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Iris Biometric System and the Challenges – A Review

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Abstract: *In this paper, a brief survey of the various research works which were carried out by various authors researchers in the field of iris biometric recognition and the challenges faced in recent decade. Biometric approaches are adapted for the proof of identification and authentication. The use of image processing techniques has become almost ubiquitous. As it is an external organ and it remains same throughout the life, allures towards other means of biometric identity systems. With an increasing demand for stringent security systems, automated identification of individuals based on biometric methods has been a major focus of research and development over the last decade. Biometric recognition analyses unique physiological traits or behavioral characteristics, such as an iris, face, retina, voice, fingerprint, hand geometry, keystrokes or gait. The iris has a complex and unique structure that remains stable over a person's lifetime, features that have led to its increasing interest in its use for biometric recognition. In this review, we discuss about the challenges involved in iris biometric system.*

I. Introduction

Biometrics is the reliable, secure authentication tool for systems where controlled access to physical assets is provided by recognizing the individual either based on physiological or behavioral characteristics. The physiological characteristics are Iris, fingerprint, face and hand geometry while behavioral characteristics include voice, signature, and ECG, gait and keystroke dynamics. Biometric recognition methods are based on properties which cannot be forgotten, stolen, disclosed or lost unlike traditional authentication such as passwords or PIN's. Iris is a thin, circular structure in the eye which is protected internal organ thus it is not affected by environmental condition. Amongst all the biometric recognition systems Iris is the promising solution because of its uniqueness, reliability and stability over the lifetime. Even the genetically identical twins have different Iris textures. The Iris recognition system has wide applications in variety of fields such as premise access control (home, office, laboratory), secure financial transactions, internet security, credit card authentication, secure access to bank accounts, anti-terrorism (e.g. security screening at airports) and many more. Iris recognition system acquires the image of eye; extracting the Iris region from the image to determine the unique texture for individual identification during the verification phase and matches it with the database created in enrolment process. Thus identifying the individual's identity in a convenient, faster, precise and more reliable manner. The various stages of processing involved in the design of Iris recognition system are:

- Localization of eye
- Boundary segmentations of Iris and pupil,
- Normalization,
- Local feature extractions and
- Matching

II. Methodology

Iris recognition processing generally consists of the following steps:
(i) Image Acquisition
(ii) Iris segmentation
(iii) Normalization
(iv) Feature extraction and
(v) Classification.

In our approach presented here, segmentation was achieved using the Hough transform for localizing the iris and pupil regions. The segmented iris region was normalized to a rectangular block with fixed polar dimensions using Daugman's rubber sheet model. A combined PCA and DWT were applied on a fixed size normalized iris for feature extraction. The Support Vector Machine was used for classification the similarity between the iris templates.

III. Challenges In Iris Biometric System

Biometrics is definitely better than passwords when it comes to security, but they aren't fool-proof. Here are the three main reasons biometrics are not secure. The next time you log into your bank account to pay a bill, instead of entering your password, you might have to take a picture of your eye to gain access. Welcome to the world of biometric authentication, where your eyes, ears, and fingerprints are the access code to prove individual identity. Biometric technology will become commonplace sooner rather than later.

Despite the benefits, some flaws still must be addressed. Here are three major issues facing biometric security.

1: Biometrics isn't private:

Biometrics seems secure on the surface. After all, you're the only one with your ears, eyes, and fingerprint. But that doesn't necessarily make it more secure than passwords. A password is inherently private because you are the only one who knows it. Of course hackers can acquire it by brute force attacks or phishing, but generally, people can't access it. On the other hand, biometrics is inherently public.

Think about it: your ears, eyes, and face are exposed. You reveal your eyes whenever you look at things. With fingerprint recognition you leave fingerprints everywhere you go. With voice recognition, someone is recording your voice. Essentially, there's easy access to all these identifiers.

Your image is stored in more places than you realize.

Not only does Facebook recognize your face, but every store you visit records and saves your image in its database to identify you and analyze your buying habits. In fact, it's legal in 48 states to use software to identify you using images taken without your consent for commercial purposes. And law enforcement agencies nationwide can store your image without consent.

The problem is identity management and security. Personal identifiable information (PII) needs to have access control in place to protect from identity theft. All it takes is for a hacker to breach any of those databases to leak and steal your biometric identification.

2: Biometrics Are Hackable

Once a hacker has a picture of someone's ear, eye, or finger, they can easily gain access to their accounts. The hacker obtained high-resolution photos of the politician's thumb from press conferences and reconstructed the thumbprint using VeriFinger software. If you think an eye scan may be more secure, think again. Hackers fooled the Samsung S8 iris recognition system by placing a contact lens over a photo of a user's eye. And it wasn't a high- priced hack either.

3: Biometrics Hacks May Have Greater Consequences

Since a biometric reveals part of a user's identity, if stolen, it can be used to falsify legal documents, passports, or criminal records, which can do more damage than a stolen credit card number.

Biometrics may be the security measure of the future, but it isn't time to discard your passwords yet. Biometrics provides another level of security, but it's not foolproof.

IV. Review Of Related Work

Iris image acquisition is performed either using a CCD Camera with resolution sufficient to capture the Iris details or during the research course the Iris images are gathered from the publically available Iris database.

A. Publicly available database

This section briefs the details of publicly available database with contribution from various authors. There are many Iris databases available for research and educational purposes which will aid to verify the performance of Iris recognition systems thus encouraging the advances in this field. Several Iris image databases such as CASIA (the most widely used public datasets), MMU, Bath, UPOL, and UBIRIS are freely available for experimental purpose.

CASIA-IrisV4 is released on Biometrics ideal test. The first version has the advantage where the images are photographically edited to make the region of pupil to be of uniform intensity. BATH: images from this database are similar to that of MMU having similar characteristics and few noise factors with small eyelid and eyelash obstructions. UBIRIS is the database of noisy images constructed by University of Beira Interior taken from 241 subjects during acquisition.

B. Related work

The advancement in technology has led to innovations in Iris biometric recognition system. Many researchers and Authors have proposed various techniques to overcome the drawbacks of traditional Iris authentication system. Most of the commercial Iris recognition system makes use of patented algorithm developed by John Daugman.

Daugman proposed the algorithm to identify inner and outer boundaries of Iris using integro-differential operator, even the boundaries of upper and lower eyelid were detected. The operator assumes that the pupil and limbus are circular in nature and behaves as circular edge detector. The circular path is detected where there is maximum change in pixel value by varying the radius of circular contour. The upper and lower eyelids are detected by using parabolic curve as path for contour. Normalization is performed using Daughman's rubber sheet model where in the circular Iris region is unwrapped into rectangular block of fixed dimension. Phase information is encoded using quadrature 2-D Gabor and hamming distance is used for template matching. This method boasts the theoretical false match probability of 1 in 4 million. Further an identification technique, which is invariant to tilt and scale variation, has been proposed by V. Garagad et al. Where, the Iris region is radically traced to extract the feature. Property of discontinuity is used to crop the unwanted region in the image of an eye. To find the center coordinates of pupil, the segmented image is traced along diagonal coordinates with concentric circles of increasing radii. The coordinate that provides maximum ratio is considered as the center of pupil. Relative normalization is used where the ratio of max pupil radius of test image to max pupil radius of reference image is calculated to normalize the test image. The gray signature code of 90*180 bytes is obtained using Daugman's rubber sheet model. Then this image is code converted to binary signature code using a relative threshold. A bit by bit comparison of signature code of test image and the Iris images in the database is done to authenticate the user. The proposed work is conceptually simple as compared to differential operators with the average recognition rate of 83.14%.

Paul has proposed an automatic segmentation algorithm using the circular Hough transform to identify the Iris pupil boundary and linear Hough transform for detecting the occluding eyelids. To remove the eyelashes and reflections thresholding is employed. The segmented region is normalized using the Daughman's rubber sheet model. The normalized Iris image is convolved with the 1D Log-Gabor wavelets and the resulting phase data is used to extract the feature from the Iris image. And finally for the template matching Hamming distance is employed. This recognition rate achieved a FAR of0.005% and FRR of 0.238 % for CSISA images.

Yuan has proposed feature extraction method which is invariant to illumination. The pre-processing of image is performed by using Hough transform to localize Iris and Daugman rubber sheet model to normalize the Iris image. The annular region containing eyelid and eyelashes are discarded (45° to 135° and 225° to 325°) and the rest annular region is normalized and converted to 64 X 256 rectangle. Phase congruency depends on overall magnitude of signal making it invariant to illumination changes. In the process of feature extraction, the normalized image is convolved with the bank of 2D log-Gabor filters wit different orientation and scales. Euclidean distance of feature vectors is calculated during matching

A rotation compensated Iris matching by using Fourier domain cross correlation to estimate relative rotation of two Iris images is introduced by Monroet. It is stated that one dimensional cross correlation is more advantageous than the 2D cross correlation as it provides improved accuracy due to elimination of eyelids and eyelash affected regions during the peak and displacement calculations with the gain in time and storage efficiency. The Iris is normalized and patch based zero crossing is used to generate binary feature vector. The position of sharp peak obtained by cross correlation between the candidate's iris and stored iris will indicate the degree of rotation. Sharp peak is expected for similar Iris and a flat curve will indicate a no match. Now the candidate's Iris image is shifted to align to the registered Iris thus providing improved matching. Since cross correlation peak is used for independent discrimination, peak to side lobe ratio (PSR) is used as metrics. Threshold for PSR is used to discard the local maxima of non matches. The feature vector of stored images is compared with the feature vector of selected rotated image to obtain the weighted Hamming distance which is used for verification.

Use of fast Fourier transform and moments which compares Iris image without encoding has been proposed by Jain et al. The Fourier transform converts the image from spatial domain to frequency domain and also filters noise in the image. Moment values are scale and orientation invariant of the object under study. In the methods of moments, a sequence of numbers called moments identifies the area, centroid, moment of inertia, orientation.

The basic moments vary according to position with respect to origin, scale and orientation of the object. The invariant moments are normalized moments. Iris image matching is done using Euclidean distance formula, which is calculated by measuring the normal between two moment vectors. Hough transform that detects the circular boundaries from the edge map of the eye image. The edge map is generated using the canny edge detection algorithm. To normalize the image, it is resized to 256*256 pixels, which allows comparison of two Iris regions of variable sizes. Thus a linear pattern is generated using the edge detection method. The Hausdorff measure between two images allows the comparison of two images without encoding. It is reported that the recognition rate is more than 98%.

V. Literature Survey

Recent perceptible readings in personal identification based on the patterns and colors of the iris, below some at these researches:

Srinivasa Kumar Devireddy, G.Ramaswamy, proposed a novel approach for accurate human recognition identification through iris recognition using bit plane slicing and normalization. Iris boundaries are recognized by using simple methods and the less complex and faster algorithms than previous algorithms and it eliminates pupillary noises and reflections. Homogenization removes secularities of the pupil. By solving these parameters in circle equation, they can recognize limbic boundary (outer boundary) accurately. The region between inner and outer boundary is iris, it is in the polar form and converted into linear form by converting the polar coordinate system to Cartesian coordinate system, then converting the iris region from Cartesian coordinates to the normalized non concentric polar representation we get normalized image.

Matsoso Samuel Monaheng1, Padmaja Kuruba use horizontal and vertical derivatives for edge mapping results 95.6% whereas pervious results 88.1%. Iris recognition comes under physiological classification of biometric identification system. Digital image is used for identification. It has advantages such as simplicity, accuracy, high speed of computation because of sample size. On the unique pattern of iris in identification and verification of an individual, iris recognition works under segmentation, normalization, feature extraction and matching phases. Separation iris region from entire captured image is done through segmentation, normalization for fixing the dimension for comparison, and feature extraction draws bio templates and matches with reference template. Iris recognition closely depends on precision of iris segmentation. Problem in segmentation is having the same central point of iris as well as iris. Eyelids and eyelashes raise the problem in segmentation results in form of noise.

Noise needs to be eliminated. For this proposed circular Hough transform to deduce the radius and finding center coordinates of pupil and iris region. In edge mapping, horizontal used for eyelids vertical used for finding the circular boundary of iris. Daugman Integro differential operator localizes the circular region of both and arcs defines the upper and lower eyelids. This operator is applied iteratively for precise localization. Eyelids are localized in similar with path of “contour integration” changed from circular to an arc. Active contour model has various vertices for localizing pupil changed its position with internal and external forces.

Cong, Zhang used 1D Gabor filter for separable and variance of intensity for multiple eyelashes for noise detection.

Padma Polash, Maruf Monwar presented an iris recognition system in order to verify together the uniqueness of the person iris and also its performance as a biometric identification. A biometric system provides automatic identification of an individual based on a unique feature or characteristic possessed by the individual. Iris recognition is regarded as the most reliable and accurate biometric identification system available. The iris recognition system consists of an automatic segmentation system that is based on the Hough transform, and is able to focus the circular iris Richa Bajpai et al, International Journal of Advanced Research in Computer Science, 8 (8), Sept–Oct 2017,737-742 © 2015-19, IJARCS All Rights Reserved 739 and pupil region, occluding eyelids and eyelashes, and reflections.

Himanshu Shrivastava worked for enhancement and denoising. Normalized iris image is still has low contrast and many images have non uniform illumination due positioning of light sources. To obtain better distributed texture image, enhance the image by local histogram equalization and remove high frequency noises by filtering the image. Hamming distance algorithm is in procedure for matching of iris with the stored template. Set the threshold value, if resultant value is greater than threshold, it declines else accepts.

Sowmya, Sreedevi.S.L describes recognition through iris sequence. For recognition first of all selection of clear image is required to outperform the iris image with low EER. Recognition is performed under the either of or fusion of: texture based, appearance based and feature based. Feature based uses local variation which are characterized appearance and disappearance of an important image structure: PCA is superior in image construction for feature extraction.

By selecting cumulative variance, it controls errors during construction of image. Monochrome CCD is used for taking image from optical system. More abundant features [8] can be visible under Infra Red lightning. Captured image is in RGB form is converted into grayscale image. Lowest number of dark pixels could be diameter of inner circle is MIN of histogram. Scientists use CANNY detection for forming boundary and Hough for forming the circle. Normalization is used for generation of iris code and comparison. Segmentation normalizes iris region. It reduces iris distortion.

Navjot Kaur, Mamta Juneja use retinex algorithm as it removes illumination effects as noise provides columned constant image. Non linear spectral transformation is used for synthesizing the enhanced contrast of iris image. Kaur and Juneja use Fuzzy C mean clusters for making different clusters. Clusters are based on membership functions. One cluster is formed for high intensity value and other cluster is used for low intensity value. One other cluster is also used for in-between. For better edge detection and good segmentation,

CANNY edge detector is used. to remove noise, morphological treatment is applied. Obtaining fine edges, circular hough transform is applied. The process of recognition goes under retinex algorithm then fuzzy c mean then applied clustering techniques. Morphological operations are performed after clustering. To get iris area, vertical edge CANNY detection technique is used. Hough transform is applied to bind the iris image. After applying mentioned techniques, iris template is created and then it is stored in associated database. Comparisons will be on the basis of hamming distance. Kaur and Juneja use MATLAB 8.0, windows 7s alogh with core 2duo processor. They use UBIRIS V2 as database.

Jaemin Kim described a new iris recognition algorithm, which uses a low level of details. Combining statistical classification and elastic boundary fitting, the iris is first localized. Then, the localized iris image is down-sampled by a factor of m, and filtered by a modified Laplacian kernel. Since the output of the Laplacian operator is sensitive to a small shift of the full-resolution iris image, the outputs of the Laplacian operator are computed for all space-shifts. Ms. Rasika P. Rahane, Prof. Deepak Gupta studied for automatic identification with the help of biometric machines. They focus on approaches of 1-D DWT (Discrete Wavelet Transform) filter execution, matching and recognition and circular normalization for recognition. Tossy Thomas, Anu George, Dr.K P Indira Devi use RANSAC (Random Sample Consensus) to locate iris boundaries. RANSAC is more accurate than Hough transform. RANSAC is able to fit ellipse around non circular boundaries of iris. Duo scientists use Daugman's rubber sheet model and for template matching, they use PSR (Peak Side Lobe Ratio) is the similarity measure used for matching templates.

VI. Conclusion

A brief review of the various works done by various authors in their research papers. It's being presented as a nutshell in this paper with respect to iris recognition of biometric systems.

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