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Iris Recognition Algorithm Using Effective Localized Fuzzy Features

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Abstract: The iris has a particularly interesting structure and provides abundant texture information. In this paper we propose a novel fuzzy feature extraction method, which can provide robust and effective iris feature vectors. The IR System consists of automatic segmentation algorithm which is based on Hough Transform which is able to localize the circular iris and pupil region. The extracted iris region is normalized into a rectangular block with constant dimensions to account for dimensional inconsistencies. Image enhancement is done by using fuzzy adaptive filter and is divided into non overlapping sub blocks to capture local iris characteristics. The fuzzy features of neighbourhood are aggregated to yield a representative called cumulative response that represents the texture.

Keywords: Hough Transform, iris segmentation, Fuzzy adaptive filter, Fuzzy features.

I. INTRODUCTION

In today's information technology world, security for system is becoming more and more important. The number of systems that have been compromised is ever increasing and authentication plays a major role as the first line of defense authentication is against intruders. The three main types of authentication are something you know (password), something you have (card or token), something you are (biometric). Biometrics, provide a secure method of authentication and identification, as it is difficult to replicate and steal [1].

Biometric identification utilizes physiological and behavioral characteristics to authenticate a person's identity [2]. By using biometrics physical access can be control can be improved, like enhanced force protection measures, link identity to an inherent part of a person, have a robust audit trail of a person accessing certain physical spaces. It also compliments in the improvement of logical access control resulting in enhanced security, increased convenience, and strong audit trail [3].

The iris has many features that can be used to distinguish one from another [4]. One of the primary visible characteristic is the trabecular meshwork, a tissue which gives the appearance of dividing the iris in a radial fashion that is permanently formed by the eighth month of gestation. During the development of the iris, there is no genetic influence on it, a process known as chaotic morphogenesis that occurs during the seventh month of gestation, which means that even identical twins have differing irises [5].

II. IMAGE ACQUISITION

Sequences of eye images are captured from the subject using a specifically designed sensor. Since the iris is fairly small (diameter is about 1 cm) and exhibits more abundant texture features under infra red lighting, capturing iris images of high quality is one of the major challenges in practical applications. It is of prime importance to have adequate hardware set up to capture iris image with sufficient precision. A typical Iris Recognition System consists of following steps which are shown in the figure 1.

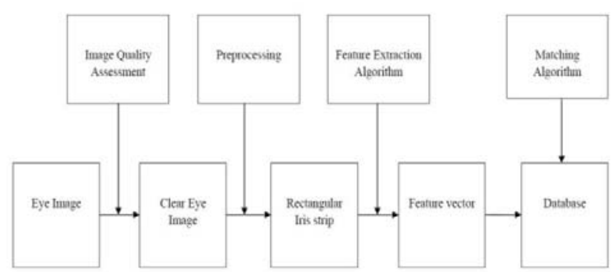

Figure 1. Typical Iris Recognition System

III. PREPROCESSING

The acquired iris images always contain not only the useful information but also some irrelevant information like eyelids, pupil etc[6]. To get an iris free of noise, independent on illumination and size, iris image preprocessing is done. The iris segmentation is the initial stage of iris recognition. This stage isolates the actual iris region from an eye image. The iris region can be approximated by two circles, namely iris/sclera boundary and iris/pupil boundary. The average diameter of the iris is 12mm, and the pupil size can vary from 10% to 80% of iris diameter [7]. The problem arising in detecting the two circles is due to the occlusion of upper and lower parts of iris region by eyelids and eye lashes. A technique is required to isolate and exclude artifacts as well as locate the circular iris region[8][9]. The success of segmentation of the circular components depends on the image quality of eye images.

An automatic segmentation algorithm based on the circular Hough Transform is employed by Wildes et al.[10],

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Kong and Zhang [11],Tisse et al.[12], and Ma et al. [13]. The output of circular Hough Transform is shown in fig 2.

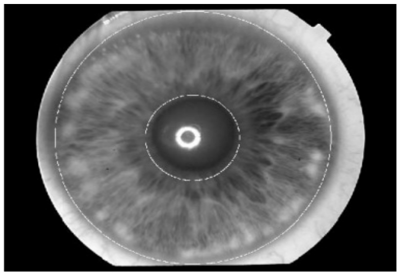

Figure 2. Iris as Concentric Circle

IV. NORMALIZATION

The dimensional inconsistencies between eye images are mainly due to the stretching of the iris caused by pupil dilation from varying levels of illumination. 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 avoid dimensional inconsistencies[14]. The normalization process will produce an iris region, which have the same constant dimensions and is shown in figure 3.

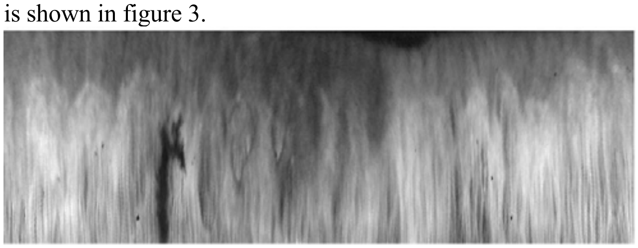

Figure 3. Normalized Iris Strip

A. *Image Enhancement*

Normalized image should be enhanced before feature extraction. To enhance the iris image and reduce the effect of non uniform illumination, fuzzy adaptive filter is used, which is capability of reasoning with vague and uncertain information. Histogram equalization was applied on normalized image and passed through median filter. Subsequently the fuzzy adaptive filter was applied.

B. *Fuzzy Adaptive Filter*

Rectangular strip is divided into non over lapping windows of 3x3. On this window fuzzy adaptive filter is applied. The adaptive algorithm evaluates a membership function based on a given pixel and then uses this value to calculate the filtered output.

The membership function is a function of the distance between pixel $I(X_i)$ and reference $I(X_r)$. Here $I(X_r)$ is the maximum intensity pixel in that window. Membership function is calculated as

$$\mu(\mathrm{I(Xi)}) = e^{-(\frac{d(I(Xi)-I(Xj)}{\sigma})} \quad (1)$$

where sigma is a distance threshold.

Let $I(X_1)$, $I(X_2)$ ……. $I(X_n)$ Be the gray levels of pixels 1…..n respectively, in a given window with n pixels in it[15]. In weighted average filtering, the gray level of centre pixel is replaced by

$$I(Xi) = \frac{\sum \mu(i,j) I(i,j)}{\sum \mu(i,j)} \quad (2)$$

where *u(i,j)* is the weight associated with the a neighboring pixel X_j.

The enhanced images by histogram equalization, median filter, and fuzzy adaptive filter is shown in the figures 4 , 5 and 6.

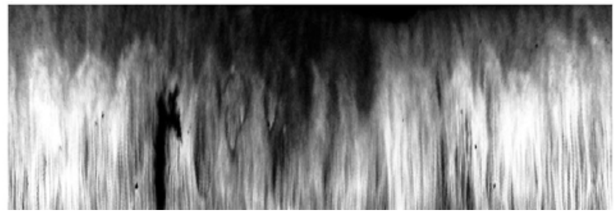

Figure 4. Enhanced Image by using Histogram Equalization

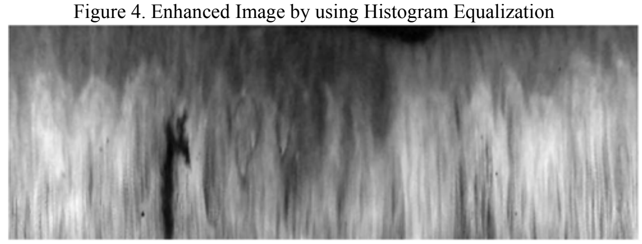

Figure 5. Enhanced Image by using Median Filter

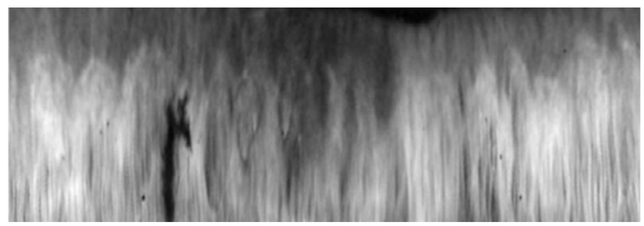

Figure 6. Enhanced Image by using Fuzzy Adaptive Filter

V. FEATURE EXTRACTION

The iris has a particularly interesting structure and provides abundant texture information. So, it is desirable to explore representation methods which can describe global and local information for an iris, the enhanced rectangular strip is divided into some fixed number of sub blocks and the proposed feature extraction is applied. The steps involved in feature extraction method are shown in figure 7.

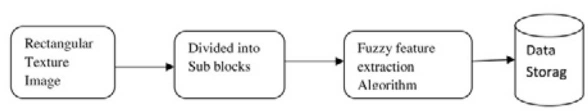

Figure 7. Feature Extraction Algorithm

A. *CUMULATIVE RESPONSE*

The information values in a fuzzy set are aggregated to yield a representative value called cumulative response that represents the texture. An algorithm for the extraction of cumulative response as follows:

1. Each sub image is divided into some non overlapping windows.
2. Considering a window size wxw, the average intensity ($\bar{I}$) is computed from
$$\bar{I}(i,j) = \frac{1}{wxw} \sum_{m,n=i,j}^{R} I(m,n) \quad (3)$$
3. The maximum intensity in the window is found.
4. Membership function is calculated as $\mu(i,j)$ for every pixel is computed as

$$\mu(i,j) = \frac{|I(i,j) - J(i,j)|}{\max\,(I(i,j))} \qquad (4)$$

5. For every window, the cumulative response called fuzzy feature (F F) is computed from the centre of gravity approach.

$$FF = \frac{\sum \mu(i,j) I(i,j)}{\sum \mu(i,j)} \qquad (5)$$

A feature vector consists of an ordered sequence of the features extracted from the local information contained in the fixed sub images. Thus, the feature elements capture the local information and the ordered sequence captures the invariant global relationships among the local patterns [13]. A feature vector is a collection of all the features from each fuzzed sub block. The difference between feature vectors of same user and different users is shown in figure 8.

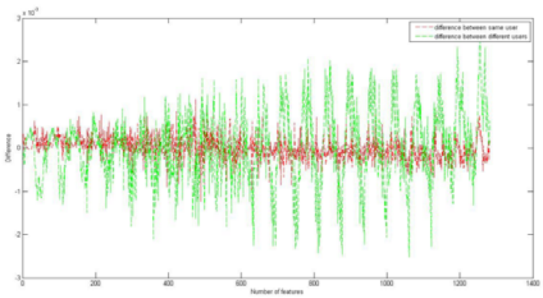

Figure 8. Comparison of Fuzzy features of same and different users.

VI. EUCLIDEAN DISTANCE

The obtained feature values should enter a comparison process to determine the user, whose iris image was taken for recognition. So the last module of an iris recognition system is used for matching two iris templates. Its purpose is to determine how similar or different. The templates are and decide whether they belong to the same individual or not.

An Euclidean classifier classified iris based on the minimum distance between two feature vectors. It has two phases of processing, namely training and testing. In the initial training phase, based on *n* different person samples, a training class is created. By finding a new vector V = (f1, f2, ------,fn) which is near to all vectors in the training set of one class and that vector is used in testing phase for classification. If v= (g1, g2, ------, gn) a feature vector, then it matches with that class whose Euclidean distance from V is minimum and Euclidean distance is given by

$$D = \sqrt{\sum_{i=1}^{n} (fi - gi)} \qquad (6)$$

VII. CONCLUSION

The proposed algorithm is validated with input eye samples of size 768x576. On the rectangular strip, image enhancement is done by using histogram equalization, followed by median filter, and is followed by applying fuzzy adaptive filter. The feature extraction algorithm is applied to get feature vectors. The size of feature vector depends on the window size chosen to partition iris sub block.

The window size is varied to get varied size of feature vector and Euclidean distance values between templates to search for a match. The highest performance occurs at window size of 3. The performance wanes as window size is increased. The results obtained with Cumulative response features and its ROC plot is shown in figure 10. The variation of accuracy with threshold values is shown in figure 9.

Threshold	Accuracy
0.45 10	0
0.455 1	00
0.458 1	00
0.459 99.1	9
0.460 98.3	8
0.465 96.7	7
0.470 90.3	2

Figure 9. Accuracy vs Threshold

The ROC plot for fuzzy feature extraction algorithm is applied on the normalized enhanced image is shown in figure 10.

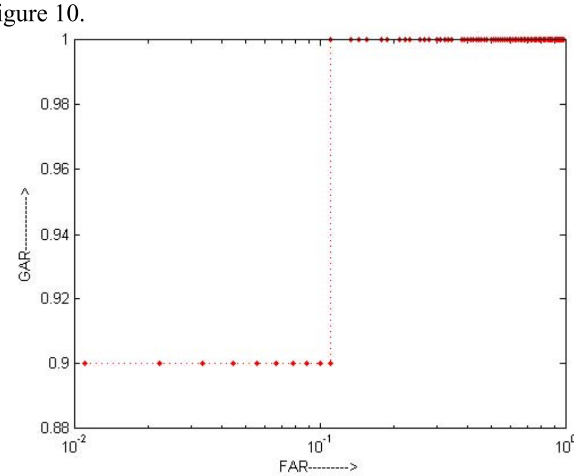

Figure 10. ROC Plot Using Fuzzy features.

This paper proposed a fuzzy based Iris recognition system. The proposed scheme uses Hough Transform for detecting the lines and circles and normalized image is divided into non overlapping blocks, on each block fuzzy algorithm is applied so as to get local features, these features constitute global feature vectors, and Euclidean distance measure is used for matching.

VIII. ACKNOWLEDGMENT

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