# Rhodopsin of Retina: An Effective Approach to Segment Iris from Color Image

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***Abstract*—In this paper, a very fast and accurate method for extraction of Iris in color images is introduced. Proposed method stems from anatomy and visual characteristics of Rhodopsin, which is a protein in the membrane of the rod photoreceptor cell in the retina of the eye. Pupil is extracted using Red and Hue Color Components. After pupil segmentation, the radius of Iris is estimated on a mask obtained by a simple thresholding on Red Component. The performance of the proposed method is compared with that of best existing methods from literature on UBIRIS databank, in terms of accuracy, degradation and time consumption. Referenced results from verification, supports the superiority of proposed algorithm both in accuracy and efficiency.**

## I. Introduction

IRIS segmentation is a pivotal step in iris recognition process. In literature, there exist several approaches for iris segmentation, most of which are implemented for infrared descriptions. H. Proenc¸a and L.A. Alexandre at al [1], the authors of UBIRIS color databank, gathered useful comparisons between four different types of famous methodologies in [2]. UBIRIS [1] is proposed in two sessions of 1877 captured images from 241 individuals. They state in [2] that the Daugman's original methodology [3] is very effective on images with clear intensity separability between iris, pupil and sclera regions and it fails when images do not have enough contrast. They applied their UBIRIS [1] databank and implemented three different parameters for Daugman's approach based on original method, Histogram equalization pre-process and threshold pre-process. The results proved their claim of enhancement on segmentation by preprocessing in second session of UBIRIS images before using original method. For Wildes methodology [4], they presented three different types of parameters which consists of Original method, Shen and Castan edge detector and Zero-crossing edge detector where they gained the best result in first original method of Wildes of their first session of UBIRIS. They even comprised there databank through Camus and Wildes method [5], Martin-Roche et al.'s method [6] and Tuceryan's methodology [7] and compared the results. Furthermore, they proposed a new methodology for segmentation of iris from gray images. This methodology includes three main levels. First it consists with clustering approaches where they used four different types including K-means, SOM, Fuzzy K-means and Expectation-Maximization clustering to cluster the images to distinct intensity levels. Second, they used Canny edge detector to extract the edges and finally, the third, they used Hough Transform to extricate the circles of both pupil and Iris. The main advantage of the composed method stands on little difference of accuracy results in both sessions, Degradation, and they gained the best results on second session between different methods with 97.88%, where it shows that the composed method is less sensitive to noisy images among the other approaches. Boyce et al. [8] proposed a thresholding method on each individual channel by means of RGB and checked for the connectivity of binarized image to detect pupil boundary. The disadvantage of the method relies on the sensitivity of contrast of image and reflections.

Although most reviewed methods could result in high accuracy, nevertheless, computation time is an important challenge to argue. Even though, using Hough transform or Integro-Differential approaches would be time consuming methods in order to detect circle from extracted edges. It has to be mentioned that all approaches for iris segmentation are based on gray image processing instead of color approaches where infrared images extricate from reflection noises.

In this paper, a very fast and accurate method for Iris extraction using color images is proposed. Unlike infrared images, extraction of pupil in color images is a challenging issue due to reflections. Proposed method extracts both Pupil and Iris Circles from Color Images. The anatomy of Retina and how it affects pupil's and Iris's color is discussed in Section 2. Section 3 explains the proposed method for pupil extraction, where Red and Hue Color Components are utilized for accurate Pupil segmentation. In section 4, a simple method is used to estimate the iris Radius. Our proposed method is compared with successful existing methods on UBIRIS databank, in terms of accuracy, degradation and time consumption in section 5. At last but not least, in section 6 we discuss our algorithm through ill-based database such as UPOL. Finally the paper is concluded in Section 6.

## II. Rhodopsin and its Visual Purple Color

A great deal of extra information may be contained in the color, and this extra information can then be used to simplify

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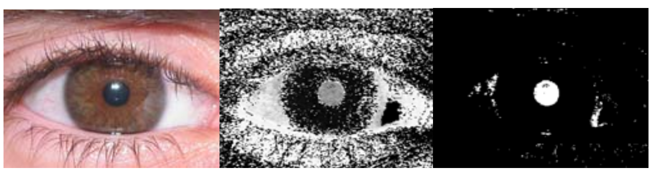
image analysis, e.i. object identification and extraction based on color [9]. Regarding the pupil portrait in a color image, it seems that it is not really dark black but near dark purple. This definition has scientific reason. After light passes through the cornea, a portion of it passes through an opening known as the pupil. Rather than being an actual part of the eye's anatomy, the pupil is merely an opening. The fact that the light which the pupil allows to enter the eye is absorbed on the retina which is the innermost layer. The retina contains a chemical called Rhodopsin, or "visual purple" [10]. This is the chemical that converts light into electrical impulses that the brain interprets as vision. This visual purple lays the pupil's color because the lens of eye is completely transparent structure.

RGB images could be fused by light of camera's flash or environment which called the noise factor. The above reality is more sensible in shiny dark regions of an image like pupil, figure.1.a. This weakness causes a problem in segmentation and recognition steps of iris recognition through the state of art. Hue intensity, which is gotten from HSI transformation, shows pure color and it has no sensitivity to light, figure.1.b. This argument is some how challengeable in the state that it has high light fusion where it damages the structure of images like shiny places, nevertheless, it has very low sensitivity to the above discussion, figure 1.b.



| a | b | c |
|---|---|---|

**Fig.1. a.** Sample color image of UBIRIS **b.** Hue component of UBIRIS **c.** Binarized image through a fixed boundaries

The average value of Rhodopsin's color in RGB is [0.16;0.2;0.25], all in scale of 1, and it can be fused by light. Nevertheless, Hue value remains fixed and it is about 0.59 gray values in scale of 1. This value is in the medium level where by defining rigid boundaries can be extracted to binarized pupil, see figure 1.b-c. This characteristic is a fixed feature to all human being. Though, because of white color of sclera, it can transparent the visual purple beneath the skin, where it will get a medium value in Hue. After all, the binarized image will contain pupil and often sclera regions.

## III. Pupil Segmentation

Intensity value of pupil in Hue component is about 0.59 of gray value. For proposed algorithm we binarized intensity values between [0.55, 0.75] to get binarized pupil in guaranteed bounds, see figure.1.c.

Hue value of pupil is absolutely fixed and even by fusing light it will not changed, just the place where the fusion damages the structure of RGB like shiny dot on pupil. So dealing with the argument that an adaptive clustering should be defined will not be accurate discussion.

### A. *Operation on Red Components*

Pupil is not the only object extracted from binarized Hue component. Where there are detections on sclera regions too and it cannot be guaranteed that the pupil is the only object shown. On the other hand, pupil component got the lowest gray intensity in Red component of RGB. The reason that we use Red instead of other gray value is because the color of skin is near pink and it has the higher value in Red component of RGB. Furthermore, sclera is shown as white where for that structure the Red component is in the highest value. By the definition, there only exist Eyelashes, Eyelids, Iris and Pupil areas where all have lower intensity, see figure.3.a.

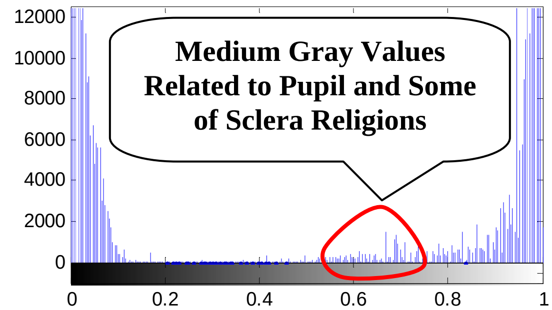



**Fig.2.** Histogram of Hue Components and

| a | b | c |
|---|---|---|

**Fig.3. a.** Red component **b.** first binarized image from first root of derivation **c.** Second Binarized Image from global thresholding

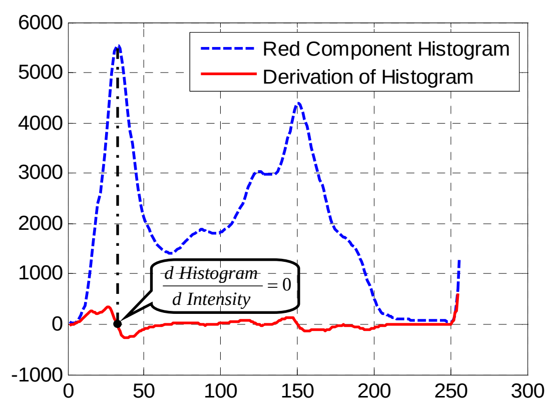



**Fig.4** Histogram of Red components and its derivation

The darkest areas are Pupil, Eyelashes and Eyelids where this feature will help us to define two binarized images. The first boundary for binarizing Red image could be detected by selecting the first root of derivation of Red image histogram, see figure.3.b and figure. 4.

$$\frac{d\ Histogram}{d\ Intensity} = 0 \Rightarrow First\ Root\ Selected \qquad (1)$$

The above derivative in equation one will assist to detect the first local maximum and relates to first maximum scatter in dark intensity values. The second boundary for binarizing Red image is defined by global thresholding method [11] which chooses the threshold to minimize the interclass variance of the black and white pixels, figure.3.c. This binarized image will be used to dedicate useful radius of iris in Section 4.

### *B. Operation on Hue Components*

By producing first binarized Red image, figure.3.b, and considering binarized image of Hue component, figure.1.c, it can easily be realized that these images are in common on pupil which can be intersected with together to extract pupil regions. The whole procedure of proposed iris segmentation method is shown as block diagram in figure.6. As it shown, after intersection of the above two binarized images there still exist few tiny objects. We used simple morphologic enhancements like eroding and dilating in order to clear the noises. Then the biggest area in objects, which released after morphologic enhancement, is taken and considered as pupil candidate.

A simple method to detect circle of pupil is used in equation 2:

$$\begin{bmatrix} O_x \\ O_y \end{bmatrix} = \frac{1}{N} \begin{bmatrix} \sum_{i=1}^{N} X\_Coordinate^i \\ \sum_{i=1}^{N} Y\_Coordinate^i \end{bmatrix}$$

$$\& \qquad Pupil\_Radius = \sqrt{\frac{N}{\pi}} \tag{2}$$

Where in here, $N$ relates to the number of pixels detected for pupil candidate. In other word it is the area of the pupil. $O_x$ and $O_y$ are the coordinates of the center of pupil's circle.

## IV. Estimating Iris Boundary

The second binarized image, which is already discussed in section 3.1, is related to dark places including Pupil, Iris, Eyelids and Eyelashes and can be extracted by global thresholding. By considering the Red component of an eye image it is clear that the left and right side of iris will fall to sclera regions which will be zero in second binarized image, figure.5.a. In some few images the upper eyelid is closer than usual and it mixes with iris in binarized image. This problem usually occurs in right hand of iris because it is closer than the left side. Nevertheless, it is not a big challenge because the proposed algorithm considers the minimum radius which is defined from both right and left sides, figure.5.a.

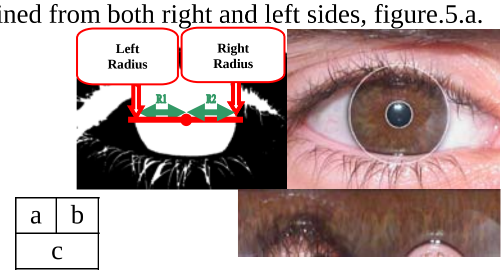



**Fig.5. a.** Iris image surrounded by eyelids. Calculating Radius of Iiris **b.** Segmented Iris **d.** Cartesian mapped iris

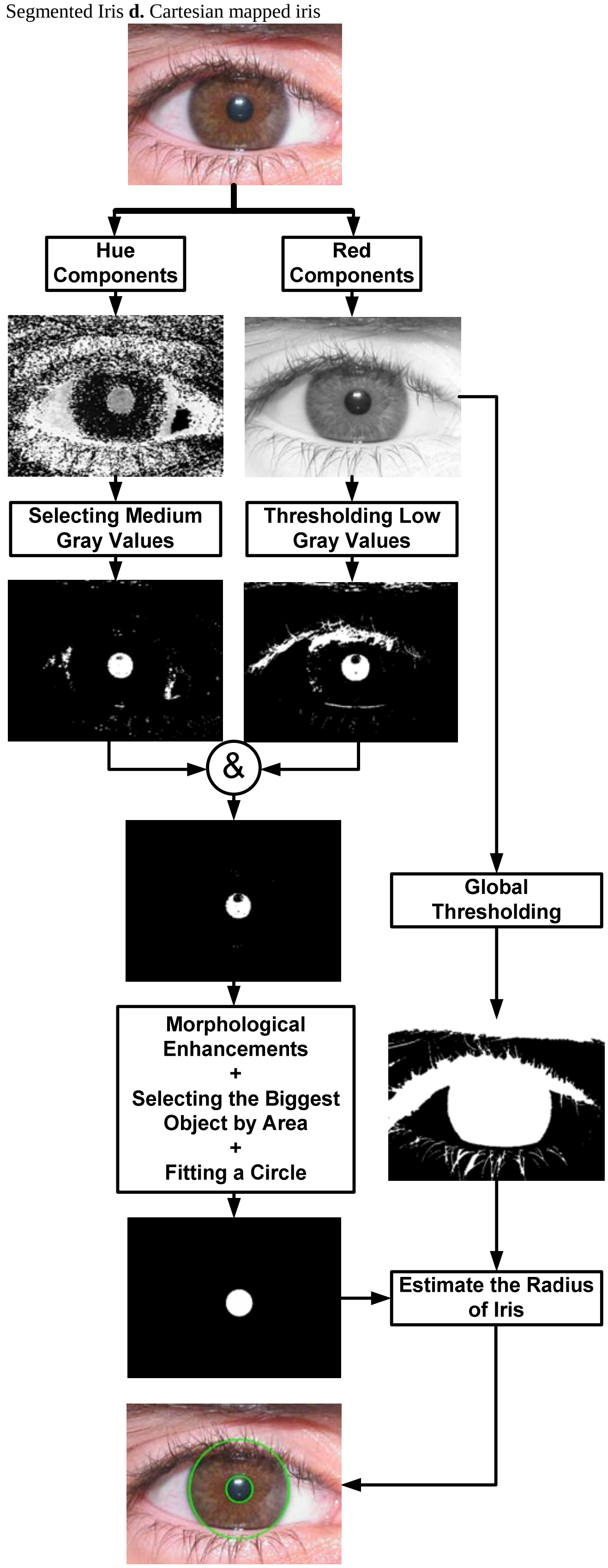



**Fig.6.** Block diagram of the implemented methodology

The whole procedure of the implemented methodology is shown in figure.6. As it is shown, two binarized image, which are gotten from Hue and Red, are intersected in order to extract pupil. After enhancement on extracted pupil and fitting circle around the extracted pupil, it is used to detect the radius of iris by applying the global thresholded Red component.

## V. Experimental Results

UBIRIS [1] images with sizes of 600*800 pixels is the considered databank to comprise the proposed methodology. The algorithms is implemented in C++ and Pentium IV- Full cash with 256 MB RAM is used. Our implemented method has got the highest accuracy in session 1 which it is 100%, Table.1. The degradation of the proposed method is 3.66% which is in medium level and it is because of error in session 2. This session has several noise factors of reflections, contrast, luminosity, eyelid and eyelash iris obstruction and focus characteristics which influences in Hue component where other areas of iris is depicts in medium level and confuses with pupil.

**Table.1**. Accuracy and Time computation results of different methodologies (results on other methods is curtesiy of Proenc¸a and L.A. Alexandre [2])

| Method | Parameters | Session 1 (%) | Session 2 (%) | Degra-dation | Time (s) |
|---|---|---|---|---|---|
| Daugman | Original Method | **95.22** | **88.23** | **6.99** | **2.73** |
| Daugman | Histogram equalization pre-process | **95.79** | **91.10** | **4.69** | **3.01** |
| Daugman | Threshold pre-process (128) | **96.54** | **95.32** | **1.22** | **2.92** |
| Wildes | Original Method | **98.68** | **96.68** | **2.00** | **1.95** |
| Wildes | Shen and Castan edge detector | **96.29** | **95.47** | **0.82** | **2.49** |
| Wildes | Zero-crossing edge detector | **94.64** | **92.76** | **1.88** | **2.51** |
| Camus and Wildes | Original Method, number of Directions = 8 | **96.78** | **89.29** | **7.49** | **3.12** |
| Martin-Roche et al. | Original Method | **77.18** | **71.19** | **5.99** | **2.91** |
| Tuceryan | Total clusters = 5 | **90.28** | **86.72** | **3.56** | **4.81** |
| Proenc¸a, H., and Alexandre, L.A | Original Method | **98.02** | **97.88** | **0.14** | **2.3** |
| Proposed Method | | **100** | **96.34** | **3.66** | **0.32** |

Here are some examples of segmented iris images from UBIRIS. We tried to show different verity of colors in iris.

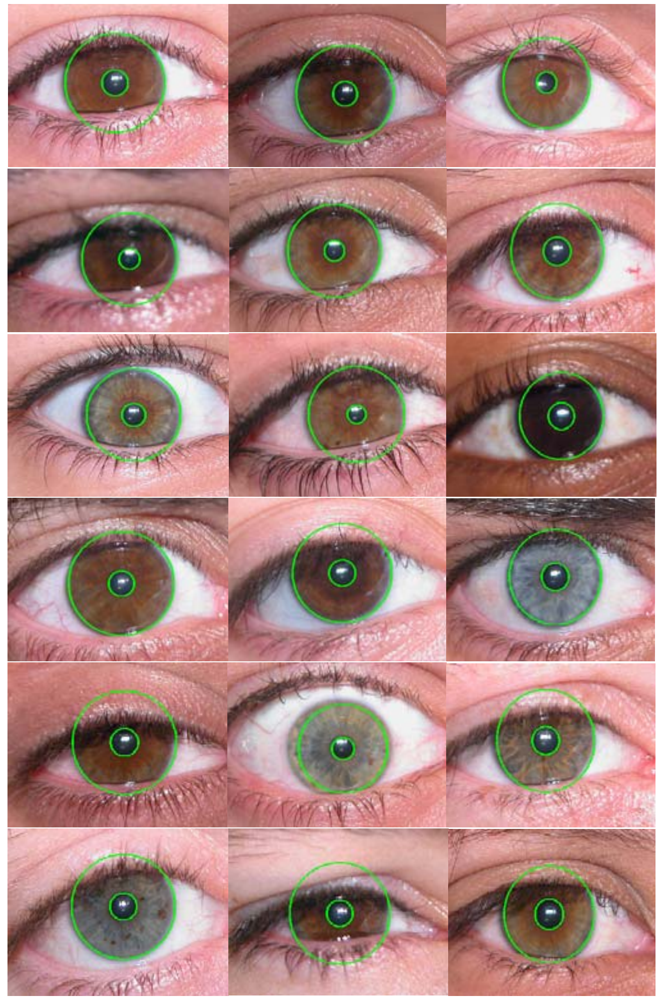


**Fig.7.** Segmented Irises from different verity of colors

The algorithm is robust when eyelids and eyelash are less open. Another important fact is time computation. Our methodology has the lowest time computation with a big difference comparing to others where Wildes [4] original method's time computation is about 1.95 seconds which is the lowest approach among the others except ours methodology. In fact the advantage of full accuracy in session 1 and getting the brilliant lowest time computation in implementation will help the positive view of color image processing in iris recognition systems.

Our recent work [12] identified the UBIRIS database, based on the extracted image from implemented methodology in this paper and proved the efficiency of the proposed algorithm. We got 95.08% of accuracy in identifying the first session by considering 2 images as test and 3 as train.

## VI. Noise Factors and Results on Some Other Databases

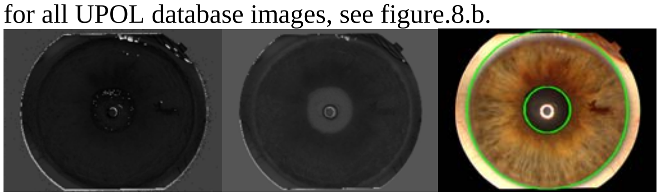
Image caption is an important skill which can leads to valuable databases. Noise factors such as Reflection, Contrast, Visibility, Light luminance, etc have considerable effects on capturing an image by CCD camera. H. Proenc¸a and L.A. Alexandre et al. [2] discussed their UBIRIS database as noisy database by providing statistics which is released on Table.2.

TABLE.2. UBIRIS DATABASE STATISTICS [2]

| Quality | Session 1 (%: Good, Average, Bad) | Session 1 (%: Good, Average, Bad) |
|---|---|---|
| Focus | (82.94, 13.67, 3.78) | (69.68, 19.45, 10.85) |
| Reflection Areas | (94.56, 2.80, 2.63) | (24.13, 38.61, 37.25) |
| Visible Iris Area | (89.29, 7.16, 3.45) | (22.32, 69.07, 8.59) |

First and the second sessions simultaneously have 88.93% and 38.71% good quality images in average. In onw hand, Degradation of the quality of images among two sessions is 50.22% which completely determines the bad quality of second session. Nevertheless, we got accuracy results on first and the second session with 95.08% and 91.37% simultaneously in [12]. On the other hand, Our result for segmentation for second session is 96.34% which shows that the implemented method for iris segmentation is very robust due to noise factors.

Applying other color images for proposed algorithm would determine the quality of the method. UPOL database [13] is another color iris database which is capture by SONY DXC-950P 3CCD camera. This database is captured in ill-based condition where the light capturing of the camera is not normal and it is fused by light brown color. This matter has nonlinear effect to color components, see figure.8.a. As it mentioned in section 2, the pupil portrait has gotten its color from Rhodopsin which is the out layer of retina. Changing the color of pupil in color images, by fusing light brown color effects linearly in defined pupil regions. The average value for pupil region in RGB level for all mentioned areas is [0.3 0.2 0.15] where by comprising with true color of pupil which is dark purple is [0.16 0.2 0.25] in RGB values, so the bias added to picture by flash camera is about [0.14 0 -0.1]. We subtract this threshold from average value of pupil in RGB for all UPOL database images, see figure.8.b.



| a | b | c |

**Fig.8. a.** Hue components of sample UPOL image **b.** Enhanced Hue components **c.** Segmented Iris

TABLE.3 SHOWS THE ACCURACY RESULTS FOR UPOL DATABASE

| UPOL Database | Accuracy (%) | Time (s) |
|---|---|---|
| **384 Images** | **95.08** | **0.35** |

## VII. CONCLUSION

In this paper, we proposed a segmenting approach through Color Iris Images by means of Hue and Red Components in order to gain high accuracy and speed. Anatomy structure of retina felled visual purple color on pupil portrait affecting by transparency of lens which allowed light to pass through cornea to retina. Visual purple color had fixed component in Hue and it never changed. By introducing Red Component as a second tool, we extracted a binarized image which used to fit a circle around pupil. Meanwhile, the above Red Component used to detect radius of Iris by using global threshold filtering. As an experimental result, we used UBIRIS and UPOL color databank to comprise our proposed method. 100% accuracy and 0.32 second as time consumption for the first session of UBIRIS and 95.08% and 0.32 second as time consumption for UPOL databases introduces our method as a superior approach among other implemented methodologies due to good verification results.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