International Journal of Advanced Information Science and Technology (IJAIST) ISSN: 2319:2682
Vol.3, No.9, September 2014 DOI:10.15693/ijaist/2014.v3i9.70-75

Implementation of Proposed Effective Segmentation Technique for Noisy Iris Images

Rajeev Gupta
Department of Computer Applications,
Maharishi Markandeshwar University, Mullana
(Ambala), Haryana (INDIA)

Ashok Kumar
Department of Computer Engineering,
Maharishi Markandeshwar University, Mullana
(Ambala), Haryana (INDIA)

Abstract: **In iris recognition systems, when capturing an iris image under unconstrained conditions, the image quality can be highly degraded by poor focus, off-angle view, motion blur, specular reflection (SR), and other artifacts. To overcome these problems, we propose a new segmentation technique to handle iris images were captured on less constrained conditions. This technique reduces the error percentage while there are types of noise, such as iris obstructions and specular reflection. The system is implemented on MATLAB R2007b and tested using a dataset of UBIRIS v1 and v2 database samples of iris data with different contrast quality. As per the results received after implementation, the proposed algorithm shows the 98.76% accuracy and at the same time the execution time of our proposed segmentation algorithm is 1.49 seconds due to the different proposed steps that applied to reduce the searching areas in circular Hough transform.**

Index terms: Iris Recognition, Iris Segmentation, Specular Reflection, Iris Obstructions, Upper eyelid, Pupil.

I. INTRODUCTION

In this paper, we present implementation of the proposed effective segmentation technique[5] to handle iris images were captured on less constrained conditions. This algorithm reduces the error percentage while there are types of noise exist, such as iris obstructions and specular reflection. The proposed algorithm starts by determining the expected region of iris using K-means clustering algorithm, then circular Hough transform is used to localize iris boundary, after that some algorithms are proposed to detect and isolate noise regions.

II. PROPOSED IRIS SEGMENTATION METHOD

This section concerns about one of the crucial steps in building an iris recognition system, which is iris segmentation. In this stage, we should accurately extract the iris region despite of the presence of noises such as varying pupil sizes, shadows, specular reflections and highlights. The segmentation stage is important because it is the basis of all further operations, such as normalization and encoding. As mentioned, there are many iris segmentation algorithms were proposed before, and gave an excellent results when iris images picked at Near Infrared camera and in ideal imaging conditions. The accuracy of current segmentation algorithms significantly decreases when dealing with noisy iris images taken in visible wavelength under far from ideal imaging conditions.

Our main motivation in this section is to implement proposed effective iris segmentation technique [5] that is not affected by types of noises and at the same time is not expensive in time. Figure 1 shows the block diagram of our proposed segmentation algorithm.

The proposed segmentation algorithm starts by determining the expected region of iris using the K-means clustering algorithm. The output image is used by vertical Canny edge detection to produce edge-maps. The circular Hough transform is applied on the edge image to determine the estimated iris center and radius. We use K-means clustering and vertical edge map to reduce the time of searching for circular Hough transform. Therefore, the circular Hough transform will be applied on the binary edge

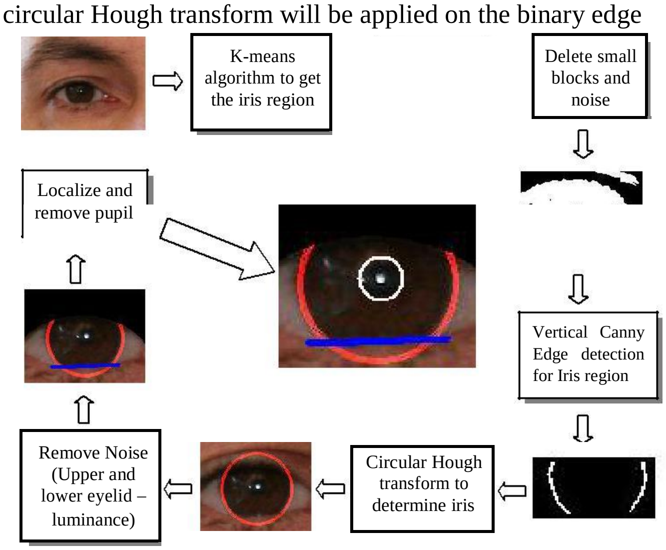

Figure 1 Block diagram of proposed iris segmentation method

image which comes from applying the edge detection on masked region, which result from K-means. After determining the iris circle, we apply some new techniques to isolate the noisy factors like eyelids, eyelashes, luminance and reflections. At last, we remove the pupil region from the

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Algorithm: Proposed Segmentation Technique for Noisy Iris Images.

Here, we input an Iris Image, and receive a segmented iris without noises.

Step-1: Determine the expected region of the iris using K-Means.

a) Apply the image clustering algorithm with specific value of input & the intensity of pixels;
b) Select the cluster of low intensities (Dark region in the image); and
c) Delete small blocks and noise.

Step-2: Apply the Edge Detection Algorithm

a) Convert RGB color space of the expected iris region into the YCbCr color space, and separate the Y component.
b) Reduce the scaling factor of the image with some extent;
c) Apply Canny Edge detection; and
d) Delete small noise components by applying some morphological operation (Erosion and Dilation).

Step-3: Apply Circular Hough transform on the binary edge image & find the Cartesian parameters *(x, y, r)*.

Step-4: Upper eyelid localization.

a) Isolate two small rectangles from the outer two sides of iris.
b) Apply horizontal Canny edge detection on these two small rectangles and isolate the noise using morphological operations.
c) Determine the coordinates of upper eyelid on both rectangles.
d) Draw an arc passes the two coordinates of upper eyelid on each rectangle and a radius equals twice the radius of the iris.

Step-5: Lower eyelid localization.

a) Take edge map of the lowest half of the iris.
b) Find the best line fit using line Hough transform.
c) If the vote of the line less than certain value, then we assume no lower eyelid occlusion occurs.

Step-6: Isolate specular reflections.

a) Compute the average intensity(AVI) in the three RGB color spaces for the iris region.
b) If the intensity of each pixel greater than the average intensity computed in the first step plus constant value, then we consider this pixel as reflection noise pixel.

Step-7: Remove pupil region.

a) Adjust iris image by mapping the values of its bits intensity to new values to focus on dark intensities.
b) Filter the image with median filter.
c) Canny edge detection is used to get the edge map.
d) The circular Hough transform is applied to localize the pupil, assuming that its circular.

iris region. The given algorithm shows the steps of our proposed Iris segmentation technique [5].

A. Determining Iris Region

One of the most causes of errors in segmentation is the high local contrast (e.g. on eyelashes, eyebrow, glass frame or white areas due to luminance on skin behind eye region) occurs on non-iris regions. Therefore, it is a good idea to avoid such segmentation errors by excluding the non-iris regions in the iris image before the iris localizing step. Obviously, if we can divide the iris image into three regions as iris region, skin region and sclera region, then we can reduce the errors in segmentation and at the same time reduce the searching time at the next steps in segmentation process.

A simple clustering method is proposed to divide the eye image into three different parts based on K-means clustering. The eye image can be divided into three regions.

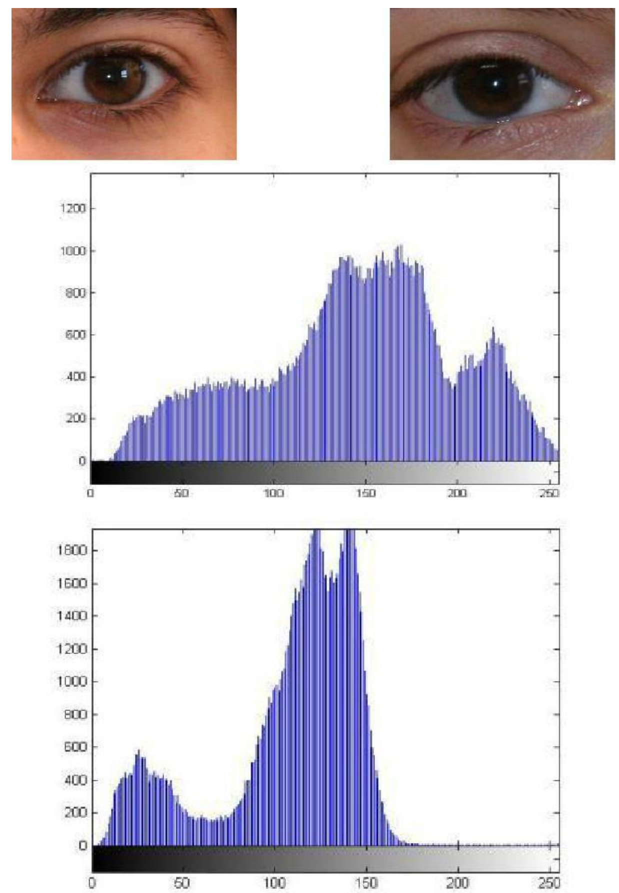

Figure 2 The Histograms of Eye Images from UBIRIS database

- The first region which has small intensity values, consists of the iris (including the pupil) and eyelashes.
- The second region which has high intensity values, consists of sclera and some highlights or luminance reflections.

- The third region is the skin region, its intensity between the previous two regions.

Figure 2 shows the histogram of two iris images and here, we can notice that the three local maxima, which present the regions of eye images. If we classify the image into four clusters, the region of the iris in images with light irises color (such as blue and green irises) will be reduced and the segmentation process will fail. This is because the iris boundary may lie outside the region of iris. While if we divide the image into two clusters, the region of iris will become wider, usually more than the half of the image area. This will insert non-iris regions to the iris region which will cause errors and increase the execution time of Hough transform in the next step.

The K-means clustering algorithm is effective, because it concerns about the darkest region only, and we will not worry about other two clusters. Figure 3 shows the result when we apply the clustering algorithm on some images. White regions present the darkest region (which is the region of iris and eyelashes) in the image. The black regions present region of sclera and some highlights or luminance reflections. The gray regions is the region of skin which its intensity between the previous two regions. As we can see in Figure 3, the white area covers the iris, eyelashes and sometimes eyebrow, but excludes luminance and specular reflections. This is very helpful in reducing the handled areas. The clustering algorithm reduces the region of iris by more than 70%. Consequently, the searching time of the next steps also will be reduced.

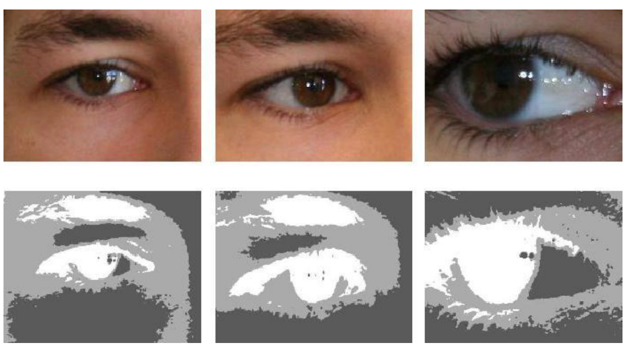

Figure 3 Examples of the results of K-Means Clustering on some images (a) Real Images (b) Clustering result images, white regions represent the estimated iris region

B. Edge Detection

To find the edge points in the iris image, Canny edge detection is used. The implemented Canny edge detection has six arguments. We adjust the upper threshold and the lower threshold inputs experimentally to make the algorithm suitable for the noisy iris images. In our algorithm, to extract the iris-sclera border, we select high value for vertical edges weight and low value for horizontal edges weight, because we interested only on vertical edges.

These values adjusted only once for the whole database (to be suitable for environment conditions) and do not need to be computed for each iris image. This process decreases the errors result from the horizontal edges due to eyelashes and eyelids.

C. Circular Hough Transform

Circular Hough transform belong to *R3* space, so the *complexity of the Hough transform is O(n3). Therefore, to* reduce the time of its execution, we use the three methods which explained in previous steps :

- **Scaling factor**, which reduces the image size and causes reduction in the edge points.
- **K-means Clustering,** to reduce the searching area, and to reduce the edge points when Canny edge detection is applied.
- **Morphological Operations**, to remove small blocks and noise in the binary edge image.

After applying the circular Hough transform on the binary edge image, we select the maximum group of parameters *(a, b, r)* from the accumulator, and then find the Cartesian parameters *(x, y, r)* to determine the iris' on the image. Figure 4 shows some examples.

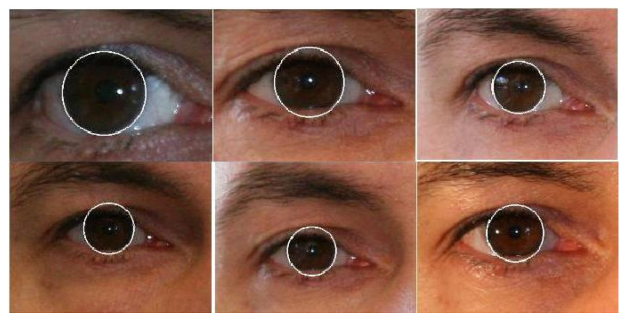

Figure 4 Samples of segmented irises from UBIRIS v2

D. Isolating Noise

In non-cooperative iris recognition, the user has little or even no active participation in the image capturing process[13]. As a result, the iris images are often captured with more noisy artifacts, such as reflections, occlusions by eyelids or eyelashes, shadows, etc. It has been reported that the most localizations fails occur on non-iris regions due to the high local contrast. Therefore, to avoid such localizations fails, we must exclude the non- iris regions and handle all sources of errors. In this subsection, we will explain how the proposed segmentation method handles each of them.

E. Upper Eyelid Localization

Researchers use many methods to localize the eyelid of the iris (e.g. edge detection, Integro-differential operator and line Hough transform), which captured in the ideal environments. Therefore, these methods are not effective to be used in noisy iris images, because the intensity contrast of iris and eyelid can be very low, especially for heavily pigmented (dark) irises, such as in

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Figure 5. We propose a new method to localize the eyelids by detecting it in the sclera region. We detect the eyelids in the sclera, because the intensity contrast of the sclera and the upper eyelid is very higher than the intensity contrast of the iris and the upper eyelid.

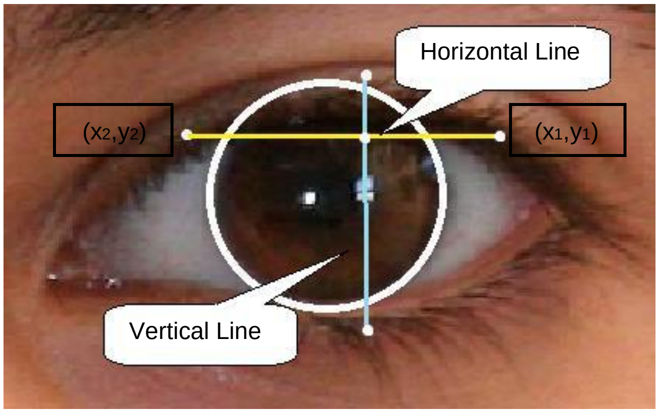

Fig 5 Upper Eyelid Localization Model

The following steps explain the upper eyelid localization algorithm.

Step-1 Isolate two small rectangles from the outer two sides of the iris. Each one starts vertically from the center of the iris and extends to value more than the iris center as shown in Figure 5.

Step-2 Apply any type of horizontal edge detection on the two rectangles (e.g. Canny edge detection) and isolate the noise using morphological operations.

Step-3 Determine the coordinates of upper eyelid on both rectangles. Assume that it is the biggest horizontal edge line on each rectangle.

Step-4 Draw an arc that passes through the two coordinates of the upper eyelid on each rectangle and a radius equals the double of the radius of the iris. The center of the arc is computed using the following steps.

Let the coordinates of the upper eyelid on the first rectangle be (x_1, y_1), and coordinates of the upper eyelid on the second rectangle be (x_2, y_2). The line passing through the two coordinates of the upper eyelid on each rectangle is given by the equation:

$$ax + bx + c_{horizontal} = 0 \quad \text{.................. (1)}$$

where

$$a = y_2 - y_1, b = x_1 - x_2, c_{horizontal} = x_2 y_1 - x_1 y_2$$

Let (p, q) be the midpoint of the horizontal line joining (x_1, y_1) and (x_2, y_2). Then The equation of the perpendicular to the horizontal line at midpoint of the two points (x_1, y_1) and (x_2, y_2) is:

$$bx - ay + c_{vertical} = 0 \quad \text{.................... (2)}$$

where $c_{vertical} = aq - bp$

Then, we find the point that lies on the vertical line and at a distance of the double of the iris' radius from the middle of the horizontal line as shown in Figure 5.

Figure 6 shows sample images of UBIRIS v2 and v1, after using our method to localize the upper eyelid of the iris. Note that, due to the use of arc in the proposed method, the iris' region will not lose non-noise regions such as happened when using Line Hough transform.

We can see from Figure 6 that our algorithm isolates the upper eyelid accurately, even if the intensity contrast of the iris and the eyelid are very low, and could not be isolated using normal processes like line Hough transform or Integro-Differential operator of Daugman. The effectiveness of our algorithm is due to the usage of the intensity contrast between the sclera and the upper eyelid rather than the iris and the upper eyelid. Also, we can see that this algorithm still working, when a huge area of iris is occluded by upper eyelid.

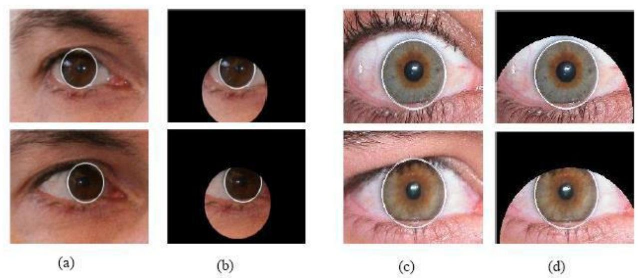

Figure 6 Upper eyelid localization algorithm (a) segmented images from UBIRIS v2 (b) segmented images from UBIRIS v2 after using the proposed upper eyelid localization (c) segmented images from UBIRIS v1 (d) segmented images from UBIRIS v1 after using the proposed upper eyelid localization

F. Lower Eyelid Localization

To localize the lower eyelid of the iris, we use the Line Hough transform, because most of the occlusions of the lower eyelid is approximately linear. We first, apply the Canny edge detection to the lowest half of the iris, and then the best line fit using Line Hough transform is found. If the vote of the line is less than a certain value, then we assume no lower eyelid occlusions occur.

Figure 7 shows some examples after localizing the lower eyelid. The blue line represents the largest edge line that separates the iris and the lower eyelid. We notice that the lower eyelid isolation process is easier than the upper eyelid, because there is no eyelashes occlusion, and usually the occluded area of the iris due to the lower eyelid is less than the occluded area of the iris due to the upper eyelid.

G. Isolating Specular Reflections

Specular reflections can be a serious problem, when there are noisy images processed by the iris recognition system. We propose a new simple reflection removal method in two steps:

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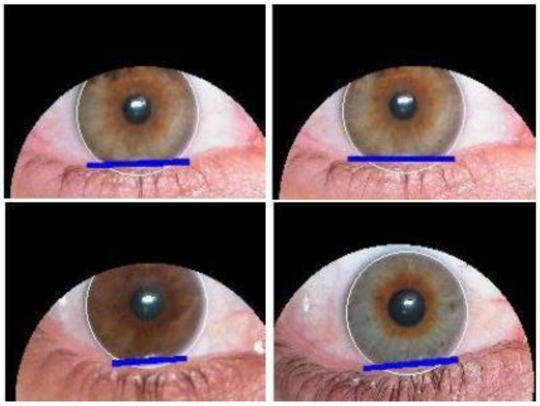
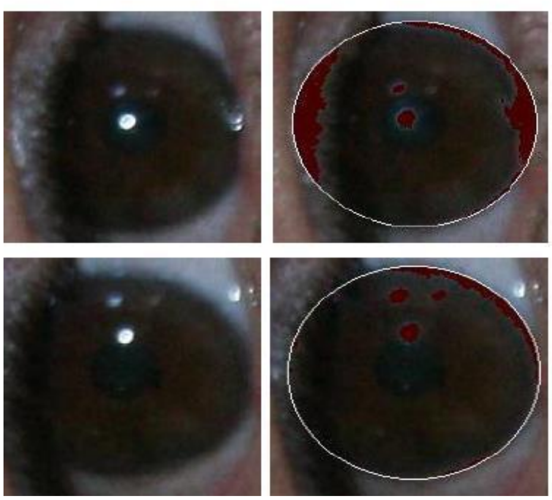


Figure 7 Lower Eyelid localization samples using UBIRIS v1 database

Step-1 Compute the average intensity of the iris region in the three RGB color spaces (After upper and lower eyelids removal).

Step-2 Test the intensity of each pixel in the iris, and if the intensity of the pixel in certain color space is greater than the average intensity computed in the first step plus constant value, then consider this pixel as a reflection noise pixel. The constant value is adjusted only once for the whole images.

Figure 8 views some images after localizing the specular reflections. The pixels which are distinctive with a red color are masked to be isolated, when iris template code is extracted. We notice that specular reflection and highlight regions are determined precisely, even if there is a light or occluded small regions as shown in Figure 8.



(a) (b)

Figure 8 Isolating reflections from irises in the proposed algorithm (a) image with reflections (b) detect the reflection regions (marked with red color)

H. Removing Pupil Region

Pupil removal is left to be performed in the last step, because one of the major differences between the eye's images in the noisy databases were captured under visible wavelengths, and with those images taken under **N**ear **I**nfra**R**ed (NIR) illumination is that the intensity contrast of the iris and the pupil are be very low, especially for heavily pigmented (dark) irises. If we try to localize the pupil directly, we will fail. Therefore, the best method is to enhance the image iris to make the pupil appearing using the contrast enhancement method[12]. The following steps explain the pupil removal process.

Step-1 Adjust iris image by mapping the intensity values of its bits to new values to focus on dark intensities. This step makes the difference between the iris and the pupil more clear.

Step-2 Apply median filter to reduce the noise factors and to preserve the edges.

Step-3 Canny edge detection is used to get the edge map.

Step-4 The circular Hough transform is applied to localize the pupil, assuming that it is circular. The pupil radius is set to be from 1/10 of the iris radius as the lower limit, to 7/10 of the iris' radius as the upper limit.

Figure 9 shows the steps of this algorithm using an image from UBIRIS v2. Note that, all previous steps are applied only on the inner square of the iris to reduce the time execution and to avoid errors that may happen due to the edge points outside the pupil region. As we can see in Figure 9, the pupil localization successes even if the intensity contrasts of the iris and the pupil are very low.

(a) (b) (c) (d)

Figure 9 Steps of Pupil removal algorithm (a) the inner square of the iris, (b) result of adjust image in (a), (c) result of Canny edge detection, (d) result of the circular Hough transform

III. RESULTS AND CONCLUSION

Noisy Iris Recognition technology provides a practically & significantly feasible technique for overcoming the performance and user acceptability obstacles to the widespread adoption of biometric systems. Much research effort around the world is being applied for expanding the accuracy and capabilities of this biometric domain, with a consequent broadening of its application in the near future. This research paper shows the outcome of the implementation of the proposed effective iris segmentation technique for noisy iris images and reduces the error percentage. As per the results received after implementation, the proposed algorithm shows the 98.76% accuracy and at the same time the execution time of our proposed segmentation algorithm is 1.49 seconds due to the different proposed steps that applied to reduce the searching areas in circular Hough transform.

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Authors Profile

Rajeev Gupta received his MCA & M.Phil. (Computer Sc. & Technology) degrees in 2004 and 2011 respectively and is currently working toward the Ph.D. degree in computer science and applications at Maharishi Markandeshwar University, Mullana (Ambala). His current areas of interest include image processing, biometrics and pattern recognition.

He is a Graduate Student member of the IEEE Computer Society. He is also an Associate Life Member of Computer Society of India (CSI), Member of Universal Association of Computer and Electronics Engineers (UACEE), Australia and Member of Middle East Association of Computer Science and Engineering (MEACSE).

Dr. Ashok Kumar received his M.Sc. & Ph.D. degrees from the University of Agra. He chaired the Department of Computer Sc. & Applications, Kurukshetra University, Kurukshetra for a very long period and is currently working as a Professor in Department of Computer Engineering at Maharishi Markandeshwar University, Mullana (Ambala).

He has over 105 publications in refereed journals, book chapters, and conferences. At present he is conducting collaborative research in the area of Optimization techniques, numerical methods, software engineering, biometrics & pattern recognition and also, 13 scholars awarded Ph.D. under his supervision.