An Effective Iris Recognition System

Ei Phyu Win, and Nyein Aye

***Abstract*—**Biometrics deals with identification of individuals based on their biological or behavioral characteristics. Iris recognition is one of the robust biometric technologies used for personal identification. Iris recognition includes image acquisition, segmentation, normalization, feature extraction and matching. Firstly, an iris image is acquired from CASIA database. Segmentation is used for the localization of the correct iris region in an eye and it should be done accurately and correctly to remove the eyelids, eyelashes, reflection and pupil noises present in iris region. This paper proposes Hough transform segmentation method for iris recognition. The segmented iris is normalized to minimize the dimensional inconsistencies between iris regions by using Daugman's Rubber Sheet Model. For extracting iris features, one-dimensional object detection is used. Finally, the two iris textures are matched using Euclidean distance. The proposed system provides accurate iris segmentation and reduces the computation and time load extracting texture information of the iris.

***Keywords*—**Daugman's Rubber Sheet Model, Euclidean Distance, Hough transform, Iris Recognition.

I. Introduction

IN the present world with the advancing technologies, the necessity of security increases. With the development of information technology and the increasing need for security, intelligent personal identification has become a very important topic. Traditional methods for personal identification are based on token (a physical key, ID card) or knowledge (a secret password, PIN). These methods suffer from various problems. For example, ID cards may be forged or lost, and passwords may be forgotten or guessed. Biometric solutions address these fundamental problems because an individual' biometric data is unique and cannot be transferred. Biometrics is a method for recognizing based on physiological and behavioral characteristics. Biometric systems provide reliable recognition schemes to determine or confirm the individual identity. Biometrics has capability to distinguish between authorized user and an imposter. An advantage of using biometric authentication is that it cannot be lost or forgotten, as the person has to be physically present during at the point of identification process. The commonly used biometric features include speech, fingerprint, face, iris, voice, hand geometry, retinal identification, and body odor identification. Iris recognition is most accurate and reliable biometric identification system available in the current scenario.

Iris is the area of the eye where the pigmented or colored circle, usually brown, blue, rings the dark pupil of the eye. Iris is like a diaphragm between the pupil and the sclera and it function is to control the amount of light entering through the pupil [4]. The highly randomized appearance of the iris makes its use as a biometric well recognized. Its suitability as an exceptionally accurate biometric derives from:

i. The difficulty of forging and using as an imposter person.
ii. It is intrinsic isolation and protection from the external environment.
iii. It is extremely data-rich physical structure.
iv. Its genetic properties—no two eyes are the same.
v. Its stability over time.

Compared with other biometrics, iris recognition is more reliable and accurate for authentication process due to these various characteristics. The current and future applications of iris recognition systems include a substitute for passport at secured and restricted areas in airport, screening at border crossings, database access and computer login, secure access to bank accounts at ATM's and credit card authentication [7].

II. Related Works

The concept of iris recognition was first proposed by Dr. Frank Burch in1939. It was first implemented in 1990 when Dr. John Daugman created the algorithms for it. Plenty of works are done on iris recognition system by many researchers. Most of the cases, authors claimed the better performance of speed in capturing images and recognition over the existing systems available at that time. To gather the knowledge, we have considered the following selective works.

Daugman is the inventor of the most successful commercial iris recognition system now and published his wonderful results in 1993 [8]. He proposed an integro-differential operator for localizing iris regions along with removing the possible eyelid noises [9].

Wildes proposed the algorithm which first convert image into a binary edge map and then detect circle using Hough transform. Laplacian filter at multiple scales is used to extract features. Finally, the matching between two iris images is done using normalized correlation [10].

Boles and Boashash [11] proposed a novel iris recognition algorithm based on zero crossing detection of the wavelet transform, this method has only obtained the limited results in the small samples, and this algorithm is sensitive to the grey value changes, thus recognition rate is lower.

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L.Ma, T. Tan, Y. Wang, and D. Zhang presented a three-stage iris localization technique [12]. The first step is to approximate the center coordinates (X_p,Y_p) of the pupil through the minima of horizontal and vertical projection of the image. The second step is to linearize a 120 * 120 region centred at (X_p,Y_p) using a reasonable threshold based on the gray-level histogram of the region. The last step utilizes canny edge detector and Hough transform to locate the circular boundaries determined by the centre of the pupil.

III. Proposed System

Generally, an iris recognition system is composed of many stages. Firstly, an image of the person's eye is captured from CASIA database. Secondly, the image is localized to determine the iris boundaries. Thirdly, the iris boundary coordinates are converted to the stretched polar coordinates to normalize the scale of the iris in the image. Fourthly, features representing the iris patterns are extracted based on texture analysis. Finally, the person is identified by comparing their features with an iris feature database. The overall performance of an iris recognition system is highly related to the proper design of its subsystems.

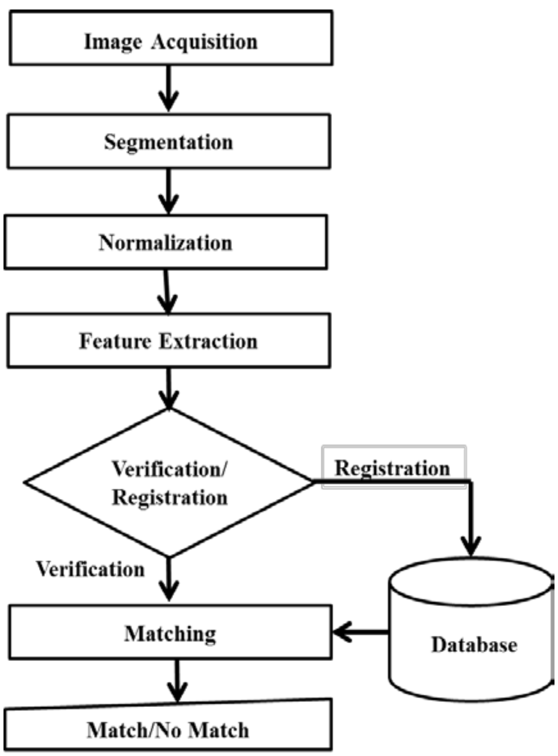

Fig. 1 Flow chart of iris recognition system

A. Image Acquisition

In order to get a fast and effective iris recognition system, an image is acquired from CASIA database to minimize the requirement of user cooperation. The Chinese Academy of Sciences - Institute of Automation (CASIA) eye image database contains 756 grayscale eye images with 108 unique eyes or classes and 7 different images of each unique eye. Images from each class are taken from two sessions with one month interval between sessions. The images were captured especially for iris recognition research using specialized digital optics developed by the National Laboratory of Pattern Recognition, China. The eye images are mainly from persons of Asian descent, whose eyes are characterized by irises that are densely pigmented, and with dark eyelashes [3]. Due to specialized imaging conditions using near infra-red light, features in the iris region are highly visible and there is good contrast between pupil, iris and sclera regions. The main reason of choosing gray iris image can provide enough information to identify different individuals [2].

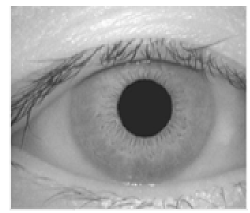

Fig .2 Original eye image

B. Segmentation

For every iris recognition system, accuracy of the system is highly dependent on accurate iris segmentation. Segmentation is an important stage of an iris recognition system that isolates the iris region in an eye image by locating pupil, two eyelids and eyelashes that may cover some areas of the iris texture. The iris region is isolated by approximating two circles, one for the iris-pupil boundary and the other for iris-sclera boundary. The Hough transform is an algorithm presented by Paul Hough in 1962 for the detection of features of a particular shape like lines or circles in digitalized images. It can be applied to many computer vision problems as most images contain feature boundaries which can be described by regular curves. The classic Hough transform is a standard algorithm for line and circle detection. The main advantage of the Hough transform technique is that it is tolerant to gaps in feature boundary descriptions and is relatively unaffected by image noise, unlike edge detector. The Hough transform is applied on these images after canny edge detection to identify the circles of desired radii (i.e. those corresponding to pupil and iris boundary) and then is marked on the image [5]. The circular Hough transform can be employed to deduce the radius and center coordinates of the pupil and iris regions. Firstly, an edge map is generated by calculating the first derivatives of intensity values in an eye image and then threshold the result. From the edge map, votes are cast in Hough space for the parameters of circles passing through each edge point. These parameters are the center coordinates x_c and y_c, and the radius r, which are able to define any circle according to the equation.

$$x_c^2 + y_c^2 - r^2 = 0 \quad (1)$$

A maximum point in the Hough space will correspond to the radius and center coordinates of the circle best defined by the edge points.

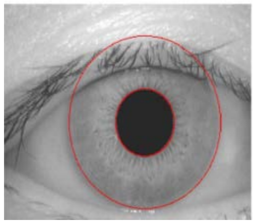

Fig. 3 Segmented iris image

C. Normalization

Once the iris region is successfully segmented from an eye image, the next stage is to transform the iris region so that it has fixed dimensions in order to allow comparisons. The dimensional inconsistencies between eye images are mainly due to the stretching of the iris caused by pupil dilation from varying levels of illumination. Other sources of inconsistency include varying imaging distance, rotation of the camera, head tilt, and rotation of the eye within the eye socket. The normalization process will produce iris regions, which have the same constant dimensions, so that two photographs of the same iris under different conditions will have characteristic features at the same spatial location. This process, often called iris unwrapping, yields a rectangular entity using Daugman's Rubber Sheet Model. This method transforms the iris region from Cartesian coordinates to polar coordinates (r, θ) where r lies in the interval of [0, 1] and θ is in the range of [0, 2Π]. The remapping of the iris region from (x, y) Cartesian coordinates to the normalized non-concentric polar representation is modeled as:

$$I(x(r,\theta), y(r,\theta)) \longrightarrow I(r,\theta) \quad (2)$$

with

$$x(r,\theta) = (1-r)x_p(\theta) + rx_i(\theta)$$
$$y(r,\theta) = (1-r)y_p(\theta) + ry_i(\theta)$$

I(x, y) is the iris image where (x, y) are the Cartesian coordinates and (r, θ) are the polar coordinates; x_p and y_p are the pupil coordinates and x_i and y_i are the iris coordinates along the direction of θ.In normalized iris image, the eyelashes (noise) are presented.

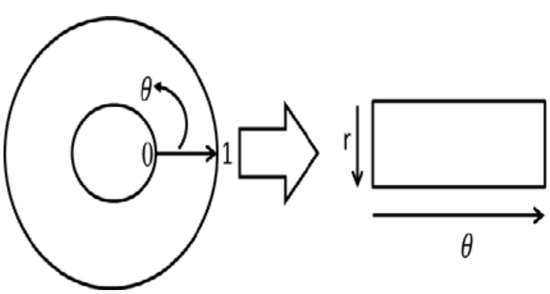

Fig. 4 Daugman's Rubber Sheet Model

For isolating the eyelashes, the intensity values (not 0 -255) are set for these eyelashes to separate the noise and iris texture easily.

Fig. 5 Normalized texture image iris

D. Feature Extraction

The most important step in iris recognition is the ability of extracting some unique attributes from iris, which help to generate a specific code for each individual. Therefore, feature extraction is a crucial step to the success of an iris recognition system. In order to provide accurate recognition of individuals, the most discriminating information present in an iris pattern must be extracted. Only the significant features of the iris must be encoded so that comparisons between templates can be made. For extracting features on iris texture, one- dimensional object detection is used. In this method, the secant lines are set on the normalized iris texture. Then, the same distance of iris textures are counted along the secant line pixel by pixel as a histogram.

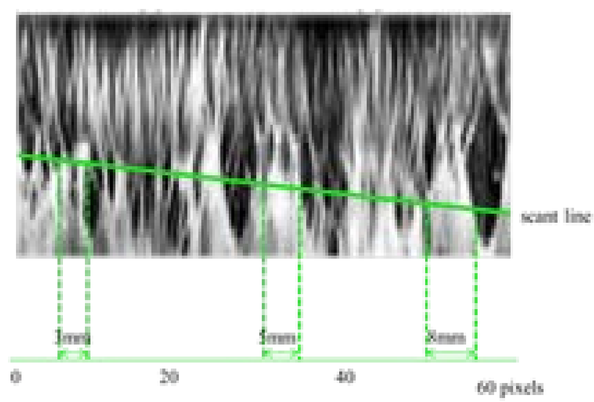

Fig. 6 Counting iris texture along the secant line

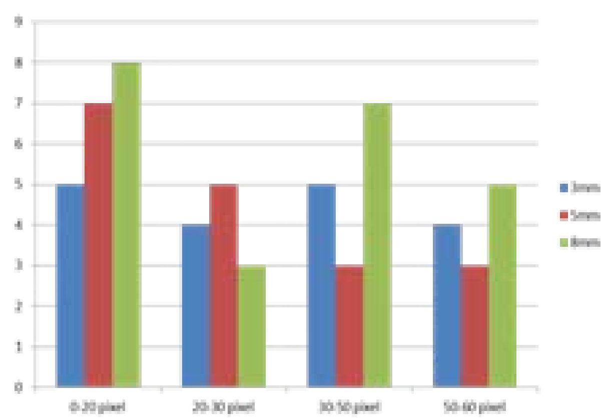

Fig . 7 Histogram of counting of same iris distance

E. *Matching*

Once features are extracted and template that is generated in the feature extraction process will need a corresponding matching metric, which gives a measure of similarity between two iris templates. This metric should give one range of values when comparing templates generated from the same eye and another range of values when comparing templates created from different irises. These two cases should give distinct and separate values so that a decision can be made with high confidence as to whether two templates are from the same iris or from two different irises. Euclidean distance is used to measure similarity between two iris images for matching in iris recognition system.

IV. Results And Discussion

In order to get accurate iris segmentation, the Hough transform is applied on these images after canny edge detection to identify the circles of desired radii (i.e. those corresponding to pupil and iris boundary) and then is marked on the image. The Hough transform is a standard computer vision algorithm that can be used to determine the parameters of simple geometric objects, such as lines and circles, present in an image. The main advantage of the Hough transform technique is tolerant to the presence of gaps in feature boundary descriptions and is relatively unaffected by image noise. The automatic segmentation model using Hough transform proved to be successful. Moreover, the CASIA database provided good segmentation, since those eye images had been taken specifically for iris recognition research and boundaries of iris pupil and sclera were clearly distinguished. The segmentation technique managed to correctly segment the iris region from 624 out of 756 eye images, which corresponds to a success rate of around 83%.

Next, the segmented iris region is normalized to eliminate dimensional inconsistencies between iris regions. This is achieved by implementing a version of Daugman's Rubber Sheet Model, where the iris is modeled as a flexible rubber sheet, which is unwrapped into a rectangular block with constant polar dimensions [1]. In normalized iris image, the eyelashes (noise) are presented. For isolating the eyelashes, the intensity values (not 0 -255) are set for these eyelashes to separate the noise and iris texture easily.

Feature extraction is an essential part of iris recognition system. The performance of biometric system also based on iris recognition depends on the selection of iris features. Most commercial iris recognition systems use patented algorithms developed by Daugman's Gabor filter for feature extraction. These methods have large computation. To extract the most significant features in iris, one-dimensional object detection using secant lines is used. In this method, only the significant features of the iris are extracted to provide accurate recognition and to make comparisons between templates. So, the secant lines are set on the normalized iris texture. Then, the same distance of iris textures are counted along the secant line pixel by pixel as a histogram.

Finally, the histogram generated in the feature extraction stage needs a matching metric to measure the similarity between two iris histograms. The matching module determines how closely the histogram matches the histogram stored in the database. Euclidean distance is chosen as a classifier, which calculates the similarity between the two iris histograms. Therefore, the proposed system provides accurate iris segmentation and reduces the computation and time load extracting texture information of the iris.

V. Conclusion

This paper has presented a fast and effective iris recognition system, which is tested using CASIA database, a database of digitized gray scale eye images, in order to get accurate and efficiency rate. Segmentation is presented which localizes the iris region from an eye image and isolates eyelids, eyelashes. The Hough transform is applied on these images after canny edge detection to identify the circles of desired radii of the pupil and iris boundaries and then is marked on the image. The Hough transform is a standard computer vision algorithm that can be used to determine the parameters of simple geometric objects, such as lines and circles, present in an image. The segmented iris is normalized to produce iris regions, which have the same constant dimensions using Daugman's Rubber Sheet Model so that two photographs of the same iris under different conditions will have characteristics feature at the same spatial location. The accuracy of iris recognition depends on the performance of the segmentation method and feature extraction. To extract the features of iris, one-dimensional object detection is used. For determining the performance of the proposed iris recognition system, Euclidean distance is used as a classifier, which calculates the similarity between the two iris histograms. The proposed system provides accurate iris segmentation and reduces the computation and time load for localizing iris and extracting texture information of the iris.

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