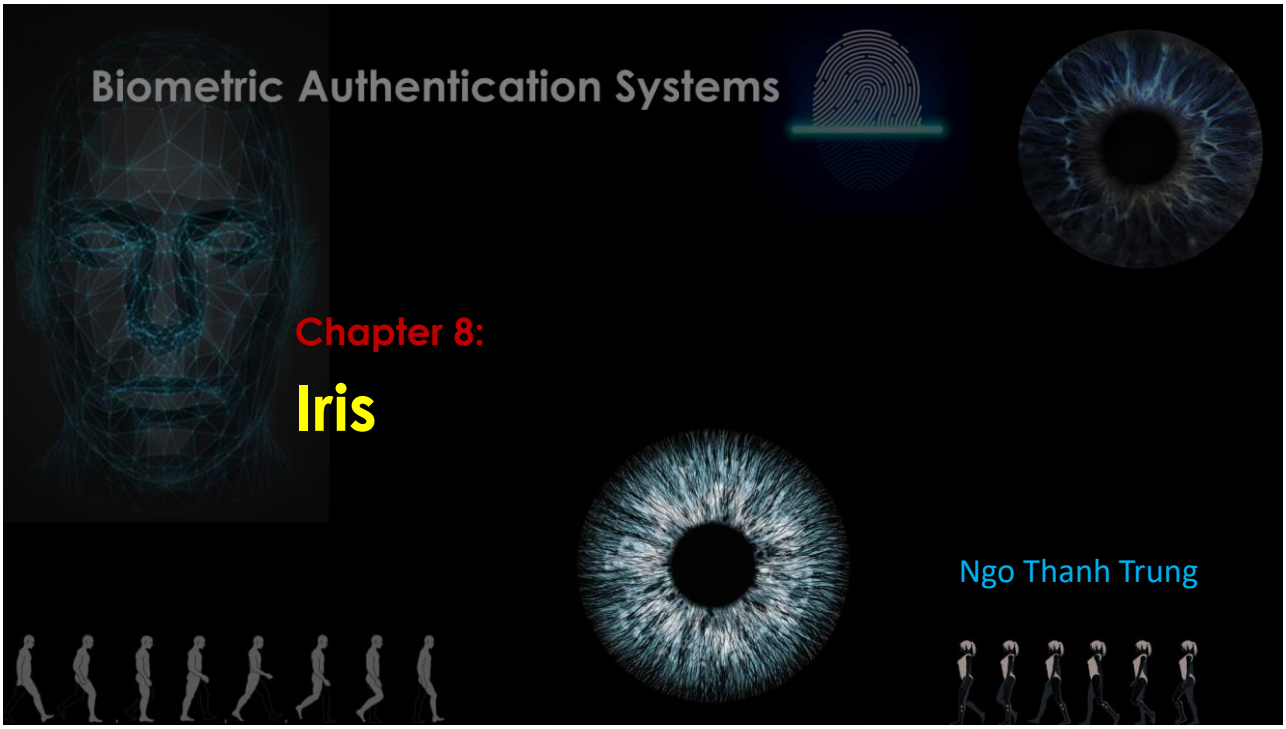
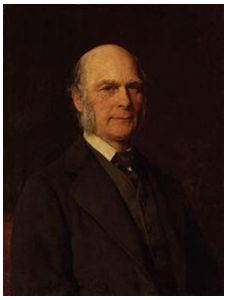



## Review of fingerprint

# 1- Fingerprint

- *"Perhaps the most **beautiful** and **characteristic** of all superficial marks are the small furrows with the intervening ridges and their pores…"*

  Francis Galton, *Nature*, June 28, 1888.



Fingerprint

Fingerprint in macro - friction ridge skin

Smooth skin

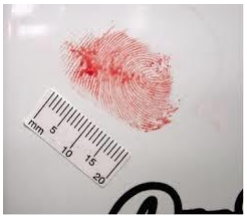
Galton was Charles Darwin's half-cousin

3

# 1- Fingerprint

- 3 types of fingerprint

Which one is hardly visible?



Patent fingerprint

visible marks by transferring materials such as blood, dirt, ink, grease

Plastic fingerprint

formed by fingers leaving three-dimensional impressions in materials such as wet paint, tar, soap, or wax

Latent fingerprint

sweat and oil on the skin's surface

hardly visible under normal condition

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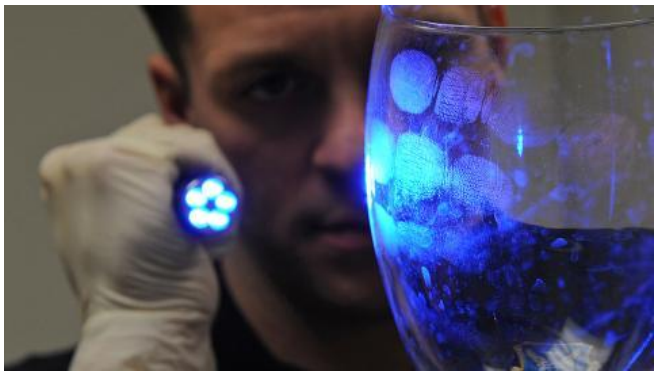
# 2-How to reveal latent fingerprint?



Examining latent fingerprint with light

Enhancing latent fingerprints in criminal scene

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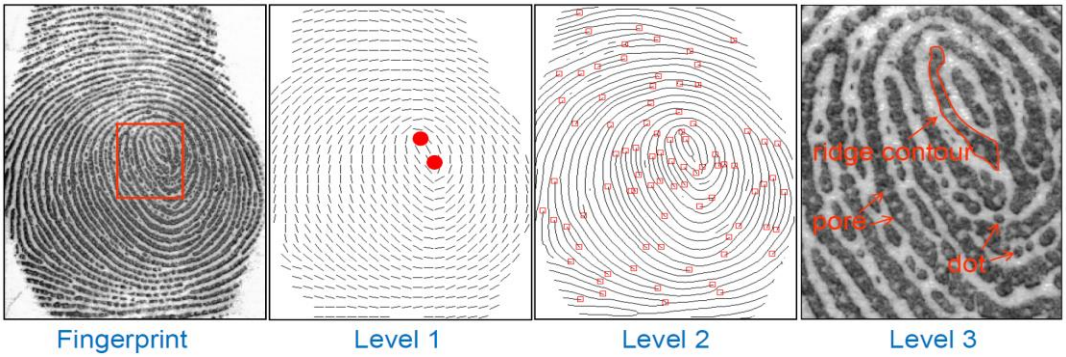
# 3-What features are used in fingerprint recognition?

- Most fingerprint recognition method are feature-based
- Features
  - Different levels: coarse to fine




Features at three different levels in a fingerprint. (a) Grayscale, (b) Level 1 feature (orientation field or ridge flow and singular points), (c) Level 2 feature (ridge skeleton), and (d) Level 3 features (ridge contour, pore, and dot).

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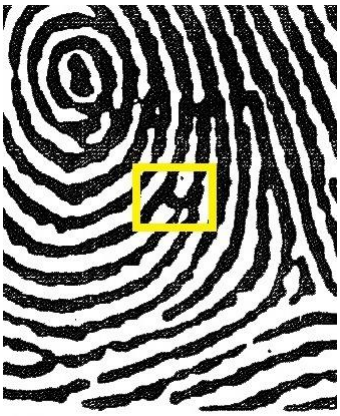
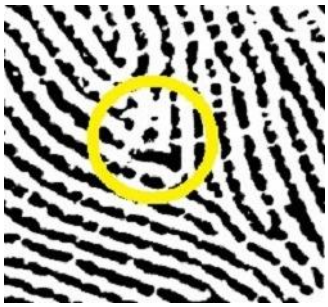
# 4- What are these features? What level?





| | |
|---|---|
| | Termination |
| | Bifurcation |
| | Lake |
| | Independent ridge |
| | Point or island |
| | Spur |
| | Crossover |

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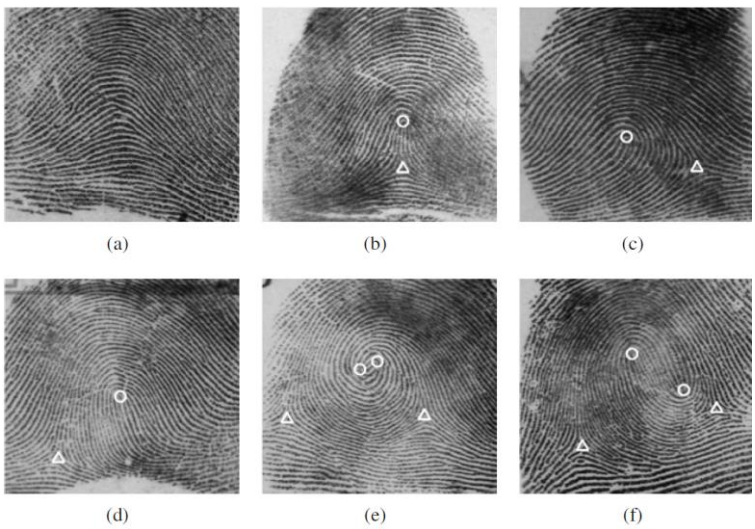
# 5- How to call these features? What level?




Major fingerprint pattern types:
(a) Plain arch,
(b) tented arch,
(c) left loop,
(d) right loop,
(e) whorl, and
(f) twin loop.

A loop is denoted by a circle and a delta is denoted by a triangle. Loop and whorl-type of fingerprints are found most commonly; about 65% of fingerprints belong to loop type, and 24% are whorl-type

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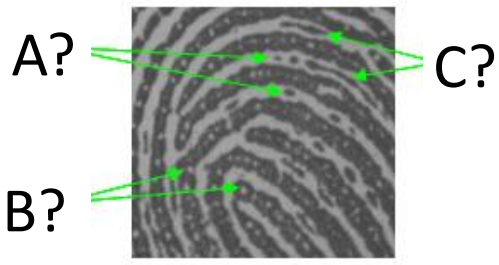
# 6- How to call these features?

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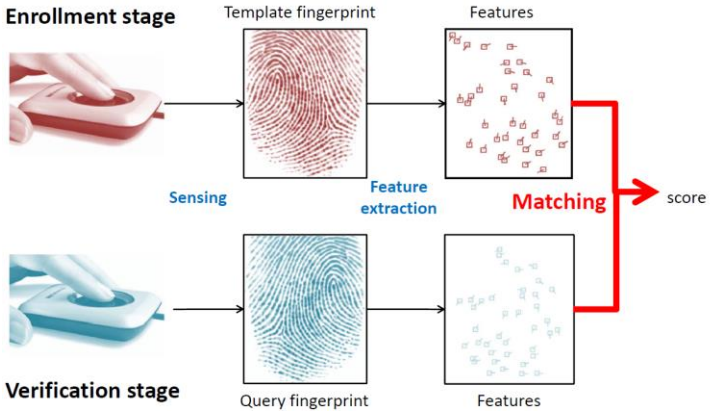
# 7- Fingerprint recognition?

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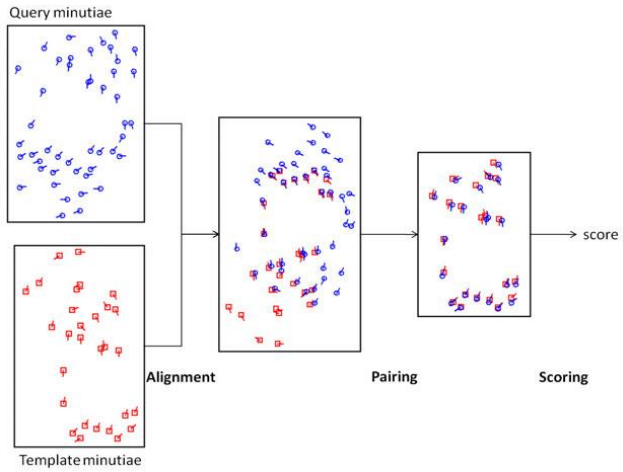
# 8- Minutiae matching?

- Almost all fingerprint matchers are based on minutiae matching.

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# Today Outline:

1- Iris introduction
2- Why the Iris?
3-History of Iris Recognition
4-Applications
5-Methods Of IRIS Recognition System
6- Image acquisition
7-Segmentation
8-Normalization
9-Feature Encoding
10-Feature Matching
11-Disadvantages

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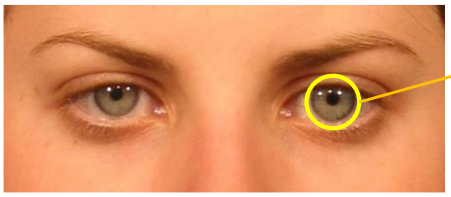
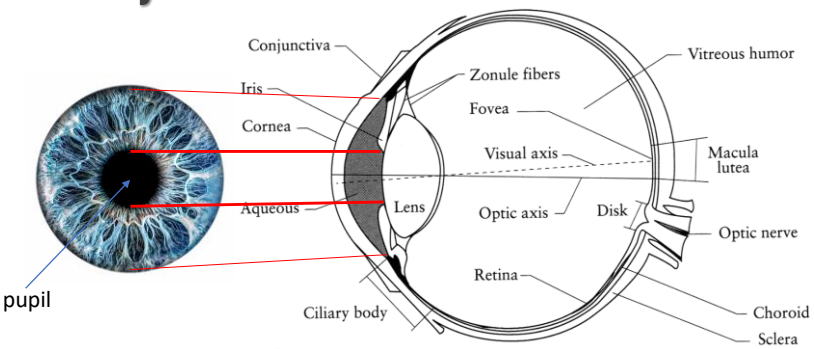
# 1- Iris introduction



iris

Ocular region of human face includes the eyes, eyebrows, nose bridge, and facial skin. The **iris** is the **colored structure** located in the annular region of the eye

# The eye

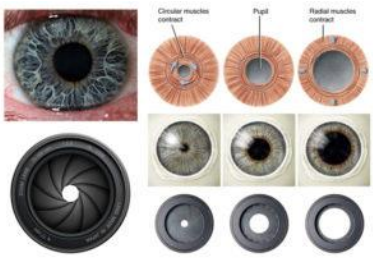




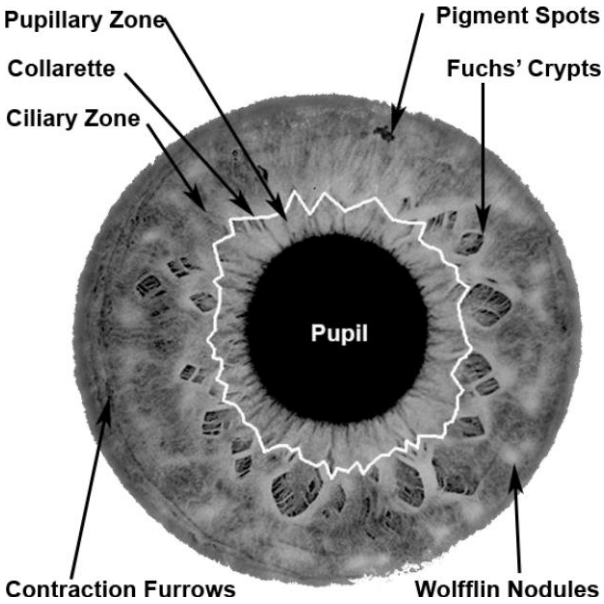
Camera also has iris

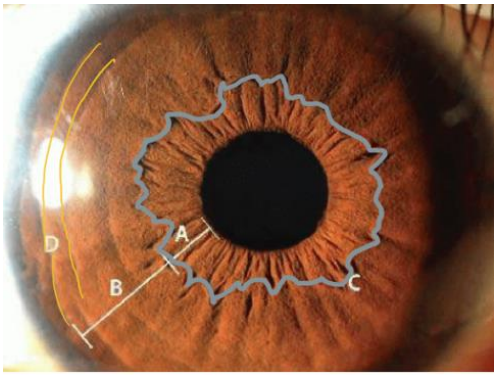
Human iris

Camera iris



# Anatomy of the iris




A: ciliary zone
B: pupillary zone
C: collarette
D: contraction furrows

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# Iris structure is multilayered structure

The cross-section reveals:

- **Posterior layer** at the back: two cells thick, heavily pigmented, block the light
- The **muscle layer** above : sphincter and dilator muscles that contract and dilate the pupil
- The **stromal layer**, above the muscles: collagenous connective tissue (arranged in an arch-like configuration) and blood vessels (arranged along the radial direction)
- The **anterior border layer:** the foremost layer, increased density of chromatophores (i.e., pigment containing cells) compared to the stromal layer.

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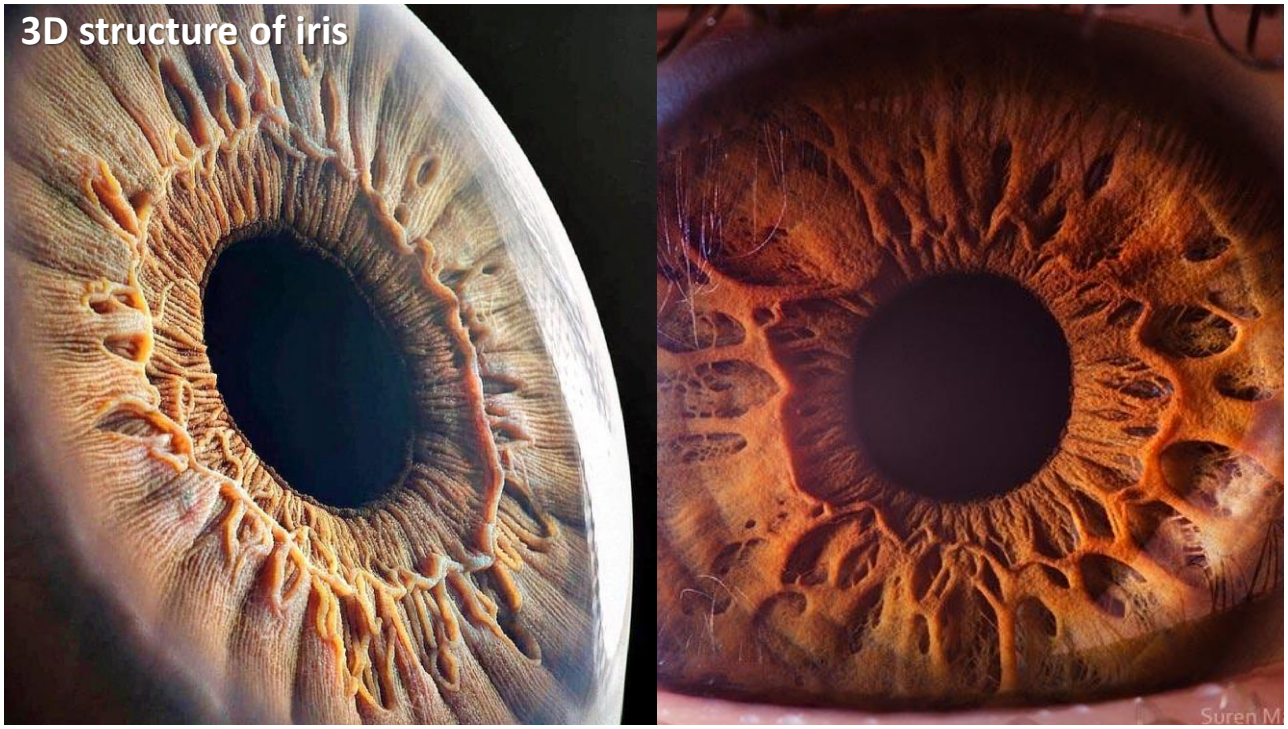
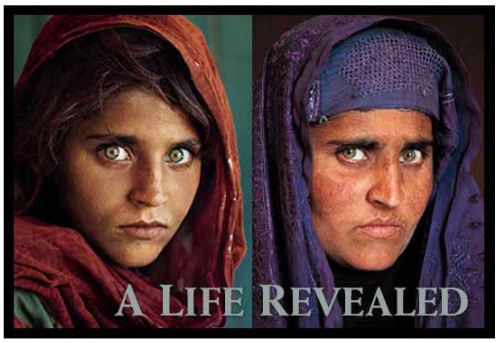

3D structure of iris


Variation of irises

# A famous story

National Geographic 100 best Pictures, 1994 by Steve McCurry




Source: National Geographic Magazine, 17 year later

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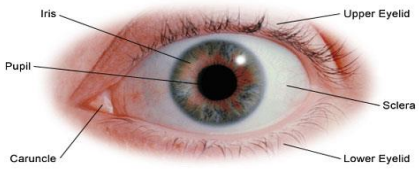
# 2- Why the Iris?



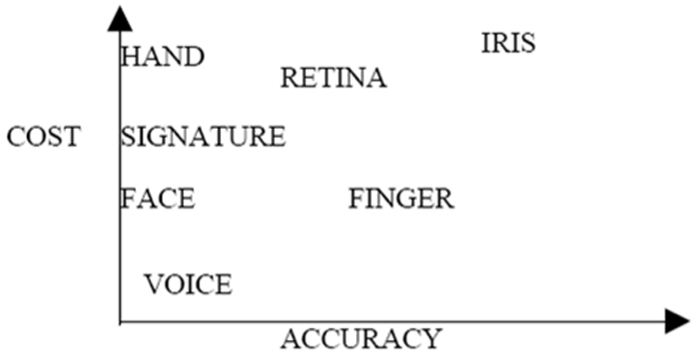

- ✓ Externally visible highly protected internal organ.
- ✓ Unique patterns.
- ✓ Not genetically connected unlike eye color.
- ✓ Stable with age.
- ✓ Impossible to alter surgically.
- ✓ Living Password, Can not be forgotten or copied.
- ✓ Works on blind person.
- ✓ User needs not to touch appliances.
- ✓ Accurate , faster , and supports large data base.

# 2-Why the Iris?

| Method | Coded Pattern | MisIdentific --ation rate | Security | **Applications** |
|---|---|---|---|---|
| Iris | Iris pattern | 1/1,200,000 | High | high-security |
| Fingerprint | fingerprints | 1/1,000 | Medium | Universal |
| voice | Voice characteristics | 1/30 | Low | Telephone service |
| Signature | Shape of letters, writing<br>Order, pen pressure | 1/100 | Low | Low-security |
| Face | Outline, shape & distribution of eyes, nose | 1/100 | Low | Low-security |
| Palm | size, length, & thickness hands | 1/700 | Low | Low-security |

Iris recognition is widely considered to be the **most accurate modality** of biometric identification

# 3-Why the Iris?




**Comparison between cost and accuracy**

# 3-History of Iris Recognition

❖The concept of Iris Recognition was first proposed by Dr. Frank Burch in 1939.

❖It was first implemented in 1990 when Dr. John Daugman created the algorithms for it.

❖These algorithms employ methods of pattern recognition and some mathematical calculations for iris recognition.

# 4-Applications

- ATMs
- Computer login: The iris as a living password.
- National Border Controls
- Driving licenses and other personal certificates.
- benefits authentication.
- birth certificates, tracking missing.
- Credit-card authentication.
- Anti-terrorism (e.g.:— suspect Screening at airports)
- Secure financial transaction (e-commerce, banking).
- Internet security, control of access to privileged information.

…

# 5-Methods Of IRIS Recognition System

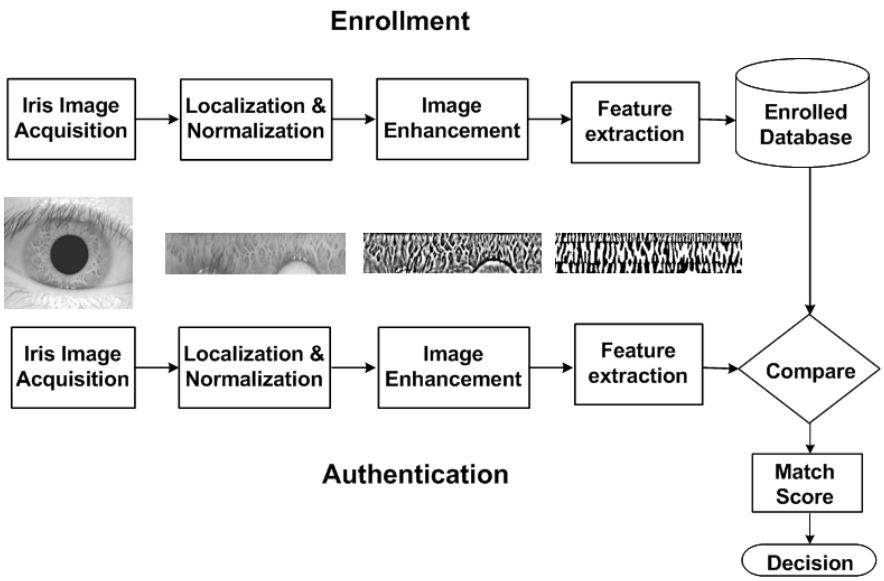
❖In identifying one's iris, there are 2 methods for its recognition and are:

1. Active
2. Passive

❖ The active Iris system requires that a user be anywhere from six to fourteen inches away from the camera.

❖The passive system allows the user to be anywhere from one to three feet away from the camera that locates the focus on the iris.

# 5-Iris Recognition Diagram



# 6- Image acquisition

- The first step, image acquisition deals with **capturing sequence of iris images** from the subject using cameras and sensors with High resolution and good sharpness.
- These images should clearly show the entire eye especially iris and pupil part, and then some preprocessing operation may be applied to enhance the quality of image e.g. histogram equalization, filtering noise removal etc.

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# Image acquisition: devices


Panasonic BM-ET 330


LG IrisAccess 4000

Datastrip Easy Verify

IrisGuard IGH1000

Oki IrisPass

Retica MobileEyes,

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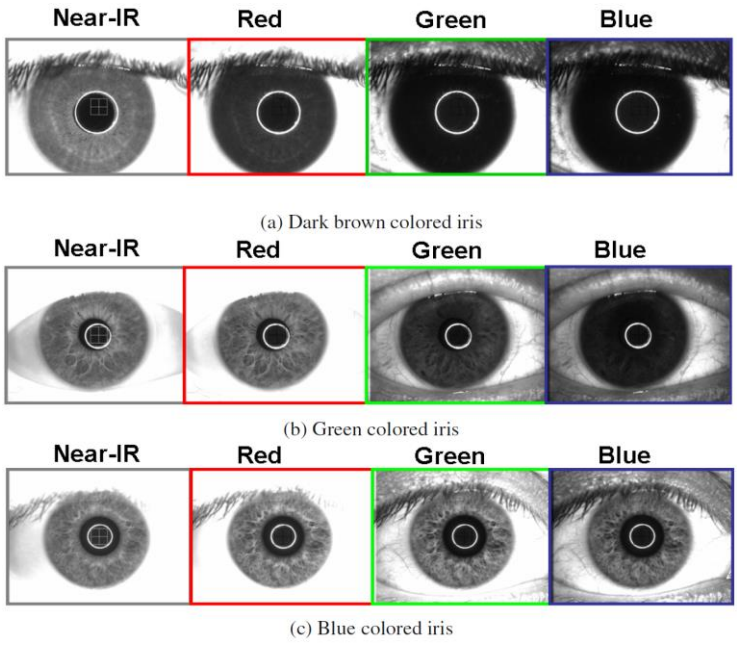
# Image acquisition

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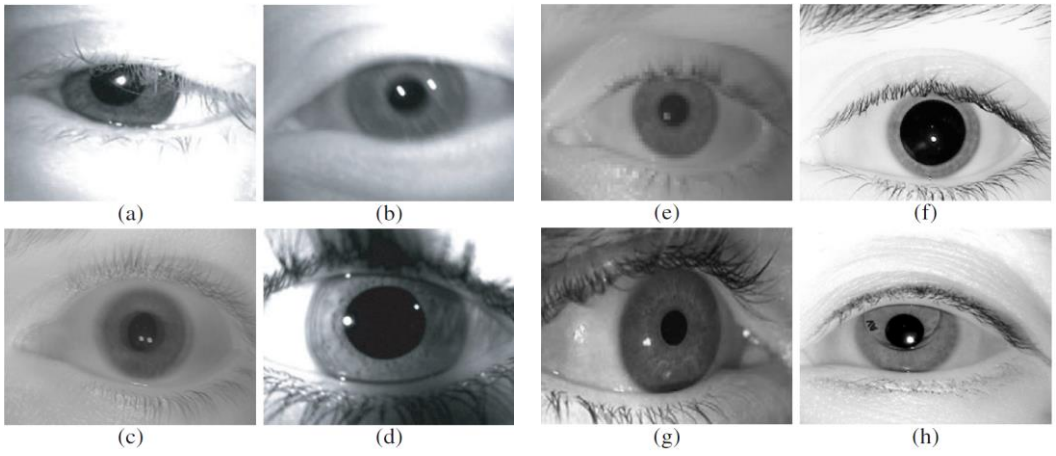
# Poor quality examples




Poor quality iris images caused by (a) occlusion, (b) defocus, (c) motion blur, (d) nonuniform illumination, (e) low resolution sensor, (f) iris dilation, (g) off-angled imaging, and (h) the presence of a printed contact lens.

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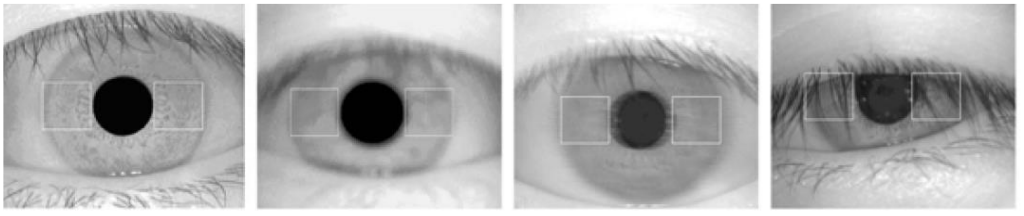
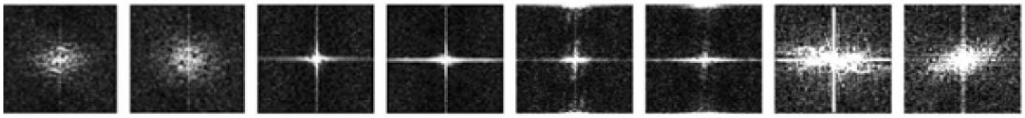
# Image quality vs. Fourier spectrum



Good quality | defocus blur | motion blur | occlusion



Fourier spectrum of 2 areas on each image

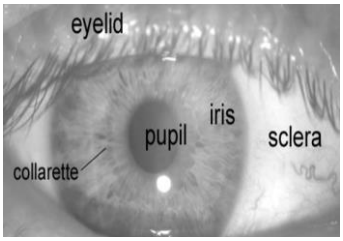


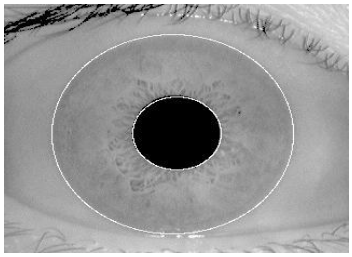
# 7-Segmentation

Purpose:

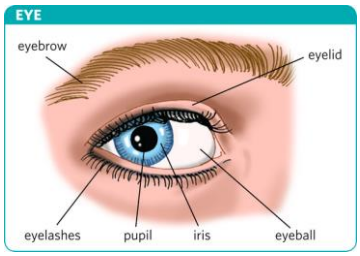
- The first stage of iris segmentation to isolate the actual iris region in a digital eye image.

- The iris region, can be approximated by two circles, one for the iris/sclera boundary and another, interior to the first, for the iris/pupil boundary.

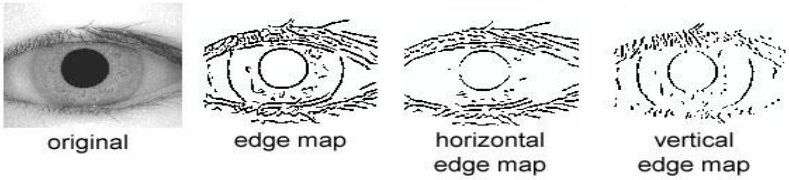


# 7-Segmentation: eyelids




- the derivatives in the horizontal direction for detecting the eyelids, and in the vertical direction for detecting the outer circular boundary of the iris .
- Taking only the vertical gradients **for locating the iris boundary** will reduce influence of the eyelids when performing circular Hough transform.

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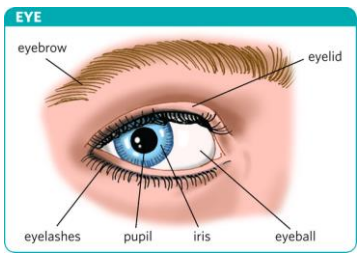
# 7-Segmentation: pupil detection




- The circular Hough transform can be employed to deduce the radius and center coordinates of the pupil and iris regions:
- Firstly, an edge map is generated by calculating the first derivatives of intensity values in an eye image and then thresholding the result.
- From the edge map, votes are cast in Hough space for the parameters of circles passing through each edge point, These parameters are the centre coordinates $x^c$ and $y^c$, and the radius r, which are able to define any circle according to the equation :

$$x_c^2 + y_c^2 - r^2 = 0$$

A maximum point in the Hough space will correspond to the radius and center coordinates of the circle best defined by the edge points.

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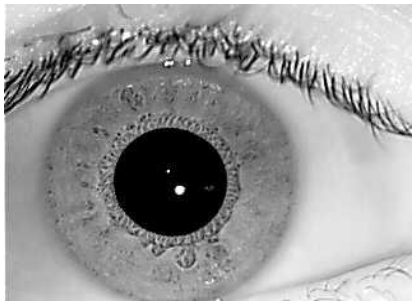
# 7-Segmentation/eyelash

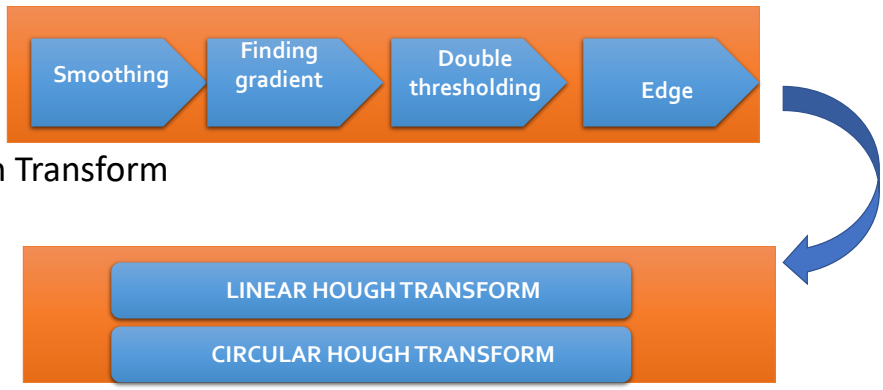


- Eyelashes are treated as belonging to **two** types :
  1 -separable eyelashes:
  which are isolated in the image .

  2-multiple eyelashes:
  which are bunched together and overlap in the eye image.
- Eyelids and Eyelashes are the main noise factor in the iris image.
- These noise factors can affect the accuracy of the iris recognition system.
- After applying circular Hough transform to iris, we are applying linear Hough transform and we get line detected noise region in the iris image.
- We have to remove these detected eyelids and eyelashes from the iris image Thresholding is used for the removal of eyelashes. Then, the noise free iris image can be available for future use.

# 7-Segmentation Diagram

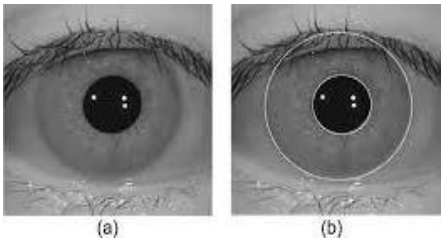
1- Edge Detector



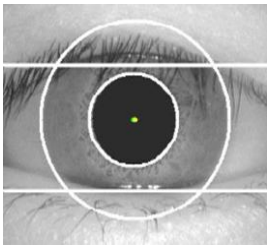
# 7-Segmentation( cont…)

**Process of finding the iris in an image**

a. Iris and pupil localization: Pupil and Iris are considered as two circles using Circular Hough Transform .



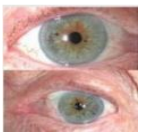

b. Eyelid detection and Eyelash noise removal using linear Hough Transform method.



# 8-Normalization

- Once the iris segmented ,the next stage transform the iris region so that it has fixed dimensions in order to allow comparisons.
- Since variations in the eye like pupil dilation and the inconsistence iris normalization is needed.

Pupil dilation



inconsistence iris

- Normalization process involves unwrapping the iris and converting it in to its polar equivalent .

# 8-Normalization ( cont...)

$$r' = \sqrt{\alpha}\beta \pm \sqrt{\alpha\beta^2 - \alpha - r_I^{\,2}}$$

with

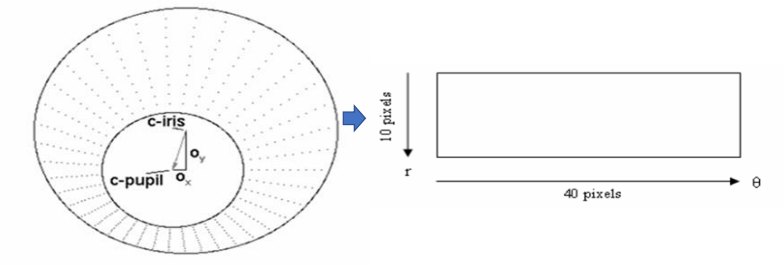
$$\alpha = o_x^2 + o_y^2$$

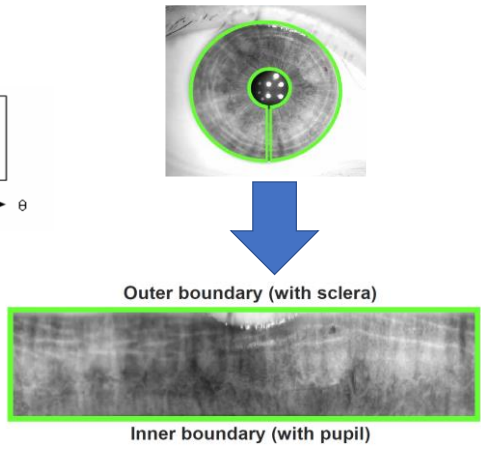
$$\beta = \cos\left(\pi - \arctan\left(\frac{o_y}{o_x}\right) - \theta\right)$$

- where displacement of the center of the pupil relative to the center of the iris is given by $o_x$ , $o_y$ .
- $r'$ is the distance between the edge of the pupil and edge of the iris at an angle, θ around the region, and $r$ is the radius of the iris.
- The remapping formula first gives the radius of the iris region as a function of the angle θ.

# 8-Normalization ( cont...)

- Normalization produces a 2D array with horizontal dimensions of angular resolution and vertical dimensions of radial resolution.




- Rubber sheet model does not compensate for rotational inconsistencies

# 9-Feature Encoding

- Various feature encoding methods :

**1-Gabor Filters** employed by Daugman and Tuama

2- Log-Gabor Filters employed by D. Field

.

3- Haar Wavelet employed by Lim et al.

4- Zero –crossing of the 1D wavelet employed by Boles and Boashash

5- Laplacian of gaussian filters employed by Wildes et al.

# 9-Feature Encoding

- Feature Encoding : creating a template containing only the most discriminating features of the iris .
- Extracted the features of the normalized iris by filtering the normalized iris region .
- a Gabor filter is a sine ( or cosine) wave modulated by a Gaussian. It is applied on the entire image at once and unique features are extracted from the image
- Feature encoding was implemented by convolving the normalized iris with 1D Gabor wavelets.

# 9-Feature Encoding ( cont …)

- The Daugman system makes use of polar coordinates for normalisation, therefore in polar form the filters are given as :

$$H(r,\theta) = e^{-i\omega(\theta-\theta_0)} e^{-(r-r_0)^2/\alpha^2} e^{-i(\theta-\theta_0)^2/\beta^2}$$

*($r_0$, $\vartheta_0$)* specify the centre frequency of the filter. *($\alpha$,$\beta$)* specify the effective width and length.

- The angular direction is taken rather than the radial one , since maximum independence occurs in the angular direction .

# 9-Feature Encoding ( cont …)

- Daugman demodulates the output of the Gabor filters in order to compress the data this is done by quantising the phase information in to four levels , for each possible quadrant in the complex plane . [7]
- The demodulation and phase Quantization process can be represented as

$$h_{\{\mathrm{Re,Im}\}} = \mathrm{sgn}_{\{\mathrm{Re,Im}\}} \int_{\rho}\int_{\phi} I(\rho,\phi) e^{-i\omega(\theta_0-\phi)} e^{-(r_0-\rho)^2/\alpha^2} e^{-(\theta_0-\phi)^2/\beta^2} \rho d\rho d\phi$$

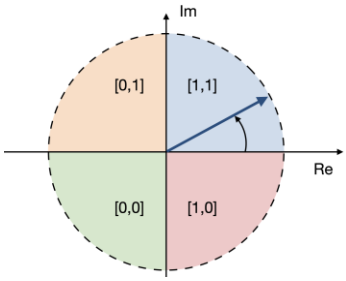
where $h^{\{Re,\ Im\}}$ can be regarded as a complex valued bit whose real and imaginary components are dependent on the sign of the 2D integral, and I( ρ,θ ) is the raw iris image in a dimensionless polar coordinate system.

# 9-Feature Encoding ( cont …)

- Using real and imaginary values, the phase information is extracted and encoded in a binary pattern .

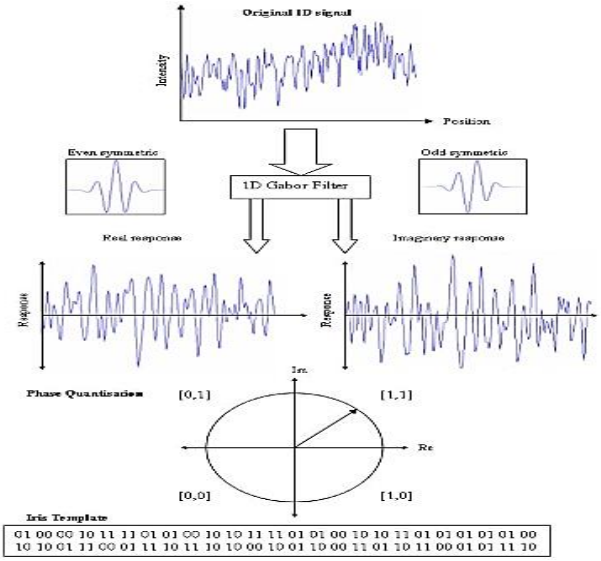
$$P(r,\theta) = tan^{-1}\left(\frac{Im\ I_g(r,\theta)}{Re\ I_g(r,\theta)}\right)$$

$$I_p[r,\theta] = \begin{cases} [1,1] & if \quad 0^0 < P(r,\theta) \leq 90^0 \\ [0,1] & if \quad 90^0 < P(r,\theta) \leq 180^0 \\ [0,0] & if \quad 180^0 < P(r,\theta) \leq 270^0 \\ [1,0] & if \quad 270^0 < P(r,\theta) \leq 360^0 \end{cases}$$




- The total number of bits in the template will be the angular resolution times the radial resolution , times 2, times number of filters used .
- The number of filters,their centre frequencies and parameters of the modulating Gaussian function must be detecting according to the used data base .

# 9-Feature encoding process



# 10-Feature Matching

Various feature matching methods :

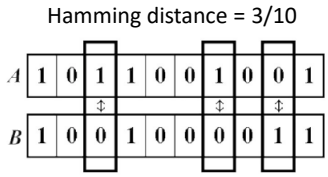
**1- Hamming distance employed by Daugman**

2- Weighted Euclidean Distance employed by Zhu et al.

3- Normalized correlation employed by Wildes

# 10-Feature Matching

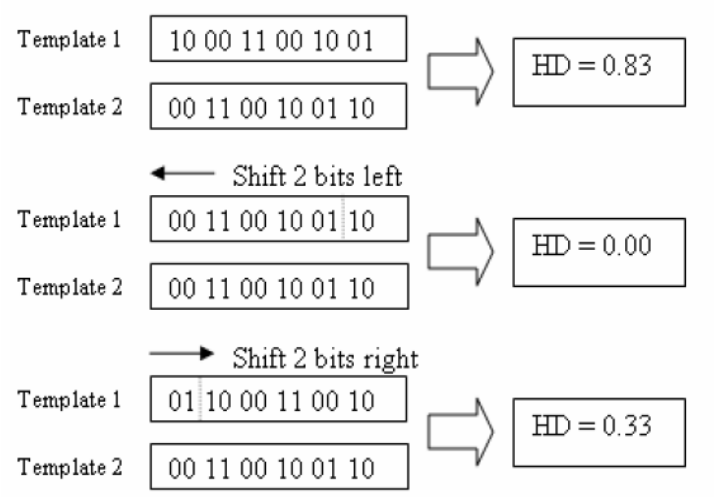
- The Hamming Distance was chosen as a matching metric , which gave a measure of how many bits disagreed between two templates .
- When the Hamming Distance of two templates is calculated , one template is shifted left and right bit-wise and a number of hamming distance values are calculated from successive shifts , in order to account for **rotational inconsistencies** .



# 10-Feature Matching ( cont …)

- The actual number of shifts required to normalize rotational inconsistencies will be determined by the maximum angle difference between two images of the same eye .
- One shift is defined as one shift to the left , followed by one shift to the right .
- This method is suggested by Daugman .

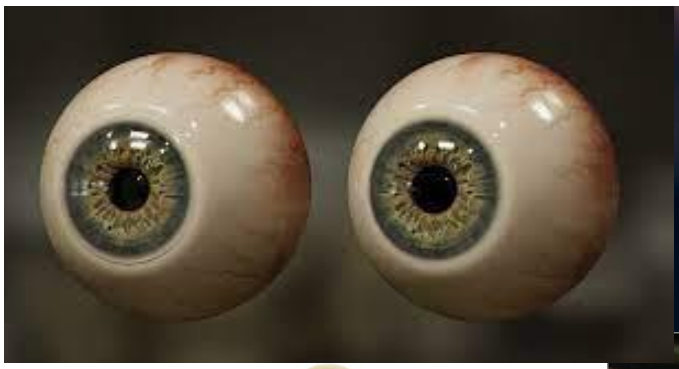
# 10-Feature Matching ( cont …)



# 11-Disadvantages

- ✓ Accuracy changes with user's height ,illumination , Image quality etc.
- ✓ Person needs to be still, difficult to scan if not co-operated.
- ✓ Risk of fake Iris lenses.
- ✓ Alcohol consumption causes deformation in Iris pattern
- ✓ Expensive .

# Fake biometrics



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# Thank you for listening !