Accurate Iris Segmentation based on Geometric Method of Pupil Localization

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Abstract – Pattern based analysis of biological data allows iris recognition technology to be highly reliable for personal identification. Universality, uniqueness, permanence, performance, acceptability etc., characteristics of iris signals make iris recognition system to be robust. The pupil of an eye is like a black circular disk leads to pupil detection that means finding of a black disk in the input image. It can be achieved by evaluating the circularity and area of the black region of the input image. So this paper focus on use of pupil parameters such as pupil circularity and pupil radius features of iris. These features can be used for authentications and are generally called as "dynamic features (DFs)" of iris. These features are dependent on some parameters such as how the human eye reacts to light. Extraction of information is done by using these parameters by using segmentation system which localizes the circular iris and pupil region; including removal of eyelids and eyelashes, and reflections and such information is used for biometric recognition purposes.

Keywords – Iris, Iris Recognition, Segmentation.

I. INTRODUCTION

Biometrics system uses hardware as well as software part for authentication. The hardware is used to capture the biometric information, and software to analyze, manage and store that information. In general, the software system translates these measures into a mathematical, computer readable format. When a user first creates a biometric profile, the biometric information is processed to get a template, that template is stored in a database. The biometrics system then compares this template to the new image created every time a user accesses the system.

John Daugman a Professor of Computer Vision and Pattern Recognition is best known for his pioneering work in biometric identification, in particular the development of the Gabor wavelet based iris recognition algorithm. He proposed Image analysis algorithms to find the iris in a live video image of a person's face, and encode its texture into a compact signature, or "iris code." So that the iris texture is extracted from the image at multiple scales of analysis by a self-similar set 01’ quadrate (2-D Galror) bald pass filters defined in a dimensionless polar coordinate s1, Snten [1]. A method for rapid visual recognition of person is also described by John Doughman which is based on the failure of a statistical test of independence [2]. Then he worked on encoding of the visible texture of a person's iris in a real-time video image is into a compact sequence of multi-scale quadrate 2-D Gabor wavelet coefficients [31].

W. W. Boles and B. Boashash presented new approach for iris reorganization based on wavelet transform. Zero-crossings of the wavelet transform at various resolution levels are calculated over concentric circles on the iris, and the resulting one-dimensional (1-D) signals are compared with model features using different dissimilarity functions [4]. Zhenan Sun, Member, IEEE, and Tieniu Tan has Proposed a method of using ordinal measures for iris feature representation with the objective of characterizing qualitative relationships between iris regions rather than precise measurements of iris image structures[5]. Ronaldo Martins da Costa and Adilson Gonzaga worked on the evaluation of the texture features observed during pupil movements and the iris contraction and dilation rates due to the alteration of the illumination conditions [6]. Libin Wang, Zhenan Sun, Tieniu Tan has proposed a robust regularized linear programming feature selection method for iris recognition which includes use of compact and effective ordinal feature set for iris recognition. [7]. Hugo Proenc’a and Lur's A. Alexandre have focused on the capture of iris images at large distances, under less controlled lighting conditions, and without active participation of the subjects. i.e. non cooperative view of iris recognition[8].

II. SEGMENTATION

The human eye is sensitive to visible light. When bright light fall on the eye light sensitive cells in the retina, including rod and cone photoreceptors and melanopsin ganglion cells, will send signals to the oculomotor nerve, which terminates on the circular iris sphincter muscle. When this muscle contracts, the pupil size reduces. This is called the pupillary light reflex. Furthermore; the pupil will dilate if a person sees an object of interest. The pupil contracts and dilates depending on the intensity of visible light, and the iris and the sclera reflect light exceptionally well [9].

The first step in any pattern recognition method is the image acquisition. The image of the iris can be captured using a standard camera using both visible and infrared light. Then the next stage is to isolate actual iris region in an eye image. The iris region, shown in Figure 1, can be approximated by two circles, one for the iris/sclera boundary and another, interior to the first, for the iris/pupil
boundary. The eyelids and eyelashes normally occlude the upper and lower parts of the iris region. Also, specular reflections can occur within the iris region corrupting the iris pattern. A technique is required to isolate and exclude these artifacts as well as locating the circular iris region. The success of segmentation depends on the imaging quality of eye images.

Fig.1. Sample image of eye from CASIA database. (Image No. 001 2_1)

Iris segmentation is one of the important operations involved in iris recognition system. The successful and precise feature extraction and recognition, and consequently the high performance level of the iris recognition system depend upon accurate iris segmentation. Iris segmentation requires detailed study of modeling parameters and characteristics, which prevents their effective real-time applications and makes the system highly sensitive to noise [10][11]. The 3 important stages of segmentation are as given below.

- Edge detection
- Finding a circle.
- Eyelid detection.

A) Edge Detection:

Edges characterize object boundaries. A region where intensity function changes abruptly is considered Edges. Edges in images are areas with strong intensity contrast i.e. a jump in intensity from one pixel to the next. Edge detection in an image not only reduces the amount of data from image and filters out useless information but also preserves the important structural properties in an image. In segmentation process to detect the iris boundary, it is necessary to create an edge map. The Canny edge detection principle is used to generate an edge map. The canny edge detector first smoothen the image to eliminate noise. It then finds the image gradient to highlight regions with high spatial derivatives. The algorithm then tracks along these regions and suppresses any pixel that is not at the maximum (nonmaxima suppression). The nonmaxima array is now further reduced by hysteresis. Hysteresis is used to track along the remaining pixels that have not been suppressed. Hysteresis uses two thresholds, if the magnitude is below lower threshold, it is set to zero. If the magnitude is above higher threshold, it is treated as edge. And if the magnitude is between the two thresholds, then it is set to zero unless there is a path from this pixel to a pixel with a value above lower threshold.

1) Image Smoothing:

The smoothing of image is done to suppress the noise. Noise is associated with high frequency and suppression of high frequencies leads to the noise suppression. The input eye image is firstly smoothened using a Gaussian Filter. Sharp edges are blurred due to the smoothing. Let I [i, j, o] be a Gaussian smoothing operator. Gaussian smoothing operator is a 2D convolution operator which is used to blur images and remove noise and is given by 2D Gaussian equation:

\[ G(i, j) = \frac{1}{2\pi\sigma^2} \exp \left( -\frac{i^2 - j^2}{2\sigma^2} \right) \]  

Where \( \sigma \) is the standard deviation i.e. spread of the Gaussian and controls the degree of smoothing. `\( \sigma \)’ act as deciding factor of degree of smoothing. Increase in \( \sigma \) will make the gap between different levels of edges larger. This means that large value of sigma will give more blurring. And decrease in \( \sigma \) will make the gap between different levels of edges smaller. This means small value of sigma will give less blurring [2][13].

2) Gradient Calculation:

The application of gradient operators detects changes in image function. Change in pixel value corresponds to large gradient value. Gradient operators are based on local derivatives of image function. So, at locations where image function undergoes rapid change, derivatives are larger. Gradient operators suppress only the low frequencies in Fourier transform domain. As noise is generally associated with high frequencies, the gradient operator increases noise level. Firstly, the gradient of the smoothed array \( S[i, j] \) is used to produce the x and y partial derivatives \( P[i, j] \) and \( Q[i, j] \) respectively. The magnitude and orientation of the gradient can be computed as,

\[ M[i, j] = \sqrt{P[i, j]^2 + Q[i, j]^2} \]

\[ \theta[i, j] = \tan^{-1} \left( \frac{Q[i, j]}{P[i, j]} \right) \]  

Figure 2 shows Gradient amplitude image showing outer and inner boundary of iris.

Fig.2. Gradient amplitude image showing outer and inner boundary of iris
In order to detect the edges, it is essential to determine intensity changes in the neighborhood of a pixel. Thus the contrast enhancement is applied in order to have prominent edge map [4]. Figure 3 shows the contrast enhanced images while finding outer and inner boundary.

3) Nonmaxima Suppression:

In canny edge detection method, an edge point is defined to be a point whose strength is locally maximum in the direction of the gradient. This means that zero value is assigned every, where except the local maxima points. At the local maxima points the value is preserved and all other values are marked as zeros. This process, which results in one pixel wide ridges, is called as non-maxima suppression[3] [15]. A snapshot of the image after non-maxima suppression is as shown in figure 4.

The non-maxima suppression follows following steps:

- For each pixel with non-zero magnitude.
- For each adjacent pixels in Radial direction of edge
- If the edge magnitude of either of these two exceeds that of pixel under Inspection then marks the pixel inspection for deletion.
- When all the pixels have been inspected rescans the image and erases all edge Data points which are marked for deletion [5]

4) Hysteresis Thresholding:

There may contain many false edge fragments caused by noise and fine texture in the nonmaxima suppressed magnitude image N [i, j]. These false edge fragments in the nonmaxima suppressed image should be reduced by applying a threshold to nonmaxima suppressed magnitude image N [i, j]. The threshold T is decided such that a prominent edge map is created. All values below threshold are set to zero. After application of threshold to the nonmaxima suppressed magnitude image, an any E [i, j] containing the edges detected in the image I [i, j] is obtained. If T is too low, some false edges will remain and if T is too high, some useful edges will disappear. So a more effective thresholding scheme uses two thresholds T1 (upper threshold) and T2 (lower threshold) to find the edge mapped image. Thresholding reduces the nonmaxima suppressed image array. Hysteresis thresholding is an algorithm proposed by Canny [13] in order to mark the edges of the underlying image and is used so that lines that include strong and weak gradients are not split up. The following statements below describe the process.

- If the gradient magnitude value at any pixel is above T1, that pixel is immediately marked as a part of an edge.
- For a given pixel, if the gradient magnitude is below T2 it is unconditionally set to zero.
- If the gradient is between these two, that pixel is considered to be a part of an edge only when it is connected to a pixel already marked as a part of an edge. This step is repeated until no new pixel is marked as a part of an edge.

This algorithm simply treats an edge as a connected set of pixels [6][17]. Figure 5 shows the image obtained from Figure 4 after applying thresholding.

B) Finding A Circle (Hough Transform):

After finding the edge map of input eye image by canny edge detector, next step is to find radius and center coordinates of the outer and inner circular boundary of iris region. The circular Hough transform is employed to find out the radius and centre coordinates of the circular boundary of pupil and iris outer boundary. From the edge map, votes are cast in Hough space for the parameters of circles passing through each edge point. Then, votes in a circular Hough space are analyzed to estimate the three parameters of one circle \((x_o, y_o, r)\). A Hough space is defined as:

\[
H(x_o, y_o, r) = \sum iH(x, y, x_o, y_o, r) \tag{4}
\]

Where: \(H(x, y, x_o, y_o, r) = \begin{cases} 1 & \text{if } (x, y) \text{is on the circle} \\ 0 & \text{otherwise} \end{cases} \tag{5}\)
The location \((x_o, y_o, r)\) with the maximum value of \(H(x_o, y_o, r)\) is chosen as the parameter vector for the strongest circular boundary. [18][19]

C) Eyelid Detection:

The occlusion due to eyelids over the iris region affects the performance of the recognition system. The eyelid detection procedure is near about same as that of edge detection Firstly edges are detected using the canny edge detector and then horizontal lines are detected. Eyelids are isolated by first fitting a line to the upper and lower eyelid using the linear Hough transform [19][20]

III. ALGORITHM FOR IRIS LOCALIZATION

By accurate iris segmentation we get the Cartesian coordinates of the center of the eye image. Similarly we can find out inner and outer boundaries of pupil. From these parameters we can compute the radii of the boundaries. In this way we can localize the iris by drawing a perfect geometry that fits the boundaries [21]. This can be achieved by following steps

1) Consider the center points as parameter 1. Let \(x, y\) are coordinates of the center of the eye image.

2) Consider the geometry for the boundaries of the iris as parameter 2. Let \(r_1\) be radius 1 and \(r_2\) be radius 2

3) Capture parameter 1.

4) Capture the co-ordinates of 2 points on the inner boundaries of the iris \(pX, pY\) respectively.

5) Compute radius \((r_1)\) by using the centre of the eye image and the vertical points co-ordinates using formula

\[ r_1 = \sqrt{x_1^2 + y_1^2} \]  

\( r_1 \) is distance between the centre of the eye image and the vertical points co-ordinates

Where

\[ x_1 = pX - \text{pcenter}\cdot x_1 \]

\[ y_1 = pY - \text{pcenter}\cdot y_1 \]

6) Compute radius \((r_2)\) by using the centre of the eye image and the horizontal points co-ordinates using formula

\[ r_2 = \sqrt{x_2^2 + y_2^2} \]  

\( r_2 \) is distance between the centre of the eye image and the horizontal points co-ordinates

Where

\[ x_2 = pY - \text{pcenter}\cdot x_2 \]

\[ y_2 = pX - \text{pcenter}\cdot y_2 \]

7) By using the co-ordinates of the centre of the eye and radius \(r_1\) and \(r_2\) Draw an ellipse.

8) Store the co-ordinates of the centre of the eye image and the computed radius \(r_1\) and \(r_2\) for the inner boundary.

9) Repeat step 3 to 5 for the outer boundary.

10) Store the co-ordinates of the centre of the eye image and the computed radius \(r_1\) and \(r_2\) for the outer boundary.

11) Stop.

IV. CONCLUSION

Extraction of information is done by using segmentation system which localizes the circular iris and pupil region; including removal of eyelids and eyelashes and reflections. The performance of the identification system is closely related to the precision of the iris localization step. From proposed method we can accurately define both the inner and outer boundaries of the iris. From the captured parameters we can have the geometry which may be (circle or eclipse). So this method is simple, robust, and flexible and computes accurately.

REFERENCES


[9] Mayank Vatsa , Richa Singh,and Afzel Noore,, Improving Iris Recognition Performance Using Segmentation, equality Enhancement, Match Score Fusion, and Indexing,, IEEE transactions on systems, man, and cybernetics-part b: cybernetics, 10g3.4419s25.00 0 2008 rEE

[10] Richard P. Wildes, Member, IEEE,*, Iris Recognition: An Emerging Biometric Technology., proceedings of the IEEE, vol. g5, no. 9, september 1997


[12] JOHN CANNY,* A Computational Approach to Edge Detection", IEEE transactions on pattern analysis and machine intelligence, vol. pami-8, no. 6, november 1986


[20] Duratulain Mirza, Imtiaz A. Taj, Ayesha IGIalid. ', A robust eyelid and eyelash removal method an a local binarization based feature extraction technique for Iris Recognition System.,, 978 1 4244 4873 3 9 1 09/525.00 02009 IEEE