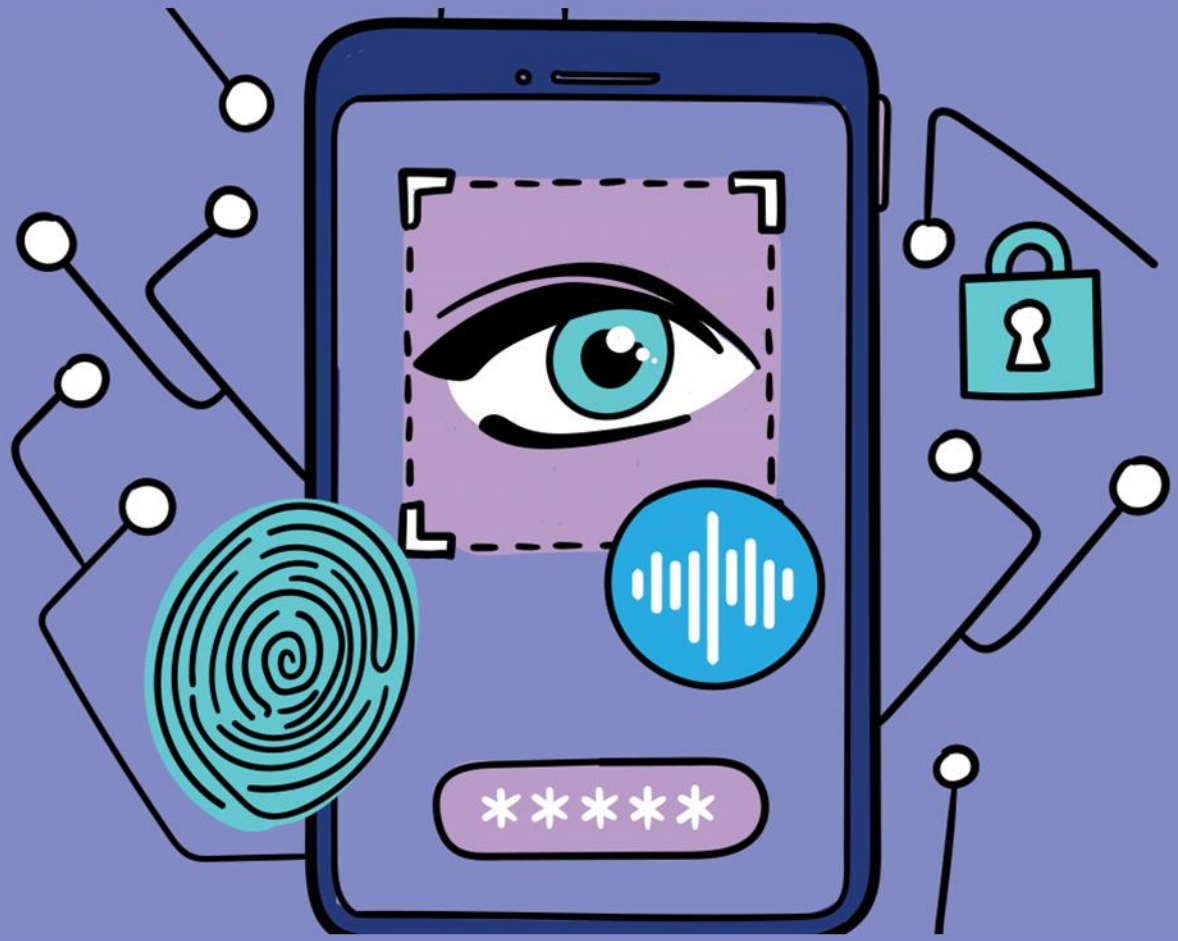
Chapter 4
Biometrics



Definition

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

Automated : Different from human identification

Living person: - Single persons, no groups
- Alive not dead

Definition

Physiological biometrics

Fingerprint , Iris, Face, Hand (unchangeable)

Behavioral biometrics

Signature, Gait , Voice (very specific to a person)

Positive / Negative :

- **Positive recognition** منع عدة أشخاص من استخدام نفس الهوية

To prevent multiple people from using the same identity

Negative recognition منع الشخص من استخدام اكثر من هوية واحدة

To prevent one person from using multiple identities

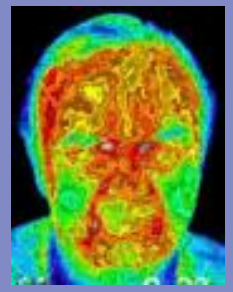
Examples – Ear

Shape of ear can be used for authentication

- Face

Used by humans
Many different techniques available

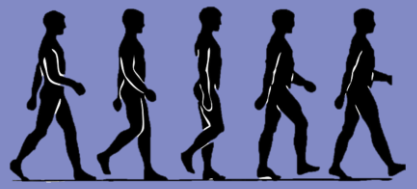
- Thermograms



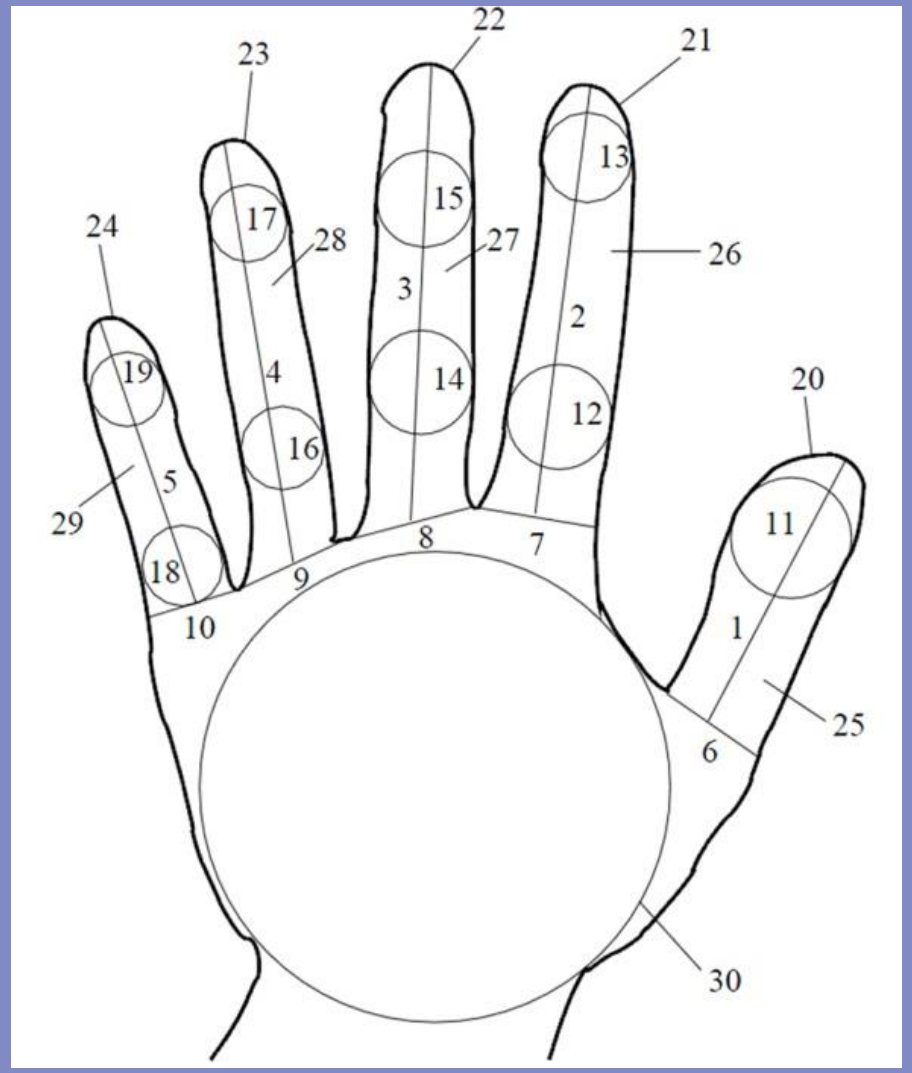
Facial, hand, hand vein

- Fingerprint

- Gait



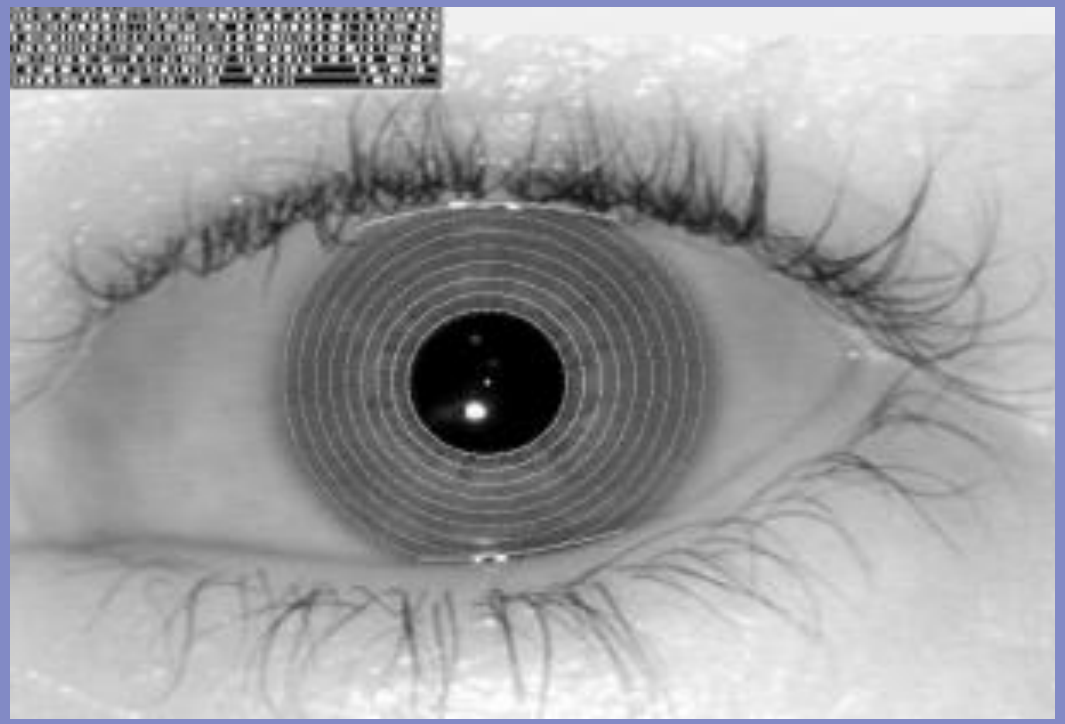
Geometry



Iris

Remains unchanged after 2 years

Iris code



Keystroke (طريقة الكتابة على الكيبورد)

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

Odor (رائحة الشخص)

Used by humans

Many problems

Retinal Scan (الشعيرات الدموية الخاصة بالعين)

Supposed to be the most secure biometric

Not user friendly

Characteristics

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

Universality (كل شخص يجب ان يكون لديه صفة مميزة مثل بصمة الاصبع)

Each person should have the characteristic

Failure to Enroll Rate (FER)

Distinctiveness (كل شخص لديه قياسات حيوية مختلفة عن الاخر)

Different persons should have different biometric properties

False Match Rate (FMR)

Permanence (يجب أن تكون الخاصية ثابتة بما فيه الكفاية على مدى فترة من الزمن)

The characteristic should be sufficiently invariant over a period of time

False Non-Match Rate (FNMR)

Circumvention (يعكس مدى سهولة خداع النظام)

Reflects how easy it is to fool the system

False Match Rate (FMR)

Collectability يجب ان يكون تجميع القياسات الحيوية يجب ان يكون سهلا

The biometric property should be easy to collect

(electronically) and to quantify

Performance يشير هذا إلى دقة التعرف والسرعة التي يمكن تحقيقها

This refers to the achievable recognition accuracy and speed

False Non-Match Rate (FNMR)

Failure to Capture Rate (FCR)

Acceptability موافقة الاشخاص على استخدام قياسات حيوية محددة

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

biometric

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

Covert : user is unaware that the biometric feature is being measured

Habituated vs. non-habituated

Habituated : System is used on a daily basis.

non-habituated : System is used irregularly.

Attended vs. non-attended

Attended : guided users to help them access system

non-attended: No observation or (regular) help is provided

Standard vs. non-standard

Standard : System is in a static environment with controlled conditions (face recognition)

Non – standard : System in a dynamic environment (voice recognition)

Public vs. private

Public : anybody can use the system
Private : only employees can use the system

Open vs. closed

Open: System can interact with other (biometric) system
closed: System is stand-alone, and no information is shared

Biometrical Systems :

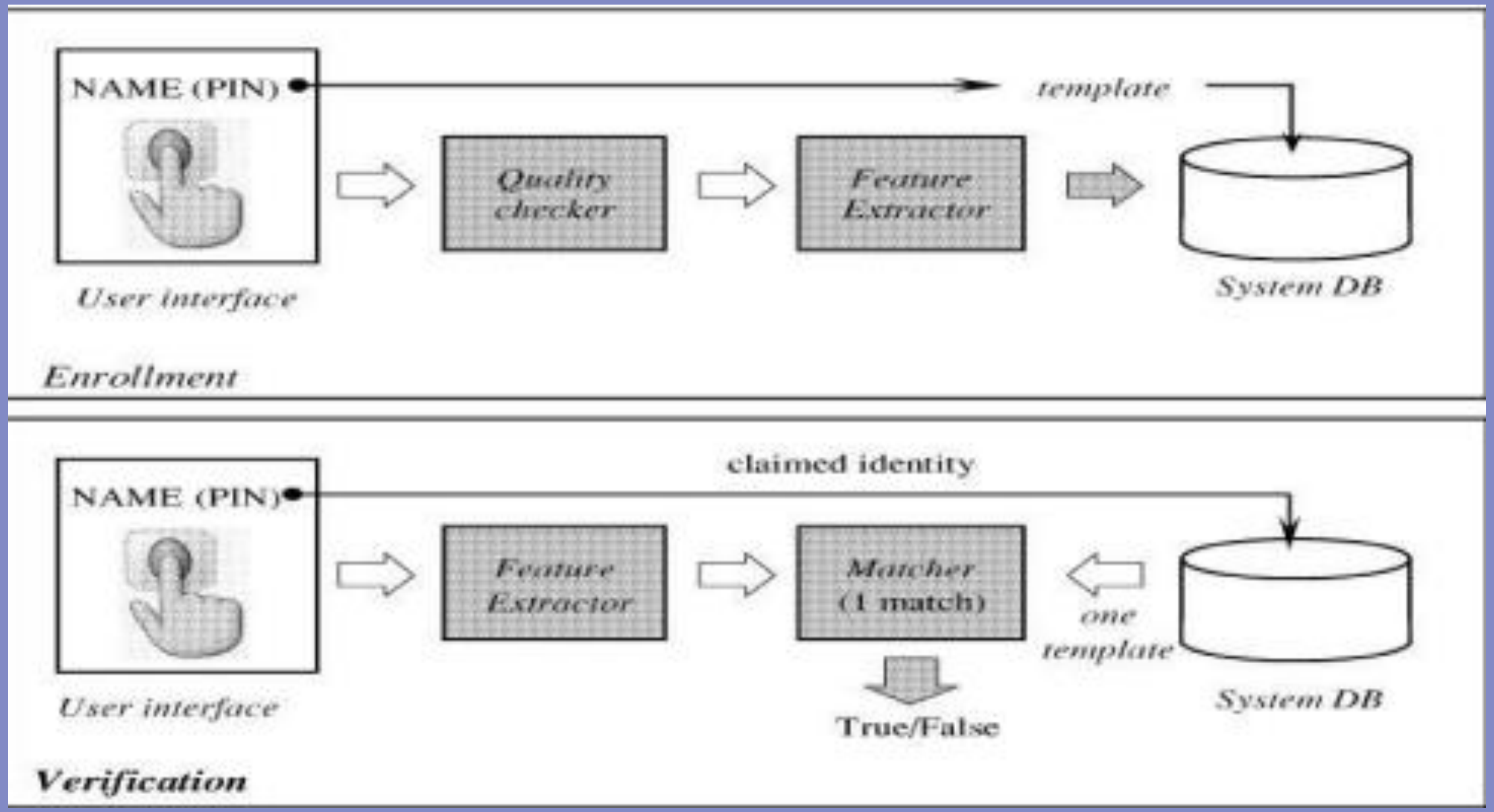
A biometrical systems consists of 2 modules:

- Enrollment module

Template created and stored in database

- Authentication module

Checked against stored template



Errors

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

Hypotheses and decisions

H0 : input biometric does not belong to the same person as the template biometric

H1 : input biometric does belong to the same person as the template biometric

D0 : Person is not who he claims to be

D1 : Person is who he claims to be

False Match Rate (FMR) :

Allowing the wrong person to enter the system, for example, the user Muhammad has an account on a certain site, and Khaled wanted to enter the account, and the system allowed him to enter the system

(D1 | H0)

Depends on a threshold t

False Non - Match Rate (FNMR) :

Not allowing the correct person to enter the system, for example, the user Muhammad has an account on a certain site and the system did not allow him to enter the system

(Do | H1)

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 x and y are apart or how close together they are.

Let $x = (x1,x2,\ldots,xn)$

Let $y = (y1,y2,\ldots,yn)$

Assume x can be compared to y

Absolute Distance

Sum the absolute differences between each of the components of x and y

$$d1(x,y) = \Sigma \mid xi-yi \mid$$

Extremely easy to calculate

Euclidean Distance

Sum the squares of the differences between each of the components of x and y

$$d2\,(x,y) = \sqrt{\left[\ \Sigma\ (\ xi-yi)^2\ \right]}$$

Also easy to calculate

Maximum Difference Distance

The distance between x and y is defined as the maximum absolute difference of its components

$$d_3(x,y) = \max |x_i - y_i|$$

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 ≤ 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

(FNMR,FMR) = (0/5 , 3/20)

If t=0.213 we see that

(FNMR,FMR) = (1/5 , 1/20)

If t=0.212 we see that

(FNMR,FMR) = (2/5 , 1/20)

If t=0.207 we see that

(FNMR,FMR) = (2/5 , 0/20)