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IRIS Segmentation Using Geodesic Active Contour Method

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Abstract: Iris identification and recognition is one of the technology used for automatic personal identification and verification. This paper present a simple and efficient method based on the geodesic active contour model to segment iris from human eye image. First we apply edge detection method to find the edges, then Hough circle transformation method is performed to identify the circular object present in the edge image and it is treated as rough eye image. Then Geodesic active contour method detect the actual eye boundary in the rough eye image. This proposed method is tested with the eye images obtained from UBIRIS iris database. The performance of this proposed method is quantitatively evaluated by calculating the similarity measures Jaccard (J) and Dice (D).

Key words: Iris Segmentation · Canny edge detection · Hough circle transform · Geodesic active contour · Biometric authentication and recognition system

INTRODUCTION

Biometric is an unique human identification and authentication system in computer vision and it is recognized as an attractive security method. A biometric system is classified into two category, physiological and behavioural. Finger print, iris, hand geometry, face etc are physiological while voice and human signature are classified into behavioural biometric. The first step of any biometric system is to capturea sample features, such as recording a digital sound signal for voice recognition, or taking a digital eye image for iris recognition etc., Then computational technique is applied to segment and recognize the biometric features for human authentication. Among the various biometrics systems, iris recognition is found to be most advantages and has high computational speed because of small size, simplicity and accuracy compared to other biometric traits [1]. Iris recognition relies on the unique patterns of the human iris in identification and verification of an individual [2]. Eyes of two twins either they are phenotype or genotype have different iris structure of their eyes. Iris is a gray coloured portion of eye among pupil and sclera. Iris colour is determined primarily by the density of melanin in the interior layer and stroma. The algorithm for iris recognition developed by Jhan Dauman [3], segment and recognize the inner and outer boundary of iris. The main purpose of their work was to use edge detection operator such as canny, Sobal for finding the most accurate iris images during extraction and matching process [4]. A simple automatic iris segmentation method proposed in [5] uses active contour method to segment iris in human eye images. A method byDugman [6] makes uses of an integral differential operator for locating the circular iris and pupil regions and also the arcs of the upper and lower eyelids. The operator searches for the circular path where there is maximum change in pixel values, by varying the radius and center x and y position of the circular contour [7]. Eyelids are localized in a smilar manner, with the path of contour integration changed from circular to an arc. In the method [8], a set of one-dimensional signal, extracted from the iris image using the illumination intensity value and Chan-Vese algorithm for edge detection are used to detect the iris. Then iris images are projected vertically and horizontally to estimate the center of the iris. An integral differential operator for automatic segmentation of an iris is developed in [9]. Masek and kovesi [10] proposed gradient-based approach using a combination of kovesi's modified canny edge detection and the circular Hough-transform [11] for iris recognition.

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Most segmentation models in the literature assume that the pupillary, the limbic, the eyelid and iris boundaries are circular or elliptical in shape.

Therefore, they focus on determining model parameters that best fit these hypotheses [12] [13]. In this paper, geodesic active [14] contour-based method to segment iris from eye image is developed. This is a Hough transform-based method, which detect circular shape object in the edge image of iris and is then refined to segment the fine iris image.

Methodology: This section illustrates the overall technique of this proposed iris segmentation method. In this method, we use a geodesic active contour method for automatic segmentation of the iris in the eye image. The flowchart of the proposed method is given in Fig 1 and the process of iris segmentation is illustrated in Fig. 2. In order to find the edge in the given eye image, we need to convert it into binary image. We used Otsu's thresholding technique to obtain the binary image. Otsu is a well known automatic thresholding method [15] which produce efficient binary image. Then, we applied canny edges detection method to detect edge in the converted binary image. The canny algorithm uses optimal edge detector to detect fine edge present in the eye image.

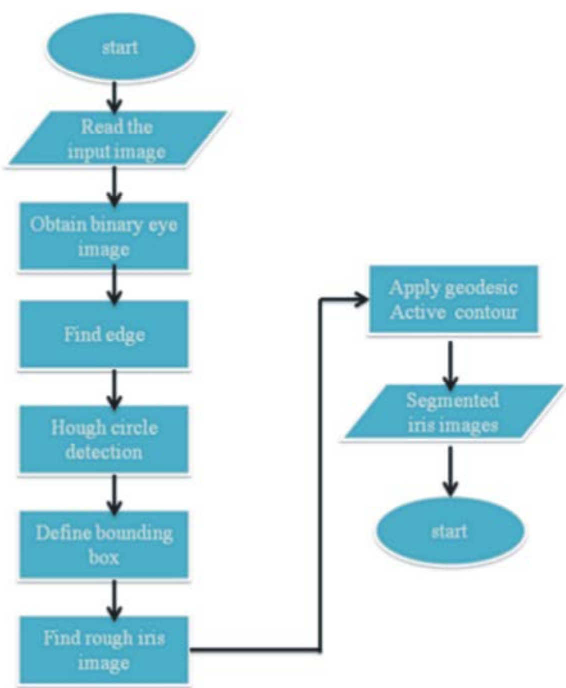

Fig. 1: Flowchart of the proposed method

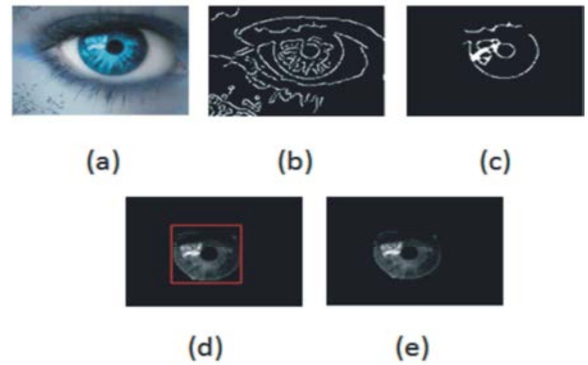

Fig. 2: Process of iris segmentation: (a) Original image (b) Edge image (c) Detected Circle (d) Boundary detection to obtain rough iris image (d) Segmented iris image

The canny edge detection technique is more efficient to detect both light and strong variation of gray level edge in the image. It is known that the eye iris boundary are always circular, therefore circular Hough transform is performed to detect the circle shaped object in the edge image. Hough transform algorithm detect some simple geometric object such as line, circle, elipses etc., in the image. The circular Hough transform is used to detect circular object present the edge image. To identify the circle in the edge image, we need to define radius r and the center coordinates (x0, y0). Hough transform was originally employed by Wildes [16] [17] and it generates edge map by calculating the first derivatives of the intensity values in the image. Then based on the edge map, votes are cast in Hough space for the parameters of circle passing through each edge point.

Then the parameters, radius r and the center corrdinates (x0, y0) are defined as per the following circle equation.

$$(x - x_0)^2 + (y - y_0)^2 = r^2 \quad (1)$$

The location (x_0, y_0, r) with the minimum value of Hough space is chosen as the parameter vector to detect iris circular boundary. After detecting circular edge in the eye image, we need to find out the rough iris area in the input eye image. For this purpose, we define a bounding box sourrounding the detected circular edge image, with the assumption that the defined bounding box covers the entire iris region of the input image. To detect the accurate outer bonudary of the iris, we apply the geodesic active contour method.Geodesic active contour model proposed by Caselles *et al.* [18], is an efficient model for finding an edge present in the digital image. This method recognize multiple objects simultaeously and also uses less number of parameters. This method is equivalent to finding geodesic distance of two points on a carefully chosen Riemannian space. This approach is less prone to variation on the edge and allow object with non-ideal edges to be recognized. Geodesic active contour method is formulated as below:

Let $I(x,y): \Omega \rightarrow R \pm C$ be a given iris image. The evolving curve for geodesic active contour is denoted by C(t) and represented by the zero level set of a level set function Φ(t, x,y). The level set function Φ is normally selected to be a signed distance function and that is negative in the interior and positive in the exterior of the zero level set. The evolution of the geodeic active contour embedded in the level set function can be formulated by the following partial differential equation:

$$\frac{d\phi}{dt} = g(I)|\,|\nabla\phi\,||[\mathrm{div}\,(\nabla||\,\nabla\phi\,+\,v)] + \nabla g\,(I) \times \nabla \qquad (2)$$

where, v is a constant parameter controlling the balloon force and g is the edge indicator function, which is commonly defined by:

$$g(I) = \frac{1}{1+||\nabla(G\sigma \times I)||^2} \qquad (3)$$

where, G_σ denotes the Gaussian filter with standard deviation σ. With an appropriate initialization, the evolving curve C represented by the zero level set of the level set function ? and will stop at the desired edges where the function g is approximated to zero.

The summary of the steps involved in this proposed method is given below:

Step 1: Read the input image

Step 2: Convert the input image into binary image.

Step 3: Find the edge using the binary image

Step 4: Find circular shaped object in the edge image using circular Hough transform.

Step 5: Define the bounding box on the detected object

Step 6: Find the rough iris image and segment the iris based on the geodesic active contour method

Step 7: Compute the similarity measure using the segmented iris image by the proposed andexpert segmentation method.

Performance Evaluation: The performance of the proposed method is evaluated using the similarity measures Jaccard (J) and Dice (D). These methods will take two images as input and produce the value between 0 and 1. The Jaccard [19] similarity measure is calculated by:

$$J(S_1, S_2) = \frac{|S_1 \cap S_2|}{|S_1 \cup S_2|} \qquad (4)$$

The Dice [19] similarity measure is calculated by:

$$D(S_1, S_2) = \frac{2|S_1 \cap S_2|}{|S_1| + |S_2|} \qquad (5)$$

where, S1 represents the total pixels of the image obtained by the proposed segmentation method and S2 represents the total pixels in image obtained from the ground truth (expert segmented) image.

Dataset Used: In this paper, we usedUBIRIS [20], a new public and free iris database available in the internet. UBIRIS provides images with different types of segmentation, simulating image captured without or with minimal collaboration from the subjects, pretending to become an effective resource for the evaluation and development of robust iris identification methodologies. UBIRIS database is composed of 1877 images collected from 241 persons during September, 2004 in two distinct sessions. It is one of the world's largest public and frely available iris database.

RESULTS AND DISCUSSION

In this method, we used images from UBIRIS to evaluate the performance of the proposed method. A quantitative evaluation was done by computing the similarity measures Jaccard (J) and Dice (D) as per the equation given in Eq (4) and (5). A selected sample image from the eye dataset along with the automatic segmentation result, by the proposed and expert method are shown in Fig. 3.In Fig.3, the original eye image is given in column (a) and the segmented iris by the proposed method is shown in Fig 3(b). The obtained result dipict that the circular Hough transform efficiently detects the external iris boundary and separate the other parts in the eye image such as eyelashes, eyelids,

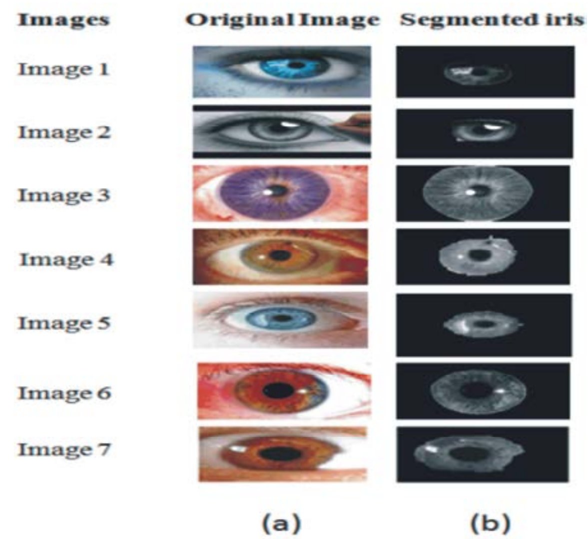

Fig. 3: Iris Segmentation result by the proposed method: (a) Original image (b) Segmented iris image

Table 1: Computed Jaccard (J) and Dice (D) Similarity Measure for the images shown in Fig 3.

S.No	Images	Jaccard Values (J)	Dice Value (D)
1	Image 1	0.6234	0.7563
2	Image 2	0.7465	0.7895
3	Image 3	0.6753	0.7230
4	Image 4	0.7834	0.8210
5	Image 5	07398	0.7930
6	Image 6	0.7260	0.7823
7	Image 7	0.7239	0.7516

sclera etc., The geodesic active contour, accurately detects the iris in its real shape. We have also computed the similarity measures Jaccard (J) and Dice (D) for quantitative result. The computed J and D values for the images shown in Fig.3 are given in Table 1. It is evident from Fig.3 and Table 1 is that the proposed geodesic active contour based iris segmentation method efficiently segmented the iris from the eye image.

CONCLUSIONS

In this paper, an automatic geodesic based iris segmentation algorithm was presented. This segmentation approach could efficiently remove eyelid and eyelash from the eye image, using Hough transformation technique. For quantitative analysis, the Jaccard (J) and Dice (D) similarity measure have been calculated based on the expert segmented result. The experimental results show that the proposed method has an acceptable performance compared to manual/expert segmentation. In this work, we have only segmented the iris in the eye image. In our future work, we could extend this method to extract the iris features for human recognition.

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