Performance Evaluation of Different Distance Measures Used in Color Iris Authentication

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Abstract

This paper proposes performance evaluation of different distance measures used in color iris authentication. The color iris segmentation is carried out using histogram and circular Hough transform. The color iris features are extracted using histogram method. Different distance measures are used for iris authentication. The experimental evaluation shows that Euclidean and Manhattan distance are computationally efficient as compared to other distances. The proposed method gives very promising results which achieves classification accuracy of 92.1%. Equal error rate of 0.005 and 0.072 for Euclidean and Manhattan distance for HSV model and 0.09 and 0.098 for RGB model respectively.

Keywords: Biometrics, authentication, feature extraction, Euclidean distance.

I. INTRODUCTION

Biometric traits [1], such as recognizing one’s iris, fingerprint, face, retina, etc. helps in person authentication and identification. This authentication or identification of an individual is based on his/her behavioral or physiological characteristics. Biometric traits, has the capability to distinguish between an authorized person and an impostor. As biometric characteristics of different traits such as fingerprints, face, iris, ear, voice, palm print, hand geometry, etc., are unique and distinctive, they are used for authentication and identification. Biometric traits offer different degrees of reliability and performance. Biometric systems have gradually become an accepted means for person identification and verification. In biometric authentication/identification system, person to be authenticated needs to be physically present at the point of identification.

Iris recognition [2, 3] is widely accepted as one of the most reliable biometric technique. The iris patterns are very complex which contains many distinctive features such as radial furrows, concentric furrows, zigzag collarette, crypts, freckles, rings and corona [3,4]. In the last two decades, there is significant progress of use of iris recognition [4–7]. Compared with some other biometrics, iris has various advantageous factors such as greater speed, simplicity, and accuracy. Literature reveals that the irises of identical twins are different and also right and left irises of an individual are different. The properties of iris makes it as one of the most secure biometrics for identification and authentication. Iris recognition is widely accepted as one of the best biometrics recognition methods [3], in the world because of its stability, uniqueness and non-invasiveness.

A generic iris recognition system [3] consists of image acquisition, iris segmentation, feature extraction, matching and recognition. For recognition/identification of a person, the eye image is captured using infrared (IR) camera. While acquiring the eye image, eyes are illuminated using infrared light. The acquired image of the eye contains data, derived from the surrounding eye region along with iris. Therefore, initially the iris is localized in the segmentation module from the acquired image. The size of the individual iris goes on changing with respect to changes in illumination, also the size of iris each individual is different. In order to avoid inconsistency in the size of the iris, it is normalized. In the feature extraction module, features are extracted from the normalized iris. This feature is encoded and then matched with the other template.

The limitations of this IR based iris authentication system is that the color information is lost and special IR cameras are required for acquiring iris images. This paper proposes a new method for iris extraction and color histogram based approach is used for iris authentication. The color histogram information is directly adopted as features. Color histogram has simple mathematical analysis which reduces complex mathematical computations. The computational complexity of the feature extraction process is much lower than other filtering based approaches. This proposed method can be implemented effectively on embedded platforms.

The rest of this paper is organized as the following. Section II and Section III presents the developed method for iris extraction and feature extraction technique using color histogram. Section IV describes the matching process of the proposed approach. Experiments and results are elaborated in Section V. The last section is a conclusion of our work.

II. IRIS PREPROCESSING

Iris patterns are unique for a person which remains stable throughout the life [2,4]. The iris image of a person is acquired at different instant of time. During this instant the external environments are not same, i.e. the distance between the camera and eyes, tilting of head, eye....
movements and pupil dilation. All these factors need to be considered while feature extraction. Therefore, prior to feature extraction iris image need to be preprocessed.

Iris segmentation plays an vital role in the performance of iris identification system. Several segmentation techniques have been proposed in the literature. The most two popular techniques used for iris segmentation are integro-differential operator [2] and the Hough transform [4] respectively. The first stage of iris segmentation is to find out pupil boundary and then the limbus boundary. The UBIRIS [8], iris database consist of color images. The color eye image consist of RGB colors which is used for iris segmentation. The red channel (plane) of this color eye image is used for iris segmentation, which reduce the processing time required for conversion into gray level format. The pupil boundary and its radius are extracted using the histogram method [9]. The limbus boundary and its radius are detected using integro-differential operator [2]. The circular Hough transform is based on voting scheme which is tolerant to noise. To detect the limbus boundary of noisy iris images from UBIRIS database the circular Hough transform is selected for limbus boundary detection. In circular Hough transform the voting process is carried out in a parameter space. A circular Hough space is given in equation 1 as

$$H(x_c, y_c, r) = \sum_{i=1}^{n} h(x_i, y_i, x_c, y_c, r)$$

where $r$ is radius, $(x_c, y_c)$ are center circle, $(x_i, y_i)$ is an edge point and $(x_o, y_o, r)$ are location. $H(x_c, y_c, r)$ is an accumulator array. The maximum value of the accumulator is selected as the parameter for the largest circular boundary. This parameter gives the limbus center and radius value. Using pupil radius, limbus radius and center values, pupil boundary and limbus boundary are mapped on color iris as shown in Figure 1.

![Segmented iris image](image1.png)

Figure 1. Segmented iris image

The segmented image consists of the original eye image on which pupil boundary and limbus boundary is mapped. The pixels inside the pupil boundary are not useful, which are considered as noise and similarly the portion outside limbus boundary are not useful which are also considered as noise. This noise from the segmented image is to be removed and only iris image is to be preserved. Here the pixels outside the limbus boundary and the pixels inside the pupil boundary are replaced with white pixels. The sample extracted iris image from segmented images are shown in Figure 2. The size of extracted iris image is different for every image.

![Extracted iris image](image2.png)

Figure 2. Extracted iris image

There is pupil constriction and dilation due to illumination conditions, environmental, physiological factors, the distance between the camera and iris image, etc. This iris deformation will affect the overall performance during matching. In order to compensate this elastic deformation iris image is normalized. Normalization method transforms a localized iris texture from Cartesian to polar coordinates. The majority of the iris recognition algorithm uses rubber sheet model suggested by Daugman [2] for normalization. In this color iris authentication system normalization step is eliminated.

### III. IRIS FEATURE EXTRACTION USING HISTOGRAM OF COLOR MODELS

The first method of iris recognition was proposed by Daugman [2] which uses 2-D Gabor filter for feature extraction using IR images. Laplacian of Gaussian (LoG) filter was used by Wildes for feature extraction. In the literature, it has been observed that various filter bank techniques have been suggested by authors for iris feature extraction. An alternative to IR images based iris recognition is to use color information of iris for iris recognition. Krichen [10] used wavelet packets for iris identification using color iris images. Hugo [8] created a noisy iris database UBIRIS were gray scale images were used for experimentation. Boyce et. al. [11] used multispectral iris images for segmentation and recognition. Here RGB images are converted into Lab color space, for feature extraction 2D Gabor filters and radial feature vectors are used. Monaco [12] used color space analysis for iris recognition in which Gabor filters are used for feature extraction from each band. For color iris recognition and indexing Gabor filter and other filter bank techniques have been used. This filter banks provide excellent accuracy, but their design is complex and are computationally expensive.

The infrared iris image is a gray scale image were as color iris images consists of three channel data. The color image data is acquired from three sensors, i.e. red, green and blue. The RGB image is used for segmentation. Prior to feature extraction the segmented RGB image is to be converted to the desired different color space. A color space is a model used for representing color values in intensity. There are a number of color spaces available, from this a particular color space is selected depending upon the application. The RGB color model is the most popular model used for processing digital images. The RGB color space, describes colors by three components: red, green and blue. The disadvantage of RGB model is

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that gets effected due to intensity variations. The other color space models are transformed from the RGB model using linear and nonlinear transformation matrix such as YUV, YIQ, HSV, HIS, etc.

The HSV color model is a popular model for computer graphics. The hue of an image refers to a pure color. The hue ranges from 0 – 360° where each value corresponds to one color. The saturation and value ranges from 0 to 1 where saturation is the intensity of the color and value is the measurement of brightness of color. Unlike other color models HSV is not device independent. HSV is popular due to its similarity with the way human perceive color.

Different color models have been used for iris recognition. Boyce et. al. [11] uses CIE Lab color space, Monaco [12] uses RGB, CIE lab, HSV, CMYK, YcbCrSun [13], Al-Quanieer [14] , Tan [15] and Sibai [16] used RGB color models for preprocessing. RGB and nine different color models, i.e. YUV, YIQ, HSV, HIS, HSL, Lab, Luv, LCH and YCbCr are used for transforming segmented RGB iris image into different spaces. Based on experimentation five color models HSI, HSV, YIQ, Lab and RGB model are finally selected. Using this color model RGB extracted iris images are transformed into different color spaces. From this transformed image features are extracted.

**Figure 3.** Color histogram of eye image

Color histogram is a standard method of extracting features from a color image. As color iris images are considered, the color histogram is used for feature extraction. The Color histogram of an image is rotation, translation, and scale invariant [17]. The color histogram is the probability distribution of color pixels in an RGB image defined as

\[ H_{R,G,B}(i) = \text{Probability}(N_{R,G,B}) \quad (2) \]

This probability function is a color histogram \( H_{R,G,B} \) where \( H_R, H_G \) and \( H_B \) represents the frequency of occurrences of red, green and blue channels respectively. For color images, the histogram is fragmented into three histograms of the three channels as \( H_R, H_G \) and \( H_B \) as shown in Fig. 3.

\[ \sum_{i=1}^{d} (a_i - b_i)^p \]

**IV. MATCHING**

Once the features are extracted, then these features are used for matching. As the features extracted from iris are independent from other channels, their respective levels are considered as feature vectors. There are various distances available to compare the similarity between two values using this pdfs. For measuring the similarity distances Euclidean distance and Manhattan are used.

The Euclidean distance (ED) and Manhattan distance (MHD) is commonly used for similarity measurement due to its efficiency, effectiveness and less time for computation. The ED compares the similarity between two feature vectors of iris image by estimating the square root of the sum of the squared absolute differences as given in equation 3. The value of \( p \) is taken as 2 in Euclidean distance.

\[ \text{Euclidean Distance} \quad ED_{(a,b)} = \sqrt{\sum_{i=1}^{d} (a_i - b_i)^2} \quad (3) \]

Manhattan Distance (MHD) also called as city block distance measures the similarity between two iris image by taking the sum of the absolute values of the differences between the two feature vectors as shown in equation 4

\[ \text{ManhattanDistance} \quad MHD_{(a,b)} = \sum_{i=1}^{d} |a_i - b_i| \quad (4) \]

The Minkowski distance (MinkD) compares the similarity between two feature vectors of iris image by estimating the square root of the sum of the squared absolute differences as given in equation 5. The value of \( p \) is taken as 3 in Minkowski distance.

\[ \text{Minkowski Dist.} \quad M_{\text{Mink}}D_{(a,b)} = \sqrt[3]{\sum_{i=1}^{d} (a_i - b_i)^3} \quad (5) \]

Similarly the cosine distance and histogram intersection is given in equation 6 and 7 respectively.

\[ \text{Cosine Dist.} \quad \text{CosineD}_{(a,b)} = \frac{\sum_{i=1}^{d} a_i b_i}{\sqrt{\sum_{i=1}^{d} a_i^2} \sqrt{\sum_{i=1}^{d} b_i^2}} \quad (6) \]

\[ \text{Histogram Inters.} \quad \text{HistI}_{(a,b)} = \frac{\sum_{i=1}^{N-1} \min(a_i, b_i)}{\min(||a||, ||b||)} \quad (7) \]

Experiments are carried out using above distances. The computational complexity is different for different distance measures. This is computed based on number of multiplication, addition and subtraction. For a feature vector of size \( d \). Euclidean distance requires \( d \) subtractions for \( ai - bi \), \( d \) squares of the previous, \( d - 1 \) further additions and one square root at the end. Similarly Manhattan distance requires \( d \) subtractions for \( ai - bi \), \( d - 1 \) addition. The comparison of the above distances based on time is shown in table I. The time required for
comparing two iris image is 0.000025 and 0.000021 secs using Manhattan and Euclidean distance. Experiment are carried out using distances shown in table I.

### TABLE I. **TIME REQUIRED FOR COMPARING SIMILARITY FOR TWO IRIS IMAGES**

<table>
<thead>
<tr>
<th>Distance Metrics</th>
<th>Time in secs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Euclidean distance</td>
<td>0.000025</td>
</tr>
<tr>
<td>Minkowski distance</td>
<td>0.00025</td>
</tr>
<tr>
<td>Spearman</td>
<td>0.000654</td>
</tr>
<tr>
<td>Cosine</td>
<td>0.000741</td>
</tr>
<tr>
<td>Manhattan</td>
<td>0.000021</td>
</tr>
<tr>
<td>Chi Square Statistics</td>
<td>0.000484</td>
</tr>
<tr>
<td>Histogram Intersection</td>
<td>0.000348</td>
</tr>
</tbody>
</table>

The performance of the system can be improved if fusion is carried at the matching score level [18, 19]. The fusion, at matching score is performed using a sum rule, max rule, min rule and product rule. The matching score of all the three channels is fused.

### V. RESULTS

To evaluate the performance of the proposed distance method UBIRIS database is used. In this section set of experiments are conducted to evaluate the performance of the proposed method and summarize the results. The performance is evaluated in two stages: first based on segmentation, color transformation, feature extraction and pattern matching and second based on authentication mode. For authentication mode the performance is measured in terms of genuine accept rate (GAR), false match rate (FMR), false non match rate (FNMR) and equal error rate (EER). The experiments are conducted on a COREi5 system with 4 GB RAM and MATLAB 2014A environment.

5.1 Iris Database

The performance of the proposed algorithm is evaluated on the UBIRIS database [8]. The images from the database have been captured from 241 persons with 5 images for each user in first session resulting in total 1205 images with image resolution of 200 x 150 . In a second session images are captured from 132 persons. The color images are acquired in visible light spectrum. The important characteristic of this database is that it incorporates several noise such as poor illumination, contrast, reflection, focus and occlusion in the iris images. Performance of segmentation method is tested on session one images in percentage using histogram and integro-differential operator (IDO) and histogram and circular Hough transform (CHT). The segmentation accuracy achieved using combination of histogram and circular Hough transform is 91.86%.

5.2 Performance evaluation using different color models

Experiments are carried out using five color models HSI, HSV, YIQ, Lab and RGB model. Table II presents the EER for individual channel of HSV, HSI, YUV, YIQ and Lab color model. In order to improve the performance of color models, the data is fused at score level. This score level fusion improves the EER. Fig. 4 and 5 shows the DET curves for best five color models. Based on these DET curves the EER is estimated. The EER obtained from these five color models is listed in Table II.

### VI. CONCLUSIONS

The paper presented the performance evaluation of different distance measures used in color iris authentication. The iris features are extracted using color histogram. This method of color histograms deals with different image sizes, colors, eyelashes, eyelids and illuminations. The experimental results reveal that HSV and YIQ color spaces are powerful as compared to RGB, YUV, HIS, HSL, Lab and YCbCr color spaces for iris authentication. Experimental results demonstrate that Manhattan and Euclidean distance are computationally efficient than all other distances. The performance of the method using the HSV color model is very simple, effective, efficient and faster. Based on the results presented above HSV model is an optimal color model suitable for color iris authentication. The proposed method using Euclidean and Manhattan distance achieves EER of 0.072 and 0.05 respectively. The execution time required for iris authentication is less as compared with earlier algorithms.
Experimental results suggest that the combination of HSV channels, its histogram and matching score fusion using weighted sum rule is more promising. The accuracy of the proposed system can further be improved by developing new models for feature extraction which are more efficient in terms of accuracy and EER.

REFERENCES


