Biometrics Seminar

Iris Recognition

Presentation by:

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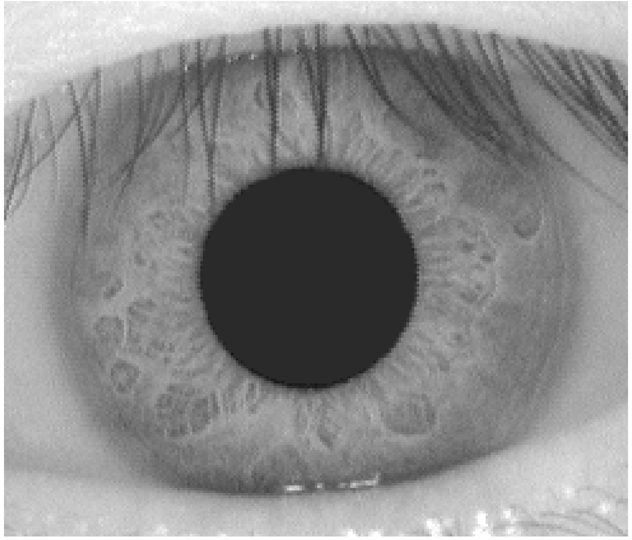
Elec. Engg. (dual deg.)

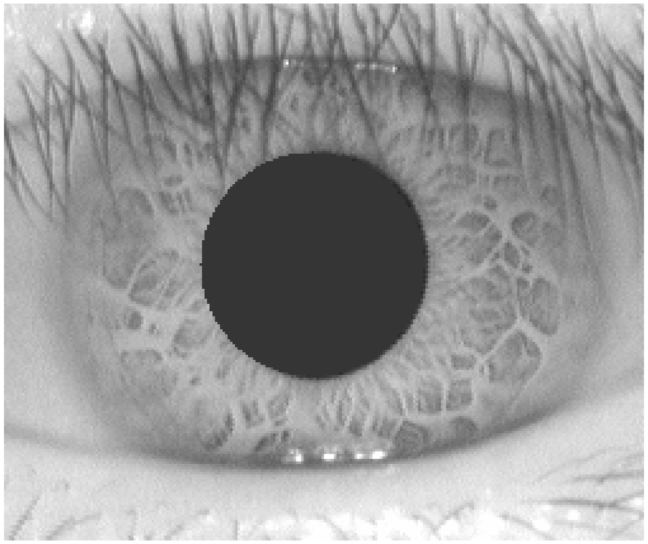
Outline

- Introduction
- Model of a biometric system
- Why Iris ??
- Image Pre-processing
- Eyelash and Eyelid Removal
- Feature Extraction
  - Gabor filter
  - Log-Gabor filter
- Performance of the systems
- Time of Operations
- References

Introduction

- Iris is the annular portion between the dark pupil and white sclera





- It has got a rich texture information which could be exploited for a biometric recognition system

Why Iris ??

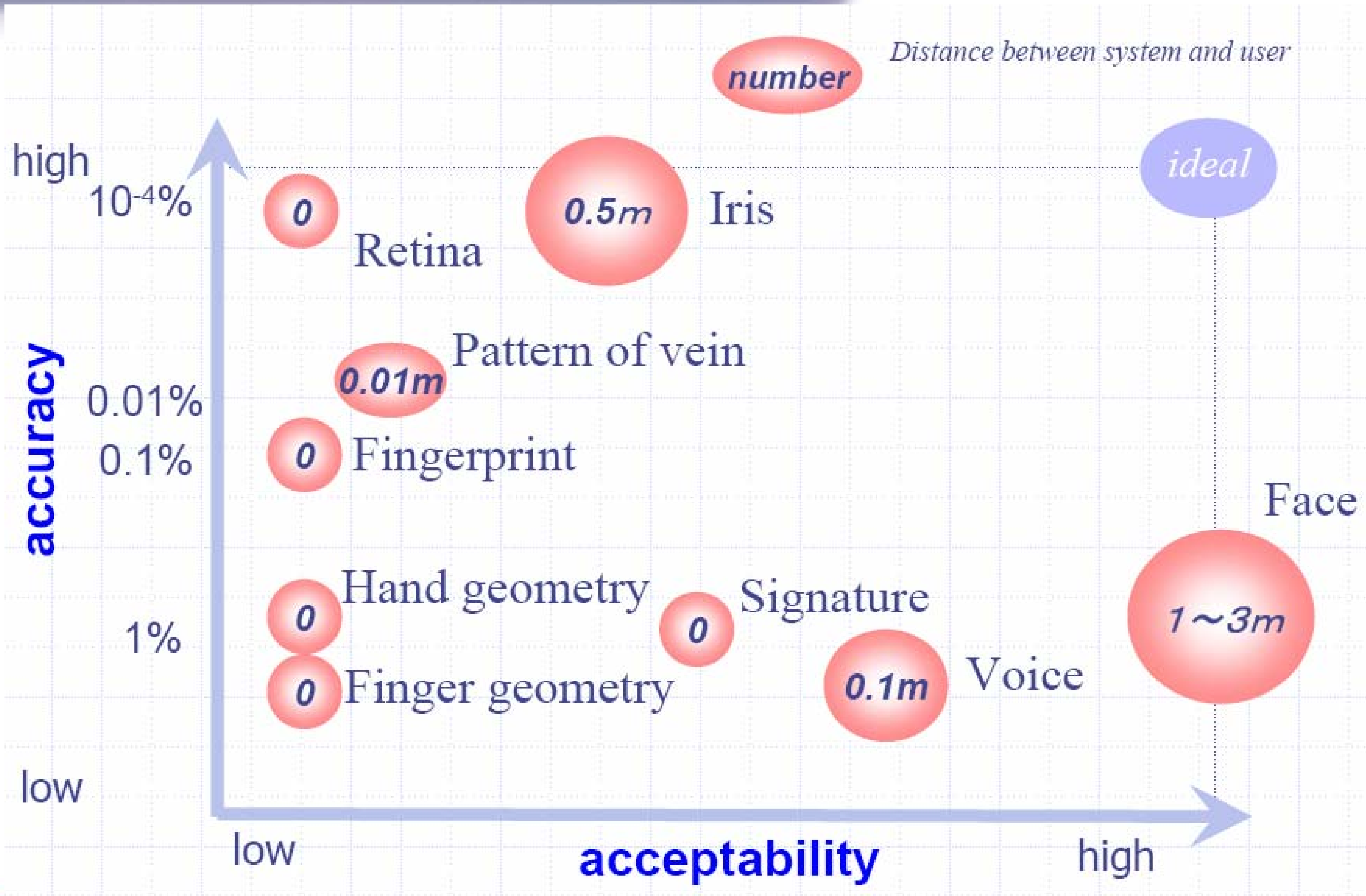
- Its error rate is extremely low
- Iris a permanent biometric
- User acceptability is reasonable
- Real time biometric verification
- Less susceptible to spoofing

Why Iris ??

Biometric identifier	Universality	Distinctiveness	Permanence	Collectability	Performance	Acceptability	Circumvention
DNA	H	H	H	L	H	L	L
Ear	M	M	H	M	M	H	M
Face	H	L	M	H	L	H	H
Facial thermogram	H	H	L	H	M	H	L
Fingerprint	M	H	H	M	H	M	M
Gait	M	L	L	H	L	H	M
Hand geometry	M	M	M	H	M	M	M
Hand vein	M	M	M	M	M	M	L
Iris	H	H	H	M	H	L	L
Keystroke	L	L	L	M	L	M	M
Odor	H	H	H	L	L	M	L
Palmprint	M	H	H	M	H	M	M
Retina	H	H	M	L	H	L	L
Signature	L	L	L	H	L	H	H
Voice	M	L	L	M	L	H	H

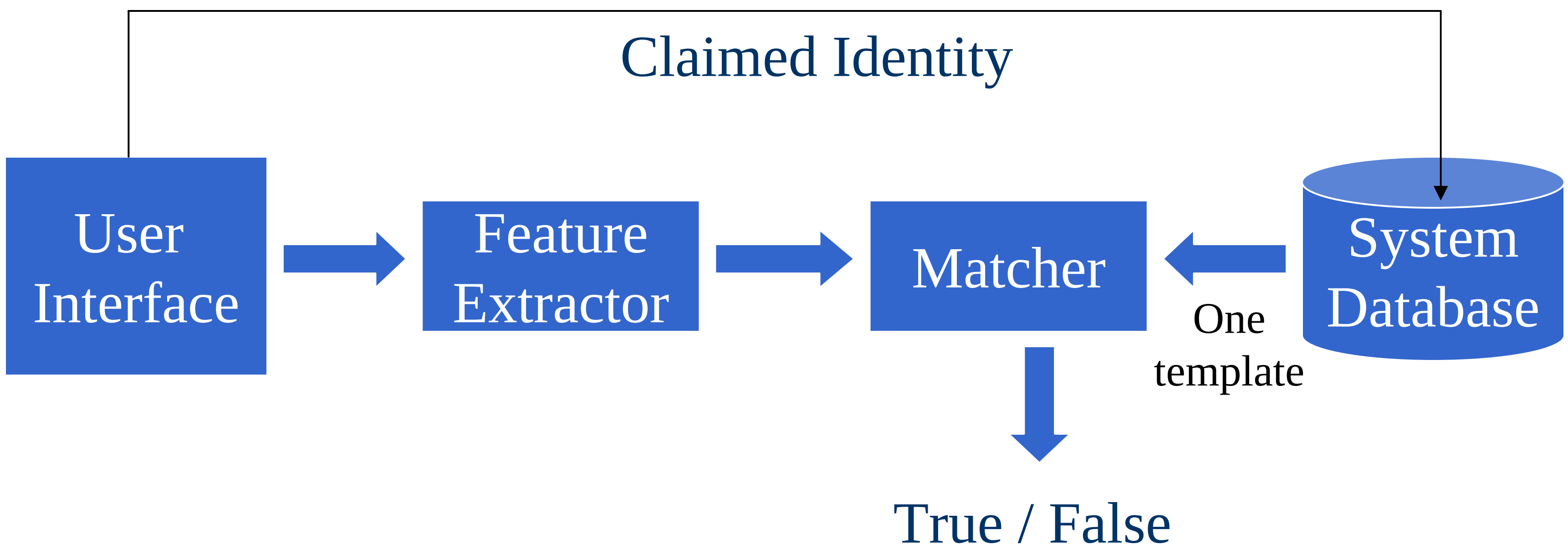
Source: *IEEE Transactions on Circuits and Systems for Video Technology, Special Issue on Image- and Video-Based Biometrics, Vol. 14, No. 1, January 2004*

Why Iris ??



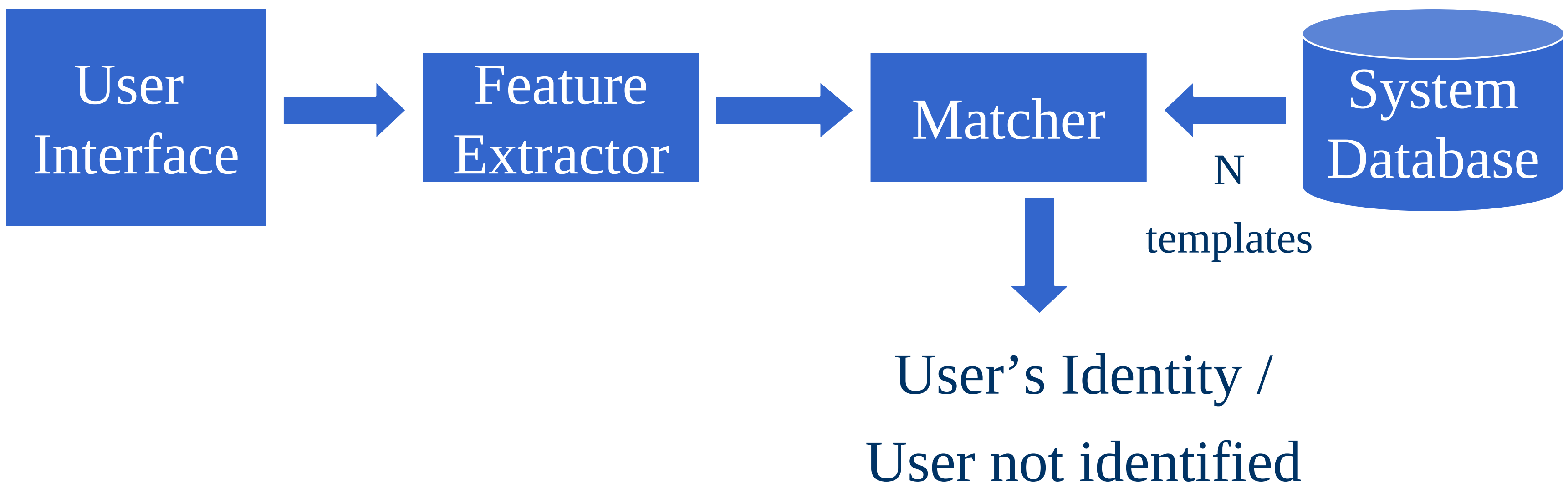
Source: *Lecture Slides of EE851N, by Dr. Ajay Kumar Pathak, Jan-May, 2006.*

System Model



Verification Mode

System Model



Identification Mode

Image Acquisition

- Images are generally acquired in near infra red illumination
- The distance between the eye and the camera may vary from 4-50 cm
- Iris diameter typically should be between 100-200 pixels for extracting good texture
- Careful selection of intensity level

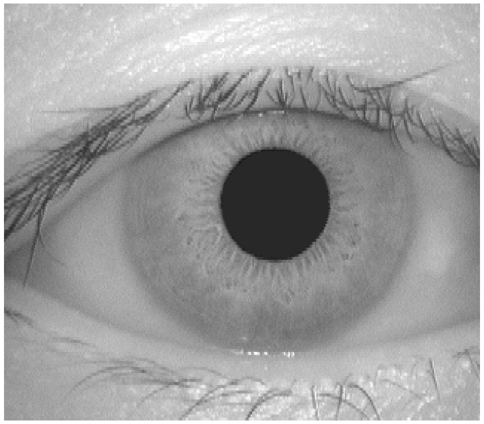
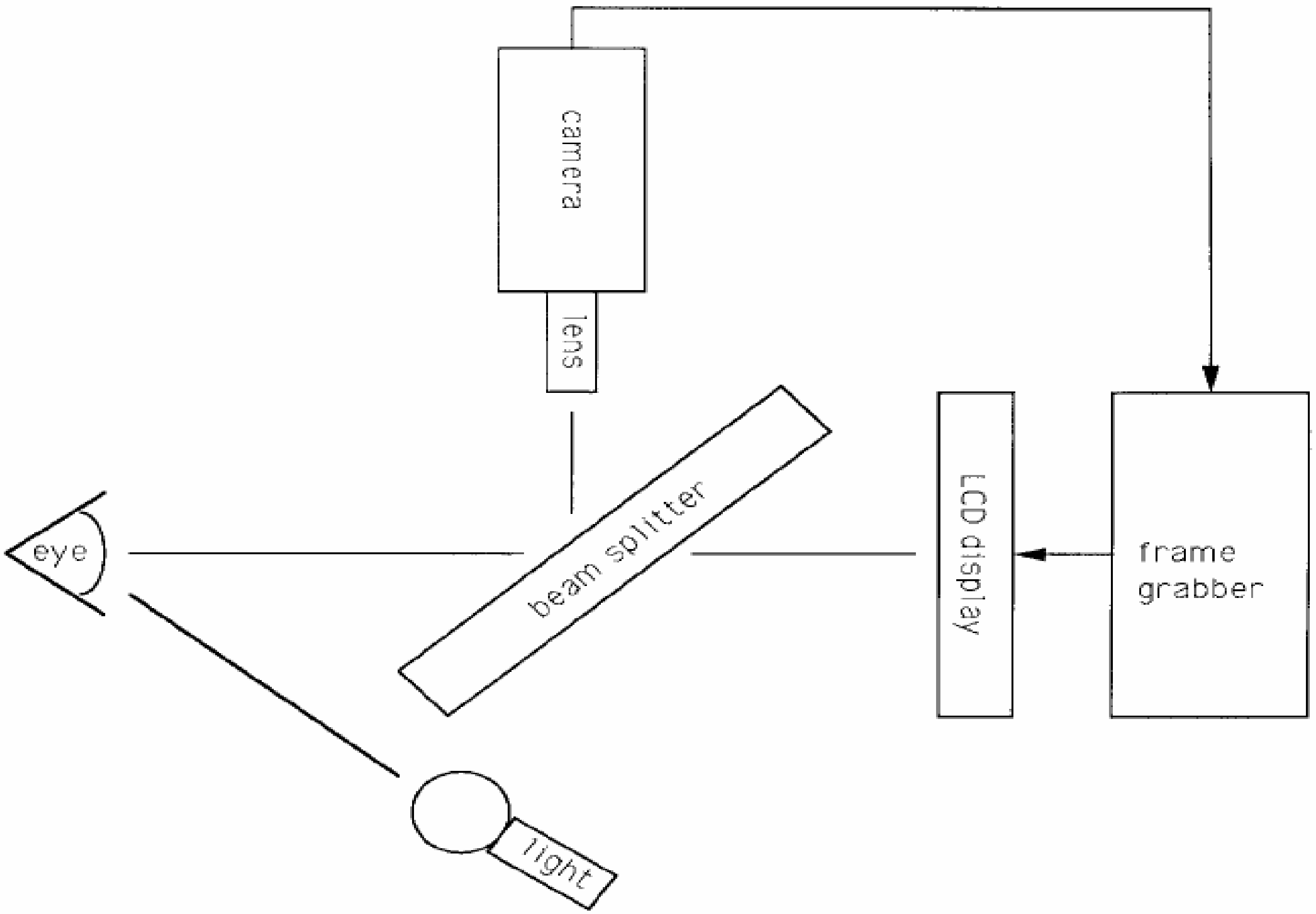


Image Acquisition



Source: R. Wildes, "Iris Recognition: An Emerging Biometric Technology," Proc. IEEE, vol. 85, pp. 1348-1363, 1997

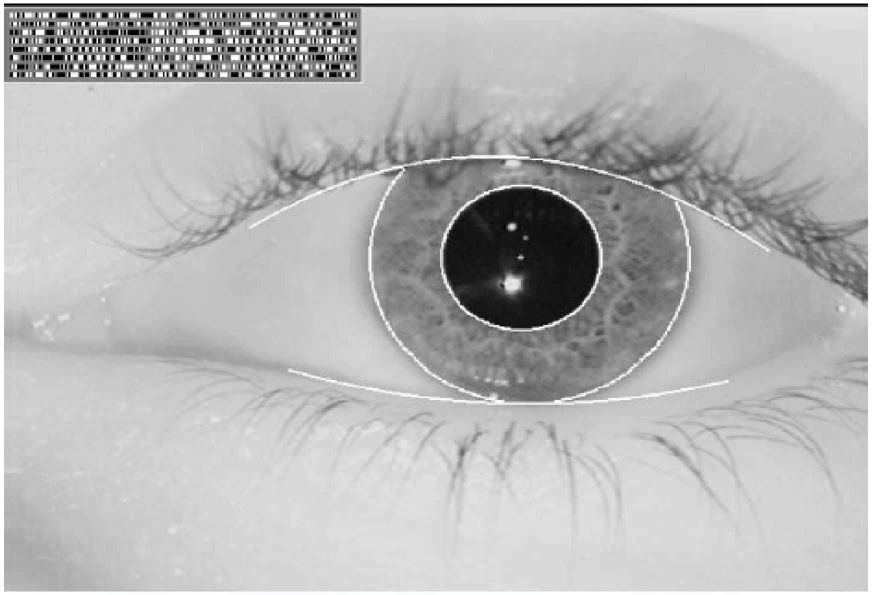
Image pre-processing

- Image localization
  - Detecting the Pupillary circle
  - Detecting outer Iris circle
- Image normalization
- Image enhancement

Image localization

John Daugman's approach

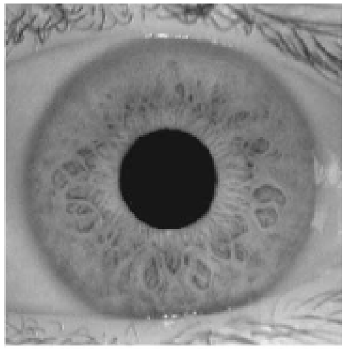
$$\max_{(r,x_0,y_0)} \left| G_\sigma(r) * \frac{\partial}{\partial r} \oint_{r,x_0,y_0} \frac{I(x,y)}{2\pi r} ds \right|$$

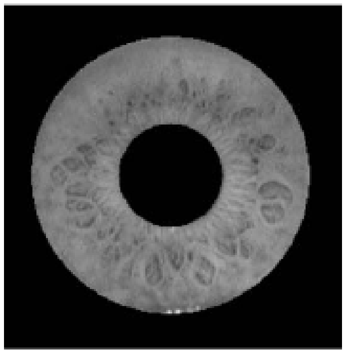


Detecting the Pupil

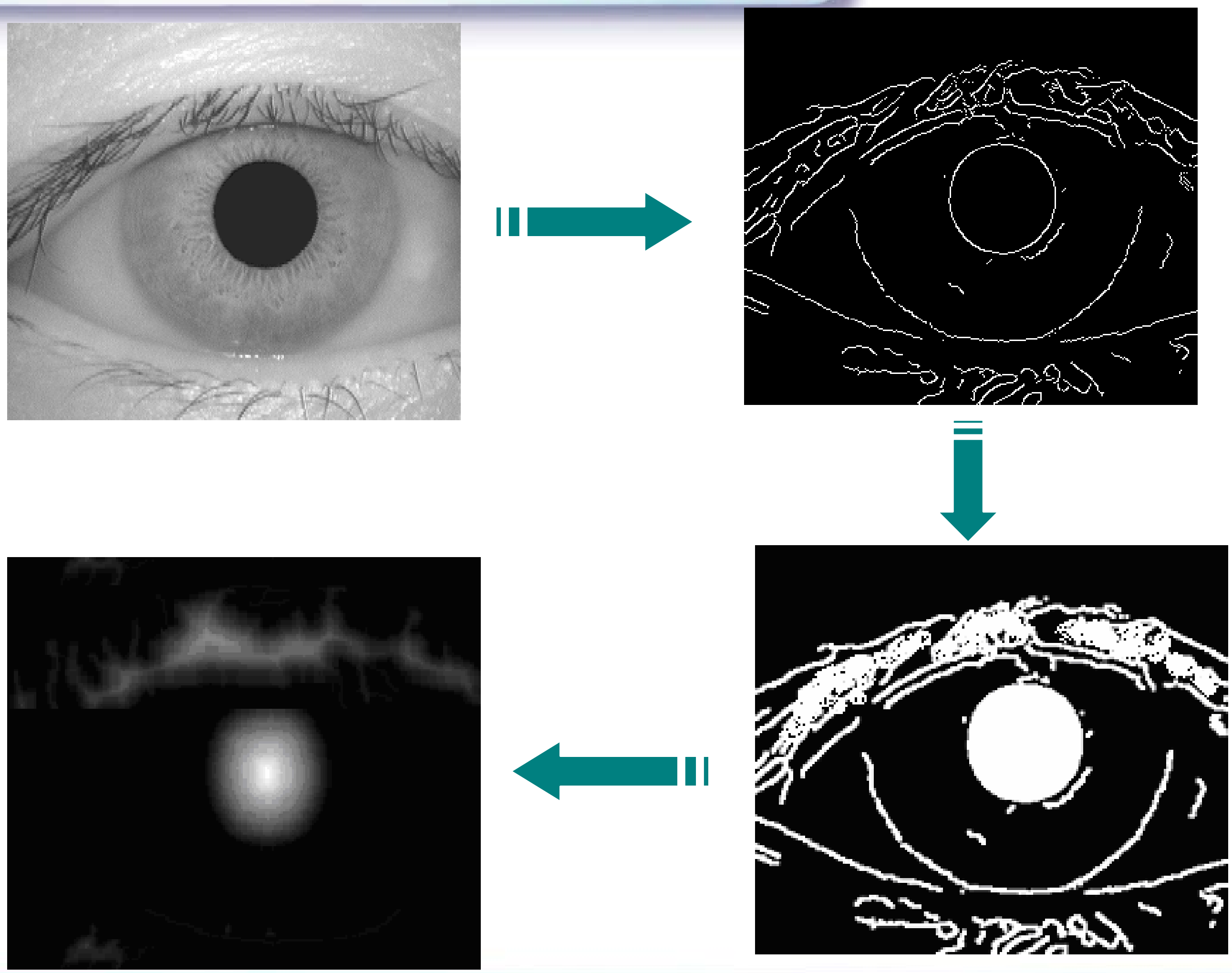
Li Ma's approach

- Project image in vertical and horizontal directions
- Minima of two projections will be a rough estimate of pupil center
- Binarize 120x120 region centered at that point using adaptive threshold
- Centroid of this binarized region is a better estimate of the pupil center

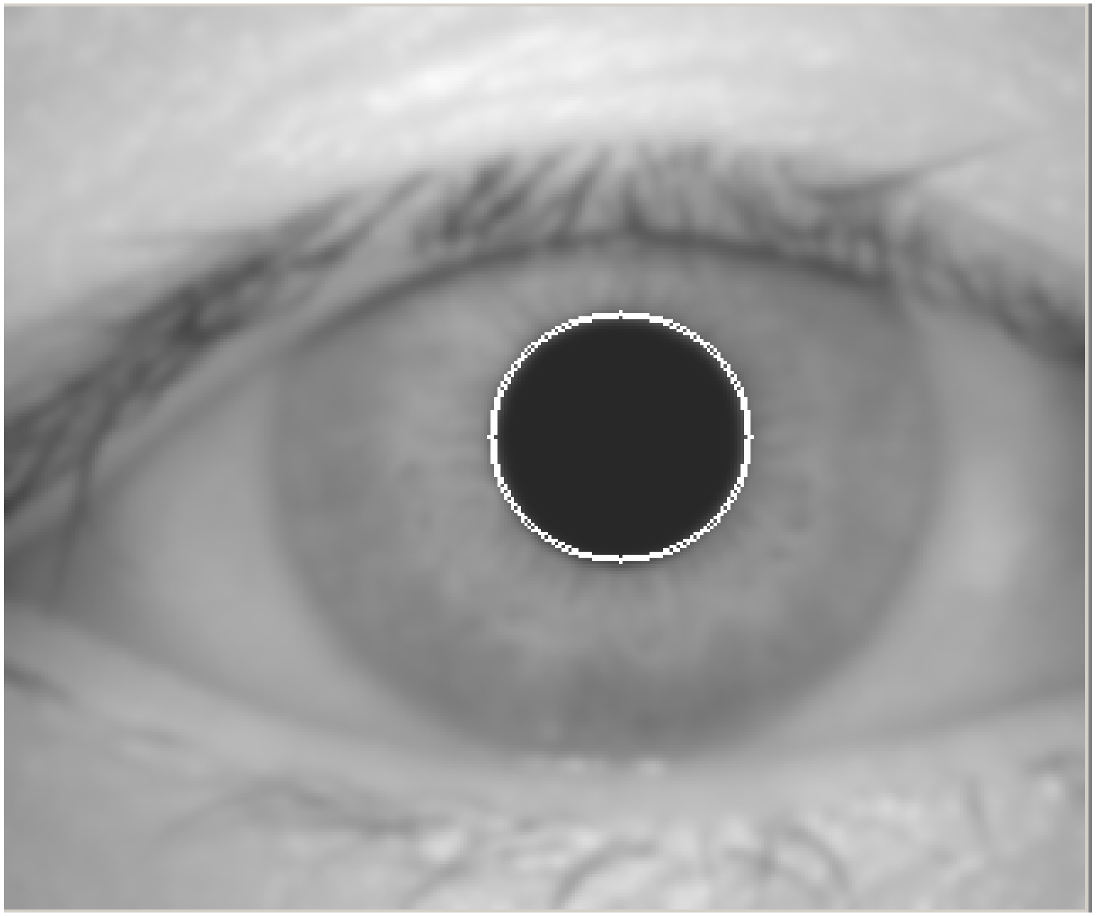




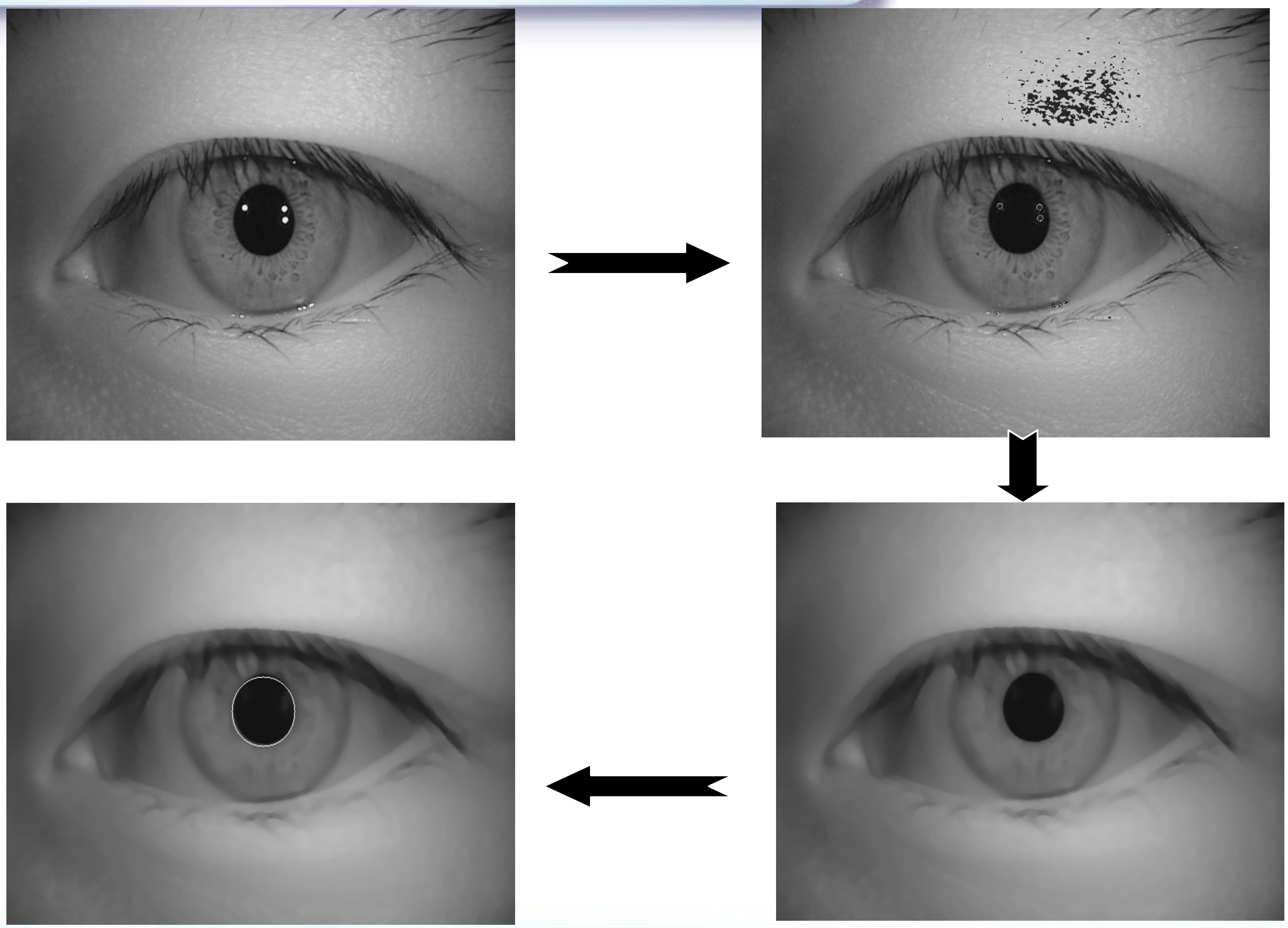
Detecting the Pupil



Detecting the Pupil



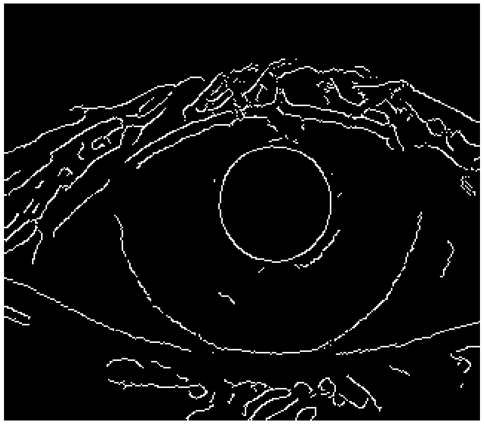
Detecting the Pupil

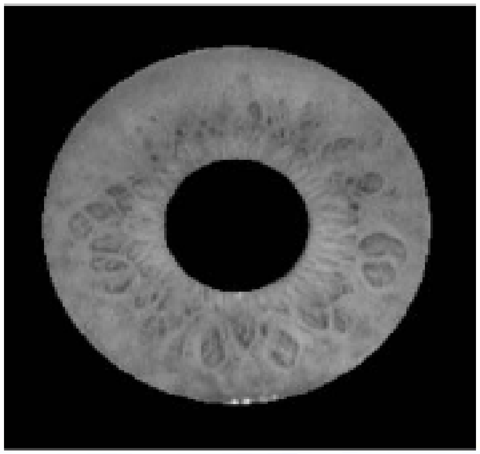


Detecting outer circle

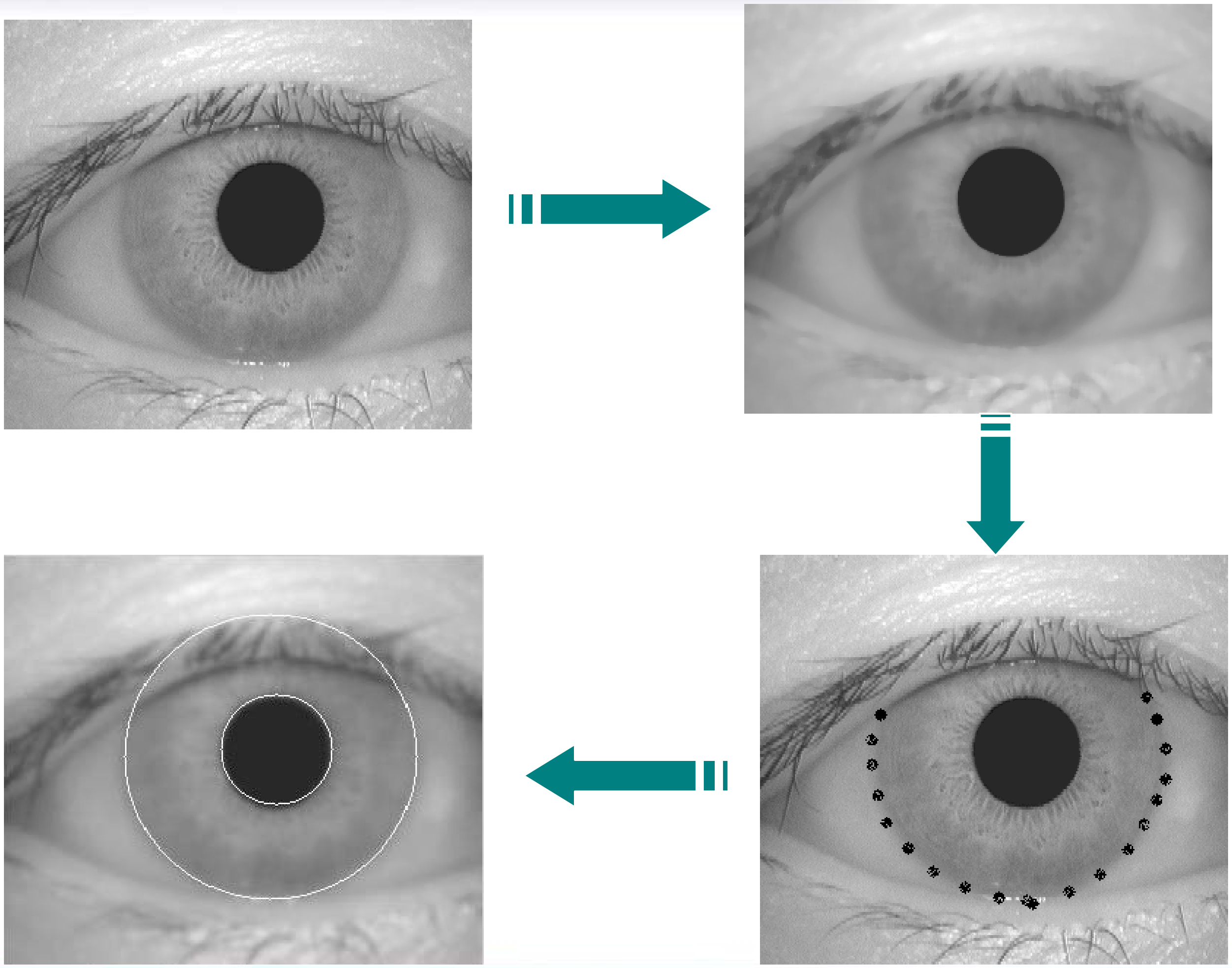
Li Ma's approach

- Edge detection is used on the image
- Hough transform is used to find the outer circle in a region determined by the center of pupil

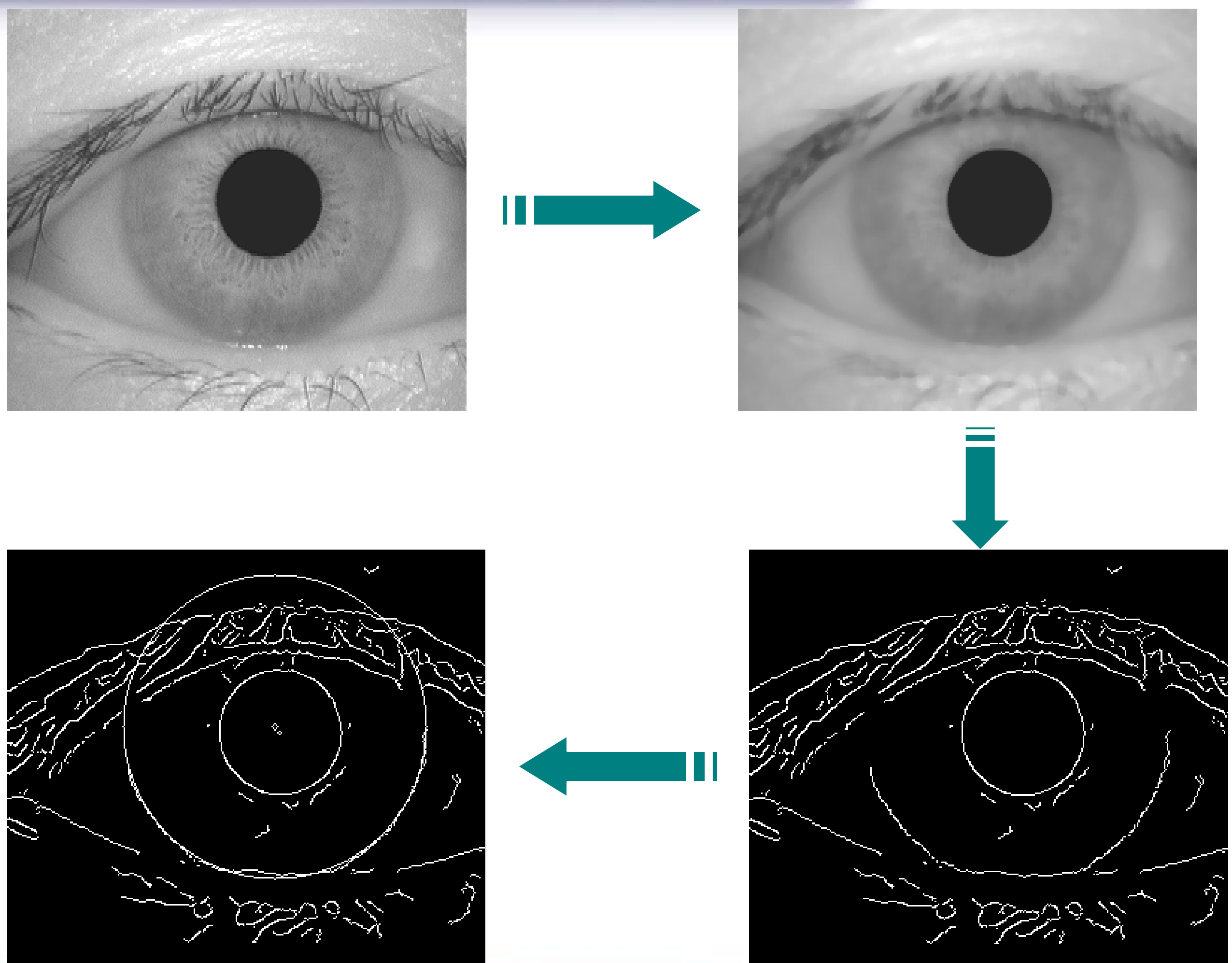




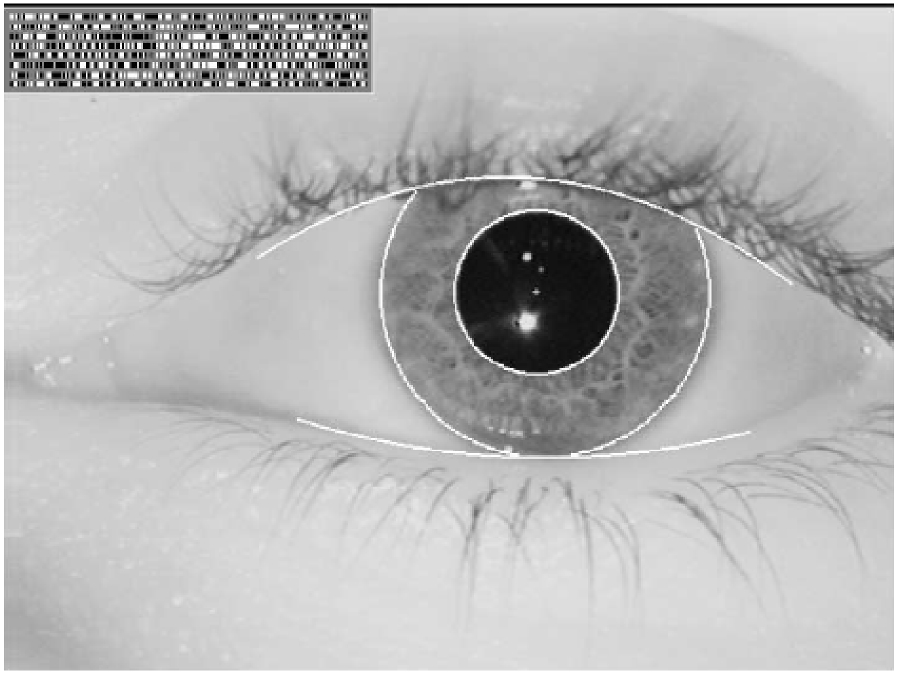
Detecting outer circle



Detecting outer circle



Iris Normalization

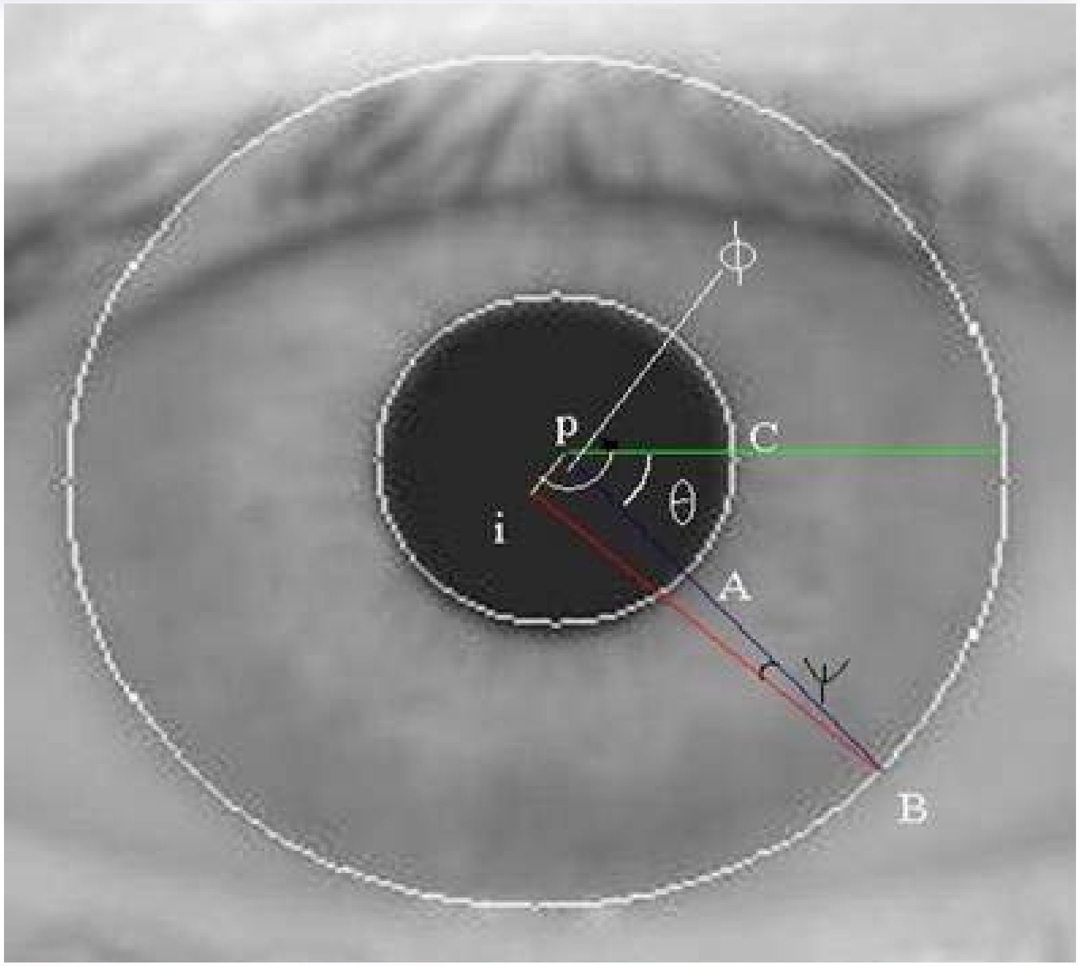


$$I(x(r,\theta), y(r,\theta)) \rightarrow I(r,\theta)$$

$$x(r,\theta) = (1 - r)x_p(\theta) + r x_s(\theta)$$

$$y(r,\theta) = (1 - r)y_p(\theta) + r y_s(\theta)$$

Iris Normalization



$$\alpha = \phi - \theta$$

$$\frac{\mathrm{Sin}(\psi)}{ip} = \frac{\mathrm{Sin}(\alpha)}{i\mathrm{B}}$$

$$\frac{\mathrm{Sin}(\alpha + \psi)}{pB} = \frac{\mathrm{Sin}(\alpha)}{i\mathrm{B}}$$

$$\mathrm{AB} = \mathrm{pB} - \mathrm{pA}$$

Iris Normalization

➢ **Unwrap the Iris region onto a rectangular block of size 64x512**

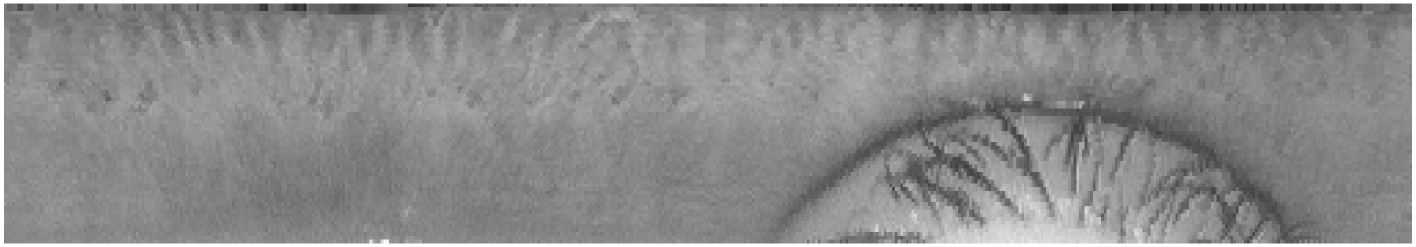


Image Enhancement

- **Mean of every 16x16 block is calculated**
- **Image obtained is resized to 64x512 using bi-cubic interpolation**

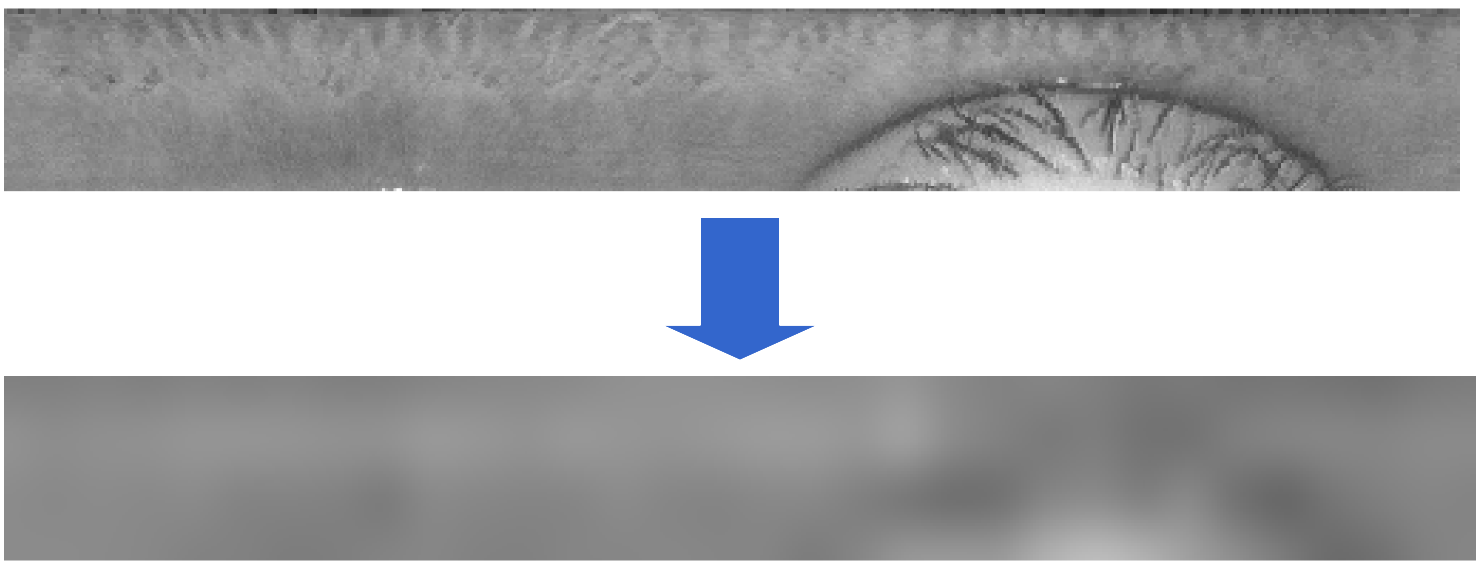
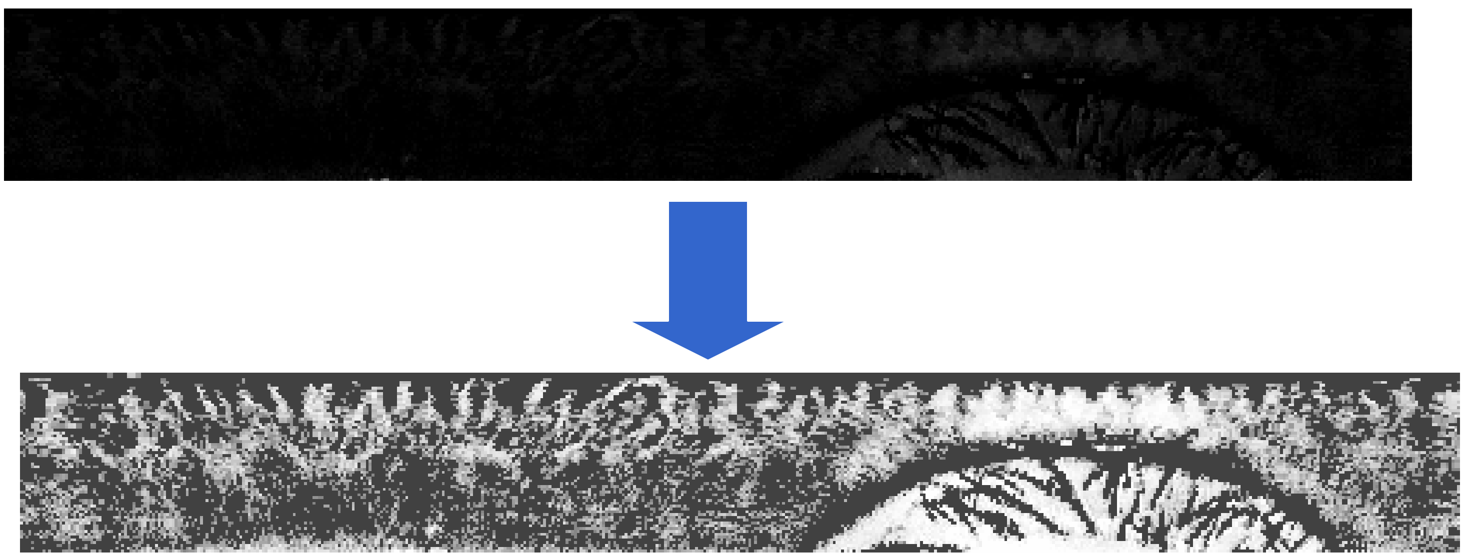


Image Enhancement

- Interpolated image is subtracted from original normalized image
- Image is enhanced through histogram equalization



Eyelash & Eyelid removal

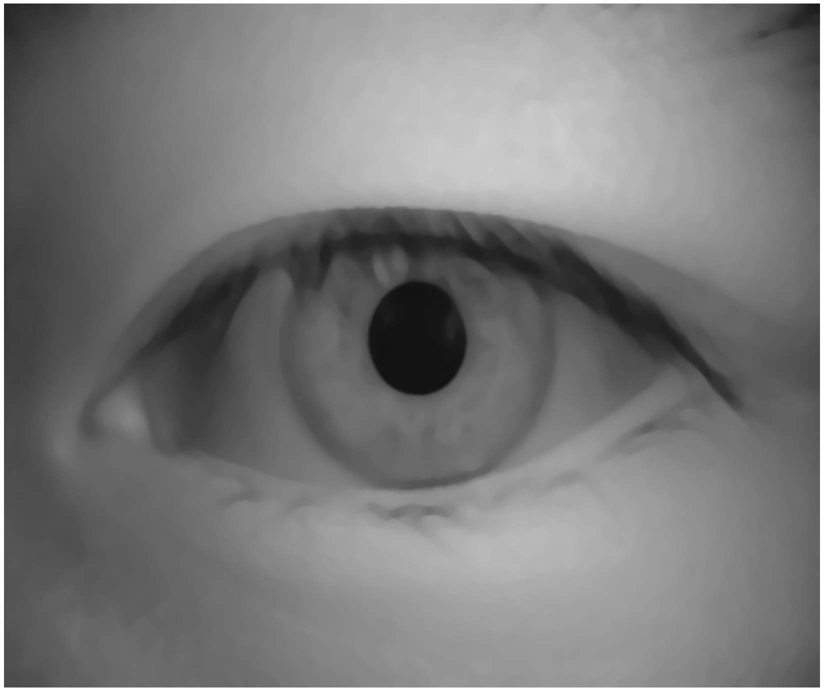
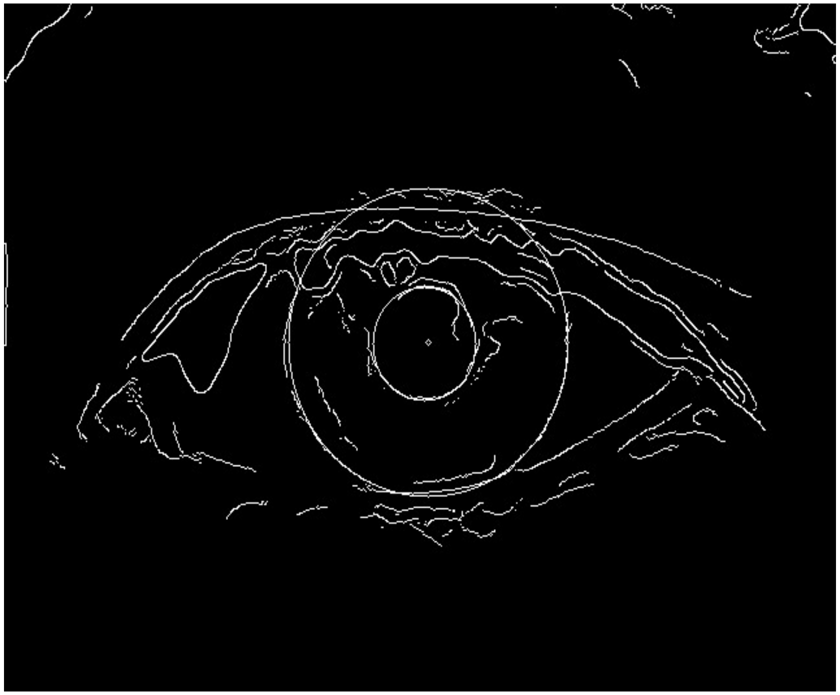
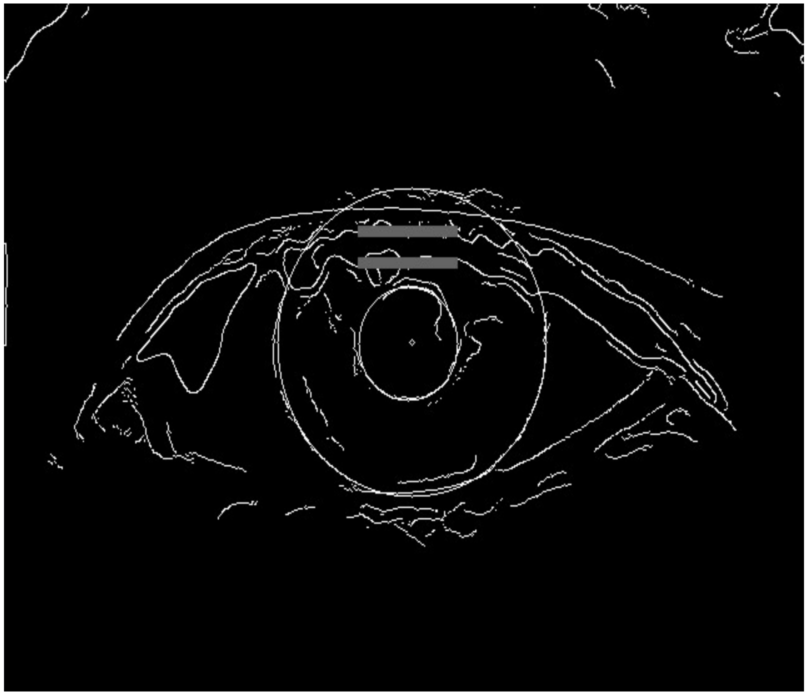


Image after median filter

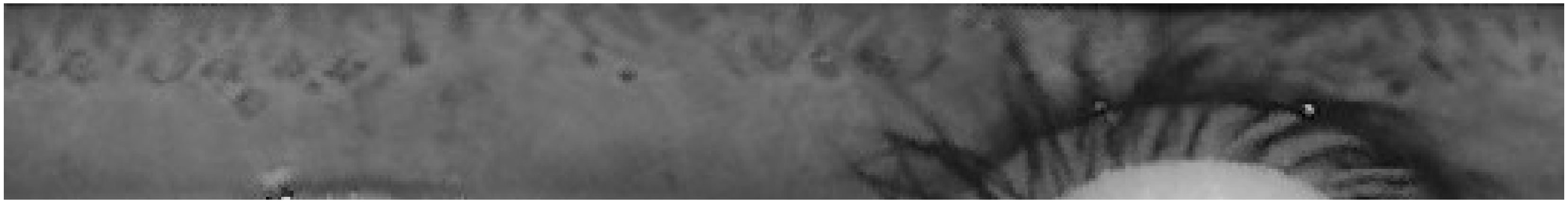


Edge detected image

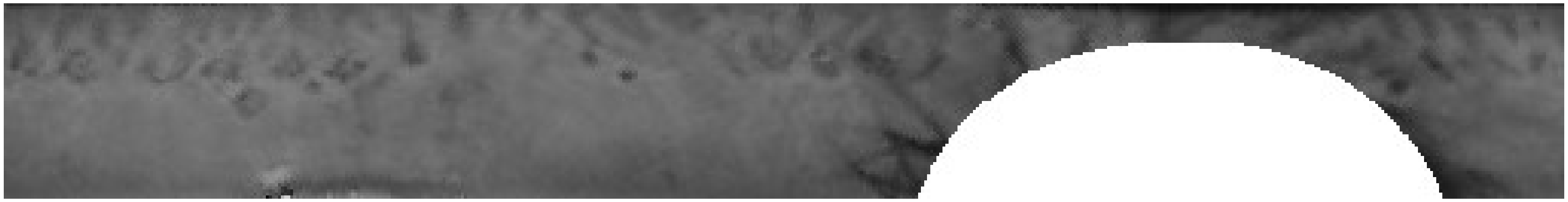
Eyelash & Eyelid removal



Eyelash & Eyelid removal



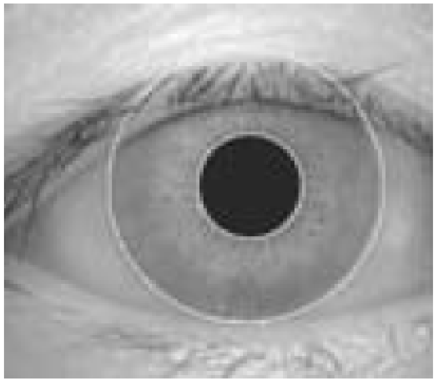
Normalized Image

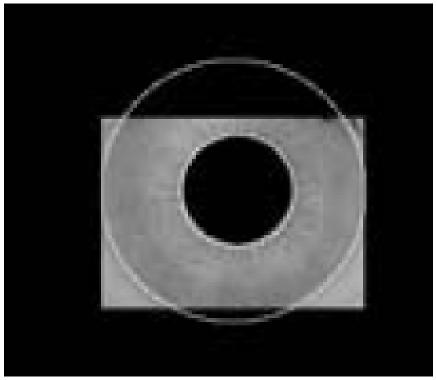


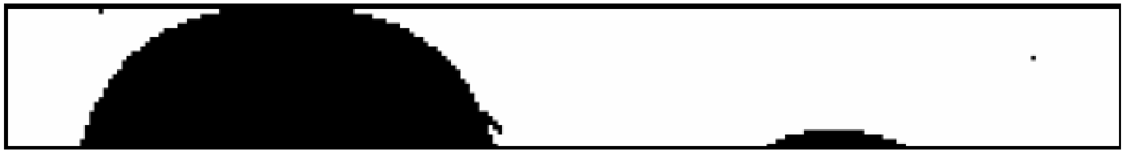
Normalized Image after noise removal

Eyelash & Eyelid removal

- Horizontal edge detection is used on the image
- Linear Hough transform is used to fit a line on lower and upper eyelid
- A horizontal line is then drawn intersecting the first line on the iris edge which is closest to the pupil







Feature Extraction

- Gabor filter
- Log-Gabor filter
- Laplacian of Gaussian filter
- Dyadic wavelet transform
- Mexican hat filter
- …….

Gabor Filter

- A Gabor filter is constructed by modulating a sine/cosine wave with a Gaussian
- Provides the optimum simultaneous localization in both space and frequency
- The centre frequency of the filter is specified by the frequency of the sine/cosine wave, and the bandwidth of the filter is specified by the width of the Gaussian
- Daugman makes uses 2D Gabor filters in order to encode iris pattern data
- The output of Gabor filter is then demodulated to get the phase information which is quantized to four levels for each possible quadrant in complex plane

Gabor Filter

- **The enhanced image is convolved with a bank of Gabor filter at different frequencies and orientations**

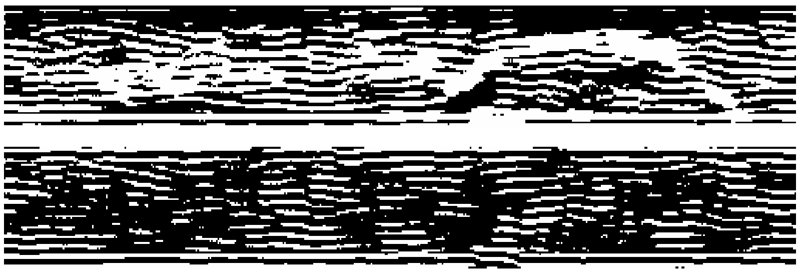
$$G(x,y,\theta,u,\sigma)=\frac{1}{2\pi\sigma^2}\exp\left\{-\frac{x^2+y^2}{2\sigma^2}\right\}\times\exp\{2\pi i(ux\cos\theta+uy\sin\theta)\}$$

- **Each point in the enhanced image is coded in two bits (b_r, b_i)**

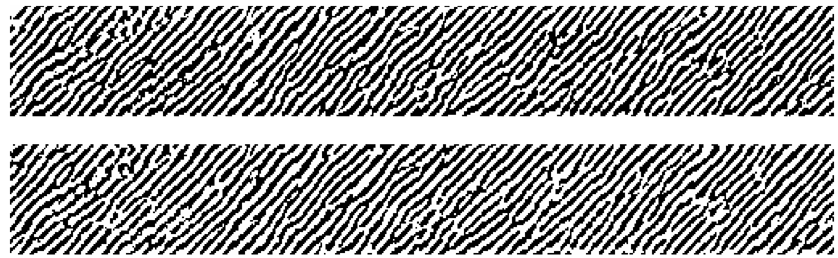
$$\begin{aligned}
&b_r = 1 \quad \text{if} \quad \mathrm{Re}\{G(x,y,\theta,u,\sigma)*I\}\geq 0\\
&b_r = 0 \quad \text{if} \quad \mathrm{Re}\{G(x,y,\theta,u,\sigma)*I\}< 0\\
&b_i = 1 \quad \text{if} \quad \mathrm{Im}\{G(x,y,\theta,u,\sigma)*I\}\geq 0\\
&b_i = 0 \quad \text{if} \quad \mathrm{Im}\{G(x,y,\theta,u,\sigma)*I\}< 0
\end{aligned}$$

Gabor Filter

- **The enhanced image is convolved with a bank of Gabor filter at different frequencies and orientations**

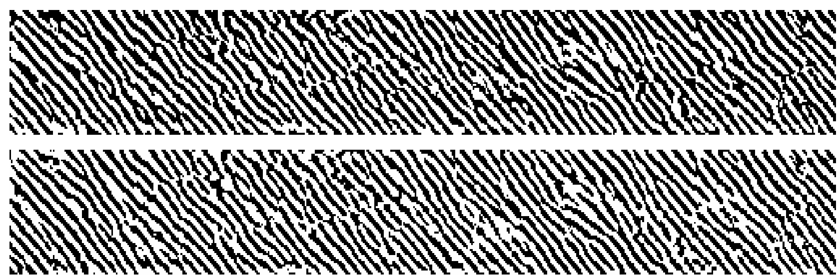


Frequency = 0.1832 Orientation = 0



Frequency = 0.1832 Orientation = pi/4

Frequency = 0.1832 Orientation = pi/2



Frequency = 0.1832 Orientation = 3*pi/4

Log-Gabor Filter

- Gabor filter which is Gaussian on a logarithmic scale, this is known as the Log-Gabor filter

$$G(f) = \exp\left(\frac{-(\log(f / f_o))^2}{2(\log(\sigma / f_o))^2} \right)$$

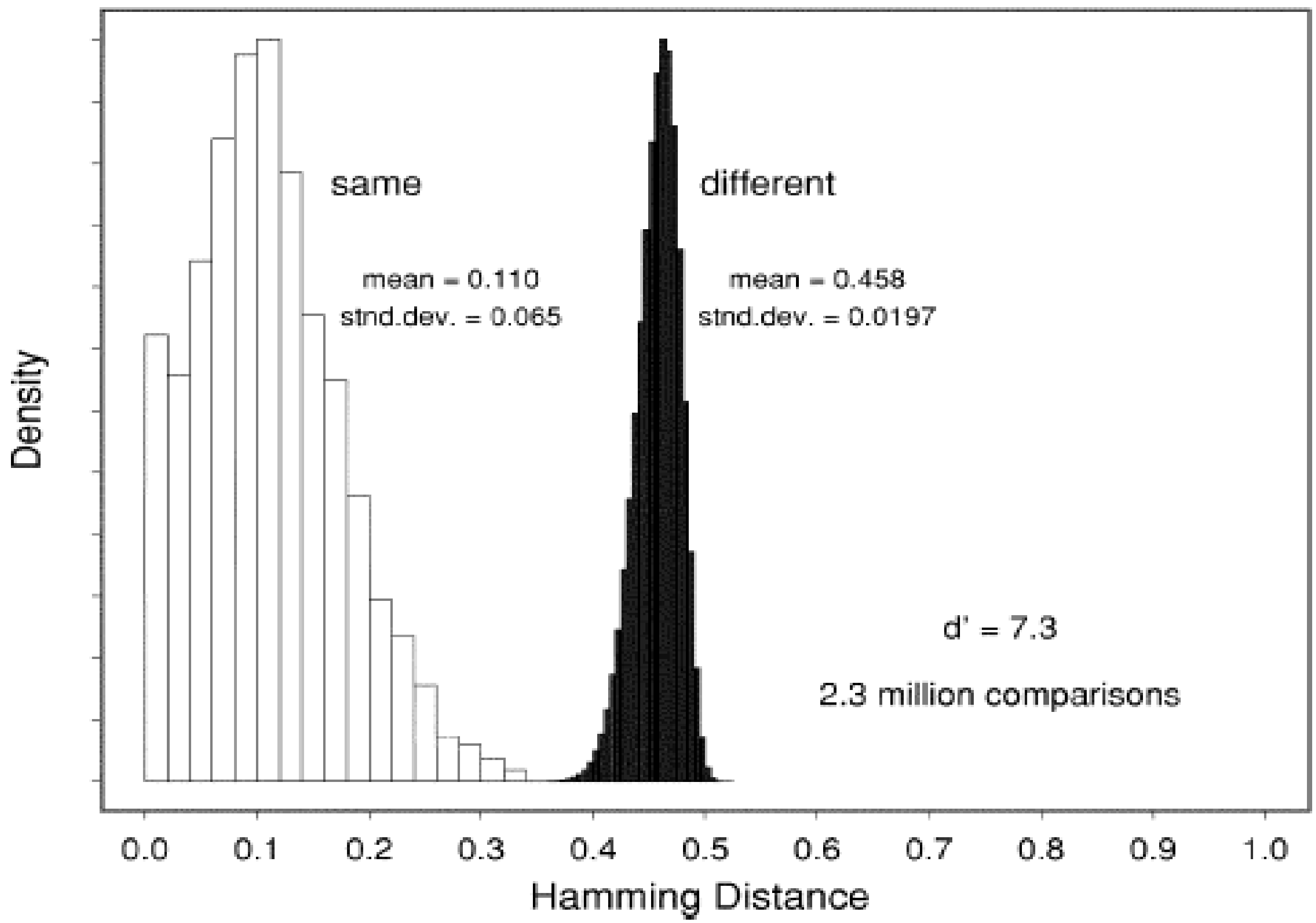
- It always has the zero DC component irrespective of the bandwidth of the filter
- Log-Gabor filter have extended tail at high frequency end, similar to the amplitude spectra of natural images
- It is consistent with our visual systems which indicate that we have cell response that are symmetric on log frequency scale

Feature Matching

- Feature are matched through the normalized hamming distance.

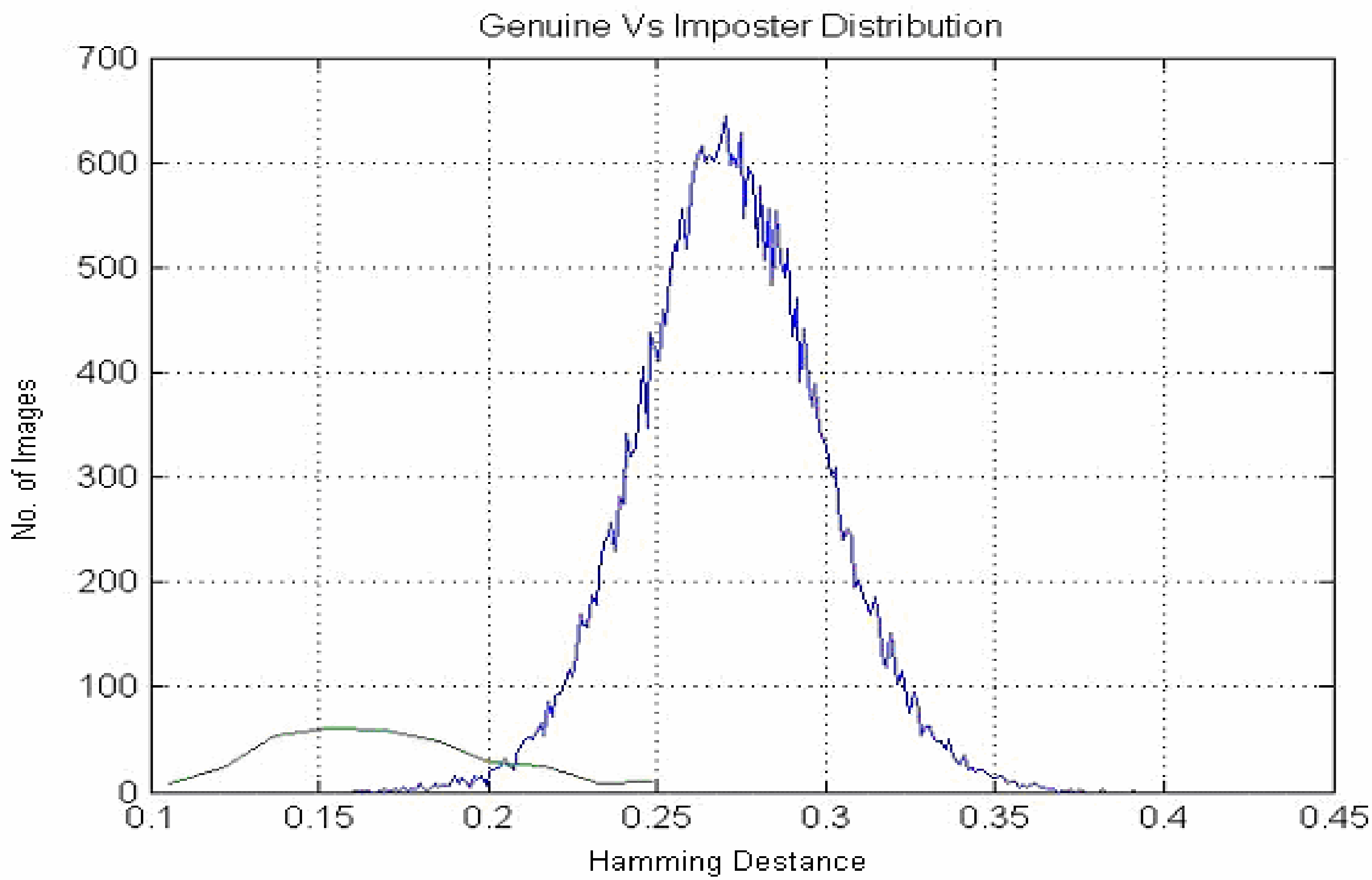
$$D_o = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}\{P_R(i,j)\otimes Q_R(i,j)+P_I(i,j)\otimes Q_I(i,j)\}}{2N\times M}$$

Genuine & Imposter Distribution

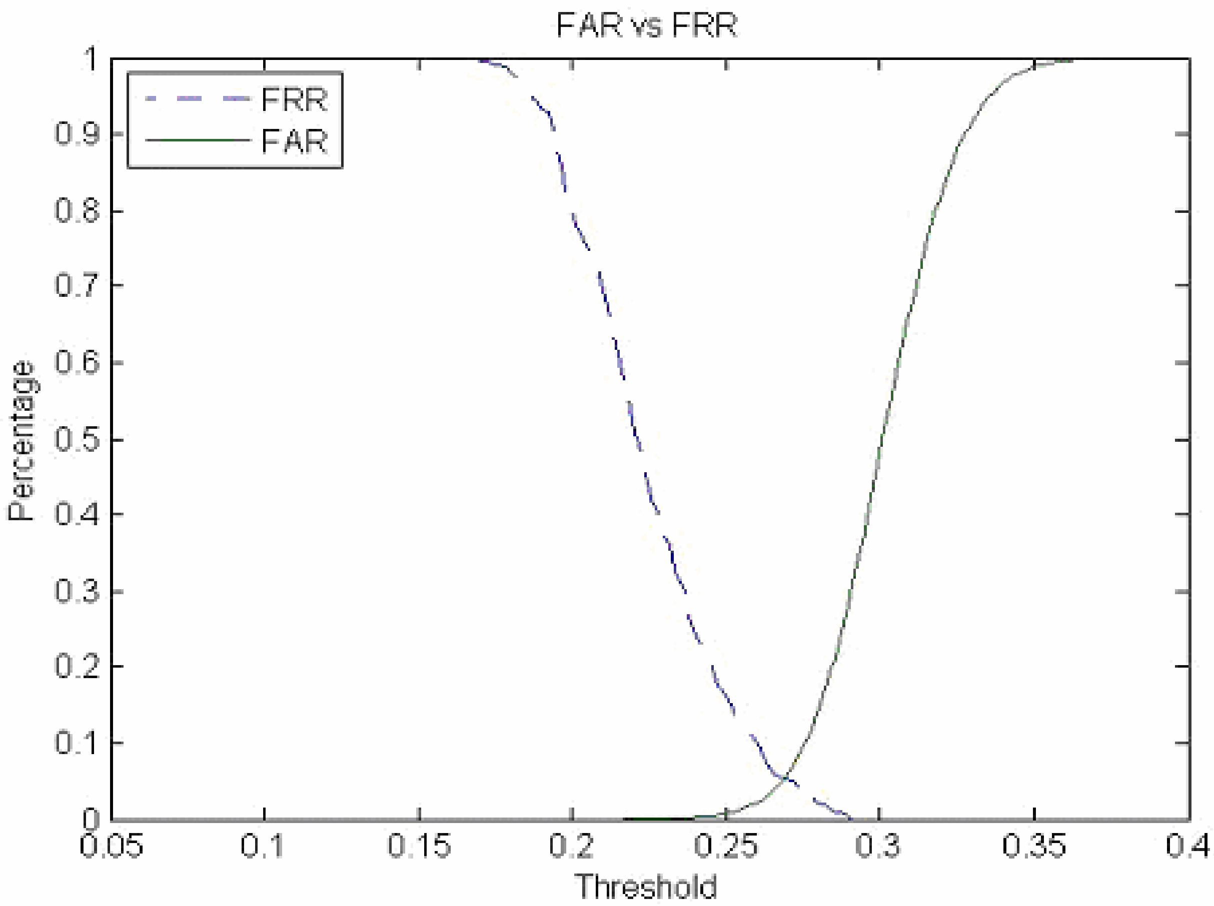


Source: Daugman, J. 2004. How iris recognition works. *IEEE Trans*, CSVT 14, 21--30

Genuine & Imposter Distribution

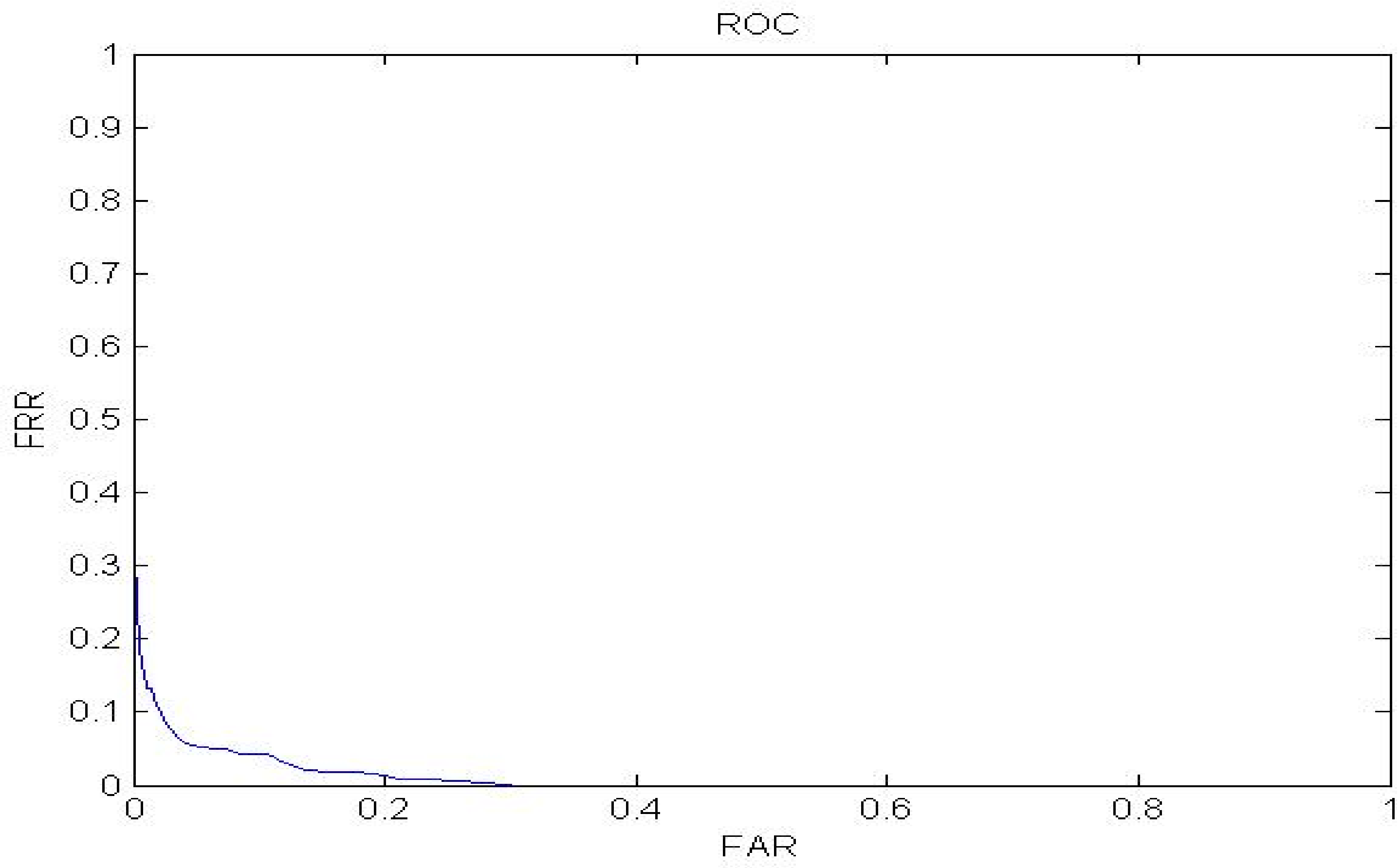


FAR & FRR



FAR vs FRR
FRR
FAR
Percentage
Threshold
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4

Receiver Operating Characteristics



Time of operation

Operation	*Time*
Assess image focus	15 msec
Scrub specular reflections	56 msec
Localize eye and iris	90 msec
Fit pupillary boundary	12 msec
Detect and fit both eyelids	93 msec
Remove lashes and contact lens edges	78 msec
Demodulation and IrisCode creation	102 msec
XOR comparison of two IrisCodes	10 μs

Source: Daugman, J. 2004. How iris recognition works. *IEEE Trans*, CSVT 14, 21--30

Time of operation

Operation	Time
Fit Pupillary boundary	68 msec
Fit outer Iris boundary	380 msec
Image Normalization	7 msec
Eyelash and Eyelid removal	1 msec
Image Enhancement	44 msec
Feature Extraction	271 msec
Feature matching (XOR of 2 Iris codes)	12 msec

Performance

Implementation by	Correct recognition	Equal error rate
Boles	92.64 %	8.13 %
Daugman	100 %	0.08 %
Li Ma	100 %	0.07 %
Tan	99.19 %	0.57 %
Wildes	-	1.76 %

Source: Li. Ma, Y. Wang, and T. Tan, "Iris recognition based on multi-channel Gabor filtering," in *Proc. 5th Asian Conf. Computer Vision*, vol. I, 2002, pp. 279-283

Thank You

References

1) Li. Ma, Y. Wang, and T. Tan, "Iris recognition using circular symmetric filters," in *Proc. 16th Int. Conf. Pattern Recognition*, vol. II, 2002, pp. 414-417

2) Li. Ma, Y. Wang, and T. Tan, "Iris recognition based on multi-channel Gabor filtering," in *Proc. 5th Asian Conf. Computer Vision*, vol. I, 2002, pp. 279-283

3) Daugman, J. 2004. How iris recognition works. *IEEE Trans*, CSVT 14, 21--30

4) Daugman, J. The importance of being random: Statistical principles of iris recognition. *Pattern Recognition*, vol. 36, num. 2, pp. 279-291, 2003

5) Ma Li, Tan T., Wang Y. and Zhang, D. (2004): Efficient Iris Recognition by characterizing Key Local Variations, *IEEE Trans*. Image Processing, vol 13, no.6, pp. 739-750

6) A. Poursaberi, B. N. Araabi, "A Novel Iris Recognition System Using Morphological Edge Detector and Wavelet Phase Features", *ICGST International Journal on Graphics, Vision and Image Processing*, P1150517004, June 2005