Contemplation of Image Based Iris Recognition

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ABSTRACT

This Paper presents a comparative analysis of few of the existing methods available for iris recognition. The iris is a portion of the inner eye of an individual and contains an abstract and randomly generated texture pattern arising from orientation of complex tissues within this region. This random pattern can provide a unique identifier of a person if a mathematical model can be built to represent and compare it. Iris recognition is divided into four steps, viz Image Acquisition, Pre-processing, Feature Extraction and Matching. Iris recognition technology is able to give highly accurate results for human identification. But this technology needs more attention to overcome the disadvantages of the existing algorithms. In this paper comparative analysis of various iris recognition methods is done considering various performance evaluation criteria's like False Acceptance Ratio (FAR) , Genuine Acceptance Ratio(GAR), Feature extraction, Feature vector size, test bed used and accuracy of the identification.

Keywords – Biometrics, Feature Vector, Performance Evaluation.

1. INTRODUCTION

A wide variety of systems require personal recognition schemes to either confirm or determine the identity of an individual requesting their services. The purpose of such schemes is to ensure that the rendered services are accessed only by a legitimate user and not by anyone else. Verification of identities can be done whenever people log onto computers, access an ATM, pass through airport security, use credit cards, or enter high-security areas. People typically use user names, passwords, and identification cards to prove that they are who they claim to be. However, passwords can be forgotten, and identification cards can be lost or stolen. Thus, there is tremendous interest in improved methods of reliable and secure identification of people.

Biometric methods, which identify people based on physical or behavioural characteristics, are of interest because people cannot forget or lose their physical characteristics in the way that they can lose passwords or identity cards. The basis of every biometric trait is to get the input signal image and apply some algorithms like neural network, fuzzy logic, wavelet transform, etc to extract the prominent features. Biometric methods based on the spatial pattern of the iris are believed to allow very high accuracy, and there has been an explosion of interest in iris biometrics in recent years. Biometrics deals with automated methods of recognizing a person based on physiological characteristics such as face, fingerprints, hand geometry, iris, retinal, and vein.

The iris (plural: ***irides*** or ***irises***) is the ''colored ring of tissue around the pupil through which light enters the interior of the two muscles, the dilator and the sphincter muscles, control the size of the iris to adjust the amount of light entering the pupil [1].

The iris is formed in early life in a process called morphogenesis where it begins to form during the third month of gestation (Kronfeld, 1962). The structures creating its striking patterns are developed in the eight month (Wolff, 1948), although pigment accretion may continue into the first postnatal years. Once fully formed, the texture is stable throughout life while the pattern becomes permanent after puberty [25]. These visible patterns are unique to all persons and the chance to find two individuals with identical iris patterns is about zero.

The probability for the existence of two irises that are same has been theoretically estimated to be very high, i.e. one in 1072 which counts for the unique characterization of the iris [27, 28]. "Eye color" is the color of the iris, which can be green, blue, or brown. In some cases it can be hazel (a combination of light brown, green and gold), grey, violet, or even pink. In response to the amount of light entering the eye, muscles attached to the iris expand or contract the aperture at the center of the iris, known as the pupil. The larger the pupil, the more light can enter. The iris consists of two layers: the front pigmented fibro vascular tissue known as a stroma and, beneath the stroma, pigmented epithelial cells. Fig.2 shows an example image acquired by a commercial iris biometrics system. The minute details of the iris texture are believed to be determined randomly during the fetal development of the eye. They are also believed to be different between persons and between the left and right eye of the same person [2]. The color of the iris can change as the amount of pigment in the iris increases during childhood. Nevertheless, for most of a human's lifespan, the appearance of the iris is remains constant.

The accuracy of iris recognition systems is proven to be much higher compared to other types of biometric systems like fingerprint, handprint and voiceprint. Iris based security systems capture iris patterns of individuals and match these patterns against the record in available databases.

First section of the paper include the introduction, need, methods and various applications of Iris Recognition. Further sections include various similarity measurement criteria and performance evaluation criteria's in iris recognition, existing databases. End part consists of comparative analysis of various Iris recognition Methods from spatial and frequency domain followed with conclusion.

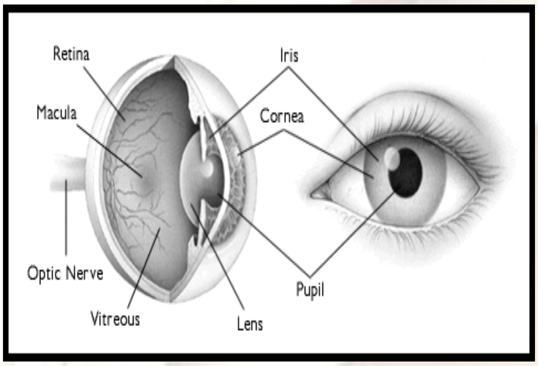

Fig.1 Human Iris

Fig.2 Iris Scan Image

2. LITERATURE SURVEY

Research in the area of iris recognition has been made in 1936 by the Ophthalmologist Frank Burch, he proposed iris patterns as an method to recognize an individual [24]. In 1985 Dr. Leonardo Flom and Aran Safir proposed the concept that no two irides are alike and in 1987 they were awarded a Patent for iris recognition. Iris was proposed as a reliable biometrics in 1987 by L. Form [2]. The core algorithms that underlie iris recognition were developed in the 1990's by Professor John Daugman, Ph.D, OBE (University of Cambridge Computer Laboratory). In 1993 Defense Nuclear Agency began work to test and deliver a prototype unit. In 1995 the prototype was completed with the help of Drs Daughman, Flom and Safir. In 2005 patent covering the basic concept of Iris Recognition expired providing market opportunities for other companies that have developed their own algorithms for Iris recognition. Daugman's algorithms are the basis of all commercially deployed iris recognition systems, although many alternative approaches have been studied and compared in the academic literature in hundreds of publications. Iris recognition remains a very active research topic in computing, engineering, statistics, and applied mathematics.

Wildes [11] represented the iris texture with a Laplacian pyramid constructed with four different resolution levels and used the normalized correlation to determine whether the input image and the model image are from the same class.

Boles and Boashash [12] calculated a zero-crossing representation of one-dimensional (1D) wavelet transform at various resolution levels of a concentric circle on an iris image to characterize the texture of the iris. Iris matching was based on two dissimilarity functions. In this seminar we have made a survey of various existing iris recognition algorithms and comparative analysis of three methods [13, 14, and 15] is done. Here [13] iris recognition is done using the image feature set extracted from Haar Wavelets at various levels of decomposition. Euclidean distance is used as an similarity measure on the feature set. Analysis was performed of the proposed method, consisting of the False Acceptance Rate and the Genuine Acceptance Rate.

In paper [14] it proposes an iris recognition algorithm in which a set of iris images of a given eye are fused to generate a final template using the most consistent feature data. Features consistency weight matrix is determined according to the noise level presented in the considered images. A new metric measure formula using Hamming distance is proposed.

In this paper[15], the novel techniques is developed to create an Iris Recognition System, Here a fusion mechanism that amalgamates both, a Canny Edge Detection scheme and a Circular Hough Transform, to detect the iris' boundaries in the eye's digital image is used. Then applied the Haar wavelet in order to extract the deterministic patterns in a person's iris in the form of a feature vector.

3. APPLICATIONS

Iris Recognition is robust among all the Biometric systems and provides more security as compared with other systems. Kadhum et al. proposed that using iris biometrics authorized entry through doors to secure areas, and this is an application for which commercial iris biometric systems already exist (e.g., LG Iris). Wang et al. [29] propose to use face and iris multi-biometrics as part of a scheme to enforce digital rights management, which would allow only authorized remote users to access content.

Hassanien et al. [30] showed that an iris template can be embedded in a digital image to prove ownership of the image. Mondal et al. [31] proposed that using biometrics secure access to home appliances over the network is possible. Garg et al. [32] proposed a vision system that will recognize a set of hand gestures to control devices and use iris biometrics to authenticate the user identity.

Leonard et al. [33] proposed using fingerprint, iris, retina and DNA (“FIRD”) to distinctively identify a patient to his or her complete electronic health care record. Mohammadi and Jahanshahi [34] proposed an architecture for a secure e-tendering (offering and entering into a contract) system, with iris as the example biometric for identity verification.

Wang et al. [35] proposed using Daugman-like iris biometrics “to make the large animals be recognizable and traceable from the farm to the slaughterhouse”, in order to achieve the goal of food chain safety. Dutta et al. [36] [37] [38] propose embedding the iris code of a person in an audio file as a watermark to prove ownership of the audio file. They apply Haar wavelets at four levels of decomposition to create a feature vector from an iris image.

Liu-Jimenez et al. [39] and Rakvic et al. [40] describe the implementation of iris biometric algorithms on FPGAs. Zhao and Xie [41] describe an implementation of an iris biometric system on a DSP. Vandal and Savvides [42] present results of iris matching parallelized for execution on graphics processing units, and report a 14-times speedup relative to state-of-the-art single-core CPUs. Jang et al. [43] describe the design and implementation of a “portable” or handheld iris biometric sensor. Kang and Park [44] describe an iris biometrics system implemented to operate on a mobile phone. The system repeatedly takes images of both eyes and performs a quality assessment until at least one image passes the quality assessment check. Then it performs authentication either with one image, or with score-level fusion of two images.

Besides this Iris Recognition can also be used [18] -In National border controls: where iris can be used as a living passport, Computer login: the iris as a living password, Cell phone and other wireless-device-based authentication, Secure access to bank accounts at cash machines, Ticket less travel; authentication of rights to services, Driving licenses; other personal certificates, Entitlements and benefits authorization, Forensics; birth certificates; tracing missing or wanted persons, Automobile ignition and unlocking; anti-theft devices, Anti-terrorism (e.g. security screening at airports), Secure financial transactions (electronic commerce, banking), Internet security; control of access to privileged information, "Biometric-Key Cryptography" (stable keys from unstable templates), Any existing use of keys, cards, PINs, or passwords.

4. Methods of Iris Recognition

Iris Recognition methods can be mainly classified into Spatial Domain and Frequency Domain Techniques as shown in the Fig 5.1. Further frequency domain methods can be sub classified into orthogonal transform based and optimal transform based (k-l transform) , optimal transform based can be further sub classified into PCA (Principal component Analysis)and LDA(Linear Discriminant Analysis)

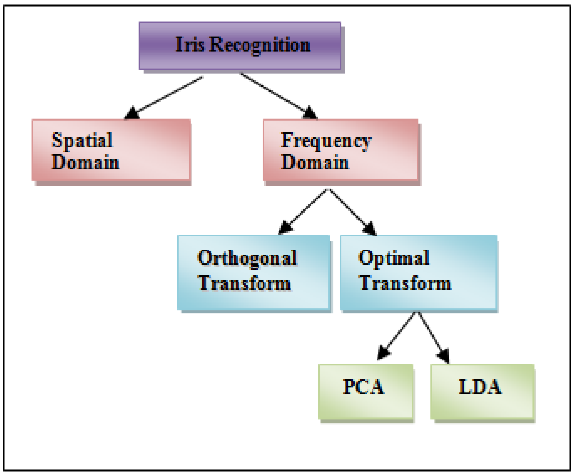

Fig.3 Classification of Iris Recognition methods

4.1 Spatial Domain:

It refers to image plane itself and approaches in this method/category are based on direct manipulation of pixels in an image. The value of a pixel with coordinates (x, y) in the enhanced image $\hat{F}$ is the result of performing some operation on the pixels in the neighborhood of (x, y) in the input image, F. Neighborhoods can be any shape, but usually they are rectangular.

4.2 Frequency Domain

Image enhancement in the frequency domain is straightforward. Frequency Domain processing techniques are based on modifying the Fourier transform of an image. Here we simply compute the Fourier transform of the image to be enhanced, multiply the result by a filter (rather than convolve in the spatial domain), and take the inverse transform to produce the enhanced image.

4.2.1 Orthogonal Transform

It is a linear transformation of a Euclidean vector space that preserves the lengths or (equivalently) the scalar products of vectors. In an orthonormal basis an orthogonal transformation corresponds to an orthogonal matrix. Orthogonal transformations form a group, the group of rotations of the given Euclidean space about the origin. In three-dimensional space an orthogonal transformation reduces to a rotation through a certain angle about some axis passing through the origin, if the determinant of the corresponding orthogonal matrix is +1. If the determinant is -1, then the rotation must be supplemented by a reflection in the plane passing through origin perpendicular to the axis of rotation. In two-dimensional space, that is, in a plane, an orthogonal transformation defines a rotation through a certain angle about origin or a reflection relative to some line passing through origin. Orthogonal transformations are used to reduce a quadratic form to the principal axes. [22]

4.2.2 Optimal Transform

Transform coding is a low complexity alternative to vector quantization and is widely used for image and video compression. A transform coder compresses multidimensional data by first transforming the data vectors to new coordinates and then coding the transform coefficient values independently with scalar quantizers. A key goal of the transform coder is to minimize compression distortion while keeping the compressed signal representation below some target size [21].

4.2.2.1 PCA (Principal Component Analysis)

It is a way of identifying patterns in data, and expressing the data in such a way as to highlight their similarities and differences. PCA is a powerful tool for analyzing data. Principal component analysis (PCA) involves a mathematical procedure that transforms a number of correlated variables into a smaller number of uncorrelated variables called principal components. The first principal component accounts for as much of the variability in the data as possible, and each succeeding component accounts for as much of the remaining variability as possible.

By means of PCA one can transform each original Image of the training set into a corresponding eigenface. An important feature of PCA is that one can reconstruct any original image from the training set by combining the eigenfaces.

4.2.2.2 LDA (Linear Discriminant Analysis)

This method is used in statistics, pattern recognition and machine learning to find a linear combination of features which characterizes or separates two or more classes of objects or events. The resulting combination may be used as a linear classifier or, more commonly, for dimensionality reduction before later classification. [20]. LDA is closely related to ANOVA (analysis of variance) and regression analysis, which also attempt to express one dependent variable as a linear combination of other features or measurements.

5. Iris Recognition System

Iris recognition is an automated method of biometric identification that uses mathematical pattern-recognition techniques on video images of the irides of an individual's eyes, whose complex random patterns are unique and can be seen from some distance[17].A typical iris recognition system consist of four main modules as shown in Fig 4.1

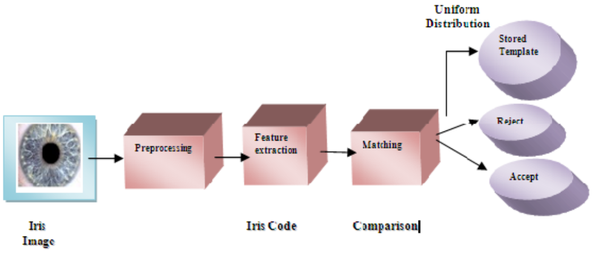

Fig.4 Iris Recognition System.

5.1 Image Acquisition

- The first module, *Image Acquisition* deals with capturing sequence of iris images from the subject using cameras and sensors. An image acquisition consists of illumination, position and physical capture system. The occlusion, lighting, number of pixels on the iris are factors that affect the image quality [4].

5.2 Image Preprocessing

- The second module, *Preprocessing* involves various steps such as iris liveness detection, pupil and iris boundary detection, eyelid detection and removal and normalization. Several methods can be used like Hough transformation, integrodifferential operator, gradient based edge detection to localize the portions of iris and the pupil from the eye image. The contours of upper and lower eyelids are fit using the parabolic arcs resulting the eyelid detection and removal. It is essential to map the extracted iris region to a normalized form. The iris localization methods are based on spring force, morphological operators, gradient, probability and moments. The inner boundary is detected by applying threshold, image opening and closing operators. The outer boundary is detected by applying threshold, closing and opening operators. The clustering algorithms like self-organizing maps, kmeans and fuzzy k-means were used to segment the image to produce as output the clusters-labeled images.

5.3 Feature extraction

- The third module, *Feature extraction* identifies the most prominent features for classification. Iris provides abundant texture information. A feature vector is formed which consists of the ordered sequence of features extracted from the various representation of the iris images. Some of the features are x-y coordinates, radius, shape and size of the pupil, intensity values, orientation of the pupil ellipse and ratio between average intensity of two pupils. The features are encoded to a format suitable for recognition. Gabor filters, Wavelet Transform, Laplacian of Gaussian Filter are some of the methods used for feature Extraction

5.4 Matching

- The fourth module, *matching* recognition achieves result by comparison of features with stored patterns [10]. The interclass and intra-class variability are used as metrics for pattern classification problems.

6. Iris Image Data beds

Image quality of the iris images determines the accuracy of the iris recognition system. Noisy and low quality images degrade the performance of the system.

- UBIRIS database is the publicly available database [5]. It consists of images with noise, with and without cooperation from subjects. The UBIRIS database has two versions with images collected in two distinct sessions corresponding to enrolment and recognition stages. The second version images were captured with more realistic noise factors on non-constrained conditions such as at-a-distance, on-the-move and visible wavelength.
- CASIA iris image database images are captured in two sessions [6]. CASIA-IrisV3 contains a total of 22,051 iris images from more than 700 subjects. It also consists of twins' iris image dataset. ND 2004-2005 database is the superset of Iris Challenge Evaluation (ICE) dataset, uses an Iridian iris imaging system for capturing the images [7]. The system provides voice feedback to guide the user to the correct position. The images are acquired in groups of three called as shot. For each shot, the system automatically selects the best image of the three and reports values of quality metrics and segmentation results for that image. For each person, the left eye and right eye are enrolled separately.
- Besides this various techniques are tested on Iris Database created at Palacky University [16]. This database has 6x64 (i.e. 3x64 left and 3x64 right) iris images (each with 512 pixels by 512 pixels), corresponding to 64 persons, including both males and females. The irises were scanned by TOPCON TRC50IA optical device connected with SONY DXC- 950P 3CCD camera. The images were taken in a single session.
- MMU1 iris database contributes a total number of 450 iris images collected from 45 persons (class) each of them contributed five iris images for each eye. Part of Libor Masek iris recognition code is used for iris segmentation, normalization and, feature encoding. A minor adjustment to the localization algorithm is introduced in order to properly locate the iris–pupil and the iris–sclera boundaries for images from, MMU1.

7. Performance evaluation criteria's

7.1 Threshold (False Acceptance / False Rejection)

The concept of scores (also called weights) is used to express the similarity between a pattern and a biometric template. The higher the score is, the higher is the similarity between them.

7.2 Performance metrics for biometric systems

- **False accept rate or false match rate (FAR or FMR)**: the probability that the system incorrectly matches the input pattern to a non-matching template in the database. It measures the percent of invalid inputs which are incorrectly accepted. In case of similarity scale, if the person is imposter in real, but the matching score is higher than the threshold, and then he is treated as genuine that increases the FAR and hence performance also depends upon the selection of threshold value.
- **False reject rate or false non-match rate (FRR or FNMR)**: the probability that the system fails to detect a match between the input pattern and a matching template in the database. It measures the percent of valid inputs which are incorrectly rejected.
- **Receiver operating characteristic or relative operating characteristic (ROC)**: The ROC plot is a visual characterization of the trade-off between the FAR and the FRR. In general, the matching algorithm performs a decision based on a threshold which determines how close to a template the input needs to be for it to be considered a match. If the threshold is reduced, there will be less false non-matches but more false accepts. Correspondingly, a higher threshold will reduce the FAR but increase the FRR. A common variation is the *Detection error trade-off (DET),* which is obtained using normal deviate scales on both axes. This more linear graph illuminates the differences for higher performances (rarer errors).
- **Equal error rate or crossover error rate (EER or CER)**: The rates at which both accept and reject errors are equal. The value of the EER can be easily obtained from the ROC curve. The EER is a quick way to compare the accuracy of devices with different ROC curves. In general, the device with the lowest EER is most accurate.
- **Failure to enroll rate (FTE or FER)**: the rate at which attempts to create a template from an input is unsuccessful. This is most commonly caused by low quality inputs.

- **Failure to capture rate (FTC)**: Within automatic systems, the probability that the system fails to detect a biometric input when presented correctly.
- **Template capacity**: the maximum number of sets of data which can be stored in the system.
- **Genuine Acceptance rate (GAR)**: The genuine acceptance rate (GAR) is the measure of the likelihood that the biometric security system will correctly accept an access attempt by an authorized user. A systems GAR typically is stated as the ratio of the number of correct acceptance divided by the number of identification attempts.

8. Similarity Measurement Criteria

Functioning of a biometric system in large part depends on the performance of the similarity measure function. Frequently a generalized similarity distance measure function such as Euclidian distance, Mean Square error, squared differences and Correlation coefficient, Hamming distance is applied to the task of matching biometric feature vectors.

8.1 Euclidean distance

One of the most popular similarity distance functions is the Euclidian distance. The **Euclidean distance** between points **p** and **q** is the length of the line segment connecting them (pq).In Cartesian coordinates, if **p** = (p_1, p_2,..., p_n) and **q** = (q_1, q_2,..., q_n) are two points in Euclidean *n*-space, then the distance from **p** to **q**, or from **q** to **p** is given by:

$$d(p,q) = d(q,p) = \sqrt{(q_1-p_1)^2+(q_2-p_2)^2+\cdots+(q_n-p_n)^2} = \sqrt{\sum_{i=1}^{n}(q_i-p_i)^2}. \quad \textbf{(1)}$$

Euclidian distance is variant to both adding and multiplying all elements of a vector by a constant factor. It is also variant to the dimensionality of the vectors, for example if missing values reduce the dimension of certain vectors produced output will change. In general the value of Euclidian similarity measure may fall in the range from zero indicating a perfect Match to sqrt (*n*) (where n-dimensional vector is used) indicating maximum dissimilarity of playing styles. However both of those extreme cases don't occur in real life and represent only theoretical possibilities not related to any viable playing style.

8.2 Mean Square Error.

Mean squared Error (MSE) is used to quantify the difference between values implied by an estimator and the true values of the quantity being estimated. It measures the squares of the "errors."The error is the amount by which the value implied by the estimator differs from the quantity to be estimated. The difference occurs because of randomness or because the estimator doesn't account for information that could produce a more accurate estimate.

MSE= $\left((a-a1)^2+(b-b1)^2+(c-c1)^2+(d-d1)^2\right)\div 4$ **(2)**

Where

a	b
c	d

Image-I

a1	b1
c1	d1

Image-II

8.3 Hamming Distance

Hamming distance is defined as the fractional measure of dissimilarity between two binary templates. A value of zero would represent a perfect match. The two templates that are completely independent would give a Hamming distance near to 0.5. A threshold is set to decide the two templates are from the same person or different persons. The fractional hamming distance is sum of the exclusive-OR between two templates over the total number of bits. Masking templates are used in the calculation to exclude the noise regions. Only those bits in the templates that correspond to '1' bit in the masking template will be used in the calculation. The advantage of Hamming distance is fast matching speed because the templates are in binary format. The execution time for exclusive-OR comparison of two templates is approximately 10μs. Hamming distance is suitable for comparisons of millions of template in large database.

9. Comparison of Methodologies

In this section comparison of various methodologies of Iris Recognition is done based on various criteria like whether the method required preprocessing or not, Feature Extraction is done by applying which method, size of feature vector, similarity measurement done using, initial image size, data beds used, Average correct recognition and query execution time required etc. In the first methodology a novel Haarlet Pyramid based iris recognition technique is discussed [13]. Here iris recognition is done using the image feature set extracted from Haar Wavelets at various levels of decomposition. Euclidean distance is used as a similarity measure on the feature set. Analysis was performed of the proposed method, consisting of the False Acceptance Rate and the Genuine Acceptance Rate. The technique is tested on an iris image database having 384 images. The results show that Haarlets level-5 outperforms other Haarlets, because the higher level Haarlets are giving very fine texture features while the lower level Haarlets are representing very coarse texture features which are less useful for discrimination of images in iris recognition.

In the second methodology the novel techniques is developed to create an Iris Recognition System, a fusion mechanism that amalgamates both, a Canny Edge Detection scheme and a Circular Hough Transform, to detect the iris' boundaries in the eye's digital image is used[15].Then applied the Haar wavelet in order to extract the deterministic patterns in a person's iris in the form of a feature vector. By comparing the quantized vectors using the Hamming Distance operator, finally it is determine whether two irises are similar. Results showed that this system is quite effective.

In the third method an iris recognition algorithm in which a set of iris images of a given eye are fused to generate a final template using the most consistent feature data. Features consistency weight matrix is determined according to the noise level presented in the considered images. A new metric measure formula using Hamming distance is proposed. This algorithm has the capability of reducing the amount of data storage and accelerates the matching process. Simulation studies are made to test the validity of the proposed algorithm. The results obtained ensure the superior performance of such algorithm over any other one. The table shows the comparison based on various methods depending on various criteria's.

In the last paper iris recognition is done using various transformation methods. A novel approach of selecting feature vector for performance comparison is implemented. Performance comparisons of all the transformation methods is done to achieve better accuracy and efficiency on the basis of number of correct sample identified. The proposed system does not need any pre-processing and segmentation. DCT, HAAR, and WALSH, SLANT and KEKRE'S Transforms are tested on different size of feature vector to get best possible results.

After applying the transformation methods most of the important features of an image are get concentrated at its right hand side's top corner, base on this, new methods are proposed for selecting feature vector for comparisons based on nature of energy compactions which are partial FV method and Upper Diagonal FV method. Matching of two Feature vectors will be done using MSE (mean square error).

10. Conclusion

In First method recognition, accuracy, robust method and computational costs are topics that are taken into account when analyzing an iris recognition method. The FAR/GAR values show that Haarlets are outperforming Haar based image retrieval, proving that Haarlets has better discrimination capability.

In second method the work presents an algorithm by which a given set of base templates are fused to generate one final template for the set. An experimental work using 450 images for 45 person's fromMMU1database reveals a reduction in database size by nearly an 78% and an increase of verification speed of about 80% is achieved while maintaining about 99.7% accuracy of matching.

Whereas identification system in paper 3 is quite simple requiring few components and is effective enough to be integrated within security systems that require an identity check. The errors that occurred can be easily overcome by the use of stable equipment**.**

In last paper for whole FV selection method accuracy is about 66.40% for each transform. For Fractional FV selection method best accuracy is 75% for Haar, Walsh and Slant transform. For Upper Diagonal FV selection method best accuracy is 75% for Slant Transform.

11. FUTURE SCOPE

Identification can be better by considering the below two factors

1. Accuracy
2. Speed

This can be achieved by reducing Feature Vector size and by retaining or improvising accuracy. Besides this various Research issues are based on iris localization, nonlinear normalization, occlusion, segmentation, liveness detection etc. It is required to achieve lowest false rejection rate and fastest composite time for template creation and matching.

Table.1 Comparisons of various techniques

Criteria	**Methods**			
	Hough Transform	**Haarlet Pyramid**	**Template Fusion**	**Partial & Upper diagonal FV**
Preprocessing of iris Image	Required	Not required	Required	Not required
Feature extraction done using	Haar wavelets	Haar wavelets	Gabor filter	DCT,Haar,Walsh,Slant and Kekre transform
Feature Vector size	702 elements	N/128 X N/128	Reduced by 78%	8x8
Similarity measurement	Hamming distance	Euclidean distance	Hamming distance	MSE
Initial image size	100x402	512x512	-	128x128
Database used	60 Pictures (pentium IV)	Palacky university	MMU1	Phoenix
Avg correct Recognition	93% in 31s*	99%*	99.7%*	Whole FV- 66.40%* Partial FV -75%* Upper diagonal FV- 74.21%*
Query execution time required	Less	Very less	Very less	Less

As per mentioned in the respective papers.

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