ISSN No:-2456-2165

Biometric Authentication- Person Identification using Iris Recognition

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Abstract:- Biometrics are used to offer person identification by measuring and analyzing people's unique physiological and behavioral characteristics. As demands are increasing on this authentication technique a number of biometric modalities have evolved and used like fingerprint reader, face identifier and iris scanner. The human eye also has features and patterns that are distinctive for recognition. Also, the low-cost equipment for utilizing this technique has made it the most preferable framework in security reasons. As a reliable biometric authentication method, it is considered as the most explicit.

In this paper, a standard database namely CASIA v3 is used for taking iris database and different algorithms are used to recognize the targeted areas and the recognition process is performed. The algorithms we used are Morphology binary to remove the unwanted backgrounds; Circular Hough Transform to detect the iris; Gabor's filter to extract features of the human eye and KNN classifier to finally authenticate the query image. The images from the database are acquired and pre-processed before running through the algorithms.

Keywords:- *IRIS, Gabor's filter, KNN classifier, CASIA v3, Circular Hough Transform.*

I. INTRODUCTION

Biometrics is the measurement of physiological and behavioralcharacteristics of a person that can be used to identify them digitally and grant them access to devices, data or systems..Every individual can be pinpointed by the physiological or behavioral characteristics, which is the basic postulate of biometric authentication. A biological characteristic is a set of physiological characteristics determined by a biometric system, and it consists of both physiological and biological aspects.This specific collection contains DNA, Hand, Face, Earlobe, and Iris.Biometrics concerning behavioral characteristics involves the assessment of the features which are not biological or physiological but which are dominated by a biometric system. It comprises of four categories namely, Signature, Voice, Gait and Keystroke recognition.The components of a biometric device include: a scanning device or a reader for recording the biometric data, software for transforming scanned data into a standardized digital format, a database for storing and comparing the recorded data, and a storage device for securing the biometric data.Passwords, ID cards, or preset codes are common methods for identifying individuals that can be lost, forgotten, or stolen.Therefore there is a need for effective and definitive methods for personal identification. The iris recognition model is one of the most natural methods used to identify individuals as the iris is fixed and permanent and does not change throughout life. Moreover, it is impossible for two people to have the same iris features even twins[1].

Using a unique characteristic in an individual's iris, iris recognition enables people to be identified. Other methods like fingerprint readers may not be sufficient to handle the large variation in populations and also they can be copied. So it is considered as the most secure biometric authentication method available. A typical iris recognition system made up of four stages namely, image acquisition, segmentation, feature extraction and pattern matching[2]. Additionally pre-processing of can be done where image is resized, converted to gray scale and histogram equalization technique is used to enhance the image quality. In the segmentation, iris and pupil is segmented and pixel values are binarized. Feature extraction collects the appropriate feature and pixel points from the image and classification result shows the query image is authenticated or not.

II. IRIS-STRUCTURE

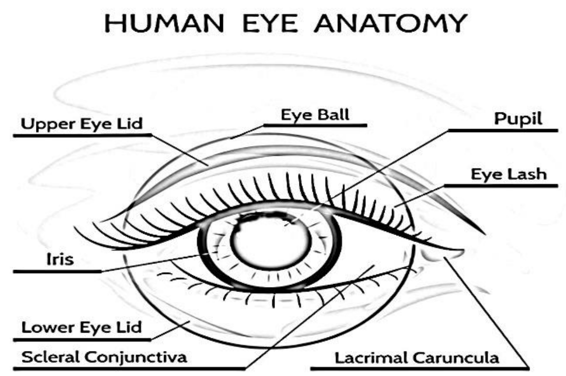

Fig. 1: Human Eye Anatomy

Iris characterization or patterns are unique to every individual; even twins have significantly different iris features or patterns, yet they remain the same throughout their lifetime. Thus, this method is now recognizedfor providing efficacious identification of a person without contact and with a high degree of confidence.

There are two portions to the front of the eye: the sclera or "white" portion of the eye, and the cornea.The sclera consists of closely interwoven fibers and a small segment in the front and center known as the cornea. The cornea consists of fibersarranged in regular fashion. Conveniently, this makes the cornea transparent, allowing light to filter in. Behind the cornea is the anterior chamber filled with a fluid known as the aqueous humor. A spongy tissue, the ciliary bodies, arranged around the edge of the cornea, constantly produces the aqueous humor. Immersed in the aqueous humor is a ring of muscles commonly referred to as iris [3].Apparently, the term was first used in the sixteenth century to refer to this multicolored portion of the eye [4].In front of the lens, the iris extends outward in a circular pattern, with a variable opening in the center, otherwise known as the pupil [5]. In addition to the iris, which is composed of two bands of muscles, the dilator, which contracts to enlarge the pupil, and the sphincter, which contracts to reduce the pupil size, all control the pupil.[6].

III. METHODOLOGY

Gabor's technique is used for filtering purposes in this study, and KNN classifiers are used for image classification.CASIA iris V3 database is used to test these techniques [7].

The following flow diagram illustrates the steps involved in iris recognition: -

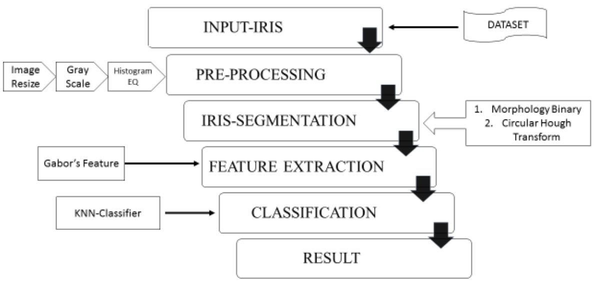

Fig. 2: Steps involved for iris recognition technique

A. Image Aacquisition or Image Capturing:

Iris recognition starts with the step of image acquisitioning or image capturing. Various people's irises have different sizes and colors, so this step is quite complicated. In this project iris pictures are obtained from the dataset.

B. Pre-Processing of Input Images:

This process is done in three steps, namely, Image Resize, Grayscale Conversion and Histogram Equalization. Each step is described in detail below:

a) Image-Resizing:
To eliminate the problem of different iris sizes in a single database, images are resized to eliminate the problem of different resolutions. Obtaining the same features on all images is facilitated by this method [6]. In this step, the image is resized to 256x256 pixels. Figures below shows the primary image of the CASIA database (320x280 pixels), and the resized image (256×256 pixels).

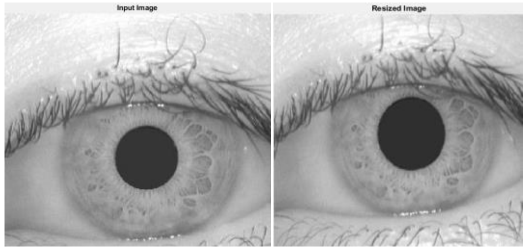

Fig. 3: Original image to Resized image

b) Gray-Scale Conversion:
Grey-scale refers to shades of gray that do not have apparent colors. As a rule of thumb, black is the darkest color and white is the lightest. A grayscale image only has one color channel. The colored image is converted to Grayscale and if the image is gray, it remains the same. Red, Green, and Blue (RGB) are the three colors of a pixel in an image.In order to convert a color image to grayscale, its RGB values (24 bits) are converted to grayscale values (8 bits).

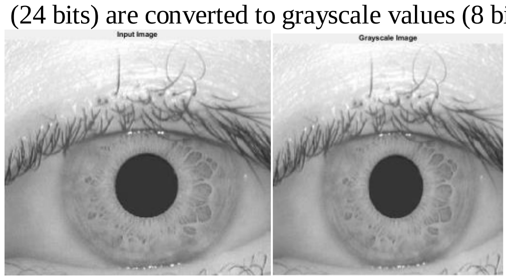

Fig. 4: Original image to Grayscale image

c) Histogram Equalization:
Histogram equalization is an example of Histogram modelling techniques. By modifying the intensity distribution of the histogram, it enables one to adjust the dynamics of a picture and the contrast. Using this technique, the cumulative probability function associated with an image is given a linear trend. Therefore, this technique, enhances the contrast and quality of the image.

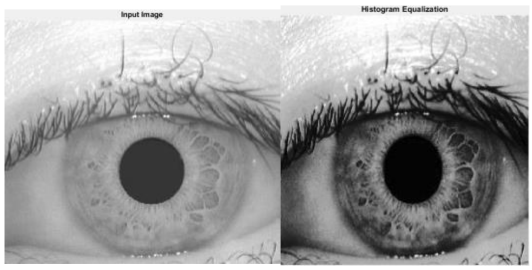

Fig. 5: Original image Grayscale image

C. Segmentation

An iris picture is segmented by automatically detecting the boundary region of the iris and the pupil in order to exclude the surrounding areas.The main purpose of segmentation is to remove non-useful regions, such as the parts outside the iris, and then convert these parts to a suitable template during normalization.[6] The segmentation process is done in two techniques Morphology Binary and Circular Hough Transformation.

a) Morphology Binary:
Using a small template, a structuring element is placed at different locations in the image and compared with different neighboring pixels. It determines whether it is overlaps the neighboring

pixels or intersects/strikes with the neighborhood. Thus, a binary image is created with non-zero-pixel values for overlapping or striking and zero for neither overlapping nor striking any pixels. Thus, dilation and erosion operations take place which adds and removes pixels from object boundaries. In the morphological binary operation, the image will be segmented (iris and pupil) by the morphology binary and the other background will be eliminated. Here the threshold value will be calculated and using the threshold value, the image will be converted into binary image[8].

Fig. 6: Original image to Binarized image

b) Circular Hough Transformation:
Circles in images can be found using the circular Hough Transform (CHT). This transform is used to determine parameters of simple geometric objects. Using the CHT, the radius and center co-ordinates of the pupil and iris boundaries can be determined. In the segment iris section, there are three outputs- circle iris, circle pupil and image with noise. After obtaining the coordinates of the iris region, the coordinates of the pupil region will be extracted.Mathematically, a circle in 2D plane can be described by:

$$(x-a)^2 + (y-b)^2 = r^2$$

where, (a,b) is the center of the circle, and r is the radius, & $x = a + r\cos\theta$

$$y = b + r\sin\theta$$

The edges are detected by an edge detecting technique and the boundary of the circle is created. For a point(x,y) in the boundary of the circle, we draw numerous circles with increasing radius such that if forms the shape of an inverted right-angled cone whose apex is at (x, y, 0). This step will be iterated for each and every point in the edge of the circle and the circle parameters (a,b,r) will be determined by the intersection of the inverted right angled cones. The common intersection point of the conic surfaces will give the center of the circle and after that the radius is found in from the boundary and center of the circle.

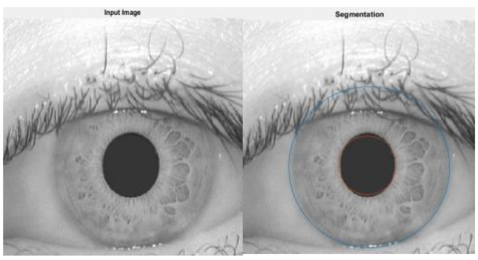

Fig. 7: Original image to Circular Hough Transform

D. Feature Extraction

Extracting features from the iris picture is the principle stage in iris recognition system; especially this system depends on the features drawn out from iris pattern. The features will be extracted in the form of pixel values. The Gabor's Filtering method is used for this step. It checks whether there is any particular frequency component in the image in a definite direction in the domain. It is a filtering method which takes features as textures. It extracts 12 values of features based on the different filtering levels. The features will be extracted based on two values i.e. Mean and Standard deviation. Therefore, there will be 24 sets of values from the features.

2D Gabor's filters are applied to the image data to gather its phase information. Breakdown of a signal is done by using a fourth-order pair of Gabor's filters, with real part given by cosine varying by a Gaussian, an imaginary part given by sine varying by a Gaussian. The real and imaginary elements of the filter also known as even and odd symmetric components. The mid-frequency of the filter is given by the frequency of the sine or cosine wave and the bandwidth is given by the breadth of the Gaussian wave. The 2d Gabor filter for a domain (x,y) is given by-

$$G(x,y) = e^{-\pi\left[+\left(\frac{x-x_o}{\alpha}\right)^2+\left(\frac{y-y_o}{\beta}\right)^2\right]} e^{-2\pi t[u_o(x-x_o)+v_o(y-y_o)]}$$

Where (x_0, y_0) refers to the position, refers to the breadth, and length and (u_0, v_0) gives modulation which has frequency given by:

$$\omega_o = \sqrt{u_o^2 + v_o^2} \quad 9 \quad .$$

The filter consists of the real part and the imaginary section which provides the orthogonal directions in the image. The above two real and imaginary sections of the filter can be establish into a complex number or may be used singularly.

Complex

$$g(x,y;\lambda,\theta,\psi,\sigma,\gamma) = exp\left(-\frac{x'^2+\gamma^2 y'^2}{2\sigma^2}\right) exp\left(i\left(2\pi\frac{x'}{\lambda}+\psi\right)\right)$$

Real

$$g(x,y;\lambda,\theta,\psi,\sigma,\gamma) = exp\left(-\frac{x'^2+\gamma^2 y'^2}{2\sigma^2}\right)\cos\left(2\pi\frac{x'}{\lambda}+\psi\right)$$

Imaginary

$$g(x,y;\lambda,\theta,\psi,\sigma,\gamma) = exp\left(-\frac{x'^2+\gamma^2 y'^2}{2\sigma^2}\right)\sin\left(2\pi\frac{x'}{\lambda}+\psi\right)$$

where

$$x' = x\cos\theta + y\sin\theta$$

and

$$y' = -x\sin\theta + y\cos\theta$$

Let $x=[x1\ x2]^T$ be the image coordinates. The impulse response of a filter g(x) is provided by:

$$g_{mn}(x) = \frac{1}{2\pi a_n b_n} e^{-\frac{1}{2}x^T A_{mn} x} \ e^{jk_{0mn}^T x}$$

Here, A matrix gives the bandwidth, and orientation or direction selectiveness of the filter.

$$A_{mn} = \begin{bmatrix} \cos\phi_m & -\sin\phi_m \\ \sin\phi_m & \cos\phi_m \end{bmatrix} \begin{bmatrix} a_n^{-2} & 0 \\ 0 & b_n^{-2} \end{bmatrix} \begin{bmatrix} \cos\phi_m & \sin\phi_m \\ -\sin\phi_m & \cos\phi_m \end{bmatrix}$$

The real and imaginary section of the impulse response of the filter is given in the figure below:

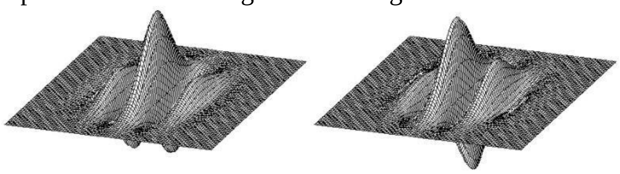

Fig. 8: Real and imaginary section of a Gabor's Filter

If g(k) is the transfer function of the Gabor filter, then it is given by:

$$G_{mn}(k) = e^{-\frac{1}{2}(k-k_m)^T \ (A_{mn}^{-1})^T (k-k_m)}$$

where k = [k1 k2], T is the spatial frequency.

2d Gabor's filter have a very well-to-do approach in processing of an image, basically in extraction of features for analysis of texture and dis-membranate or segmentation in an iris picture. By variation, we can inspect for the consistency and features in a particular direction and also we can change the image region's size being examined around the region of interest. 2D Gabor's filter in discrete domain are provided as below:

$$G_e[i,j] = Be^{\left(-\frac{i^2+j^2}{2\sigma^2}\right)} \cos\big(2\pi f(i\cos\theta + j\sin\theta)\big)$$

$$G_s[i,j] = Be^{\left(-\frac{i^2+j^2}{2\sigma^2}\right)} \sin\big(2\pi f(i\cos\theta + j\sin\theta)\big)$$

where B and C are normalizing factors to be determined [10].

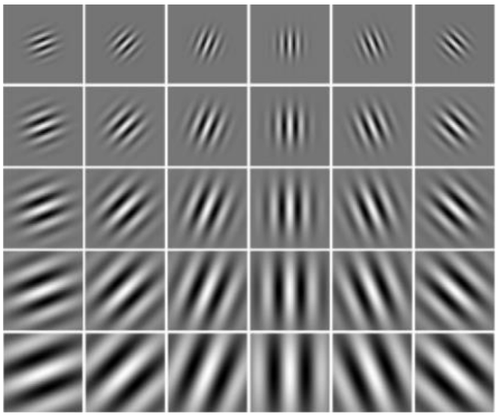

Fig. 9: Gabor Filter Extraction

E. Classification

Classification result shows the query image is authenticated or not. The K-Nearest Neighbors (KNN) classifier is used for the classification purpose. In this step, we have to give three features as input. They are Test feature, Train feature and Label feature.

- Test feature- the test feature represents the features of the input image.
- Train feature- the train feature represents the features of the dataset images.
- Labels feature- the labels feature will detect whether the image is authenticated or not.

This classifier is one of the simplest algorithms for categorizing objects, it operates under supervision. The algorithm stores all accessible cases and assigns classifications to new cases based on a similarity measure, just as it does with distance functions. As a non-parametric approach, KNN was already used in statistical approximations and pattern recognition. Several machine learning applications use KNN, including regression and pattern recognition. Additionally, it is very easy to implement and highly effective in a variety of applications that use classification techniques. In general, it takes into account the closest value in a feature space of the check data. Additionally, it is nonparametric, as the variables used are not assumed to have probability distributions. KNN algorithm classifies the objects with the help of three steps:

- Measures the distance among all training vectors and test vector.
- Chooses K closest vectors.
- Computes the average of closest vectors distances.

In other words, essentially, in KNN, the output is the class membership. Objects are classified according to the number of votes they receive from their neighbors. Having k nearest neighbors, if K = 1 means that the object belongs to the group of the nearest neighbor. KNN, on the other hand, does not have a particular way to choose K, it is a method to choose the best one. In contrast to other algorithms, KNN doesn't require training examples, rather, it uses the existing ones.Further, it uses training sets directly to train, allowing it to classify inputs with k values when inputs and training sets are given[6].

Using the K-Nearest Neighbor classifier, the iris image is checked for performance rate based on their ACCURACY, SPECIFICTY and SENSITIVITY.

Accuracy: Correctly classified samples / classified samples i.e., TP + TN/(TP + TN + FP + FN).

Sensitivity: Correctly classified positive samples / True positive rate i.e, TP/(TP + FN).

Specificity: Correctly classified negative samples / True negative samples i.e., TN/(FP + TN).

Where TN means true negative, TP means true positive & FN means false negative, FP means false positive[11].

Further the query image is checked for authentication.

IV. APPLICATIONS

- There is a demand in finding accurate, secure and cost-efficient alternatives to personal identification numbers (PIN) and passwords in e-security systems to securely access finance transactions, bank accounts or credit cards.
- Biometric provides the stage to fulfill these demands as an individual's biometric data is distinctive and non-transferrable.
- Using biometrics as a method of network authentication adds a unique identifier that is extremely difficult to reproduce, making it the most reliable authentication method.
- It is being used to replace passports, aviation security, data base access and computer login, premise control, birth certificates.

V. CONCLUSION

In this paper, examination is done on how the system behaves when an input is acquired and passed through all the algorithms and finally tested whether the query image is authenticated or not. The system is experimented for a number of eye images and the performance rate determined by the factors Accuracy, Sensitivity and Specificity are calculated. The Accuracy, Sensitivity and Specificity for a particular image found are 92.8571%, 85.7143% and 100% respectively. In this project an iris image is taken, pre-processed, unwanted backgrounds are eliminated, iris and pupil segmented, features of iris extracted and finally classified for the matching purpose. The results of these calculations have been analyzed by using different mathematical functions.MATLAB2016Ra is being used for development, and the emphasis is being placed on the software for capturing the eye image rather than hardware to perform the recognition.

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