Iris Verification Using Legendre Moments and KNN Classifier

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ABSTRACT: *A biometric system provides special and automatic identification of an individual based on characteristics and unique features showed by individuals. With the need for security system going up, Iris recognition is emerging is one of the important methods of biometrics-based identification system. Our system basically explains the Iris verification system that is attempted to implement in Matlab. Firstly, image preprocessing is performed followed by extracting the iris portion of the eye image. The extracted iris part is then normalized. Our system examines the developing automated iris verification for personal identification in order to verify both uniqueness of the human iris and also its performance as a biometric based on Legendre moment. The iris verification system consists of the iris pre-processing system and iris authentication algorithm. The algorithm of the processing for the iris verification is also able to localize the pupil region and circular iris, occluding eyelashes and eyelids, and reflections. The system performed with a test on UPOL image database resulted on false accepted rates (FAR) and false rejected rates (FRR). The performance measured which was stored in the database scored very small each for FRR and FAR since the Legendre moment invariants had matched perfectly.*

GENERAL TERMS: *Biometric Identification System ,Image Processing,ANN, Machine Learning.*

KEYWORDS: *Legendre moment, FRR, FAR, Biometrics, UPOL, Iris Verification.*

I.   INTRODUCTION

A biometric system provides automatic recognition of an individual based on some sort of unique feature or characteristic possessed by the individual. Biometric systems have been developed based on fingerprints, facial features, voice, hand geometry, handwriting, the retina [1], and the one presented in this thesis, the iris.Biometric systems work by first capturing a sample of the feature, such as recording a digital sound signal for voice recognition, or taking a digital colour image for face recognition. The sample is then transformed using some sort of mathematical function into a biometric template. The biometric template will provide a normalised, efficient and highly discriminating representation of the feature, which can then be objectively compared with other templates in order to determine identity. Most biometric systems allow two modes of operation. An enrolment mode for adding templates to a database, and an identification mode, where a template is created for an individual and then a match is searched for in the database of pre-enrolled templates.

A good biometric is characterized by use of a feature that is; highly unique – so that the chance of any two people having the same characteristic will be minimal, stable – so that the feature does not change over time, and be easily captured – in order to provide convenience to the user, and prevent misrepresentation of the feature.

1.1 The Human Iris

The iris is a thin circular diaphragm, which lies between the cornea and the lens of the human eye. A front-on view of the iris is shown in Fig.1. The iris is perforated close to its centre by a circular aperture known as the pupil. The function of the iris is to control the amount of light entering through the pupil, and this is done by the sphincter and the dilator muscles, which adjust the size of the pupil. The average diameter of the iris is 12 mm, and the pupil size can vary from 10% to 80% of the iris diameter [2].
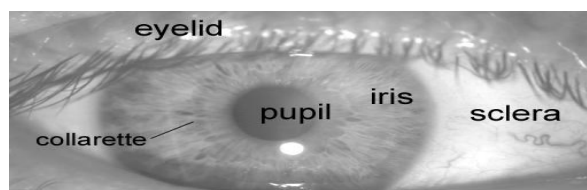

Fig 1: A front-on view of the human eye.

Formation of the iris begins during the third month of embryonic life [3]. The unique pattern on the surface of the iris is formed during the first year of life, and pigmentation of the stroma takes place for the first few years. Formation of the unique patterns of the iris is random and not related to any genetic factors [4]. The only characteristic that is dependent on genetics is the pigmentation of the iris, which determines its color. Due to the epigenetic nature of iris patterns, the two eyes of an individual contain completely independent iris patterns, and identical twins possess uncorrelated iris patterns.

1.2 Iris Verification and Recognition

The iris is an externally visible, yet protected organ whose unique epigenetic pattern remains stable throughout adult life. These characteristics make it very attractive for use as a biometric for identifying individuals. Image processing techniques can be employed to extract the unique iris pattern from a digitised image of the eye, and encode it into a biometric template, which can be stored in a database. This biometric template contains an objective mathematical representation of the unique information stored in the iris, and allows comparisons to be made between templates. When a subject wishes to be identified by iris recognition system, their eye is first photographed, and then a template created for their iris region. This template is then compared with the other templates stored in a database until either a matching template is found and the subject is verified, or no match is found and the subject remains unverified.Compared with other biometric technologies, such as face, speech and finger recognition, iris recognition can easily be considered as the most reliable form of biometric technology. However, there have been no independent trials of the technology, and source code for systems is not available. Also, there is a lack of publicly available datasets for testing and research, and the test results published have usually been produced using carefully imaged irises under favorable conditions.

1. RELATED WORKS

Ophthalmologists Alphonse Bertillon and Frank Burch were one among the first to propose that iris patterns can be used for identification systems. In 1992, John Daugman was the first to develop the iris identification software. In 2003, J. Kim et al. [5] describes a new feature representation method for recognition of iris robust to noises. The disc-shaped iris image is convolved with a low pass filter along the radial direction. After that, the smoothed iris image is decomposed in the angular direction using a 1D continuous wavelet transform. Each decomposed 1D waveform is approximated by using optimal piecewise linear curve connecting a small set of node points, used as a feature vector. The optimal approximation procedure reduces the feature vector size whereas maintaining recognition accuracy. The similarity between two iris images is calculated by the normalized cross-correlation coefficients between the optimal curves. The similarity between two iris images is thus estimated using mid-frequency bands.

In 2005, C.T. Chu et al. [6] presented an iris recognition algorithm based on LPCC and LDA. In addition, they introduced a simple and fast training algorithm, particle swarm optimization, for training the Probabilistic Neural Network . A comparative experiment of existing methods for iris recognition is evaluated on CASIA iris image databases. The proposed algorithms achieved 100% recognition rates and the result was encouraging. In 2009, M.Vatsa et al. [7],presented novel algorithms for iris segmentation, quality enhancement, match score fusion, and indexing to improve both the accuracy and the speed of iris recognition. A curve evolution approach is proposed to effectively segment a no ideal iris image using the modified Mumford–Shah functional. Different enhancement algorithms are concurrently applied on the segmented iris image to produce multiple enhanced versions of the iris image. A support-vector-machine-based learning algorithm selects locally enhanced regions from each globally enhanced image and combines these good-quality regions to create a single high-quality iris image. Two distinct features are extracted from the high-quality iris image. The global textural feature is extracted using 1-D log polar Gabor transform, and the local topological feature is extracted using Euler numbers. An intelligent fusion algorithm combines the textural and topological matching scores to further improve the iris recognition performance and reduce the false rejection rate, whereas an indexing algorithm enables fast and accurate iris identification. In the same year R.W. Ives et al. [8] presented a new algorithm for iris recognition. Segmentation is based on local statistics, and after segmentation, the image is subjected to contrast-limited, adaptive histogram equalization. Feature extraction is then conducted using two directional filters.

The presence or absence of ridges and their dominant directions are determined depending on response of   maximum directional filter. Templates were compared using fractional Hamming distance as a metric for a match/non match determination. This Ridge-Energy-Direction algorithm reduces the effects of illumination, since only direction is used. In 2008, H. Demirel et al.[9] proposes a novel iris recognition system based on matching colour pixel statistics.

The proposed system uses colour histograms as pixel statistic feature vectors for recognition of irises by cross correlation between the histogram of a given iris and the histograms of irises in the database. Majority voting (MV) has been applied to achieve the final recognition. Iris images taken from the UPOL are pre-processed and segmented. Their proposed System gives a100% recognition rate on 64 iris images. In 2010, G.Kaur et al. [10],proposed Enhanced iris recognition which is used to overcome some of the problem like to automate the recognition of the iris by reducing complexity and increasing algorithm speed. Various challenges are faced while working with the iris recognition system. Iris recognition systems make use of the uniqueness of the iris patterns to derive a unique mapping. Iris recognition, as a biometric method, outperforms others because of its high accuracy. Iris recognition also has the ability to handle very large populations at high speed.

Mostly three stages are followed while working with iris system i.e. preprocessing, feature extraction and recognition stage. This paper presents an automated and novel iris recognition system where overall computational match speed is reduced and hence makes system more reliable with accuracy of 99.38% and low FAR. In 2011, D.L. Woodard et al.[11], have explored the utility of the various appearance features extracted from different perspectives: as an independent biometric modality for identification of human, as tool for aiding iris recognition in non-ideal situations in the near infra-red spectrum.

They employed a local appearance-based feature representation, where the periocular image is divided into spatially salient patches, appearance features are then computed for each patch locally, and the local features are combined for describing the entire image. In 2011,M. Z. Rashad et al.[12] proposed an algorithm for recognition and classification of iris using a system based on Local Binary Pattern and histogram properties as a statistical approaches for feature extraction , and Combined Learning Vector Quantization Classifier as Neural Network approach for classification, in order to build a hybrid model depends on both features. The localization and segmentation were done using both Canny edge detection and Hough Circular Transform in order to isolate an iris from the whole eye image and for noise detection .Feature vectors results from LBP is applied to a Combined LVQ classifier with different classes to determine the minimum acceptable performance, and the result is based on majority voting among several LVQ classifier.

II. PROPOSED METHODOLOGY

In the experiment, an iris recognition demo system was built to make it easy to test the classification and verification performance and to expedite further algorithm investigation.

2.1 Iris Localization and segmentation

Iris localization is a very important step in Iris Recognition System in order to get rid of the image noise, and prepare the iris image to feature extraction with a little noise. The image was filtered using Gaussian filter, which blurs the image and reduces effects due to noise. The degree of smoothening is decided by the standard deviation, σ and it is taken to be 2 in this case. The part of the eye carrying information is only the iris part. It lies between the sclera and the pupil. Hence the next step is separating the iris part from the eye image. The iris inner and outer boundaries are located by finding the edge image using the canny edge detector.The Canny detector mainly involves three steps, viz. finding the gradient, non-maximum suppression and the hysterisis thresholding. As proposed by Wildes, the thresholding for the eye image is performed in a vertical direction only, so that the influence due to the eyelids can be reduced. This reduces the pixels on the circle boundary, but with the use of Hough transform, successful localization of the boundary can be obtained even with the absence of few pixels. It is also computationally faster since the boundary pixels are lesser for calculation. Using the gradient image, the peaks are localized using non-maximum suppression. It works in the following manner. For a pixel imgrad(x, y), in the gradient image, and given the orientation theta(x, y), the edge intersects two of its 8 connected neighbors. The point at (x, y) is a maximum if its value is not smaller than the values at the two intersection points.The next step, hysterisis thresholding, eliminates the weak edges below a low threshold, but not if they are connected to a edge above a high threshold through a chain of pixels all above the low threshold. In other words, the pixels above a threshold T1 are separated. Then, these points are marked as edge points only if all its surrounding pixels are greater than another threshold T2.
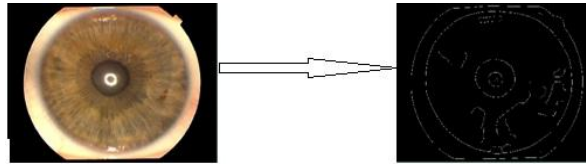
Fig. 2: Canny edge detection with UPOL dataset

Edge detection is followed by finding the boundaries of the iris and the pupil. Daugman proposed the use of the Integro-differential operator to detect the boundaries and the radii. It is given by

(4)

$$\max_{(r,x_0,y_0)} \left| G_\sigma(r) * \frac{\partial}{\partial r} \oint_{r,x_0,y_0} \frac{I(x,y)}{2\pi r} ds \right|$$

This behaves as a circular edge detector by searching the gradient image along the boundary of circles of increasing radii. From the likelihood of all circles, the maximum sum is calculated and is used to find the circle centers and radii. The Hough transform is another way of detecting the parameters of geometric objects, and in this case, has been used to find the circles in the edge image. For every edge pixel, the points on the circles surrounding it at different radii are taken, and their weights are increased if they are edge points too, and these weights are added to the accumulator array. Thus, after all radii and edge pixels have been searched, the maximum from the accumulator array is used to find the center of the circle and its radius. The Hough transform is performed for the iris outer boundary using the whole image, and then is performed for the pupil only, instead of the whole eye, because the pupil is always inside the iris.
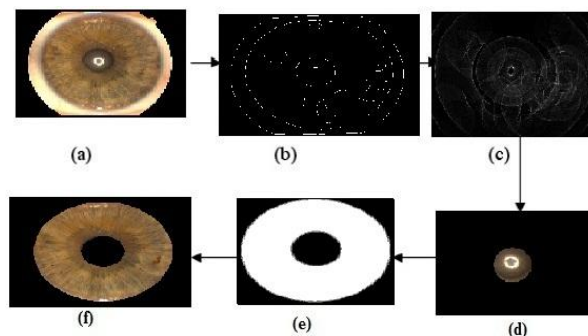
Fig. 3: Iris localization and segmentation stages.

Steps of iris localization and segmentation as shown in fig 3:
a. The input eye image,
b. Applying Canny Edge Detection with a suitable
 threshold = 0.2.
c. Hough space for localization and the Projection point inside the pupil of input eye image.
d. The output image resulting from multiplying the input eye image with a binary matrix to detect the pupil.
e. The mask for noise detection.
f. The output image results from subtracting the input image with (d).

2.2 Iris Normalization
        Once the iris region is segmented, the next stage is to normalize this part. Irises from different people may be captured in different size, and even for irises from the same eye, the size may change due to illumination variations and changes of the camera-to-eye distance. This will affect the matching results. For the purpose of achieving more accurate recognition results, it is necessary to compensate for such elastic deformation.

2.2 Feature Extraction

The final process is the feature extraction of the iris. Feature extraction involves simplifying the amount of resources required to describe a large set of data accurately. For this, the most discriminating feature in the iris pattern is extracted. In our system, we used Legendre moment invariants to extract iris moment-based rotation invariant features without any iris rotation adjustment. These invariant features are selected automatically based on the discrimination measure defined for the invariant features. Legendre moments belong to the class of orthogonal moments, and they were used in several pattern recognition applications. This moment is used in our system to attain a near zero value of redundancy measure in a set of moment functions, so that the moments correspond to independent characteristics of the iris.The two dimensional Legendre moments of order (p + q), with image intensity function f(x, y), are defined as

$$L_{pq} = \frac{(2p+1)(2q+1)}{4} \int_{-1}^{1} \int_{-1}^{1} P_p(x) X P_q(y) f(x,y) dx dy \quad x, y \in [-1,1] \tag{6}$$

Where Legendre polynomial, Pp(x), of order p is given by

$$P_p(x) = \sum_{k=0}^{p} (-1)^{\frac{p-k}{2}} \frac{1}{2^p} \frac{(p+k)! x^k}{\left(\frac{p-k}{2}\right)! \left(\frac{p+k}{2}\right)! k!} \Bigg|_{p-k=even} \tag{7}$$

The recurrence relation of Legendre polynomials, Pp(x), is given as follows

$$P_p(x) = \frac{(2p-1)x P_{p-1}(x) - (p-1)P_{p-2}(x)}{p} \tag{8}$$

Where Po(x) = 1, P1(x) = x and p>1. Since the region of definition of Legendre polynomials is the interior of [-1, 1], a square image of N x N pixels with intensity function f (i, j), $0 \le i, j \le (N - 1)$, is scaled in the region of -1 < x, y < 1. In the result of this, equation (6) can now be expressed in discrete form as

$$L_{pq} = \lambda_{pq} \sum_{i=0}^{N-1} \sum_{j=0}^{N-1} P_p(x_i) P_q(y_j) f(i, j) \tag{9}$$

Where the normalizing constant,

$$\lambda_{pq} = \frac{(2p+1)(2q+1)}{N^2} \tag{10}$$

Xi and yi denote the normalized pixel coordinates in the range of [-1, 1], which are given by

$$x_i = \frac{2i}{N-1} - 1 \quad and \quad y_j = \frac{2j}{N-1} - 1 \tag{11}$$

2.3 Matching
Our system is implemented to test the algorithm in two modes: **Classification and Verification**.

Classification deals with establishing a person's identity from a set of identities. In classification technique, we implemented KNN (**K Nearest Neighbour**) classification algorithm is widely applied in pattern recognition and data mining for classification, which is famous for its simplicity and low error rate. A train data set with accurate classification labels should be known at the beginning of the algorithm. Then for a query data qi, whose label is not known and which is presented by a vector in the feature space, calculate the distances between it and every point in the train data set. After sorting the results of distances calculation, decision of the class label of the test point qi can be made according to the label of the k nearest points in the train data set. The quality of the train data set directly affects the classification results. At the same time, the choice of parameter K is also very important, for different K could result in different classification labels. The basic process of KNN algorithm is as follows.

➢ The data pre-processing phase is to initialize the labeled d dimensional train data set as well as the test data set to be classified.
➢ Select one test point in the test data set and calculate the distances between it and each point in the train data set.
➢ Sort the results of distances computation, and find out K smallest results according to the parameter K.
➢ Determine the class label of the test point by the election result of K points. Finally, select another point in test data set and go to step two repeatedly until the test data set is empty.

For the purposes of distances comparing Euclidean distance (equation 12) is used in our system.

$$d(\mathbf{p},\mathbf{q}) \quad = \quad \sqrt{\sum_{i=1}^{n}(q_i - p_i)^2}. \qquad (12)$$

After completion of the above mention works, if the input feature data matches any data stored in the database, an identity is established for the person. The KNN algorithm is simple in calculation and can be applied to high-dimensional data sets. Nevertheless, when the test set, train set, and data dimension are larger than expected, the computational complexity will be huge and the operation time will be very long. When test set and train sets contain m and n vectors in d-dimensional feature space respectively, the time complexity of this algorithm is $O(m.n.d)$.

Verification deals with confirming or denying ones claimed identity based on the set of unique features provided by him. In verification a person provides input sample data and this

data is checked against the feature data of the same individual stored in a database for that person. Depending upon the extent of similarity (threshold value) the person's identity can be confirmed or denied.

III. RESULTS AND ANALYSIS
From four steps above, the iris performance can be performed and seen. The matching sequence of the Legendre moment invariants stored in iris database and those moments of input iris was selected as the iris verification technique. The input iris was authenticated as the valid iris if the distance between the stored and input was below the certain value.The performance measurement of the iris verification algorithm based on 100 samples that was divided into 10 classes scored 0% each for false acceptance rate (FAR %) and false rejection rate (FRR %)

$$(13)$$

$$FRR(\%) = \frac{Number\ of\ false\ rejections}{Number\ of\ enrollee\ attempts} \qquad (14)$$

Since the Legendre moment invariants had matched perfectly. In iris classification algorithm the values of FAR and FRR changes based on the values of threshold as shown in the table given below-

Table 1. FAR, FRR variation with changes in threshold

Threshold	FAR	FRR
.10	0%	9.3%
.20	3.1%	6.1%
.30	8%	1.9%

The experiment has been performed over 100 samples of iris image from UPOL database, and the results has confirmed the success of our system.

Fig.4: Verification of user using iris image

For the categorized of recognize user, the program will verified the iris image and it will sent a command to give access and identify the user. For this project if the verification of iris is successful, it will show the message box that shows the user has been verified as shown in **Fig.4.** If access is not granted by the main program the program will prompt user to 'Warning-Not Recognized' through the MATLAB command as shown in **Fig.5**
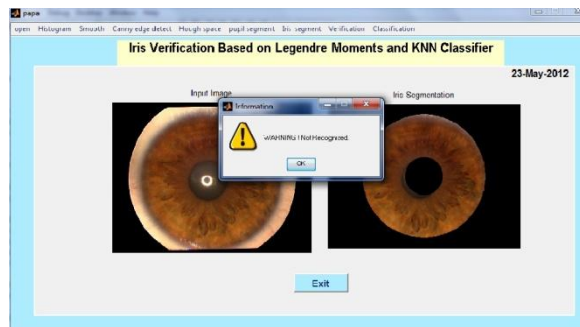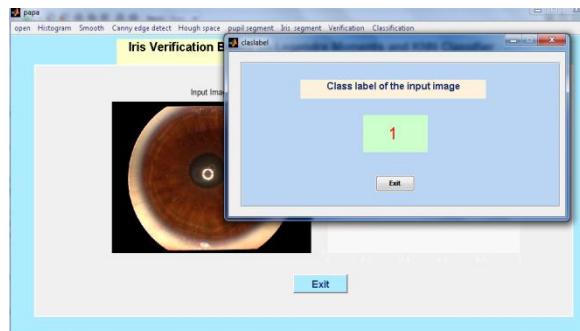

Fig.5: Verification of unknown user using iris image

Fig.6: Classification of user based on iris image

IV. CONCLUSION AND FUTURE WORK

The application developed in this work is expected to be useful for the users trying to design further applications using Pattern Recognition and for further research. The application has been developed by taking care that it will be simple and flexible for use, by the users. Though all attempts have been made to bring out all the facilities in the application; but due to limited time, it has not been possible to bring out all of them. Our algorithm takes advantage of the translation invariant property of the Legendre moments, so it can reduce the computational cost for iris recognition matching on a larger iris image database. Now, we can expect to improve the performance by using more effective moment features such as wavelet moment invariants, which can capture not only the translation invariant global information but also the rotation invariant local information of the interest objects.

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