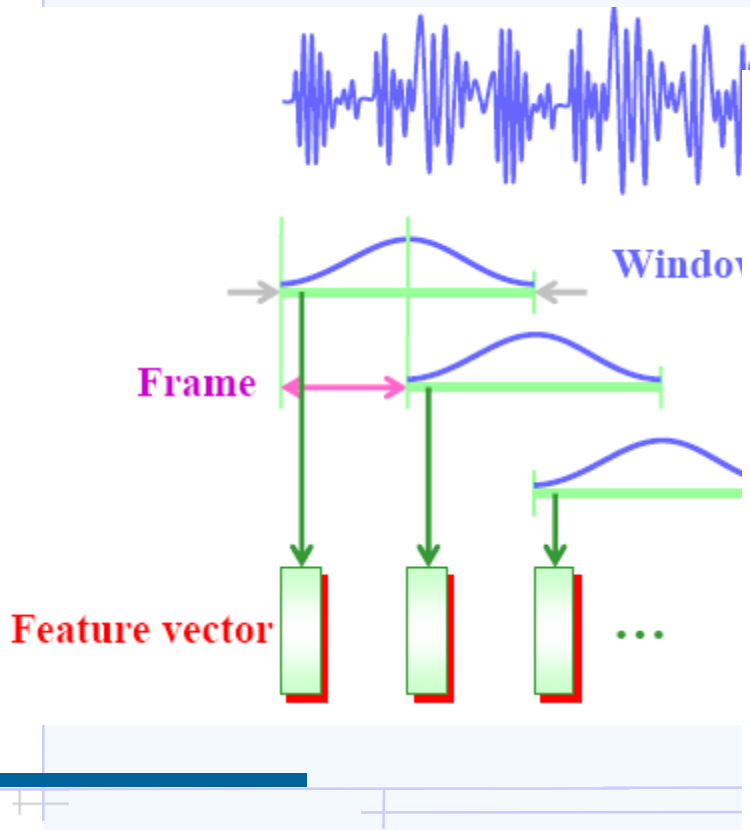
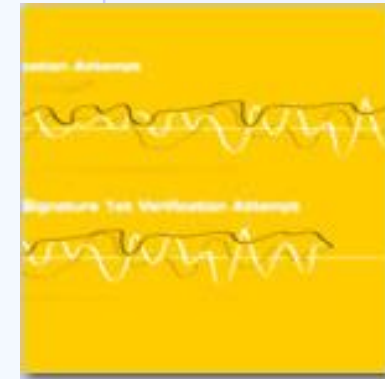


Voice recognition



3. Voice Recognition (P. Polak)

- 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



Training utterances:

"Open sesame"
"Open sesame"
"Open sesame"

GMM
training

Speaker-Dependent GMM

Enrollment session

Test session

Identity claim

Test utterance:

"Open sesame"

Database

Speaker
verifier

Scores

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 (E. Bakstein)



- 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)
<http://www.youtube.com/watch?v=QEQEht8zloQ>

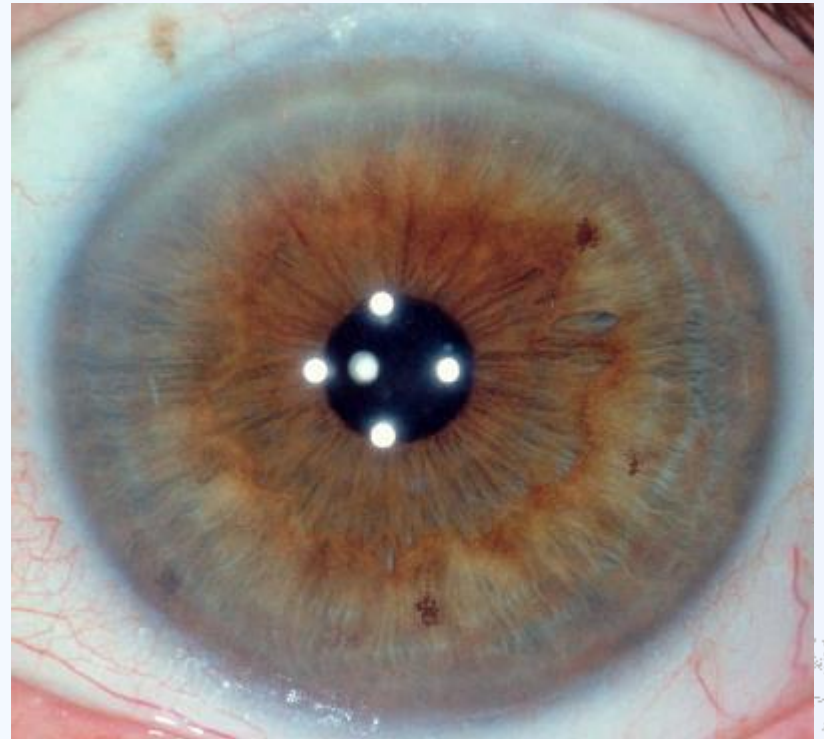
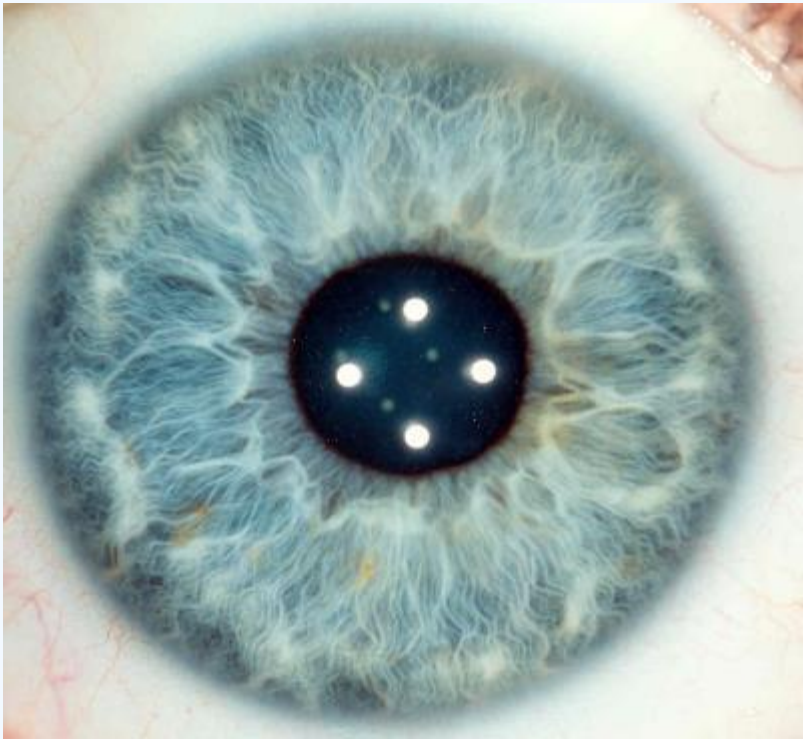




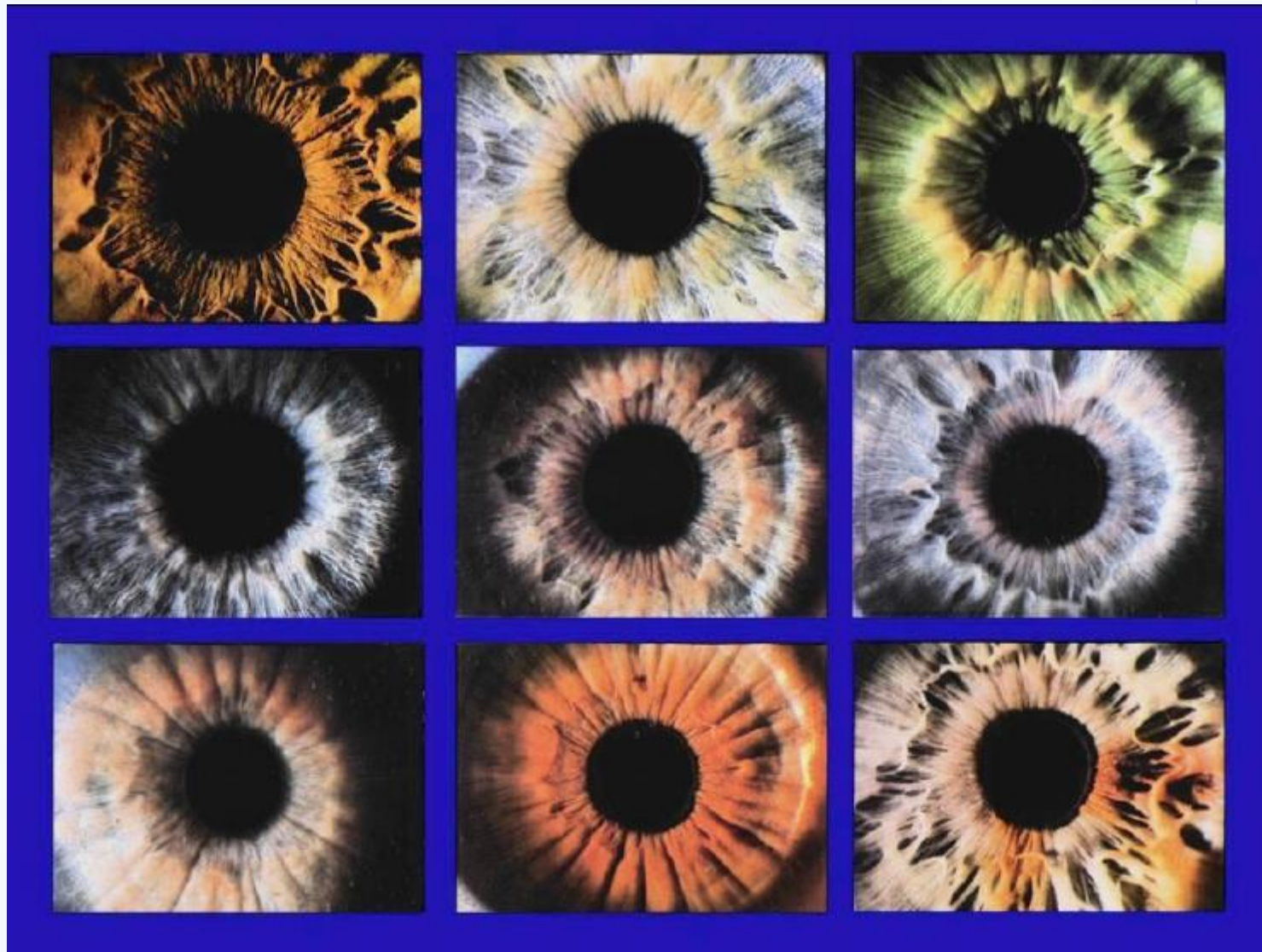
Iris recognition



Example Iris Images

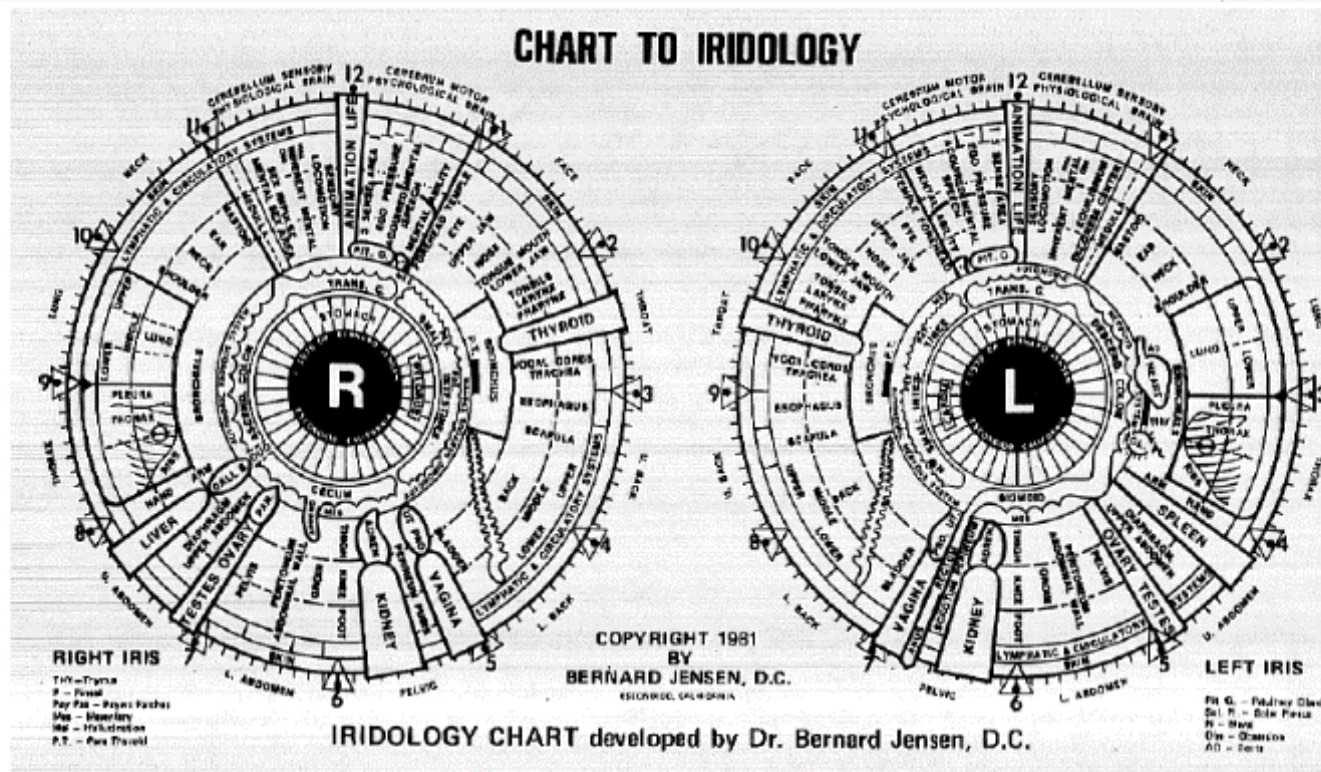


IRISES



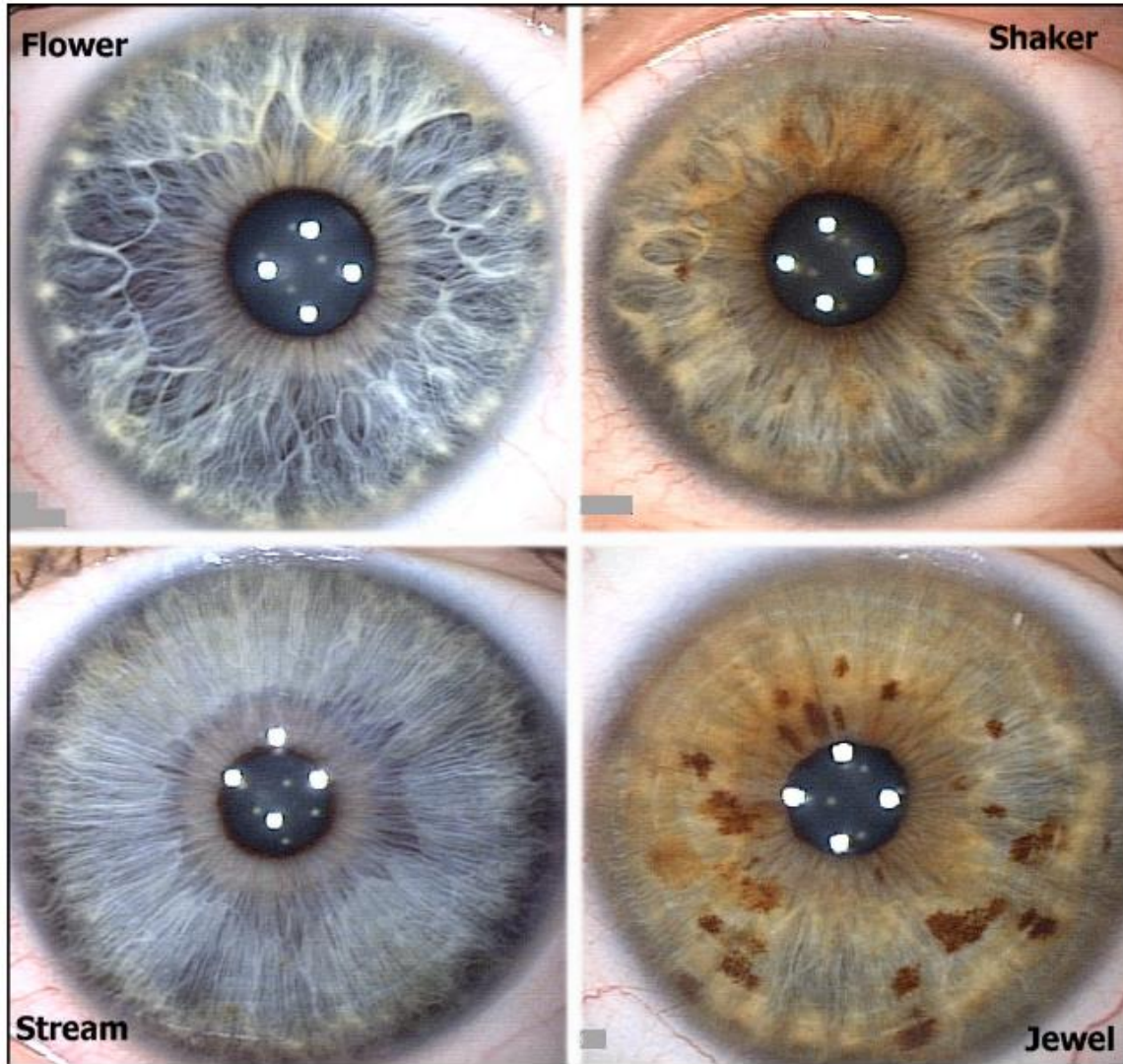
laboratory
erstner

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



laboratory
Gerstner

Iris code



Iris Code

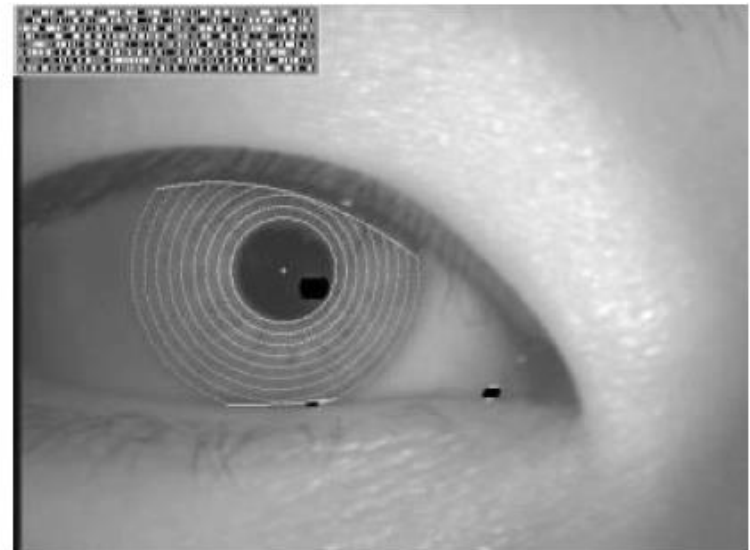
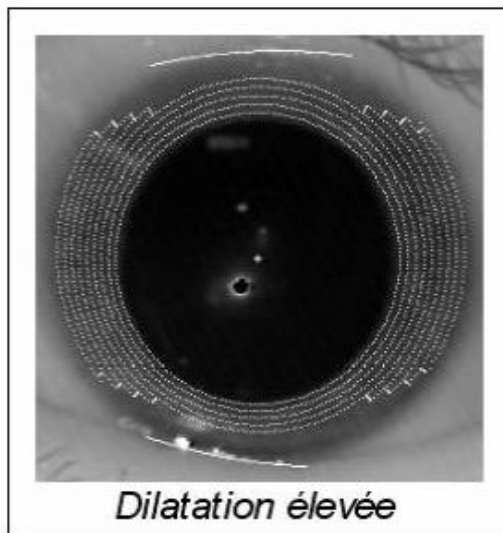
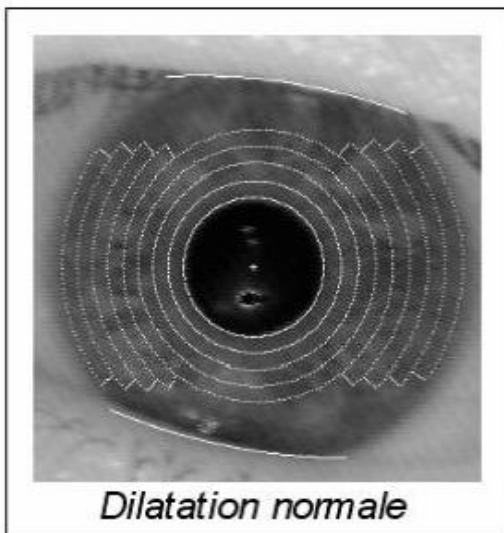
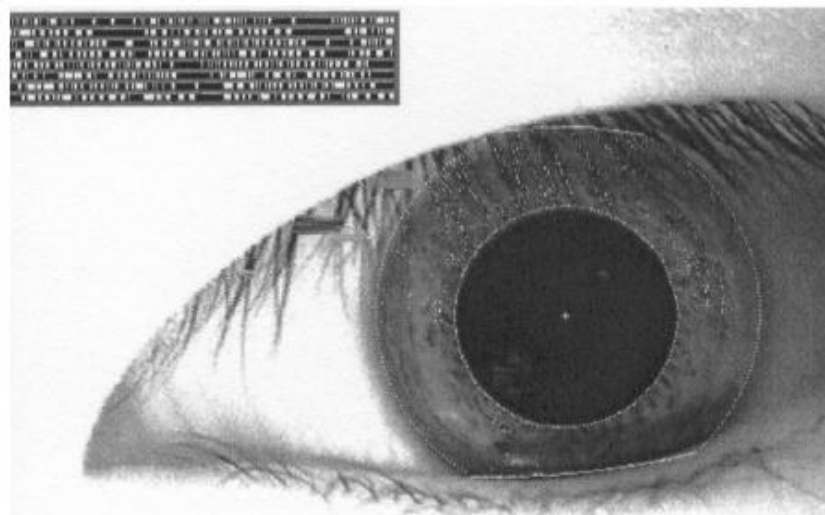
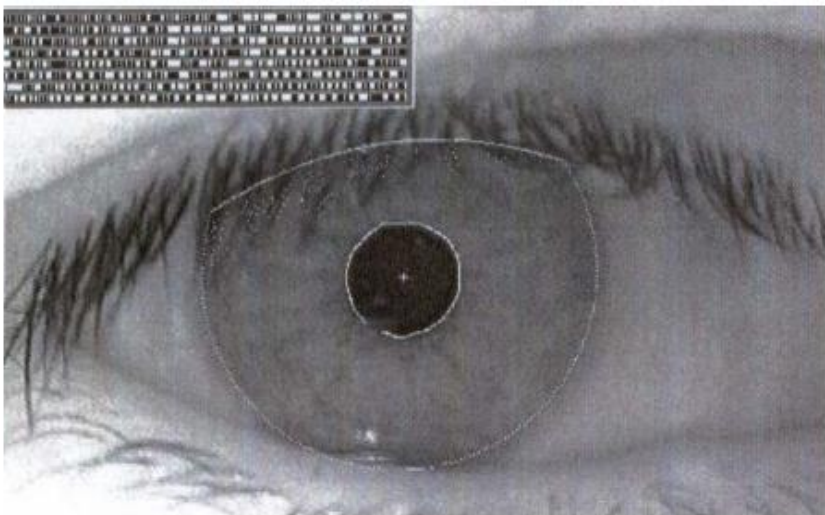


Image size is 64 x 256 bytes
and the iris code is 8 x 32
bytes

Iris mapping



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



Dynamic signature



5. Signature Verification (J. Schneider / P.Vostatek)

- 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

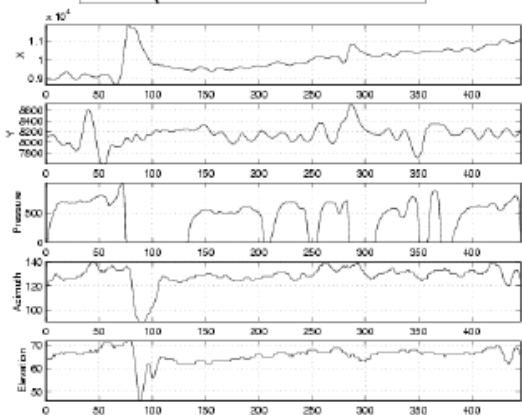
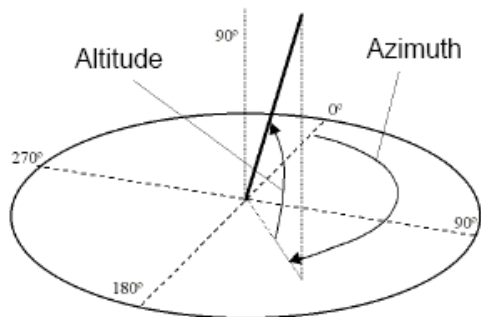
Signature



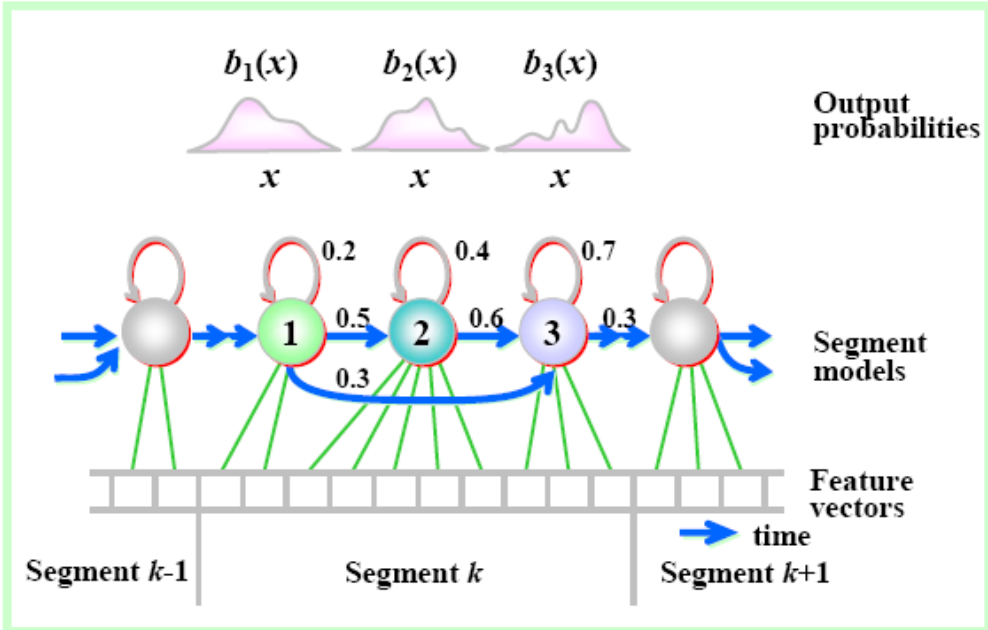
Dynamic on-line technology – signal processing and pattern recognition



Dynamic signature

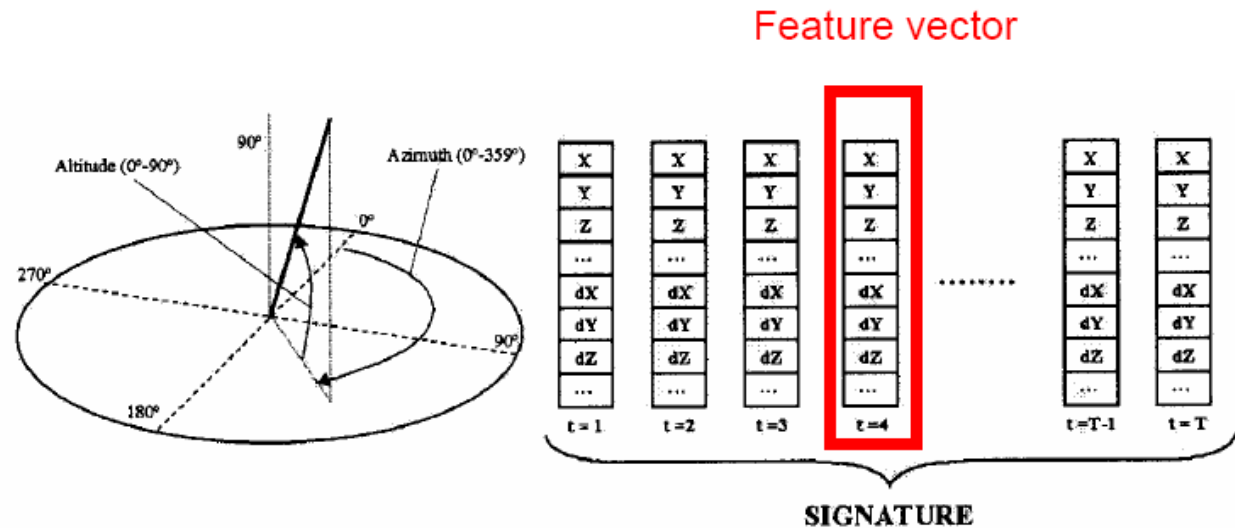


- Features:
1. coordinate X
 2. coordinate Y
 3. pressure
 4. pen azimuth ($0^\circ - 359^\circ$)
 5. pen altitude ($0^\circ - 90^\circ$)





Dynamic signature



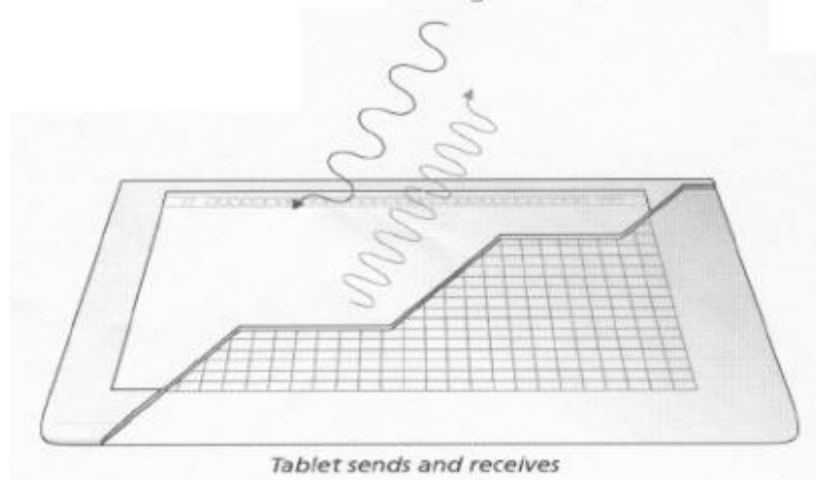
Acquisition:

- 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

	
Template signature #1	Template signature #2
	
Template signature #3	Template signature #4
	
Template signature #5	Template signature #6
	
Authentic signature (accepted)	Forged signature (rejected)



laboratory
Gerstner



Hand geometry



5. Hand geometry

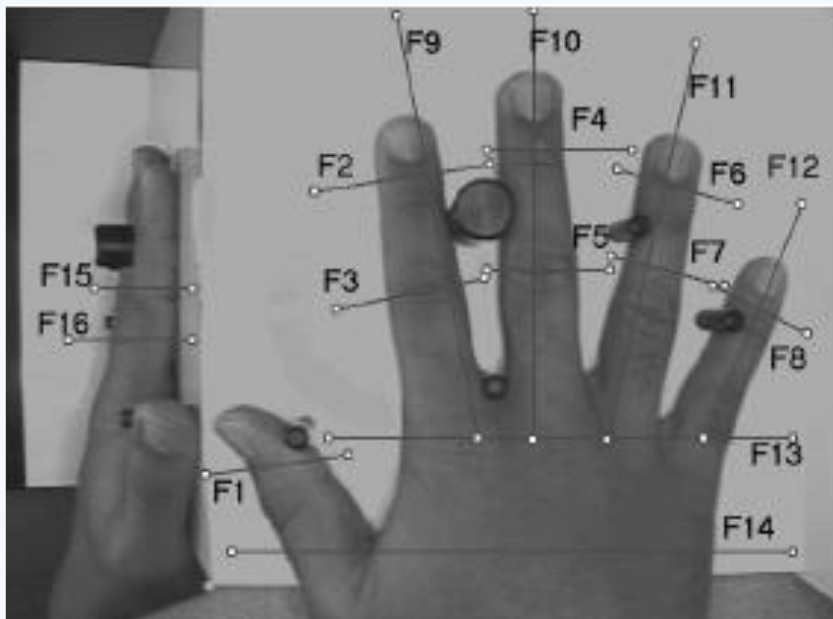


- Hand geometry systems are commonly available in two main forms. Full hand geometry systems take an image of the entire hand for comparison while Two Finger readers only image two fingers of the hand.
- Hand recognition technology is currently one of the most deployed biometrics disciplines world wide



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.



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

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

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

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

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

Applications



BenGurion Airport – Tel-Aviv,
Hand Geometry



JFK International Airport
1998

[INSPASS - Hand
Geometry](#)



laboratory
Gerstner

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



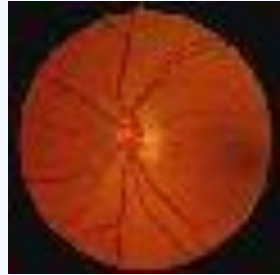
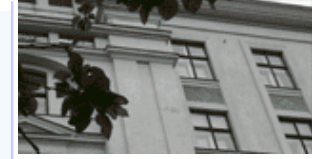
Comparison Chart: DNA



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](#)



1 12/21



III. Thermograms

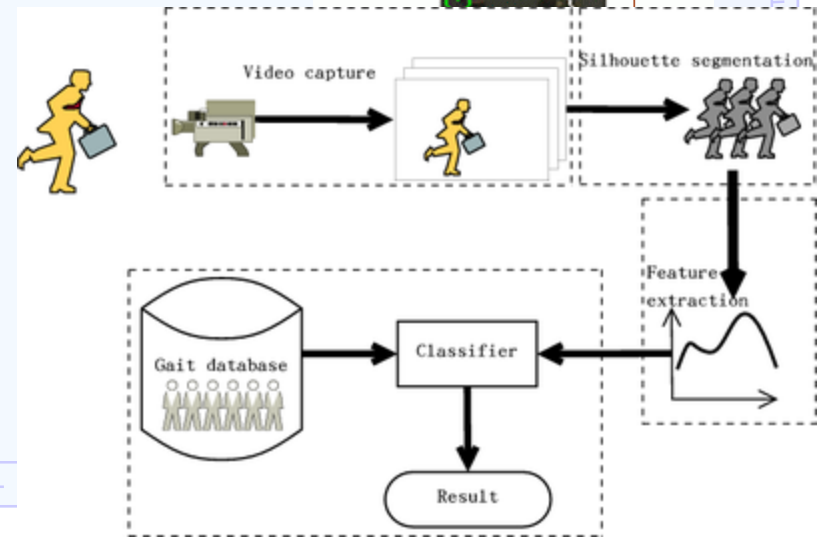
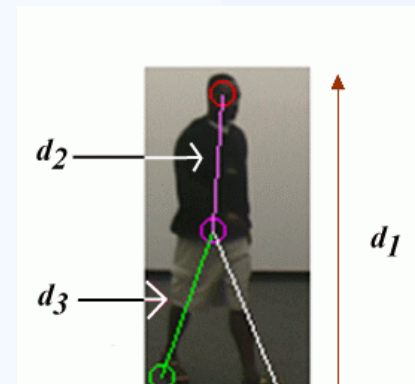
- Thermograms requires an infrared camera to detect the heat patterns of parts of the body that are unique to every human being (such as the face)
- Normally expensive because of the sensors
- Useful paper: [Illumination Invariant Face Recognition Using Thermal Infrared Imagery](#) (Solikinski & als)





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

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

Vyhledat...

Google

HNED.cz HNZPRÁVY HNBYZNYS HNLIFE HNTech HNSPORT HNDIALOG
POLITIKA 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



Pospíšil vysvětlí Rampu odvolá

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



0 velikost písma



REKLAMA

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

Hlásíme plně naloženo

S tarifem **Podnikatel Plus 1100** získáte

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

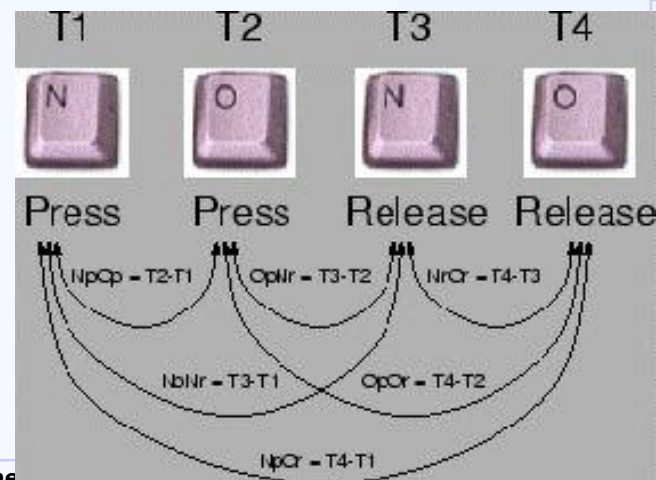
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Gerstner



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

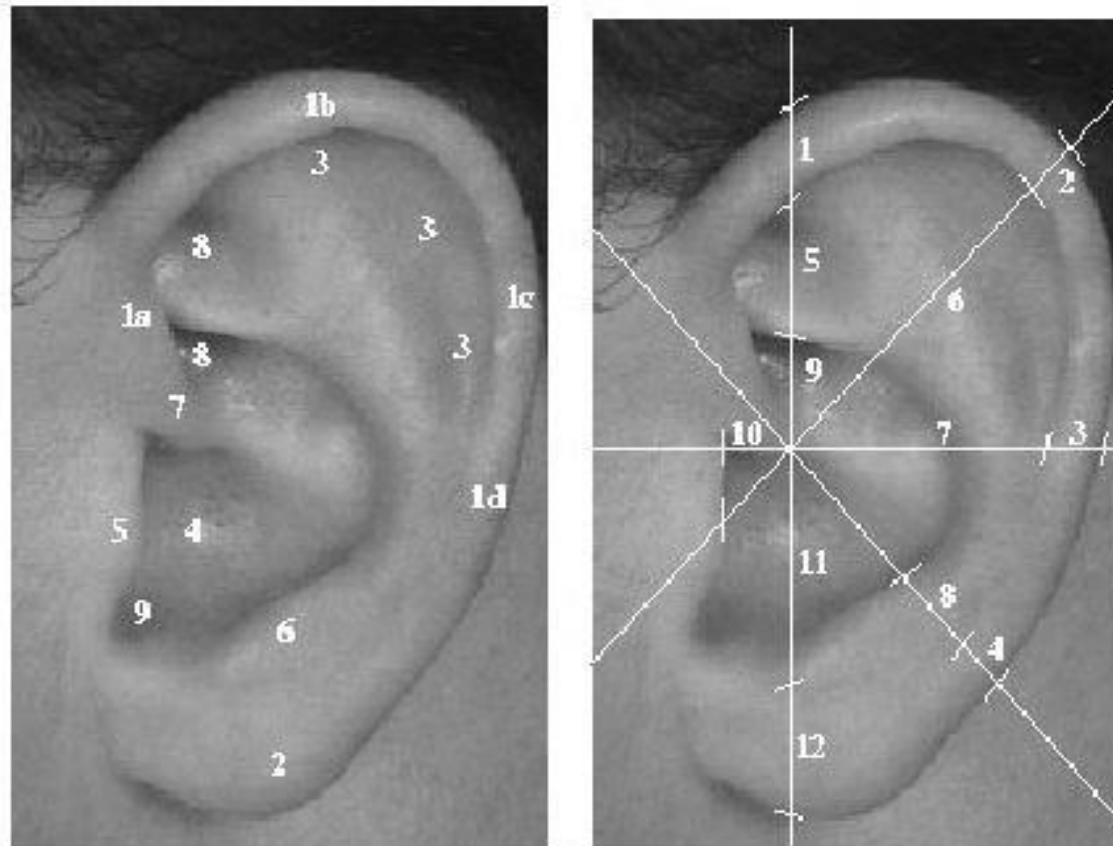
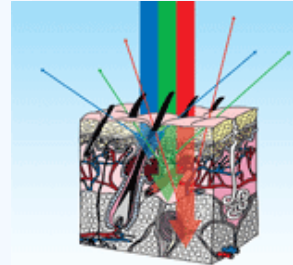


Fig. 2. (a) Anatomy, (b) Measurements. (a) 1 Helix Rim, 2 Lobule, 3 Antihelix, 4 Concha, 5 Tragus, 6 Antitragus, 7 Crus of Helix, 8 Triangular Fossa, 9 Incisure Intertragica. (b) The locations of the anthropometric measurements used in the “Iannarelli System”. (Burge et al., 1998)



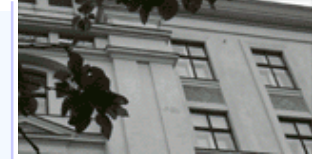
VII. Skin reflection

- [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)



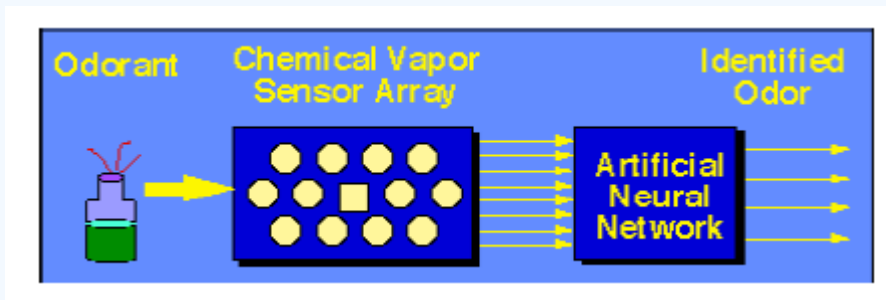
IX. Body odor

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.



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



Schematic Diagram of Artificial nose

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

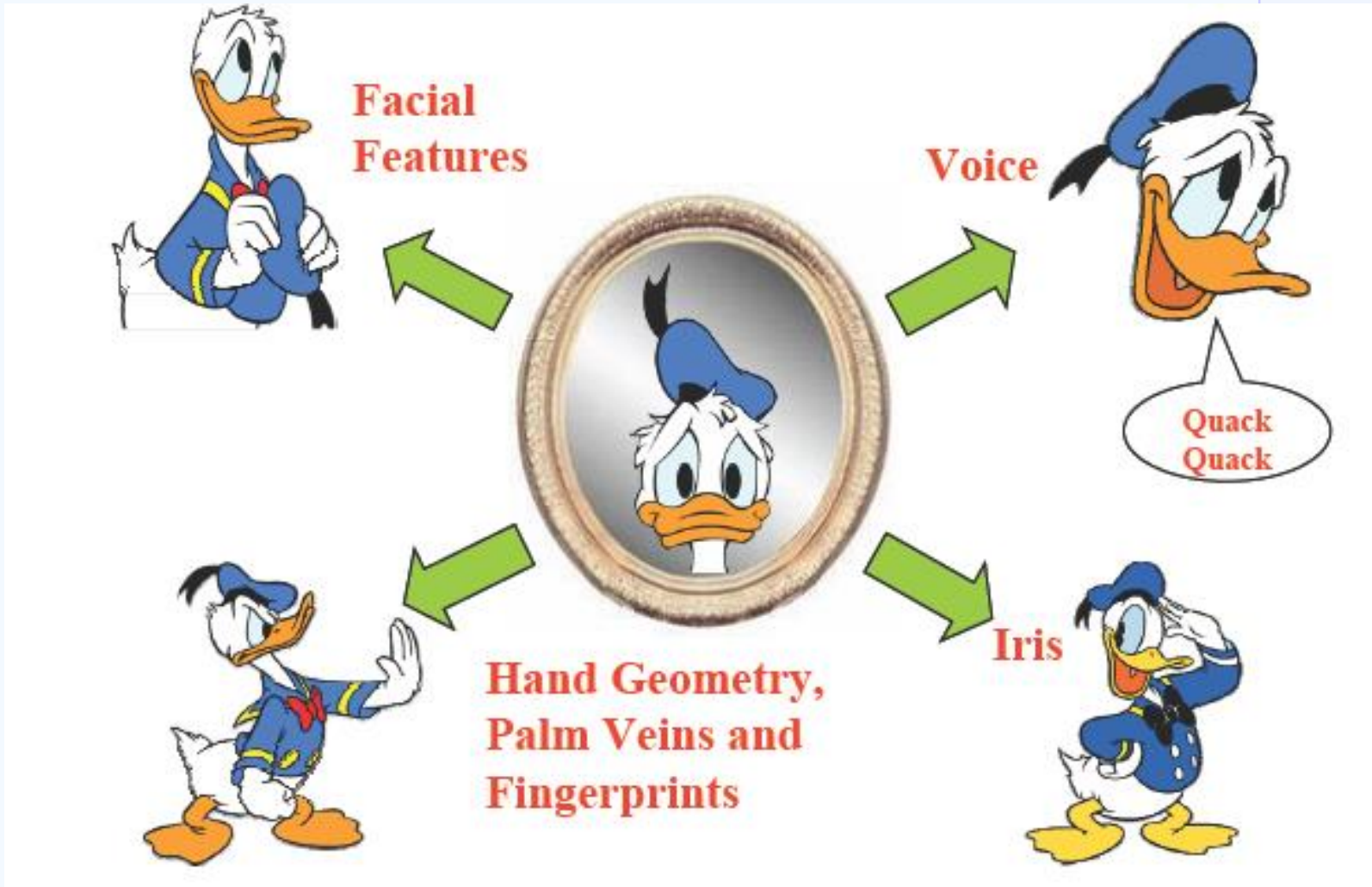


X. Heartbeats

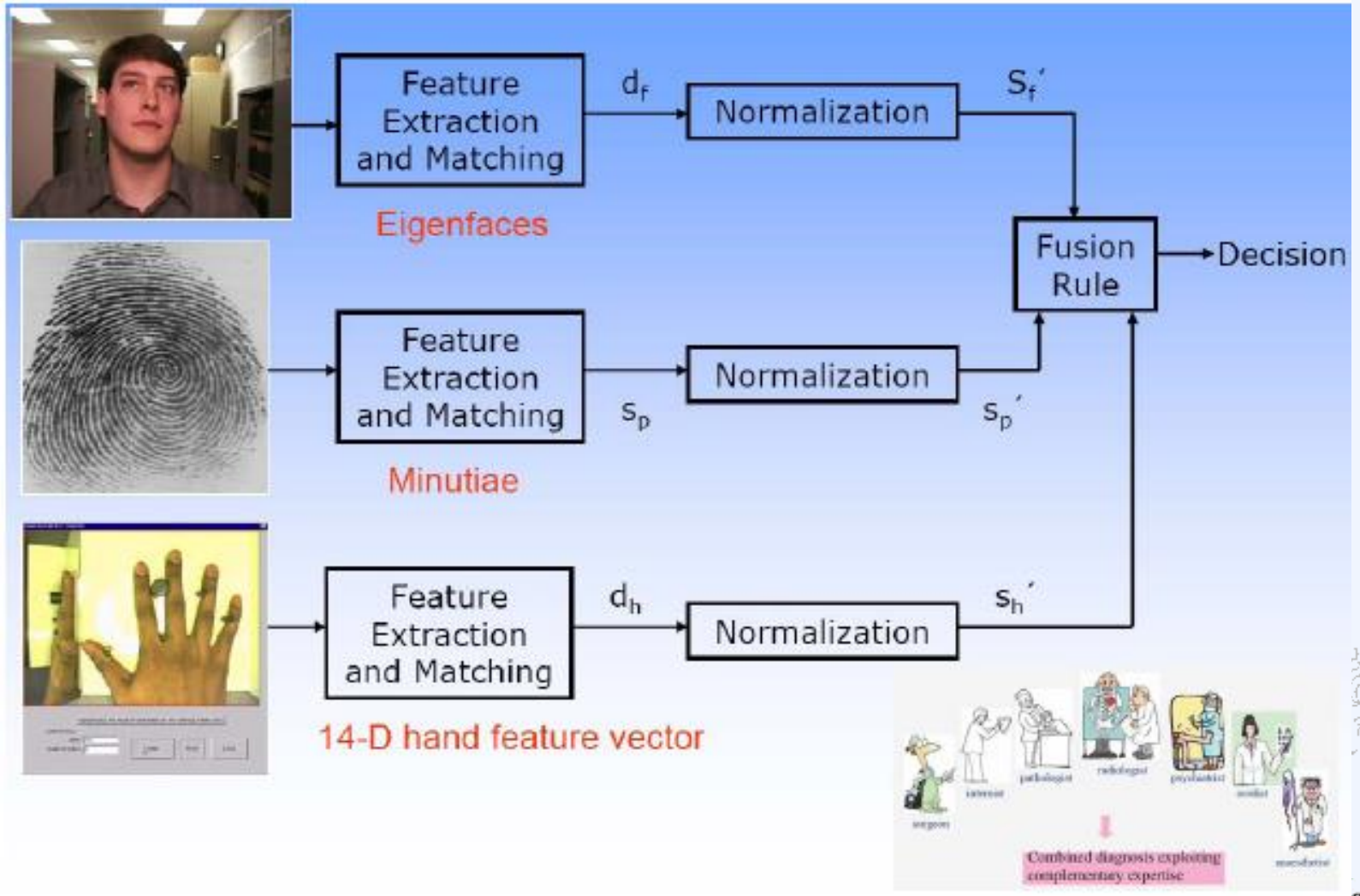
- Based on differing heartbeat patterns in each person
- [Bionym Nimy wristband](#) – commercially available (preorder, as of 09/2013)
- Security?



Multimodal Biometrics



Fusion after normalization



Comparison 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

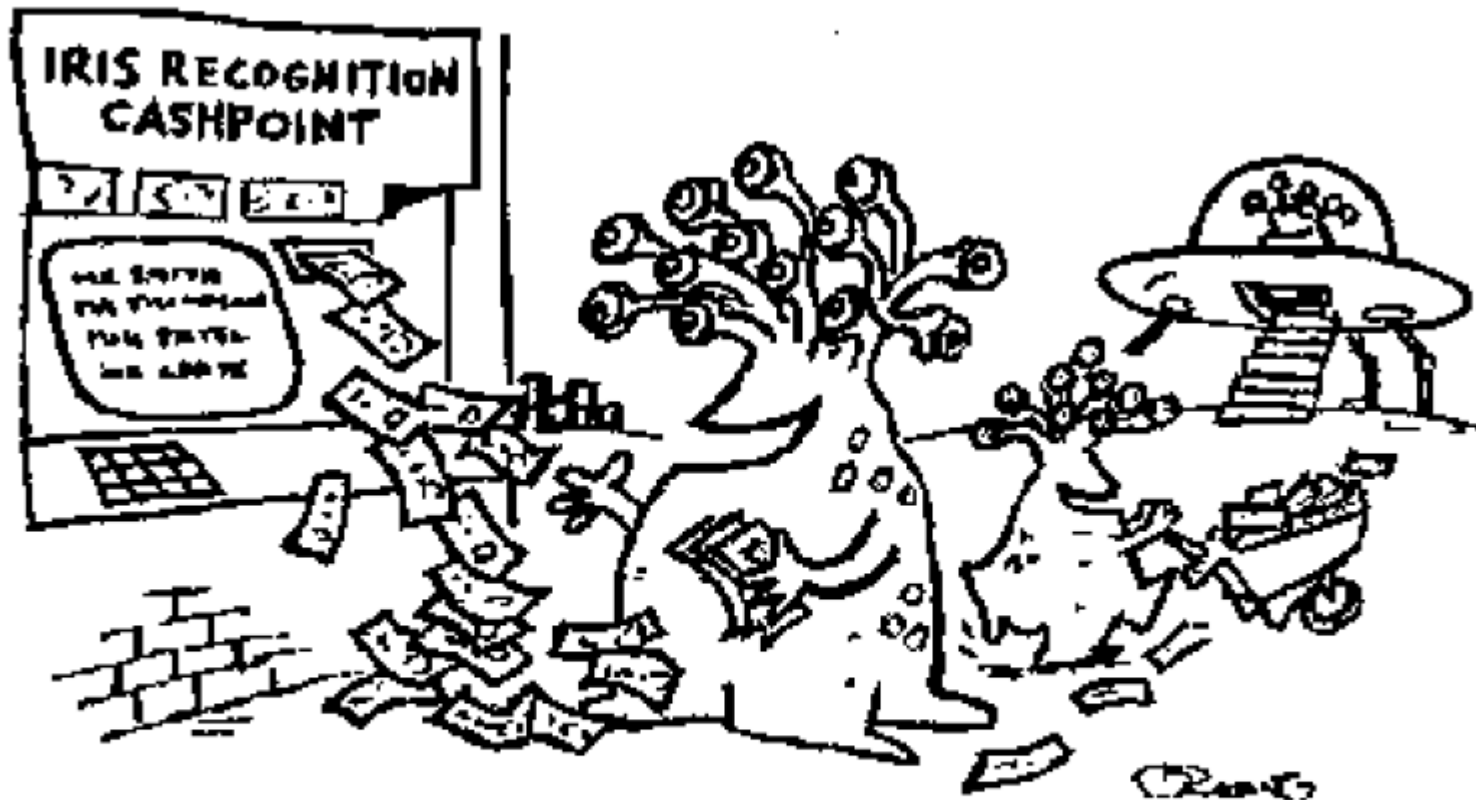


THANK YOU!





Possible Future Events



Why news about iris recognition triggered an alien invasion