

Biometrics Introduction

By
Hafez Barghouthi

Definition

"Biometric Technologies" are
automated methods
of verifying or recognizing the identity of a **living**
person based on
a **physiological**
or **behavioural** characteristic

Definition Explaining

- Automated
 - Different from human identification
- Living person
 - Single persons, no groups
 - Alive not dead (just JOKING)😊

Definition Explaining

- Physiological biometrics
 - Fingerprint, Iris, Face, Hand
- Behavioural biometrics
 - Signature, Gait, Voice

History - 1

- Dates back to ancient Egypt
- Anthropometry (bodily measurements):
 - Adolphe Quetelet (1871), Belgian mathematician
 - Alphonse Bertillon (1880's), French policeman
- Fingerprints and palmprints
 - Used already by Babylonian kings
 - Jan Evangelista Purkinje, Czech studying sweat glands
 - Juan Vucetich, Argentinian policeman, first to take fingerprints in ink
 - Francis Galton, Edward Henry: Galton-Henry system for classification

History - 2

- Fingerprints and facials, 1880's, Henry Faulds, William Herschel and Francis Galton
- fingerprint recognition on current form, 1960's
- Hand geometry, 1970's
- Retinal, signature and face verification, 1980's
- Iris recognition, 1990's
- Newer and newer: gait, keystroke dynamics, mouse movement, cardiac sounds, brain waves

Positive / Negative

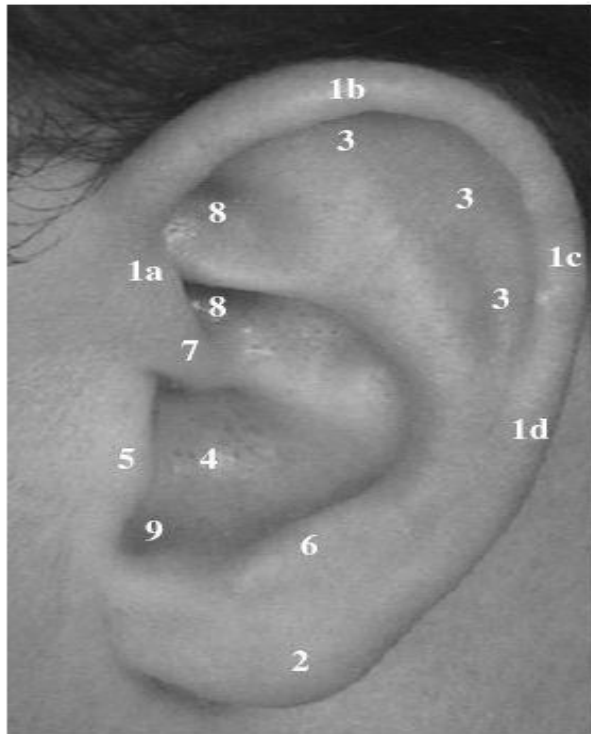
- Positive recognition
 - To prevent multiple people from using the same identity
- Negative recognition
 - To prevent one person from using multiple identities

Physiological / Behavioural

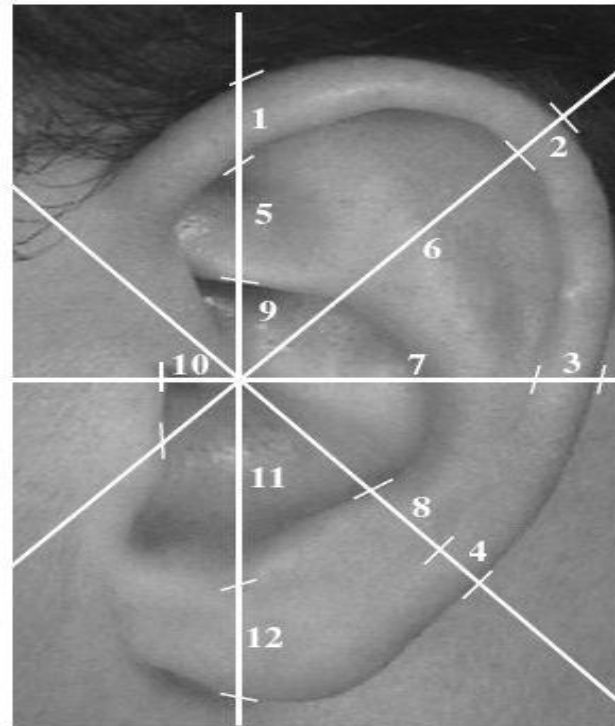
- Physiological:
 - Physical features "unchangeably" attached to a person
 - E.g. fingerprint, DNA, and face
- Behavioural:
 - Behaviour that is very specific to a person
 - E.g. signature, gait, and voice

Examples - Ear

- Shape of ear can be used for authentication



(a) Anatomy.



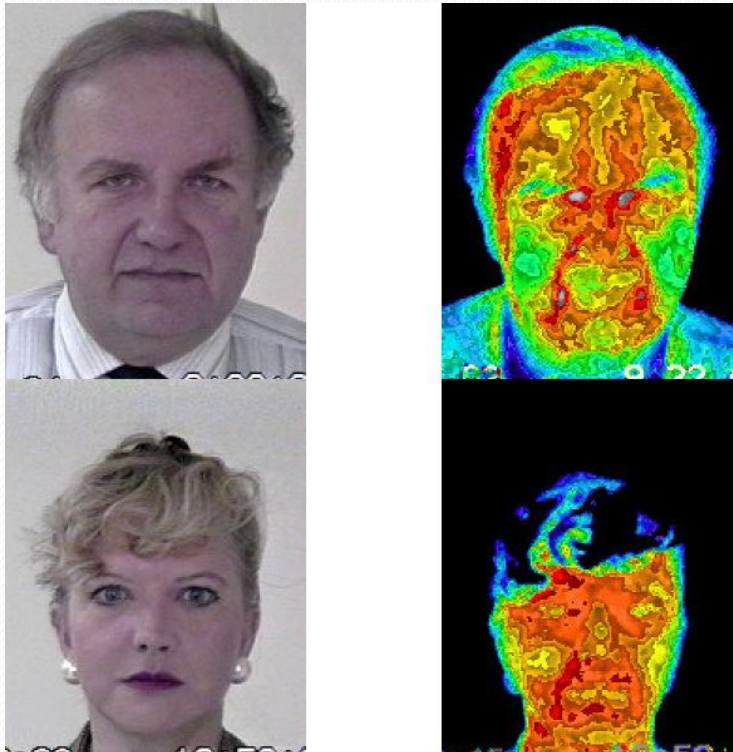
(b) Measurements.

Examples - Face

- Used by humans
- Many different techniques available

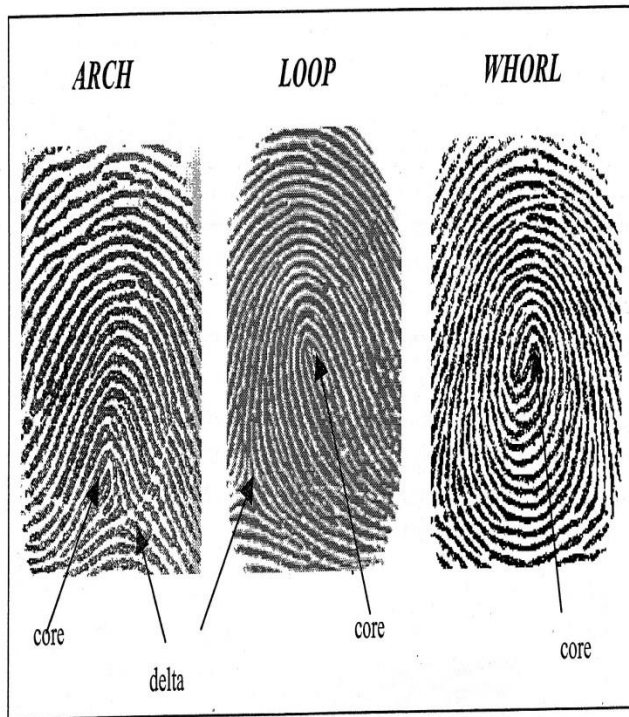
Examples - Thermograms

- Facial, hand, hand vein

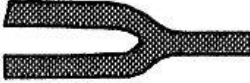


Examples - Fingerprint

- Global features

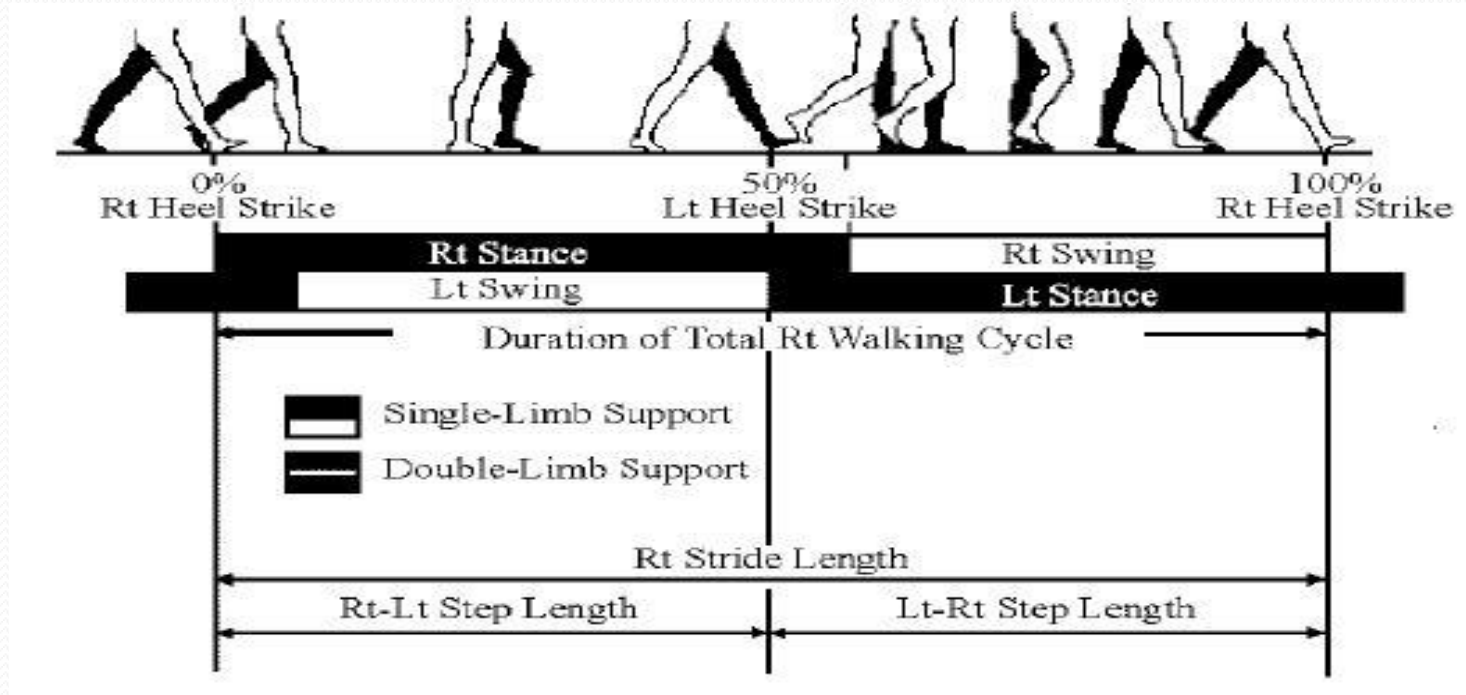


Local features

	Termination
	Bifurcation
	Lake
	Independent ridge
	Point or island
	Spur
	Crossover

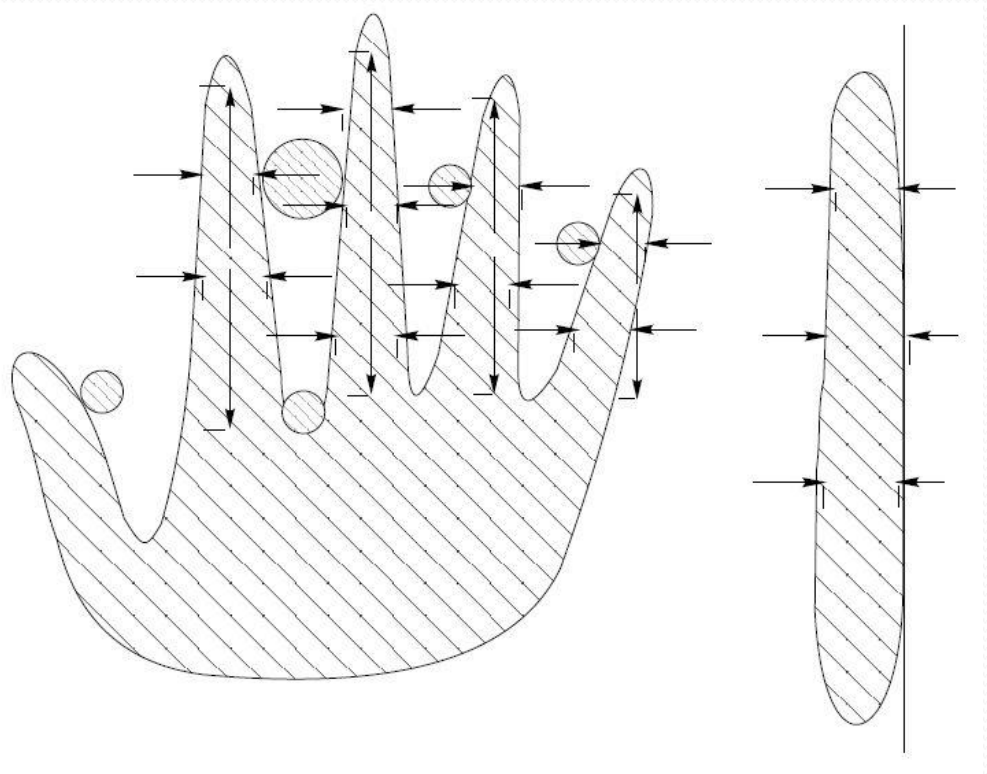
Examples - Gait

- "Great Juno comes; I know her by her gait" from "The Tempest" by Shakespeare



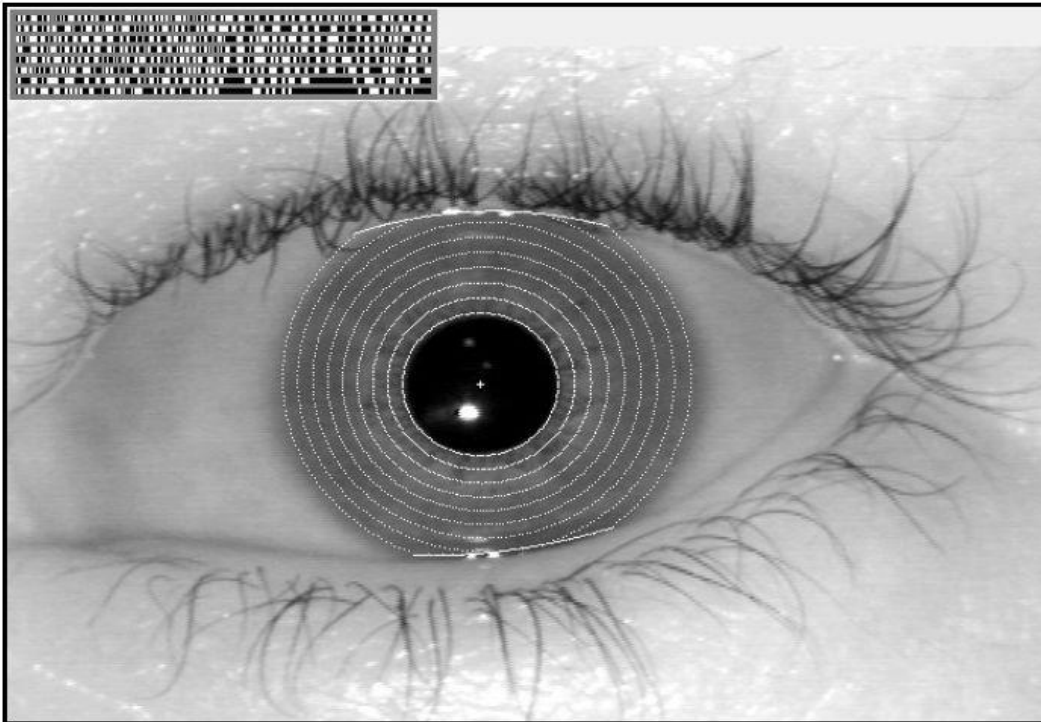
Examples - Geometry

- Hand and finger geometry



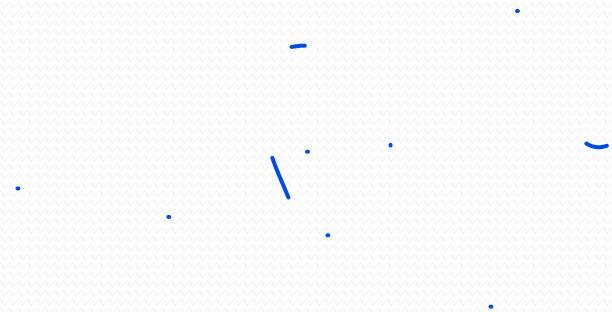
Examples - Iris

- Remains unchanged after 2 years
- Iris code.



Examples - Keystroke

- Typical way of typing
- Combinations of keys
- Speed, force and press-down

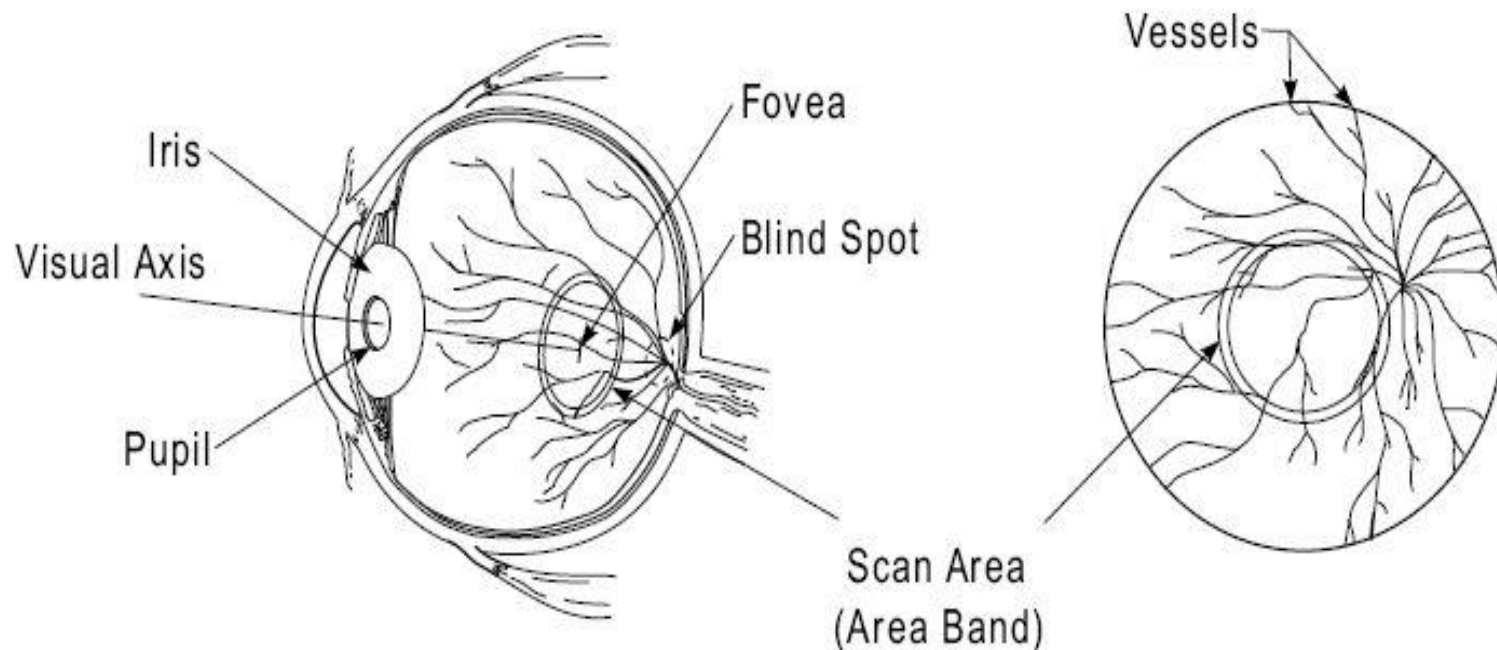


Examples - Odor

- Used by humans
- Many problems

Examples – Retinal Scan

- Supposed to be the most secure biometric
- Not user friendly



Characteristics - overview

- Universality
- Distinctiveness
- Permanence
- Collectability
- Performance
- Acceptability
- Circumvention

Characteristic - Universality

- Each person should have the characteristic
 - Failure to Enroll Rate (FER)

Distinctiveness

- Different persons should have different biometric properties
 - False Match Rate (FMR)

Characteristic – Permanence

- The characteristic should be sufficiently invariant over a period of time
 - False Non-Match Rate (FNMR)

Characteristic – Collectability

- The biometric property should be easy to collect (electronically) and to quantify

Characteristic – Performance

- This refers to the achievable recognition accuracy and speed
 - False Non Match Rate (FNMR)
 - Failure to Capture Rate (FCR)

Characteristic – Acceptability

- To which extent are people willing to accept the use of a specific biometric

Characteristic – Circumvention

- Reflects how easy it is to fool the system
 - False Match Rate (FMR)

Application Environments

- Overt vs. covert
- Habituated vs. non-habituated
- Attended vs. non-attended
- Standard vs. non-standard
- Public vs. private
- Open vs. closed

Overt vs. covert

- Overt:
 - User is aware that the biometric feature is being measured (e.g. finger on a fingerprint reader)
- Covert:
 - User is unaware that the biometric feature is being measured (e.g. face recognition)

Habituated vs. non-habituated

- Habituated:
 - System is used on a daily basis (e.g. to have access to the PC at work)
- Non-habituated:
 - System is used irregularly (e.g. to access a personal safe in a bank)

Attended vs. non-attended

- Attended:
 - Use is observed and guided by system management (e.g. access to a building)
- Non-attended:
 - No observation or (regular) help is provided (e.g. access to PC)

Standard vs. non-standard

- Standard:
 - System is in a static environment with controlled conditions (e.g. fixed lighting and background for face recognition)
- Non-standard:
 - System in a dynamic environment (e.g. background noise for voice recognition)

Public vs. private

- Public:
 - “Anybody” can use the system (e.g. voice recognition for bank transfers via phone)
- Private:
 - Only employees can use the system (e.g. access to a factory or office building)

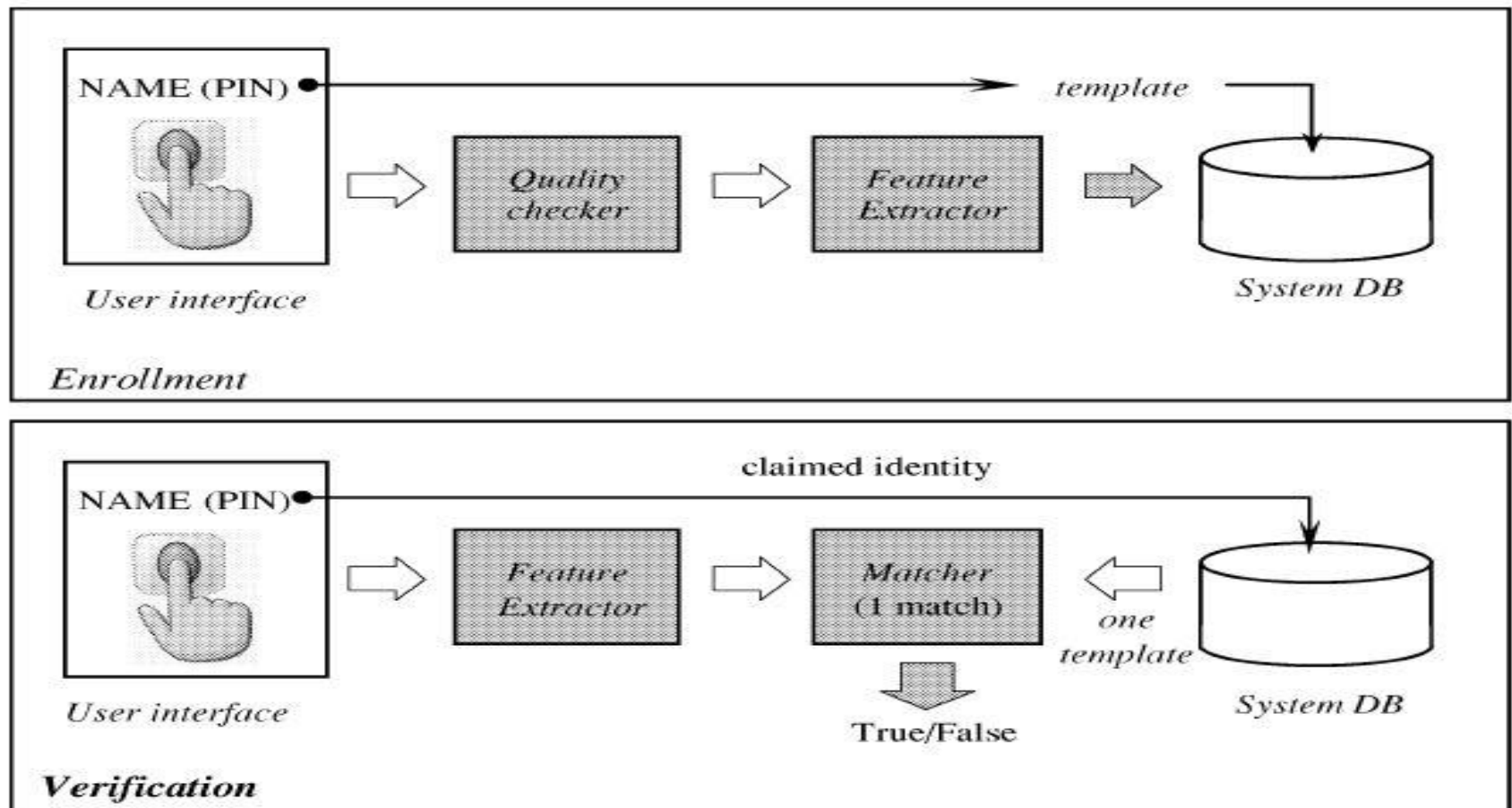
Open vs. closed

- Open:
 - System can interact with other (biometric) system (e.g. biometric passport)
- Closed:
 - System is stand-alone and no information is shared (e.g. systems to access classified information)

Biometrical Systems

- A biometrical systems consists of 2 modules:
 - Enrollment module
 - Template created and stored in database
 - Authentication module
 - Checked against stored template

Biometrical Systems



Errors

- False Non-Match Rate (FNMR)
- False Match Rate (FMR)
- False Rejection Rate (FRR) (used wrongly in literature). USE (FNMR) instead
- False Acceptance Rate (FAR) used wrongly in literature. USE (FMR) instead
- Failure to Enroll Rate (FER)
- Failure to Capture Rate (FCR)

Hypotheses and decisions

- H_0 : input biometric does **not** belong to the same person as the template biometric
- H_1 : input biometric does belong to the same person as the template biometric
- D_0 : Person is **not** who he claims to be
- D_1 : Person is who he claims to be

False Match Rate (FMR)

- Probability that a false claimed identity is not recognized as false
- Also called *Type I Error*
- Probability that D_1 is decided, given that H_0 is true:
 - $\text{Prob}(D_1 | H_0)$
- Depends on a threshold t

False Non-Match Rate (FNMR)

- Probability that a correctly claimed identity is not recognized as true
- Also called *Type II Error*
- Probability that D_o is decided, given that H_1 is true:
 - $\text{Prob}(D_o | H_1)$
- Depends on a threshold t

Failure to Enroll Rate (FER)

- Probability that a person cannot enroll in the biometric system
- Person doesn't have biometric feature
- Person has poor quality biometric feature
- Trade-off between FMR/FNMR and FER

Failure to Capture Rate (FCR)

- Probability of failure to capture the biometric feature when trying to authenticate
- Bad capturing conditions
 - Too dark for face recognition
 - Dirty fingerprint reader
 - Background noise for voice recognition

Equal Error Rate (EER)

- EER is the point where FMR and FNMR are equal

Distance metrics - 1

- In biometrics we need to compare extracted features that will differ a bit every time they are measured
- Need a way to compare extracted features
- "Inter person" distance must be large
- "Intra person" distance must be small

Distance metrics - 2

- We want to know how far 2 sequences $\mathbf{x}$ and $\mathbf{y}$ are apart or how close together they are.
- Let $\mathbf{x} = (x_1, x_2, \dots, x_n)$
- Let $\mathbf{y} = (y_1, y_2, \dots, y_n)$
- Assume $\mathbf{x}$ can be compared to $\mathbf{y}$

Absolute Distance

- Sum the absolute differences between each of the components of $\mathbf{x}$ and $\mathbf{y}$
- $d_1(\mathbf{x}, \mathbf{y}) = \sum |x_i - y_i|$
- Extremely easy to calculate

Euclidean Distance

- Sum the squares of the differences between each of the components of $\mathbf{x}$ and $\mathbf{y}$
- $d_2(\mathbf{x}, \mathbf{y}) = \sqrt{\sum (x_i - y_i)^2}$
- Also easy to calculate

Maximum Difference Distance

- The distance between $\mathbf{x}$ and $\mathbf{y}$ is defined as the maximum absolute difference of its components
- $d_3(\mathbf{x}, \mathbf{y}) = \max |x_i - y_i|$
- Extremely easy to calculate

More distance metrics?

- Many more distance metrics possible
- Sometimes first a mathematical transformation of the data is needed
- Not all parts of the data need to be taken into account

Threshold

- Features are extracted from biometric characteristic
- Features are compared to template
- Distance metric gives distance d
- Use of threshold t
- $d \leq t$: authentication OK
- $d > t$: authentication NOT OK

Example - Distance scores

	Templ 1	Templ 2	Templ 3	Templ 4	Templ 5
Test 1	0,182	0,588	0,435	0,208	0,909
Test 2	0,323	0,213	0,286	0,476	0,244
Test 3	0,909	0,625	0,147	0,476	1,111
Test 4	0,238	0,294	0,476	0,256	0,526
Test 5	0,588	0,454	1,250	0,526	0,130

Example – FNMR/FMR

- If $t=0.256$ we see that
 - $(\text{FNMR}, \text{FMR}) = (0/5, 3/20)$
- If $t=0.213$ we see that
 - $(\text{FNMR}, \text{FMR}) = (1/5, 1/20)$
- If $t=0.212$ we see that
 - $(\text{FNMR}, \text{FMR}) = (2/5, 1/20)$
- If $t=0.207$ we see that
 - $(\text{FNMR}, \text{FMR}) = (2/5, 0/20)$

ROC Curve

- ROC: Receiver Operating Characteristic

