Improved Approach to Iris Normalization for iris Recognition System

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ABSTRACT

As a part of a growing information society, security and the authentication of individuals become nowadays more than ever an asset of great significance in almost every field. Iris recognition system provides identification and verification automatically of an individual based on characteristics and unique features in iris structure. Accurate iris recognition system based on iris segmentation method and how localized the inner and outer iris boundaries that can be damaged by irrelevant parts such as eyelashes and eyelid, to achieve this aim, the proposed method applied canny edge detection then circle hough transformation on an eye image passed through preprocessing operations. The proposed iris normalization is done by using the important information that resulted from circle hough transformation such as center and radius of iris and center and radius of pupil to convert iris region in original image from the Cartesian coordinates (x,y) to the normalized polar coordinates (r,θ).The proposed approach tested conducted on the iris data set (CASIA v4.0- interval), and tested on (CASIA v**1**.0- interval) iris image database and the results indicated that proposed approach has 99.8% accuracy rate with (CASIA v4.0- interval),and has 100% accuracy rate with (CASIA v1.0- interval) .

Keywords: Iris Normalization, CASIA database, Polar Transform.

توجه جديد لتطبيع القزحية لنظام التعرف على قزحية العين

الخلاصة

كجزء من تنامي مجتمع المعلوماتية، أصبح أمن وتحقيق مصادقة الأفراد في هذه الأيام وأكثرمن أي وقت مضى، ذات أهمية كبيرة في كافة المجالات تقريبا.ان نظام التعرف على القزحية يوفر التعريف والتحقق من الفرد آلياً بالاعتماد على الخصائص والصفات الفريدة الموجودة فيهيكل القزحية.اننظام التعرف على القزحية ذات الاداء الدقيق يعتمد على طريقة تقطيع القزحية وكيفية ايجاد حدود القزحية الداخلية والخارية، التي يمكن أن تتضرر بأجزاءغير ذات صلة مثلا لرموشو الجفن، لتحقيق هذا الهدف فأن الطريقة المقترحة تستخدم مرشح كاني لاكتشاف الحواف ومن ثم تستخدم تحويلات هوف الدائرية على صورة العين بعد ان نفذت عليهاعمليات معالجة اولية. ان تطبيع القزحية المقترح قد تم باستخدام المعلومات الهامة التي نتجت من تحويلات هوف الدائرية مثل مركز ونصف قطر القزحية ومركز ونصف

قطرالبؤبؤ لتحويل منطقة القزحية في الصورة الاصلية من الإحداثيات الديكارتية (س، ص) إلى الإحداثيات القطبية (ر،θ) المطبعة. تم اختبار الطريقة المقترحة على قاعدة بيانات صورة القزحية (CASIA v4.0)، واختبارها ايضا على قاعدة بيانات صورة القزحية (CASIA v1.0) وبينت النتائج أن الطريقة المقترحة كانت بمعدل دقة 99.8% مع قاعدة بيانات القزحية (CASIA v4.0)، و100% مع قاعدة بيانات القزحية (CASIA v1.0).

INTRODUCTION

From years not far, the scientific community tried leave the traditional technologies and head toward technologies characterized by sobriety and accuracy and consistency. From these methods that have received the enthusiasm and encouragement are biometrics recognition.

Through scientific studies of medical, was knowing that each person has unique characteristics in part of his body such as fingerprints, hand geometry, iris, face shape and many others[1][2]. Biometric technologies used for measuring and analyzing a person's unique characteristics[1].from best methods that proved high success are iris pattern recognition that proposed in the 1980's by two American ophthalmologists, Leonard Flom and AranSafir that the iris could serve as a human identifier and that no two irises are alike (unique pattern), even in twins, it is stable and permanent, thus, can be tested repeatedly throughout time[3][4], but they had no actual algorithm or implementation until the computer scientist John Daugman of Cambridge University in England develop iris identification software who published his first promising results in 1993[5]. J. Daugman systems include exploit: (i) Integro-differential operators to detect iris inner and outer boundaries and then the cropped iris region is linearly normalized to rectangular image, (ii) Gabor filters to extract unique binary vectors constituting iriscode (used 2048-bit), and (iii) A statistical matcher (logical exclusive OR operator) that analyses basically the average Hamming distance between two codes (bit to bit test agreement)[4][6]. J. Daugman use a differential operators for locating the circular iris, pupil regions and the arcs of the upper and lower eyelids as show in equation (1)[4]:

$$\mathrm{Max}_{(r,x_0,y_0)} \left| G_\sigma(r) * \frac{\partial}{\partial_r} \oint_{r,x0,y0} \frac{I(x,y)}{2\pi r} ds \right| \quad \ldots (1)$$

Where:

$(r.x_0, y_0)$: the center and radius of coarse circle (for each of pupil and iris).

$I(x, y)$: the original iris image.

$G_\sigma(r)$: Gaussian function [3][4].

There are many variations in the image of eye, such as size of the iris is different for different people, as well as for the same person. This is due to several factors (e.g., variation of illumination, change in distance between the camera and the eye, eye position, rotation of the camera, head tilt and rotation of the eye within the eye socket)[1][7]. After the iris localization, J. Daugman use rubber sheet modal to map the sampled iris pixels from the Cartesian coordinates to the normalized polar coordinates, known as unwrapping process as show in figure (1)[4].

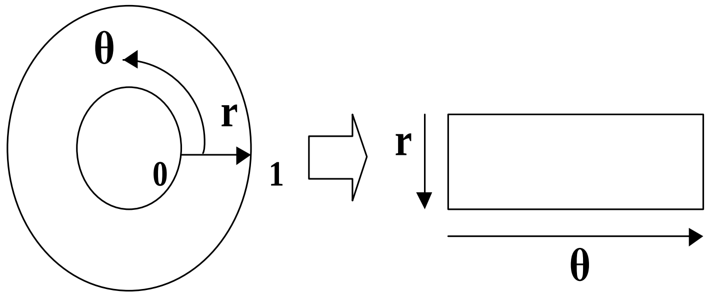


Figure (1) Daugman rubber sheet model.

The mapping functions from the Cartesian coordinates (x; y) to the Polar coordinates (r; θ) are as show in equation (2,3)[4]:

$$X(r;\theta) = (1 - r)Xp(\theta) + rXi(\theta) \quad \text{...(2)}$$

$$Y(r;\theta) = (1 - r)Yp(\theta) + rYi(\theta) \quad \text{...(3)}$$

Where:
$Xp(\theta) = Xp_o(\theta) + rp * \cos(\theta);$
$Yp(\theta) = Yp_o(\theta) + rp * \sin(\theta);$
$Xi(\theta) = Xi_o(\theta) + ri * \cos(\theta);$
$Yi(\theta) = Yi_o(\theta) + ri * \sin(\theta).$

Daugman system proved high effective on images to segment and normalized iris from eye image [7]. Integro-differential operator was proposed with some differences in 2004 by Nishino and Nayar [8]. Wildes proposed exploit: (i) used a low-light-level camera along with a diffused source and polarization, for image acquisition. He proposed the most common method of Iris segmentation through a gradient based binary edge-map construction followed by Hough transform (HT), (ii) Laplacian pyramid (multi-scale decomposition) to represent distinctive spatial characteristics of the human iris[9].*W.Boles'* prototype operates in building: (i) A one dimensional representation of the gray level profiles of the iris followed by obtaining the wavelet transform zero-crossings of the resulting representation[10]. Y. Huang proposed variant of Wildes' method to reduce the computational complexity by: (i) finding the Iris boundaries in rescaled image, (ii) using information of iris boundaries to guide search on the original image. The proposed making Iris rotation invariant for matching by making use of image of other eye as reference. He experimented independent component analysis to extract the independent components of a normalized Iris image using global approach [11].

Methodology

The proposed approach for iris normalization consist of three main stages that are shown in Figure (2):

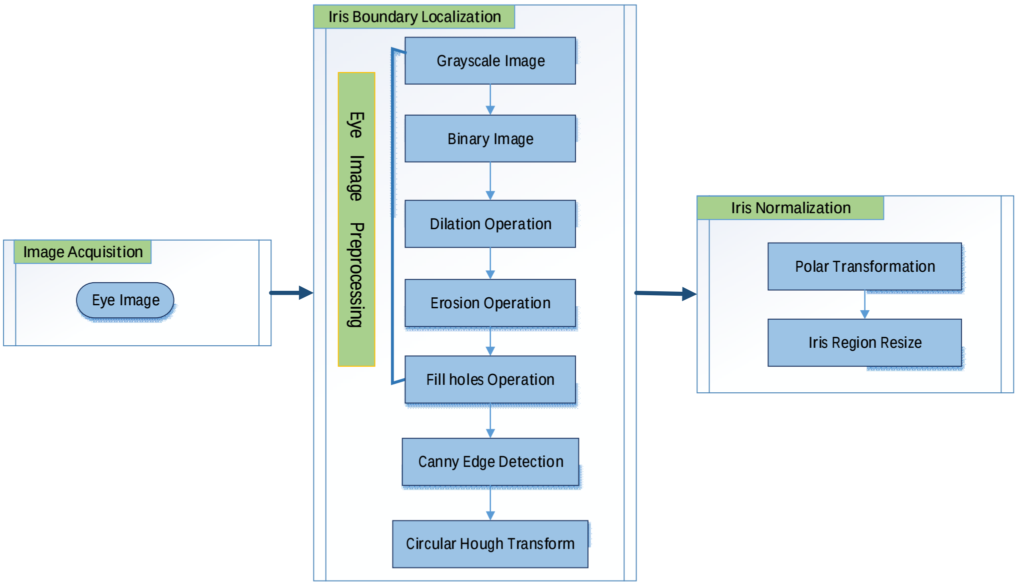


Figure (2) Block Diagram of the proposed Iris Normalization.

Image Acquisition

The proposed approach starts with eye image acquisition stage by using a special digital camera. These images should have high quality and good resolution. The image quality is influenced by the type of camera, the distance between the camera and the eye, the illumination intensity, the noise, eye movement and all events in the image capturing environment.

Iris Boundary Localization

The second stage is finding the inner and outer iris boundaries. This process aims to find iris region, which is characterized as a color region that is surrounded by white color area (Sclera) form outside and black color area (pupil) from inside. This stage should be accomplished with high accuracy because they significantly affect by the success of the system. To make the process simple and accurate, The proposed algorithm of iris boundary localization includes seven steps, in the first five are preprocessing operation and the two recent are edge detection operation as described in the Figure (2). These steps are repeated twice, the first time is to detect the inner boundary of the iris and the second time is to detect the outer boundary of the iris, the change related to the selection of the appropriate threshold every time in order to extract the require object from an image.

The steps start with converting the captures eye image into grayscale. Then converted it to binary image depending on the value of the threshold used, this can finding the pupil region with some noises (small portion of eyelashes) and iris region. Then morphological image processing (dilation and erosion) used to remove these noises and extract only the object. After that, Fill holes operation applied on pupil region only to fill all reflection light spots caused by illumination, to make pupil region appear as one region to facilitate the process of pupil edge detection especially when lighting spots lies on the pupil boundary.

The canny edge detector applied to find pupil and iris edges separately. Canny edge detector applied to an images pass through the steps above and not on an original image directly so that to reduce the amount of undesired edges in original images, as a result, this will increase the accuracy of edge detection. The Last step in iris boundary localization is circular hough transform can applied on edge images resulting from canny edge detection process to get the complete circle shape and provide necessary information such as center and radius of iris and pupil that can be used in iris normalization.

Iris Normalization

Normalization refers to preparing a segmented iris image for the feature extraction stage. The inner and outer iris boundaries are located in an original image and can getting iris region directly from an image. The proposed approach splits the iris normalization stage into two steps the first is polar transform and the second is iris region resize.

Polar Transform

The polar transform will transform iris region in original image from the Cartesian coordinates to the polar coordinates. The idea of the proposed polar transform is to employ center of iris C_I and array points $E_I(x,y)$ which represent iris edge points and center of pupil C_P and array points $E_P(x,y)$ which represent pupil edge points that are obtained from circular Hough transform step above and transform it as explained in polar transform proposed algorithm below:

Algorithm 1:- The Proposed Polar Transform
Input: Original Image O(x,y).
Output: Iris Region in Polar Coordinate P($Line_I$,θ).
Process:
- CI (x,y)= Center of Iris, R_I= Radius of Iris,
E I (x,y) Array Points of iris edge;
- Cp (x,y)= Center of Pupil,R_P =Radius of Pupil,
E P (x,y) Array Points of pupil edge;

Step1: Set θ=[0-360°] as Full cycle, Start by θ=65°; //clockwise rotation
Step2: For each θ Do
Begin
- $R_{M=}$ R_I - R_P;
- Find Line from CI (x,y) to point from E I (x,y) using θ;
- Find S(x,y)point from E P (x,y) that lies on Line ;
- Find line Lp [the distance between CI (x,y) and S(x,y)];
- Subtract the distance ($Line_I$ = Line – Lp);
- If ($Line_I = R_M$) then
  Pixels are remain the same;
- Else ($Line_I < R_M$)
  Last 10 odd pixels is twice as needed to keep the size ($Line_I = R_M$);
- Else ($Line_I > R_M$)
  Last 10 odd pixels is removed to keep the size ($Line_I = R_M$);

- Set $Line_I$ and θ as height and width of Iris Region in polar coordinate using the equations:

$x = Line_I * \cos(\theta)$;
$y = Line_I * \sin(\theta)$;

End

Step3: End

The result of polar transform is a rectangular iris image, but each iris image has a different height. The Difference came from the different sizes of the iris from one person to another. In addition to the size of the pupil in eye image for the same person which shrinks and flattens depending on lighting factor and how close the eye of the camera.

Iris Region Resize

The second step in iris normalization stage is iris region resize which uniform all iris region images in the system to be imaged in fixed size. Because the iris is captured in different sizes for different people, as well as for the same person. This is due to several factors (e.g., variation of illumination, change in distance between the camera and the eye, eye position, rotation of the camera, head tilt and rotation of the eye within the eye socket). The proposed iris region resizes algorithm is described below:

Algorithm 2:- The Proposed Iris Region Resize
Input: Polar Iris Region Image.
Output: NormalizedIris Region image.
Process:
- A( )= array of height images.
- S= smaller height in array of height.
- D= difference in heights of images.

Step1: For i=1 to last iris region image in Database do
```
  Begin
A(i) = Image.hieght;
   End
```
Step2: Fori=1 to end of A(i) do
```
  Begin
     If A(i) < A(i+1)
       S=A(i)
  End
```

Step3: Fori=1 to last iris region image in Database do
```
 Begin
D(i) = Image.hieght(i) - S;
    For j=D(i) down to 0 do
        Begin
          Remove one odd pixel from last Image.hight(i);
        End
  End
```

Step3: End

Results And Discussion

The proposed iris normalization approach tested on the iris data set (CASIA v4.0-interval), and tested on (CASIA v**1**.0- interval) iris image database, and tested on color iris image selected from the UBIRIS.v2 iris database. The eye image inputted into iris recognition system and pass through all stages as describe in the following:

Stage1: select eye image from one of databases mention above as shown figure (3). Each one of these types of image pass through the iris boundary localization steps, the difference only in conversion color image into grayscale.

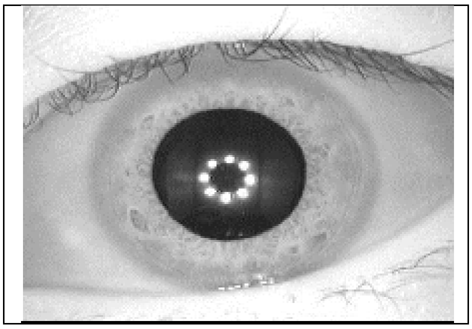
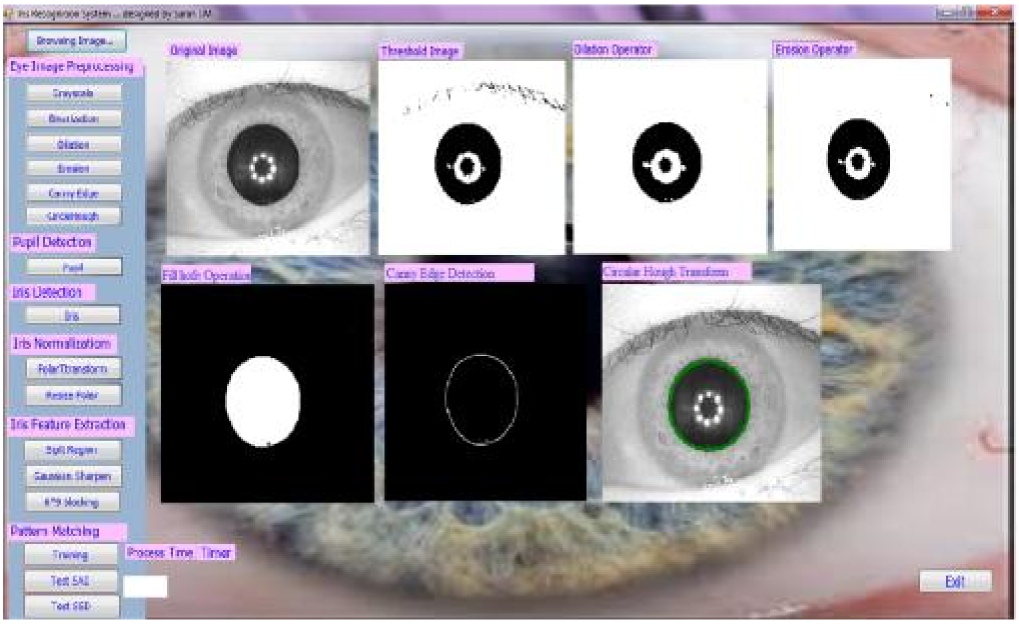
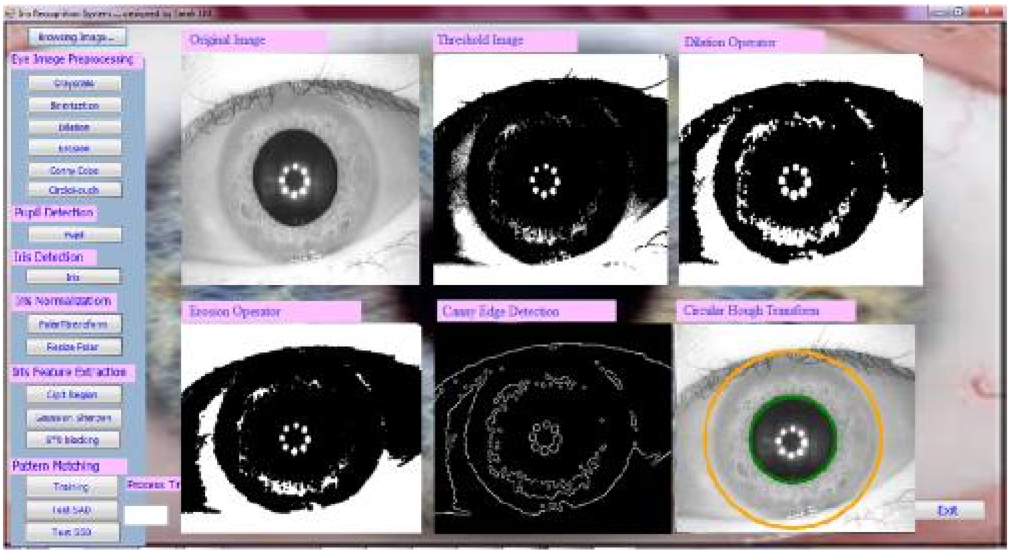


Figure (3) Original eye image (CASIA v4.0).

Stage2: the results of iris boundary localization steps are shown in figure (4).



(a) Steps to find pupil boundary.



(b) Steps to find iris boundary.

Figure (4)iris boundary localization steps.

<u>Stage3:</u> Iris normalization result, transformation of iris region to Polar Coordinate in fixed size as shown in figure (5).

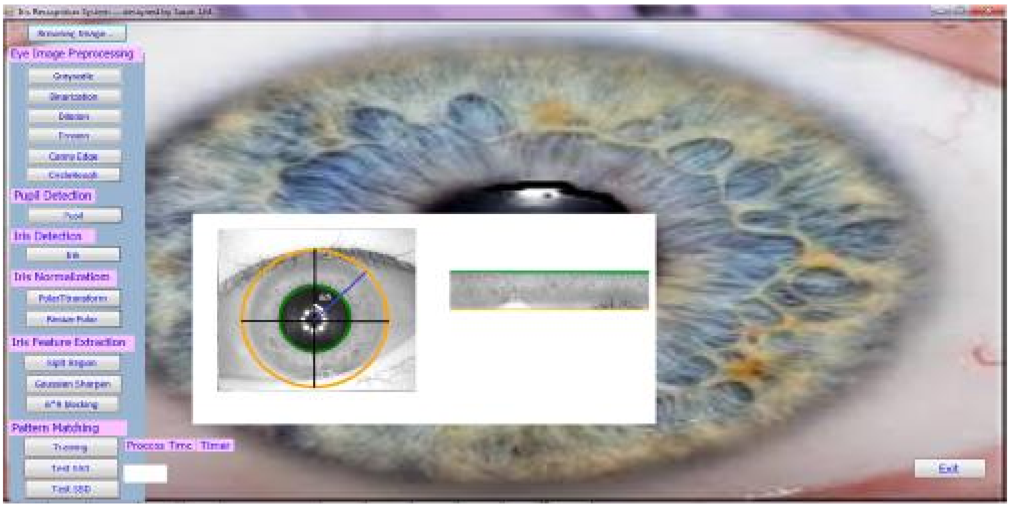


Figure (5) Iris normalization.

CONCLUSIONS

In this paper, a new approach to iris normalization is presented, which focused on iris segmentation and normalization from eye image. The idea of this paper is based on finding iris boundaries of accurate method using canny edge detector and circular hough transform, this stage is very critical and affect on iris recognition system results. In addition, the proposed iris normalization stage divided into two parts iris polar transform and iris region resize to increase the accuracy and speed. Experimental results show that this approach has a good iris normalized performance. The proposed approach has implemented in c # language and Microsoft access office 2013 run under Microsoft windows 7 Home Premium Operating System Version 6.1.7601 Service Pack 1 Build 7601. A standard iris normalization executed in ~3 ms. The proposed approach has an average high accuracy which means our approach is effective with less error rate as shown in the Table (1).

Table (1) Calculation of average accuracy.

Eye database	No. of images	No. correctly normalized	Faulty	Average accuracy
CASIA v4.0	600	599	1	99.8 %
CASIA v1.0	400	400	0	100 %

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