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A Review of Daugman's Algorithm in Iris Segmentation

Sr. Sahaya Mary James

Department of Computer Science,Periyar University,
St.Joseph's college of arts and science for women,Hosur-635126
Tamilnadu,India
sahai.james@gmail.com

Abstract

Iris recognition is considered to be the most reliable and accurate biometric identification system available. Compare to all the biometric iris is error free. Banking transaction and all the important processes are now-a-days done through mobile. Other forms of security measures like PIN are not as strong as iris recognition. The uniqueness of the iris recognition will provide no space for the hackers to break in. Daugman's algorithm is the best for recognizing iris. The algorithm has four steps such as applying Gaussian filter, Initialize center and radius, Construct circle with given center and radius, Calculate the circle gradient. The important step in this algorithm is to find out the maximum gradient. Once the maximum gradient is found, the boundary becomes iris boundary. These processes are repeated for finding the pupil boundary. This paper also discuss the situation of noise occurring and the effects of it.

Keywords: *Contour Integral, Convolution, Epigenetic, Genotypic, Gaussian Filter, Non-Circular*

1. Introduction

In pattern recognition problems, the key issue is the relation between inter-class and intra-class variability: objects can be reliably classified only if the variability among different instances of a given class is less than the variability between different classes. In face recognition, difficulties arise from the fact that face is a changeable social organ displaying a variety of expressions, as well as being an active three dimensional object whose image varies with viewing angle, pose, illumination and age. Even the best current algorithm can have error rates of 43%-50%. Against this intra-class variability, inter class variability is limited because different faces possess the same basic set of features, in the same canonical geometry. For the above reasons, iris patterns become interesting as an alternative approach to reliable visual recognition of persons when imaging can be done at distances of less than a meter.

2. Features of Iris

Every biometric lies somewhere on a continuum between being genetically determined (genotypic) or not

(epigenetic).Genotypic traits are: DNA, Blood type, Gender, Race. Epigenetic traits are: Fingerprints (except for type correlations); and iris patterns (except for eye color). Fig (1) shows how the eye closely protected by the outer layer.

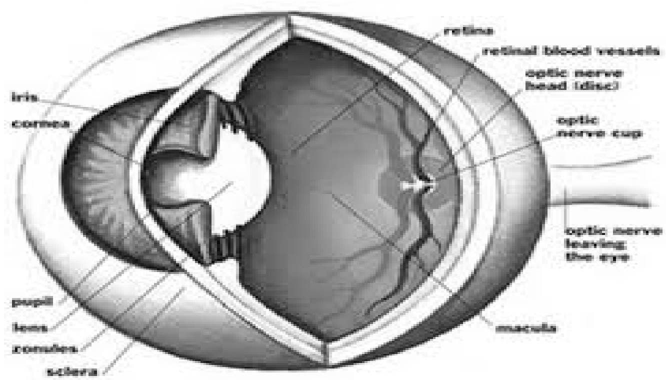

Fig 1: Structure of the eye

- Highly protected internal organ of the eye, the iris is well protected from the environment and stable over time.
- Random pattern of great complexity and uniqueness
- Pattern is epigenetic
- Presumed stable, apart from pigmentation changes.

3. Segmentation

Segmentation is to subdivide an image into its component regions or objects. It should stop when objects of interest in an application have been isolated. It is a process of localizing iris from the entire part which are acquired. Iris can be approximated by two circles. Iris/sclera boundary, iris/pupil boundary as shown in Fig (2). Segmentation is normally used to find out the boundary. In Iris, the segmentation is done with circular model.

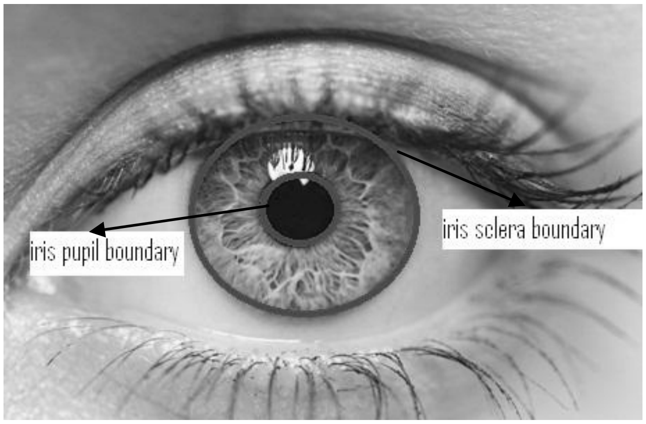

Fig : 2 Segmenting Sclera from iris and pupil from Iris.

4. Daugman's Algorithm

$$\max_{(r,x_0,y_0)} \left| G_\sigma(r) * \frac{\partial}{\partial r} \oint_{r,x_0,y_0} \frac{I(x,y)}{2\pi r} ds \right| \quad (1)$$

I(x, y) is the intensity of the pixel at coordinates *(x, y)* in the image of an iris.

r denotes the radius of various circular regions with the center coordinates at *(x0, y0)*.

is the standard deviation of the Gaussian distribution.

Gσ(r) denotes a Gaussian filter of scale sigma (σ).

(x0, y0) is the assumed centre coordinates of the iris.

s is the contour of the circle given by the parameters (*r, x0, y0*).

In Eq(1) the traditional approach integro-differential equation is used to detect the edges of the circle. In image processing, detecting the boundary is the important process. *I(x,y)* is an image containing eye. The operator searches over the image domain*(x,y)* for the maximum in the blurred partial derivates with respect to increasing radius *r*, of the normalized contour integral of *I(x,y)* along a circular arc *ds* of radius *r* and center coordinates *(x0,y0)*. The symbol * denotes the convolution and $G_\sigma(r)$ is a smoothing function such as a Gaussian of scale *σ*. The complete operator behaves as a circular edge detector, blurred at a scale set by *σ*, searching iteratively for the maximal contour integral derivative at successively finer scales of analysis through the three parameters space of center coordinates and radius*(x0,y0,r)* defining a path of contour integration.

4.1 Apply Gaussian Filter

In electronic and signal processing, a Gaussian filter is a filter whose impulse response is a Gaussian Function. When working with images it is recommended to use 2D Gaussian function. The Gaussian Smoothing Operator performs a weighted average of surrounding pixels based on the Gaussian distribution. It is used to remove Gaussian noise and is a realistic model of defocused lens. Sigma defines the amount of blurring. The radius slider is used to control how large the template is. Large values for sigma will only give large blurring for larger template sizes. Noise can be added using the sliders. The calculation is more when the *σ* value becomes high is mentioned in Fig(3).The operator generates a template of values that are then applied to groups of pixels in the image. These template values are defined by 2D Gaussian Eq (2)

$$g(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}} \quad (2)$$

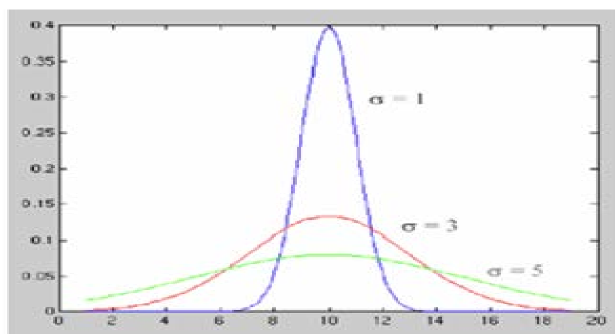

Fig:3 Sigma value variation

4.2 Initialize Center and Radius

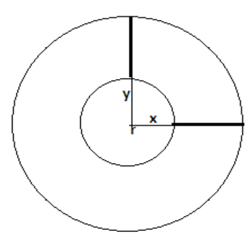

Fig :4 Initialization of center and radius

The center and co-ordinates are initialized by (r,x0,y0). The circle is formed by using these three parameters. Boundaries are identified by increasing the parameters.

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4.3 Construct Circle With Given Center and Radius

The operator searches for the circular path where there is maximum change in pixel; values, by varying the radius 'r' and the co-ordinates(x,y) of the circular contour. The operator is applied iteratively with the amount of smoothing progressively reduced in order to obtain accurate localization. The boundaries are identified in Fig(5). Assuming that the variables x, y and r belong to the ranges [0; X], [0; Y] [0; R] respectively, this method has the computational complexity of order [X × Y × R]. Thus, at every pixel, a total of R scans are necessary to compute the circle parameters using this approach. A search over the entire image (of an eye) is done, pixel by pixel.

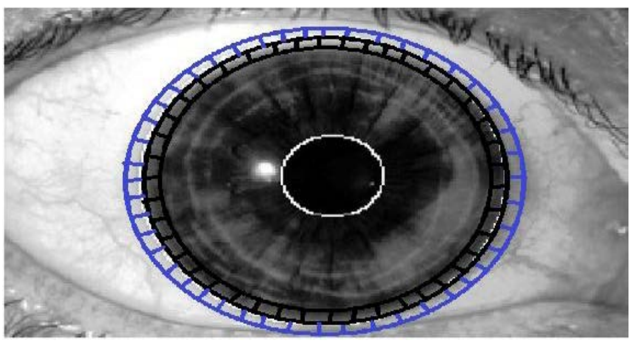

Fig: 5 Circle constructed in pupil and iris

4.4 Calculate the Circle Gradient

The goal of Gaussian filtering process is divided into two such as smoothing and gradient.

4.4.1 Smoothing

Smoothing aims to suppress noise or other small fluctuations in the image; it is equivalent to the suppression of high frequencies. Unfortunately, smoothing also blurs all sharp edges that bear important information about the image.

4.4.2 Gradient

Gradient operators are based on local derivatives of the image function. Derivatives are bigger at locations of the image where the image function undergoes rapid changes, and the aim of gradient operators is to indicate such locations in the image. Gradient operators have a similar effect to suppressing low frequencies. Noise is often high frequency in nature; unfortunately, if a gradient operator is applied to an image, the noise level increases simultaneously.

These two criteria are conflicting, but they can be optimized simultaneously using a Gausian Filtering.

The 2D Gaussian smoothing operator G(x,y) is given by

$$G(x,y) = e - \frac{x^2+y^2}{2\sigma^2} \quad (3)$$

In Eq(3) x,y are the image co-ordinates and σ is a standard deviation of the associated probability distribution. Sometimes this is presented with a normalized factor.

The standard deviation σ is the only parameter of the Gaussian filter-it is proportional to the size of the neighborhood on which the filter operates. Pixels more distant from the center of the operator have smaller influence, and pixels farther than 3σ from the center have negligible influence.

Our goal is to obtain a second derivative by increasing the co-ordinates (x, y) and ∂/ ∂r for radius. The image is smoothed by a Gaussian (expressed using a convolution(*)).

The changes of the contour integral and the maximum value of the gradient forms the boundary for iris. The equation used twice to find the boundaries of the iris first and pupil next.

5. Edge Detection For Non-Circular Iris

In some cases iris and pupil boundaries do not form a circle. The radial gradients of each are like snakes. Mapping does not instructs the code rather the structure. Precise structure is important in normalization which mapping the tissue between in and outer boundary has to know where to begin and where to end. To do the normalization properly, mapping the irregular structure is essential. The thickest zigzag boundary depicts the iris and the thinnest snake like boundary depicts the pupil as shown in Fig (6).

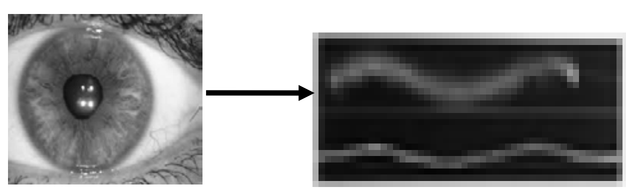

Fig. 6 Non circular iris and Radial Gradient

6. Effect Of Image Noise On Daugman's Integro Differential Operator Performance

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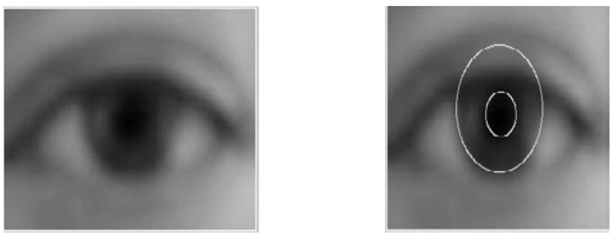
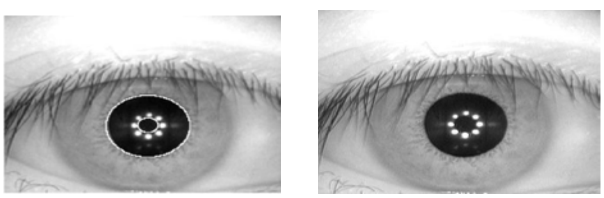
The Daugman's algorithm does not suit when the input of the image contains noise in it. This noise can be in the form of reflection, the eye in the image is not fully opened or the eyelashes covering some part of the iris area. Low quality iris images result in poor recognition performance when the traditional integro-differential equation is applied. The algorithm fails due to the difficulty of finding the inner and outer boundary. To sum up, the segmentation of an iris using Daugman's integro-differential operator may result in error if the image is poorly Focused, Rotated iris, Motion blurred shown in Fig(7 a)-(b), Contact lens, Glasses, Lighting reflection shown in Fig(8 a)-(b) , Partial captured, off-angle shown in Fig(9 a)-(b)etc.,



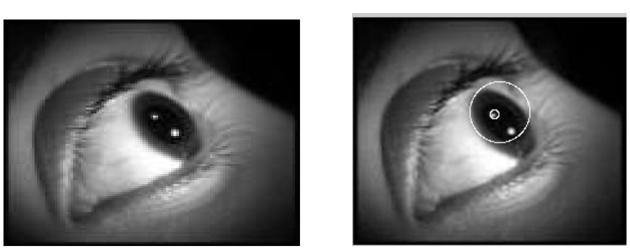
(a) (b)

Fig 7: (a) Input blur image that does not have a sharp iris to sclera and iris to pupil contrast
(b) Incorrect pupil detection



(a) (b)

Fig 8: a) Input noise image of light reflection
(b) Incorrect pupil detection



(a) (b)

Fig 9: a) Input noise image is rotated at some angle
(b) Incorrect pupil detection

7. Conclusion

This paper has presented an iris segmentation was done using Daugman's algorithm. There are various novel approaches used for identifying the boundary called Bit plane slicing, morphological operations and standard deviations windows helps to recognize pupilary radius and pupilary mid-point. By solving these parameters in circle equation, we can recognize pupilary boundary accurately. An adaptive threshold method method can find the limbic boundary. Latest development explains how to solve problems associated with image acquisition such as non-frontal face images and off angle iris.

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Author's Biography

Sr.Sagaya Mary James received her Master in Science (M.Sc)in Information science and management in the year 2005 at Bharathiar University, Coimbatore, TN, India and Master of Business Administration in 2006 at Alagappa University and M.Phil in the year 2008 at Bharathiar University and also She has completed B.Ed in 2012 at Tamilnadu Education University, Chennai. L Level Symposium conducted in Govt College,Uthangarai.She published a paper in national conference conducted by adhiyaman Eng., college hosur titled "Iris, a Suitable security measures in mobile. The same paper is also published in IJARSE. The paper entitled "Iris Recognition Process" is published in National level seminar. At Present she is working in St.Joseph's College,Hosur as Asst., Professor.