

# POSTER: Optimized Daugman's Algorithm for Iris Localization

**Dr. Mohamed A. Hebaishy**

National Authority for Remote Sensing and Space Science  
Gozif Titp St., Elnozha Elgididah.  
Egypt (11769), Cairo  
[Ma\\_hebaishy@yahoo.com](mailto:Ma_hebaishy@yahoo.com)

## ABSTRACT

Iris localization is considered the most difficult part in iris identification algorithms because it defines the inner and outer boundaries of iris region used for feature analysis. Several researches were made in the subject of iris finding and segmentation. The main objective here is to remove any non-useful information, namely the pupil segment and the part outside the iris (sclera, eyelids, skin). R. Wildes used Hough transforms to detect the iris contour. Daugman proposed an integro-differential operator to find both the pupil and the iris contour. Daugman's method is claimed to be the most efficient one. This paper proposes an implementation for Daugman's algorithm, which was found incompatible with visible light illuminated images. Then this paper proposes new algorithm for solving this problem.

## Keywords

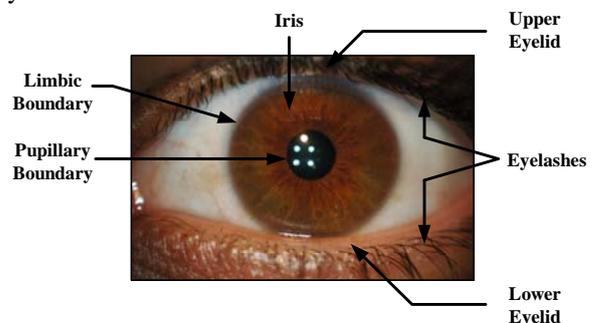
**Biometrics, Human Identification, Iris localization, Daugman's Algorithm**

## 1. INTRODUCTION

The human iris begins to form in the third month of gestation and the structure is complete by the eighth month, even though the color and pigmentation continue to build through the first year of birth. After that, the structure of the iris remains stable throughout a person's life, except for direct physical damage or changes caused by eye surgery. The iris hence parallels the fingerprint in uniqueness but enjoys a further advantage that it is an internal organ and less susceptible to damages over a person's lifetime [1]. It is composed of several layers which gives it its unique appearance. This uniqueness is visually apparent when looking at its rich and small details seen in high resolution camera images under proper focus and illumination. The iris is the ring-shape structure that encircles the pupil, the dark centered portion of the eye, and stretches radially to the sclera, the white portion of the eye see Figure 1, it shares high-contrast boundaries with the pupil but less-contrast boundaries with the sclera.

The iris identification system is to automatically recognize the identity of a person from a new image by comparing it to the human iris patterns annotated with identity in a stored database[2]. A general iris recognition system is composed of four steps. Firstly, an image containing the user's eye is captured by the system.

Then, the image is preprocessed to normalize the scale and illumination of the iris and localize the iris in the image. Thirdly, features representing the iris patterns are extracted. Finally, decision is made by



**Figure 1. Eye image expected to be used in the iris recognition system**

The iris identification system is to automatically recognize the identity of a person from a new image by comparing it to the human iris patterns annotated with identity in a stored database[2]. A general iris recognition system is composed of four steps. Firstly, an image containing the user's eye is captured by the system. Then, the image is preprocessed to normalize the scale and illumination of the iris and localize the iris in the image. Thirdly, features representing the iris

patterns are extracted. Finally, decision is made by means of matching. There are four key parts in the iris recognition system: iris image acquisition, preprocessing, feature extraction, and classifier design[3].

In a world where we will increasingly do business with parties we've never met, and might never meet, authentication will become as integral a part of the transaction as the exchange of goods and tender. The robustness of iris recognition makes it ideal for authenticating parties to commercial transactions, to reduce fraud in applications like check-cashing and ATMs, unauthorized activity in applications like treasury management, and in future, to ensure non-repudiation of sales, or to provide Letter of Credit and other authentication services in an electronic commerce environment[4]. Daugman has shown that iris patterns have about 250 degrees of freedom, i.e. the probability of two eyes having the same iris texture is about 1 in 7 billion. Even the 2 irises of an individual are different thereby suggesting that iris textures are independent of the genetic constitution of an individual. Iris recognition has been successfully deployed in many large scale and small scale applications.

Iris localization is considered the most difficult part in iris identification algorithms because it defines the inner and outer boundaries of iris region used for feature analysis[5]. The main objective here is to remove any non-useful information, namely the pupil segment and the part outside the iris (sclera, eyelids, skin). R. Wildes used Hough transforms to detect the iris contour. Daugman proposed an integro-differential operator to find both the pupil and the iris contour. Daugman's algorithm is claimed to be the most efficient one. After analyzing The Daugman's iris locating and pointing out the some limitations of this algorithm, this paper proposes optimized Daugman's algorithms for iris localization.

## 2. DAUGMAN'S ALGORITHM:

Daugman's algorithm is based on applying an integro-differential operator to find the iris and pupil contour[3].

*The equation is as follows:*

$$\max(r, x_o, y_o) \left| G_\sigma(r) * \frac{\partial}{\partial r} \oint_{r, x_o, y_o} \frac{I(x, y)}{2\pi} ds \right|$$

**Equation 1. Daugman's Integro-Differential Equation**

Where:  $x_0, y_0, r_0$ : the center and radius of coarse circle (for each of pupil and iris).  $G_\sigma(r)$ : Gaussian function.  $\Delta_r$ : the radius range for searching for.

$I(x, y)$ : the original iris image.

$G_\sigma(r)$  is a smoothing function, the smoothed image is then scanned for a circle that has a maximum gradient change, which indicates an edge. The above algorithm is done twice, first to get the iris contour then to get the pupil contour. It worth mentioning here the problem is that the illumination inside the pupil is a perfect circle with very high intensity level (nearly pure white). Therefore, we have a problem of sticking to the illumination as the max gradient circle. So a minimum pupil radius should be set. Another issue here is in determining the pupil boundary the maximum change should occur at the edge between the very dark pupil and the iris, which is relatively darker than the bright spots of the illumination. Hence, while scanning the image one should take care that a very bright spot value could deceive the operator and can result in a maximum gradient. This simply means failure to localize the pupil. The following experimental results have been getting using UPOL database.

## 3. OPTIMIZED DAUGMAN'S ALGORITHM:

As a solution to this problem, modification to the integro-differential operator is proposed to ignore all circles if any pixel on this circle has a value higher than a certain threshold. This threshold is determined to be 200 for the grayscale image. This ensures that only the bright spots – values usually higher than 245 – will be cancelled.

Another solution we considered is to treat the illumination by truncating pixels higher than a certain threshold – bright spots – to black. But this method failed in many images, this is because when the spot hits the pupil the illumination spreads on the pupil so as we treat the illumination spots it will leave behind a maximum change edges that can not be determined and the operator will consider it the pupil boundary. The sequence of the Algorithm procedure is cleared in the flowchart shown in Figure 2.

Figure 3 shows the experimental results each daugman's algorithm and optimization Daugman's algorithm.

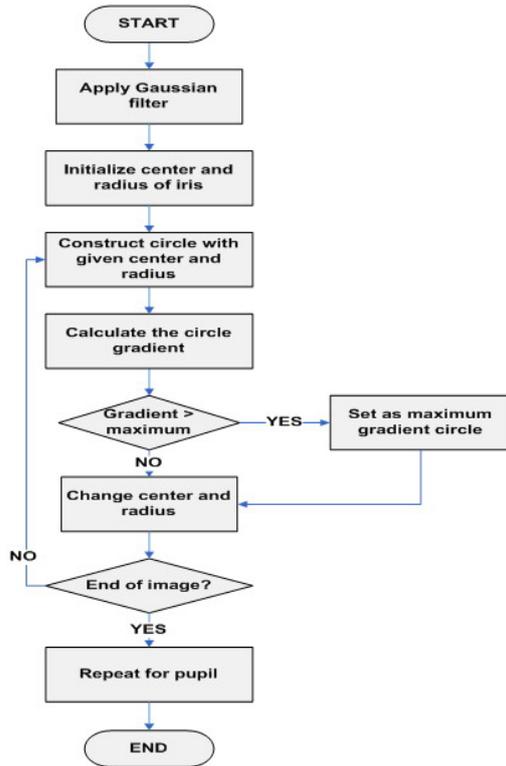


Figure 2 Flowchart of optimized Daugman's localization algorithm operation.

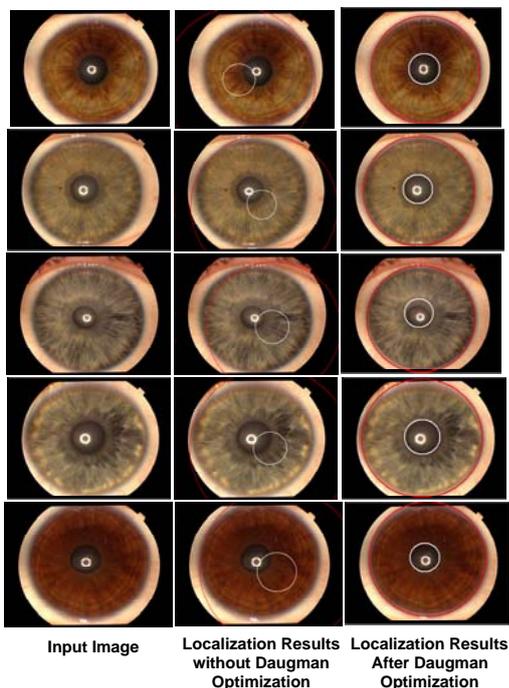


Figure 3 : Localization results

Database	Number of samples	Daugman's Algorithm		Daugman's optimization	
		Fill	Success	Fill	Success
UPOL	384	75%	25%	0%	100%

Table 1. Experimental results

The proposed algorithm is tested by applying it on UPOL database that includes about 384 images for 128 persons the localization successful percentage was 100%.

#### 4. CONCLUSION:

The above studies show that the iris-locating algorithm based on integro-differential operator suffers from bright spots of the illumination inside the pupil, so the optimized Daugman's algorithm overcome this problem and gives a successful results for iris localization process.

#### 5. ACKNOWLEDGMENTS

I would like to express my appreciation to the Egyptian space program at NARSS for their support and encouragements.

#### 6. REFERENCES

- [1] J. G. Daugman, "High confidence visual recognition of person by a test of statistical independence," IEEE Trans.PAMI 15, 1148-1161 (1993).
- [2] J. G. Daugman, "The importance of being random: statistical principles of iris recognition," Pattern. Recognition 36, 279-291 (2003).
- [3] Yong Zhu, Tieniu Tan and Yunhong Wang, "Biometric Personal Identification Based on Iris Patterns" National Laboratory of Pattern Recognition (NLPR), Institute of Automation, Chinese Academy of Sciences, P. R. China, 2003
- [4] <http://www.unisys.com/news/releases/2001/jun/06218031.asp>
- [5] J. G. Daugman, "How iris recognition works," IEEE Trans. Circuits and Syst. for Video Tech. 14(1), 21-30 (2004).