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Analysis of Iris Recognition Methods for Various Environments

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Abstract— ***Iris Recognition is one of the most reliable systems used so far for human identification among all the other biometric systems. There is great interest in the improved methods of authentic identification of people. So biometric should be used for personal identification instead of any other identity card or password. More reliable, secure and authentic biometric systems have been developed for human identification based on human physical and behavioural traits. Iris is the most powerful identification feature among all other biometric features as human iris is unique and remains unchanged during whole of the life. Iris recognition is the most precise and fastest of the biometric authentication or identification method for individuals. Even a person has distinct iris patterns for both of his eyes. The demand for iris recognition is increasing day by day due to its reliability, accuracy and uniqueness. Now iris is used as an identification which a human carries with himself all the time. Due to its distinct features, it is used in various fields of access control and security at border areas. Iris recognition has gained a great attention in various fields like industrial areas, security prone areas, border areas, airports and medical institutes etc. For efficient functioning of iris recognition system, researchers are working on various challenges like images taken in unconstrained environment, noisy images, blurred images and many more.***

Keywords— Iris Segmentation, Localization, Enhancement, Feature Extraction, Template Matching

I. INTRODUCTION

Human Iris is externally-visible part of the human eye. An iris biometric system identifies human based on its unique features and characteristic such as freckles, rings, furrows and complex iris pattern. Such unique features make it very attractive for use for human identification. The iris is considered to be an internal organ though visible externally and it is so well protected by the eyelid and the cornea from external environmental damage. Pupil is the darkest region of an eye [1]. Pupil is the portion of an eye which allows the light to enter into the eye. The size of the pupil varies depending upon the amount of light entering to it. It contracts when the amount of light is large and expands when there is lesser amount of light. The colored ring around the pupil is called Iris. Its flowery pattern is unique for each individual. As iris consists of a complex pattern formed of rings, ridges, freckles and furrows and thus it poses a great degree of randomness. Even a person has distinct iris patterns for both his eyes. Not even one egged twins or a future clone of a person will have the same iris patterns. It is stable over time even though the person ages his iris remains same. As the need for an authentic and reliable identification system is increasing day by day [1,2]. Iris as an identification is the most suitable and reliable among all the other existing biometric systems. Iris recognition is the emerging biometric technology used in today's world. Figure1 shows the block diagram of human eye showing all the essential parts of eye.

The use of iris recognition system has a number of advantages [1, 2]:

- Improves convenience, security and privacy.
- Easier fraud detection.
- Better than password/PIN or smart cards.
- Requires physical presence of the person to be identified.
- Unique physical or behavioral characteristic.
- Cannot be stolen or forgotten.
- Cannot leave it at home
- Highly protected internal organ of human eye.
- Remains stable throughout life.
- Unique for every individual.
- More accuracy.
- Fastest among all the other biometric systems.

Working of Iris Recognition System [3-13]

- Iris recognition system includes various steps to make the recognition system work efficiently and effectively. These various steps are shown in the figure 2. These various steps are: Image Acquisition, Pre-processing, Feature Extraction and Template Matching. Pre-processing is further partitioned into sub parts as Iris localization, Normalization and Image Enhancement. These parts are explained below:

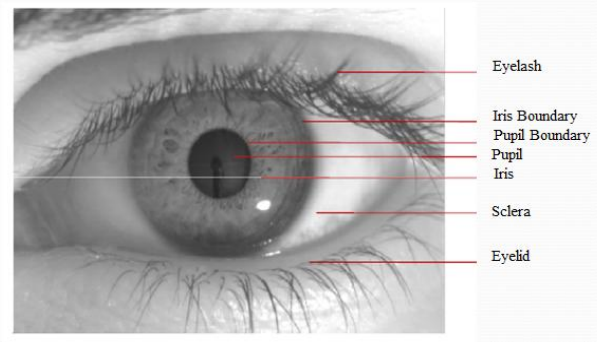

Fig.1 Block diagram of human eye showing iris

- Image Acquisition: Image acquisition is the process of getting eye images from various persons. It is the most important step in iris recognition as recognition of an individual highly depends upon the quality of the image. It uses near infrared illumination to capture the eye images. Iris is then extracted from the eye image.
- Pre-processing: Iris is then extracted from the eye image by removing various types of noise existing in the image. Eyelids and eyelashes are called noise in the image. These noise particles are then removed from the images to get good quality recognition.
- Feature Extraction: Iris features are extracted from the original eye image and stored in a particular format for further processing and matching.
- Template Matching: Extracted iris features are than matched. Point to point matching is done for iris image with every image stored in the database for similarity.
- Hamming distance is used for matching a given iris image within the whole database.

Applications of Iris Recognition System [1,2]

- Attendance system at various industries and institutes.
- Recognition at ATM's (Automatic Teller Machines)
- At Airports and harbors.
- For computer security.
- At national border control areas.
- As unique identification in India's Adhaar System.
- Various financial transactions.
- Secure access to premises (home, office, laboratories).
- Internet security control of access to privileged information.

II. SURVEY ANALYSIS

L. Flom [1] presented a patent in which iris and pupil is used for personal identification as they are visible externally and can be easily used. Pupil is detected using edge detection algorithms and then circular Hough transform is applied to the detected pupil edges. Region growing algorithm is applied to the pupil region from the central darkest position in the outward direction, until pupil boundary is reached. Radial furrows are detected using line detection algorithms or Hough transform algorithm. Collarets and crypts are detected using edge detection algorithms and chain code algorithms. The eye is illuminated with different illumination range until the pupil reaches the size determined at the time the image was

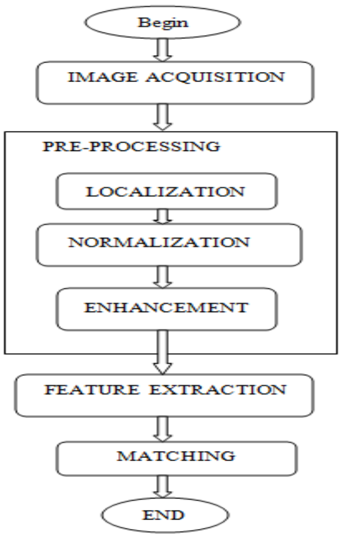

Fig.2 Steps of iris recognition system

taken. A light source is used with varying intensity to illuminate the eye from different positions. The images are taken at every contraction or expansion point of the pupil and then matched with the stored images for identification. The illuminating means, imaging means and the comparing means are the main functional components involved in it. This patent involves that every iris is unique in its detailed structure and is stable over time. It also showed that two twins have different iris for their eyes and even the iris of both the eyes of a person have different patterns. The main objective is to check whether the descriptor set obtained from the individual matches the one on the identification card or that stored in the database. A point to point comparison of the obtained image is made with the stored image. It did not provide with any procedure for identification after features have been extracted. It did not provide any mathematical formula for making decisions for comparisons between the two pairs. No method was given for calculating the confidence level of the identifications.

J. Daugman [2] detected inner and outer boundaries of iris using Integro differential operator. If derivative larger then certain value is not detected by the Integro differential operator then it says whether eye is absent or poorly focused eye or the eye with many eyelid occlusions. To detect the presence of a real eye, pupil contraction and expansion is noted after illuminating the eye constantly. To extract the detailed iris texture, 2-dimensional Gabor filter is used. Iris image is mapped to doubly dimensionless polar coordinates to maintain reference to the same iris region irrespective of pupil contractions. Hamming distance measure is used as a measure of dissimilarity between iris codes. Accurate only for images taken in constrained environment under ideal conditions.

J. Daugman [3] presented a system that takes the digital image of the eye of the person to be identified. It isolates the inner and the outer iris boundaries from the eye image using Integro-differential operators. Fixed length iris codes are generated in the universal format for all the irises. These iris codes are stored for future comparisons. As codes for all the irises are stored in universal format so comparison becomes easy. EX-OR (exclusive OR) operation is applied between the corresponding bits of two irises to compute the comparison between the two iris codes, norm of the resulting binary vector is computed. This comparison measure is called hamming distance. When a person is to be identified, his iris is scanned, analyzed and its corresponding identification code is generated and this code is than matched with the reference code and Hamming distance is calculated. Thereafter a preselected criteria is applied to this Hamming distance and based on it a decision for 'yes' or 'no' is made. Probability is calculated to get the confidence level for this decision. It uses various mathematical formulas for personal identification. It also provides a confidence level for the iris to be identified. It gives a practical approach for iris identification. Decision for a match is made by calculating Hamming distance which is computationally very fast.

H. Proenca [4] extracted the features for every image pixel and then clustering algorithm is applied to each pixel. A normalized image is produced and then Canny edge detection is used to create an accurate edge map for the application of circular Hough Transform. Thus a segmented iris image is produced. The important feature is classifying capacity, all the iris pixels in one class and the others in the different class. Four different classification algorithms viz. Kohenen's self-organizing maps, K-means, Fuzzy K-means and Expectation maximization are used for this purpose of classification. The work was done to improve the accuracy of image segmentation as image quality and features change. Images for two different sessions (ideal and non-ideal) are taken into consideration. Fuzzy K-means classification algorithm produces the best results among all. Features are then extracted and the best feature set is the one which identify the iris region clearly and minimize the noise. In this work, the feature set which preserves the information about image and individual pixel properties. Such system can provide greater security and recognize persons properly in any environment.

J. Daugman [5] presented a flexible model for properly detecting internal and external iris boundaries irrespective of their shape. The goal is to impose constrains on smoothness for non-smooth curvature. "Active contour model" is used to describe internal and external iris boundaries which are based on the discrete Fourier series expansion. Active Contour enable coordinates for non-circular boundaries also. The interruption corresponding to eyelid and eyelash occlusions are detected separately. Most iris recognition cameras require on-axis eye image and thus these systems are not much flexible. Geometry of projection also depends upon distance between the eye and camera. This method uses Fourier trigonometry for estimating gaze and off-axis image correction. The presence of reflections and various types of noise if not detected properly may dominate the iris code and affect the recognition. A test of statistical independence is applied for checking a match between two iris codes. Bit wise comparison is done by using hamming distance measure between two iris codes. Iris is assumed as planar by affine transform but it has some curvature. It prevents false matches between two iris codes, arising by chance.

J. Huang [6] discovered that iris boundaries are not always circular or elliptical and previous edge detection algorithms also take noise edges in iris edges. So to detect the iris boundaries of any shape effectively wavelet based radial suppression edge detection is used. Wavelet Transform modulus is computed by using non-separable wavelet Transform. Non-separable wavelets are used for detecting the annular iris edges. Pupillary center is taken as center point and then Radial non-maximum suppression is applied on the image to find edges. Radial suppression takes points having peak values only so detects annular edges accurately. Edge thresholding by hysteresis thresholding is used to find the final edge map and remove false edges. If edge curve length is greater than the Threshold of the edge length, the curve is retained and stored. Non-separable wavelet transform has the ability to reveal singularities in every direction of the image. So iris edge detection is very efficient using non-separable wavelet transform. It accurately segments the pupil boundary and eyelash and eyelid edge maps are removed properly. Correction rate for this method is greater than the previous methods.

D. S. Jeong [7] used Adaptive Boosting, an algorithm in which weak classifiers are coupled to construct a strong classifier, for efficient iris detection. To reduce complexity and processing time, RGB image is converted into gray scale image. The inner and outer iris boundaries are located using two circular edge detectors. Two detection cases are described based on the presence of specular reflections, as "good detection case" and "bad detection case". Pupil and iris region are properly located in good detection case having specular reflections more than one while poorly located in bad detection case having specular reflections less than one. Adaptive Boosting based eye detection is used in bad detection cases to re-detect the pupil and the iris region. Then two circular detectors are used to detect the iris boundaries. If there are no specular reflections even after applying Adaptive boosting technique, then the eye is taken as closed eye image. Two cross points are detected between the outer iris boundary and the upper eyelid. Eyelid candidate points are detected using eyelid mask. Eyelid boundary is located accurately using parabolic Hough transform. Separable eyelashes are detected using convolution kernel and multiple eyelashes are bunched together and are detected using local window. Color segmentation is used to detect ghosting effects. Color segmentation is used to remove Ghosting of light in the detected iris. It has good classification performance and fast detection speed. Cross points are not detected properly and accurately due to thick eyelashes and ghost regions.

Y. Chen [8] presented a work to enhance the iris segmentation in noisy eye images in order to get highly accurate and secure recognition. Firstly locate the eye area in the image to get a closer, refined and smaller target area. It finds approximate iris area based on sclera detection and detecting target eye region. HSI (Hue, Saturation and Intensity) color model is used to find the sclera area instead of iris area. To locate the iris area properly, the image is converted into binary edge map and checked whether there is double sclera area or single sclera area in the image. In this work, a modified Hough Transform was applied to get high speed and accuracy. The edge detection operation was conducted in horizontal direction only. This method is beneficial in getting more accurate and fast segmentation method. Modified Hough Transform reduces execution time. Good performance is achieved with lowest error rate for noisy iris images.

T. Tan [9] proposed a method to remove the non-iris regions at the initial step. So all the eye parts are labeled separately as candidate iris region, skin region, and eyebrow region based on eight-neighbor clustering method. Specular reflections are removed first by adaptive thresholding and bi-linear interpolation. Separated points are clustered using region growing algorithm. Iris intensity is lower than skin but same as that of eyebrow and eyelash region, so they may be taken as candidate iris region. These regions are hard to distinguish as candidate and non-candidate regions by computer as there are many semantic priors like intensity, position and shape. Each cluster region is described by height to width ratio to explain its shape. A novel Integro differential constellation is used to define internal and external iris boundaries. Iris is localized and inaccuracies are eliminated by applying intensity statistics. Noise due to eyelids and eyelashes are eliminated by employing eyelid curvature model and horizontal 1-dimensional rank filter. Vertical edges are detected using canny edge detector. Eyelashes and shadow are detected and eliminated using thresholding. Use of novel Integro differential constellation overcomes heavy computation of Integro differential operator. It is very effective and fast in computing.

D. M. Rankin [10] involves the study of images taken with three and six month intervals to classify the texture of the images. Gray scale eye images are taken from the left and the right eye many people to study. Iris image preprocessing includes the location and isolation of the iris region by removal of various noise factors using thresholding and edge detection methods. Integro differential operator is used to find the inner and outer iris boundaries. Image is than mapped to the polar coordinates so as to facilitate comparison between various irises. 1-D log Gabor filter is used to the normalized image for feature extraction. Final stage is the matching stage which involves the comparison between the iris codes to check if they match or not. This matching is done by using Hamming Distance measure which describes if two codes match or not. Also it has been shown that non-zero hamming distance (no. of bits that do not match for two iris codes) does not mean that there is a change in the iris pattern, but arise only because of the algorithm weakness. Intra class comparisons are made to check if two irises match or not based on a particular threshold. The study show that iris texture may change with time due to diseases or any medication. The iris is formed in the early gestation period and its texture changes and pigmentation changes may occur in early life of the child. However later in life, iris texture remains unchanged and stable throughout a person's life. Good recognition rate due to use of log Gabor filter.

G. Santos [11] described an approach for the fusion of various methods to increase the robustness of iris recognition in unconstrained environment. Iris boundaries are detected by applying segmentation mask first and then Hough Transform is used to the segmented contour to get the best fitting circle to describe iris region. Then gray scale eye image enhanced by histogram equalization. Canny edge detector and Hough Transform are used to isolate the pupil. The segmented iris image is then normalized to get stability in size, shape and pupil dilation. Two normalized iris images- with and without occlusions are then analyzed by applying 1-dimension Gaussian Wavelet Transform to every row of vector. Zero crossing is then calculated for every row of vector image. 2-dimension dyadic wavelet is applied to normalized iris image after removal of occlusions to extract features. Zero crossing is then calculated for every row of the iris image. Features are extracted by Scale Invariant Feature Transform. Dissimilarity between two iris codes is done by comparing their zero crossing representation. Comparison is made by Hamming distance measure between two iris codes. Spatial domain and frequency domain analysis is then done for the iris codes for similarity measure. Less vulnerable to motion, blur and varying camera to eye distances. Using fused methods, Non-cooperative iris recognition issues are addressed in unconstrained environment.

K. Y. Shin [12] focuses on iris recognition in unconstrained environment different from other existing methods in various novel ways. The work starts with distinction between the left and the right eye based on specular reflections and eyelash distribution which greatly enhance accuracy of system. Eyelashes and specular reflections are differently distributed from lateral canthus to medial canthus, more specular reflections are there near the medial canthus but eyelashes are less near medial canthus than lateral canthus. Rough pupil center and radius is first detected and then iris radius and center is detected by circular edge detector. Retinex algorithm is applied for normalizing the illumination and enhancing the uniqueness of gray scale image. All the iris image pixels have three components: red, green and blue, based on the presence of these components highest value per pixel is selected. Ratio is calculated for every color pixel and thus decision about the imposter is made by color components of the iris. Iris is normalized to size and then iris region is converted into polar coordinates from Cartesian coordinates for measuring dissimilarity. Intra class and inter class groups are classified by calculating hamming distance, chi-square distance and Euclidean distance between the input image and the enrolled image using various color space models. All the color channel scores are then combined by weighted sum method to describe iris image as real or fake.

S. A. Sahmoud [13] proposed a scheme for error free segmentation of the iris, regions like eyelashes, eyelids, skin and sclera are eliminated from the iris region. K-mean clustering algorithm is applied to divide the eye image into different regions based on their different intensity values. First is the region with small intensity values including iris, eyelashes and pupil. Second is the region with high intensity values, including sclera and specular reflections. Third is the skin region in between these two regions. Clustered image is treated morphologically to eliminate noise and eyebrow regions. Iris edges are then detected by first using canny edge detector in vertical direction and then applying circular Hough Transform. RGB image is converted into YCbCr color space and then image is smoothed and noise is removed by application of median filter. Y component reduces specular reflections and luminance effect. Upper eyelids are removed by using sclera region as intensity contrast is high between the upper eyelid and sclera. Lower eyelid is localized using canny edge detector and linear Hough Transform. Image is enhanced first to highlight the pupil area. Pupil detection is done by the application of median filter, canny edge detector and circular Hough Transform. Hamming Distance measure for dissimilarity of iris codes is used. Searching time is highly reduced due to k-mean algorithm for Circular Hough Transform. Vertical edge detection is applied to reduce error due to horizontal edges of eyelash and eyelid. Iris is detected accurately irrespective of its shape.

III. CONCLUSIONS

The Iris recognition is a very growing area in today's day to day life. This paper provides the review of various existing methods proposed by different researchers from time to time for iris recognition. Most of these techniques follow the main iris recognition steps- image acquisition, pre-processing, feature extraction and template matching. The performances of all these methods vary depending upon the different algorithms used by them. All these methods have their own importance depending upon the environment in which images are taken. Iris recognition has gained a great attention in recent years due to its efficient working and accuracy. The unique feature of iris which makes it stable throughout life is the main reason for it being used in the personal recognition at various places like airports, premises like home and laboratories. This paper also presents a proposed methodology to be used for iris recognition in unconstrained environment.

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