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Human Identification Based on the Pattern of Blood Vessels as Viewed on Sclera Using HOG and Interpolation Technique

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Abstract: Identification of a person based on some unique set of features is an important task. The human identification is possible with several biometric systems and sclera recognition is one of the promising biometrics. The sclera is the white portion of the human eye. The vein pattern seen in the sclera region is unique to each person. Thus, the sclera vein pattern is a well suited biometric technology for human identification. The existing methods used for sclera recognition have some drawbacks like only frontal looking images are preferred for matching and rotation variance is another problem. These problems are completely eliminated in the proposed system by using two feature extraction techniques. They are Histogram of Oriented Gradients (HOG) and converting the image into polar form using the bilinear interpolation technique. These two features help the proposed system to become illumination invariant and rotation invariant. The experimentation is done with the help of UBIRIS database. The experimental result shows that the proposed sclera recognition method can achieve better accuracy than the previous methods.

Keywords: Biometric, Sclera recognition, Histogram of Oriented Gradients (HOG), bilinear interpolation

I. Introduction

Biometric system is a pattern recognition scheme based on the physiological and behavioral features of an individual. Physiological characteristics that are tied up to the frame of the body include fingerprint, palm veins, facial expression recognition, palm print, hand geometry, retina, iris recognition, etc.... Behavioral characteristics that are tied up to the blueprint of the behavior of a person include typing, gait, voice etc.... Physiological characteristics are more stable than the behavioral characteristics. Biometric identification is unique to persons and they are more reliable than the previous identification techniques. The eyes are one of the most complicated human organs and we find lots of information by analyzing it. There are many research works done to differentiate human beings based on eye parts. Sclera is the opaque, white area and acts as a protective covering of the human eye. The sclera completely surrounds the eye. The vein patterns seen in the sclera region are unique to each person in visible wavelengths. So it is made as a biometric tool for human identification. Fig. 1 shows the sclera region and Fig. 2 shows the vein pattern. The thickness of sclera changes with the increase in the age of a person. By making this as automated system the features of the vein pattern should be extracted. The features extracted from the vein pattern are used for the matching purpose. When sclera recognition is compared with the iris recognition, sclera recognition has many advantages than the iris recognition. Some of the advantages of sclera recognition are: (1) Sclera recognition doesn't require capturing the images in the near infrared wavelength. This allows less imaging requirements like no need of NIR illuminators, images can be acquired from long distances. (2) Sclera recognition doesn't require frontal gaze images of the eye. (3) It doesn't require the position of the iris, i.e. off angle segmentation and recognition is also possible [1].

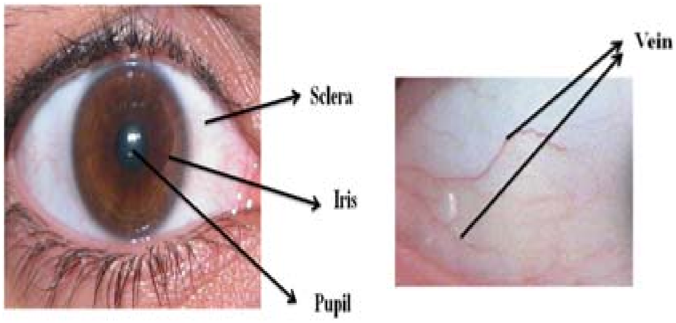

Fig. 1 Sclera region and its vein patterns

Sclera vein patterns are seen under visible wavelength. So the images acquired for sclera recognition doesn't use near infrared illumination. A database used for sclera recognition is the UBIRIS database. The UBIRIS database consists of images of iris recognition acquired in visible wavelengths. All the images are in color. The database consists of 1877 images captured from 241 users in two sessions. Its main aim is to introduce images with the several noise factors. The database is available with the multiple image resolution. Maximum image resolution is 800 x 600 pixels. In session 1, noise factors relative to reflections, luminosity and contrast of the images are minimized. In session 2, noise effects are introduced and large number of images is not in focus also. In both sessions, images are generally cropped such that eye is predominantly centered and eye region is well cropped [11]. The main aim of this study is to find a new biometric technology sclera recognition which gives more accuracy for human identification and prevents lots of security issues involved nowadays. In our work some new methods of feature extraction and matching technique are introduced.

II. Literature Survey

Many researches were conducted for the identification of human beings based on some unique biometric feature. Many studies are based on the pattern recognition techniques. But there are some problems in the identification of the previous recognition techniques. To solve these problems different solutions have been introduced for accurate recognition.

In 2012, Zhi Zhou, Eliza Yingzi Du, N. Luke Thomas, and Edward J. Delp presented a paper named `A new human identification method: sclera recognition [1]. In this paper identification is possible with the line descriptor based feature extraction, registration and matching method. In this work the segmentation errors and multilayered deformation effects are mitigated. Also, this method is useful for illumination, orientation and deformation invariant photos of the eye. It consists of four modules sclera segmentation, sclera vessel feature extraction, sclera vessel feature matching and matching decision. Segmentation is the beginning measure in the sclera recognition. They proposed fully automatic sclera segmentation method for both color and grayscale images. Steps of the sclera segmentation include: - estimation of the glare area, iris boundary detection, estimation of the sclera region in color and grayscale images and iris and eyelid boundary detection and refinement in sclera region estimation step. The sclera region in the color image is estimated using color based techniques and sclera region in the grayscale image is estimated using Otsu’s threshold method. The segmented sclera region is reflective. And then the vascular patterns in the sclera region are hard to understand. In order to make the method as illumination invariant, it is important to enhance the vascular patterns. This is performed with the help of Gabor filters. Next step is the line descriptor based feature extraction to get the features of vascular patterns. These line segments are used to create a template for vessel structure. The segments are described by three quantities, the segment angle to some reference angle at the iris center, the segment distance to the iris center, and the dominant angular orientation of the line segment. For matching, the proposed system can generate four results correctly matching, correctly not matching, incorrectly matching, and incorrectly not matching. The experimental result shows that sclera recognition is a promising biometric for positive human identification. The system can recognize the frontal looking images of human, off angle segmentation and recognition is a challenging task for this system. This is one of the main drawbacks of the system.

In 2008, Takuya Kobayashi, Akinori Hidaka, and Takio Kurita presented a paper named `Selection of Histograms of Oriented Gradients Features for Pedestrian Detection' [6]. For object recognition, Histograms of Oriented Gradients (HOG) are unitary of the well known features. The HOG features are estimated by determining the edge orientation histograms or edge intensity from a local area. The features from all local areas are combined and classified using linear Support Vector Machine (SVM) classifier. The Principal Component Analysis (PCA) applies to the obtained features of HOG to get the score vectors (PCA-HOG). These score vectors are taken using a stepwise forward selection (SFS) or a stepwise backward selection (SBS) to ameliorate the operation. The selected PCA-HOG feature vectors are used as an input of linear SVM to classify the input into pedestrian or non-pedestrian. The images used for detection is from the MIT pedestrian dataset.

In 2008, Mohammad Hossein Khosravi and Reza Safabakhsh presented a paper named ` Human eye sclera detection and tracking using a modified time adaptive self organizing map' [7]. In this paper a new method of sclera detection and tracking and its movements is done in a sequence of image based on modified time adaptive self organizing map (TASOM) based on active contour models (ACMs). The method starts with skin-color segmentation followed by eye strip localization via a novel morphological method. Next, localization of the eye components such as iris, eyelids, and eye corners is carried out. Eye features such as the iris center or eye corners are detected through the iris edge information. TASOM-based ACM is used to draw out the interior boundary of the eye. In the end, by tracking the changes in the neighborhood characteristics of the eye-boundary estimating neurons, the eyes are cut through effectively. This paper presented a fresh method for determining the neuron used, a new definition for unused neurons, and a novel method of feature selection and application to the network. Experimental results demonstrate a very dependable execution of the proposed method in general.

R. Derakhshani, A. Boss and S. Crihalmeanu in 2006 presented a paper named ` A new biometric modality based on the conjunctival vasculature'[8]. In this paper author introduced a conjunctival vasculature feature for the identification. Conjunctival vessels are seen in the visible part of the sclera. These vessels are well seen in the visible light. In this paper, the author discusses about the conjunctiva imaging, preprocessing and feature extraction to derive a suitable conjunctival vascular feature for biometric authentication. The conjunctiva is a fragile, transparent, and moist tissue that crosses the outer surface of the eye. The portion of the conjunctiva that covers the inside lining of the eyelids is called palpebral conjunctiva, and the character that spreads over the outer surface of the eye is called ocular conjunctiva, which is the focal point of this work. The ocular conjunctiva is very fragile and readable; thus the vasculature (including those of the episclera) is well visible through it. Scleral vascular scans have the immediate benefit of adding precision and security to existing iris biometric systems. An experimental result shows that the conjunctiva vasculature is a good biometric measure of human recognition.

Anil K. Jain, Arun Ross, and Sharath Pankanti presented a paper named ` Biometrics: A Tool for Information Security' in 2006 [9]. In this paper, the introduction about the biometric for human identification is described. The demand for true certification of human existence has increased a great deal. Biometrics are a basic tool of identification based on the physical and behavioral characteristics of individuals. Biometric systems have now been deployed in various commercial and forensic applications as a means of making identity. This report provides an overview about biometrics and discusses some of the salient research issues that need to be addressed in making biometric technology an effective legal document for providing data security. The primary contribution of this overview includes: 1) examining applications where biometrics can solve issues pertaining to the information security; 2) enumerating the fundamental challenges encountered by biometric systems in real-world applications; and 3) discussing solutions to address the problems of scalability and security in large-scale authentication systems.

III. Proposed System

The proposed sclera recognition consists of five steps which include sclera segmentation, vein pattern enhancement, feature extraction, feature matching and matching decision. Fig. 2 shows the block diagram of sclera recognition. Two types of feature extraction are used in the proposed method to achieve good accuracy for the identification. The characteristics that are elicited from the blood vessel structure seen in the sclera region are Histogram of Oriented Gradients (HOG) and interpolation of Cartesian to Polar conversion. HOG is used to determine the gradient orientation and edge orientations of vein pattern in the sclera region of an eye image. To become more computationally efficient, the data of the image are converted to the polar form. It is mainly used for circular or quasi circular shape of object. These two characteristics are extracted from all the images in the database and compared with the features of the query image whether the person is correctly identified or not. This procedure is done in the feature matching step and ultimately makes the matching decision. By using the proposed feature extraction methods and matching techniques the human identification is more accurate than the existing studies. In the proposed method two features of an image are drawn out.

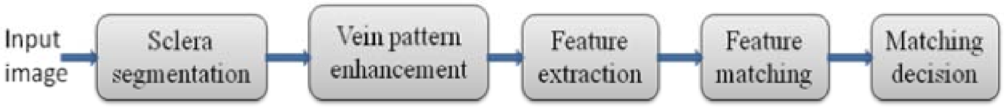

Fig. 2 Block diagram of Sclera recognition

A. Sclera segmentation

Sclera segmentation is the first step in the sclera recognition. It lets in three steps: glare area detection, sclera area estimation and iris and eyelid detection and refinement. Fig. 3 shows the steps of segmentation.

Fig. 3 Steps of Segmentation

Glare Area Detection: Glare area means a small bright area near pupil or iris. This is the unwanted portion on the eye image. Sobel filter is applied to detect the glare area present in the iris or pupil. Simply it runs only for the grayscale image. If the image is color, then it needs a conversion to grayscale image and after that apply it to the Sobel filter to detect the glare area. Fig. 4 shows the result of the glare area detection [1].

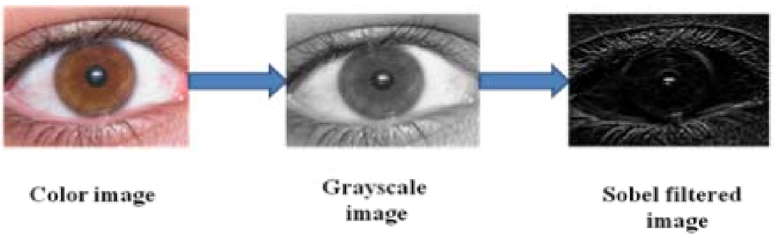

Fig. 4 Glare area detection

Sclera area estimation: For the estimation of sclera area Otsu's thresholding method is applied. The stairs of the sclera area detection are: selection of the area of interest (ROI), Otsu's thresholding, sclera area detection. Left and right sclera area is selected based on the iris boundaries. When the region of interest is selected, then apply Otsu's thresholding for obtaining the potential sclera areas [1]. The correct left sclera area should be placed in the right and center positions and correct right sclera area should be placed in the left and center. In this way non sclera areas are wiped out.

Iris and eyelid refinement: The top and underside of the sclera regions are the limits of the sclera area. And then that upper eyelid, lower eyelid and iris boundaries are refined. These altogether are the unwanted portion for recognition. In order to eliminate these effects refinement is done in the footstep of the detection of sclera area. Fig. 5 shows after the Otsu's thresholding process and iris and eyelid refinement to detect right sclera area [1]. In the same way the left sclera area is detected using this method.

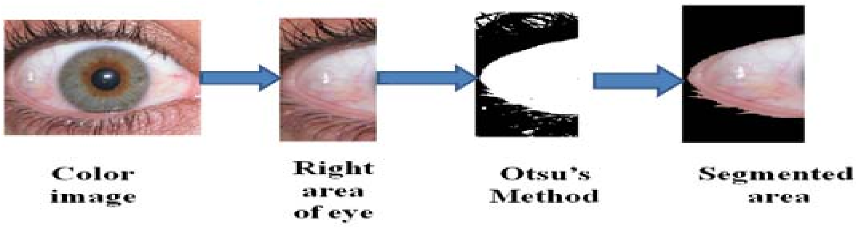

Fig. 5 Detection of the sclera area

In the segmentation process all images are not perfectly segmented. Hence, feature extraction and matching are needed to reduce the segmentation fault. The vein patterns in the sclera area are not visible in the segmentation process. To get vein patterns more visible vein pattern enhancement is to be performed.

B. Vein Pattern Enhancement

The segmented sclera area is highly reflective so vessel structure seen in the sclera region is difficult to see. To reduce these illumination effects and establish it as an illumination invariant system, it is important to raise the vein pattern. Gabor filters are used to the enhance vein pattern in the sclera. Referable to the multiple orientations in the vein pattern, a bank of Gabor filter is used for vein pattern enhancement. The image of the detecting sclera region is filtered with the Gabor filters with different orientations [1].

$$I_F(X,Y,Y,S) = I(X,Y) * G(X,Y,Y,S) \qquad (1)$$

where I (x, y) is original intensity image, G (x, y, υ, s) is the Gabor filter and I_F (x, y, υ, s) is the filtered image with different orientation `θ' and scale `s'. All the filtered images in the database are fused together to get the vessel boosted image. In the Fig. 6 Gabor enhanced image is shown.

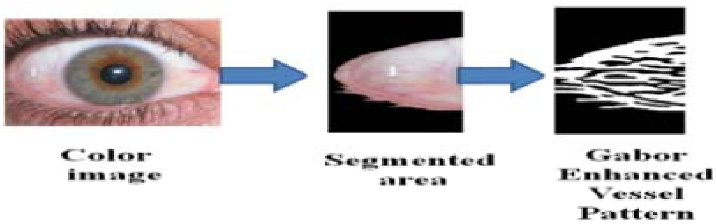

Fig. 6 Gabor enhanced vein pattern

Vein pattern have different thickness at different times, this is because of dilation and constriction of vessels. In order to avoid this effect morphological operations are used. Morphological operations can thin the detected vessel structure and remove the branch points. Fig. 7 shows the image after the morphological operations

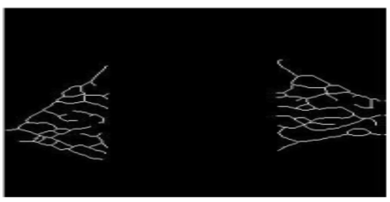

Fig. 7 Morphological operations

C. Feature extraction

Feature extraction is mainly applied in pattern identification in image processing to reduce the dimension of an image. When an image is directly utilized for processing, it is very hard to treat the large input data of an image. And then that input data are transformed to its reduced form of features which is experienced as the feature vector. When input information is transformed into set of features is known as the feature extraction.

In the proposed scheme, two characteristics are taken out from the vein pattern of the sclera region. They are Histogram of Oriented Gradients (HOG) and converting rectangular image into its polar form using bilinear interpolation.

Histogram of Oriented Gradients: Histogram of oriented gradients is the feature descriptors. It is primarily applied to the design of target detection. In this paper, it is applied as the feature for human recognition. In the sclera region the vein patterns are the edges of an image. So, HOG is used to determine the gradient orientation and edge orientations of vein pattern in the sclera region of an eye image. To follow out this technique first of all divide the image into small connected regions called cells. For each cell compute the histogram of gradient directions or edge orientations of the pixels. Then the combination of different histogram of different cell represents the descriptor. To improve accuracy, histograms can be contrast normalized by calculating the intensity from the block and then using this value normalizes all cells within the block. This normalization result shows that it is invariant to geometric and photometric changes. The gradient magnitude m(x, y) and orientation θ(x, y) are calculated using x and y directions gradients dx (x, y) and dy (x, y) [6].

$$M(X,Y) = SQRT\ (DX(X, Y)^2 + DY(X, Y)^2\ ) \quad (2)$$

$$\theta(X, Y) = TAN^{-1}(DX\ (X, Y) / DX\ (X, Y)\ ) \quad (3)$$

Orientation binning is the second step of HOG. This method utilized to create cell histograms. Each pixel within the cell used to give a weight to the orientation which is found in the gradient computation. Gradient magnitude is used as the weight. The cells are in the rectangular form. The binning of gradient orientation should be spread over 0 to 180 degrees and opposite direction counts as the same. In the Fig. 8 depicts the edge orientation of picture elements. If the images have any illumination and contrast changes, then the gradient strength must be locally normalized. For that cells are grouped together into larger blocks. These blocks are overlapping, so that each cell contributes more than once to the final descriptor. Here rectangular HOG (R-HOG) blocks are applied which are mainly in square grids. The performance of HOG is improved, by putting on a Gaussian window into each block [10].

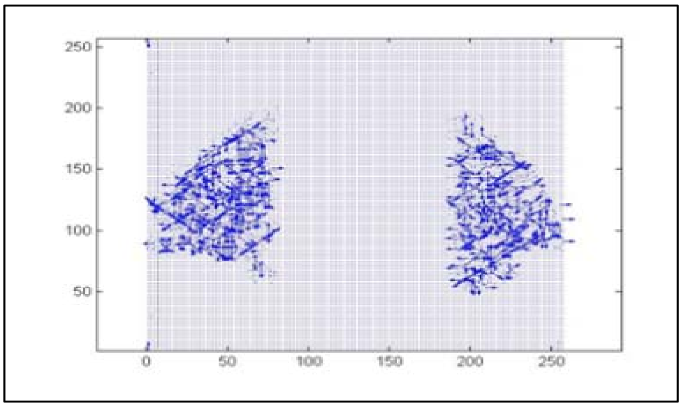

Fig. 8 HOG features

Rectangular to Polar Conversion: In the modern vision systems, images are seized and stored in a two dimensional array of data elements which are arranged in Cartesian or rectangular space having x and y coordinates. When the picture data is treated, it becomes more computationally efficient and so it requires a conversion of rectangular data to polar data in terms of radius `R' and angle `θ' coordinates. Applications are where such conversion is useful for the object in circular or quasi circular shape. This representation allows for a unique analysis of image similarity. This method is practiced as the second method of feature extraction in the proposed method. Its primary advantage is that it gives rotation invariant effect. Thus the man can be perfectly identified using this method itself. Firstly, the rectangular coordinate system of the image is changed over to the polar coordinate. In rectangular coordinate system image is represented along the x and y coordinate. But when it is converted into the polar image, it uses the x value for `R' (distance from the center) and y value to represent the angle `θ'. Then it forms a new coordinate space. Interpolation is the method of constructing new data points within the range of a discrete set of known data points. There are various types of interpolation techniques present [4]. From that, bilinear interpolation is used to find the correct value on the new grid. Bilinear interpolation generates an image of smoother appearance and computation time is also less. Its main advantage is that it is easy and simple to implement. Fig. 10 shows the conversion from rectangular to polar form using bilinear interpolation.

Fig. 9 Conversion of Rectangular to Polar form

D. Feature Matching

Feature matching is an important and final step in the recognition process. The decision making is done with the result of feature matching. In the proposed method the two types of features are used to get the desired result, to see whether the result says that the person is correctly identified or not. This is done with the help of features extracted from the vein patterns seen in the sclera region. The proposed sclera matching is done in two steps: training the set of images in the database and test with the query image and see whether the image is similar or not. The characteristics of all the images present in the database are trained and stored in the new file. Then, for testing, the feature of the query image is evoked. Then the distance is evaluated to obtain the similarity measure with the norm distance calculation method. This is performed by measuring distance between all the images in the database called the norm distance matching. Norm specifies the size of each vector. It is calculated by measuring the norm between two feature vectors [14].

$$D = \mathrm{Sqrt}\{\{X_2\text{-}X_1\}^2 + \{Y_2\text{-}\ Y_1\}^2\} \quad (4)$$

In a norm based system, the sclera is recognized by the distance from the norm of the database images. The test images are recognized by computing norm vector of the probe to the population norm and matching this vector to the database of similarity formed norms.

IV. EXPERIMENTAL RESULTS

The performance of sclera recognition is evaluated in the feature matching process. Test results are obtained for sclera recognition, which it is more accurate than the other methods of biometric identification of people. In this case false accept rate and false match are minimized. For this the proposed system provides more precise designation. These experimental results help to confirm that the sclera vein patterns are unique to each individual and recognition is more possible with this method. Firstly, the images in the database are trained, that means extract the features of all images present in the database. And so, the query image is tested for matching. From this step whether the person is correctly matched or not can be recognized. The proposed method yields a more beneficial outcome that it can identify people in off angle position. The existing method tries to identify only in the frontal looking images. These can be completely rectified in this arrangement, and the person can be identified when there is just a minor portion of sclera region visible. When a person looks normally to the camera, then it results in perfect identification in the previous systems also. The Fig. 10 indicates the matching of normal eye looking into the camera and its distance measure. The maximum value from the graph shows the correctly identified image. The maximum value is getting by taking norm distance measure between the features of the query image and images present in the database, in which the minimum distance shows the recognized person. The maximum value is getting by taking the reciprocal of the minimum value. From the graph image 8 in the database is the correctly identified person.

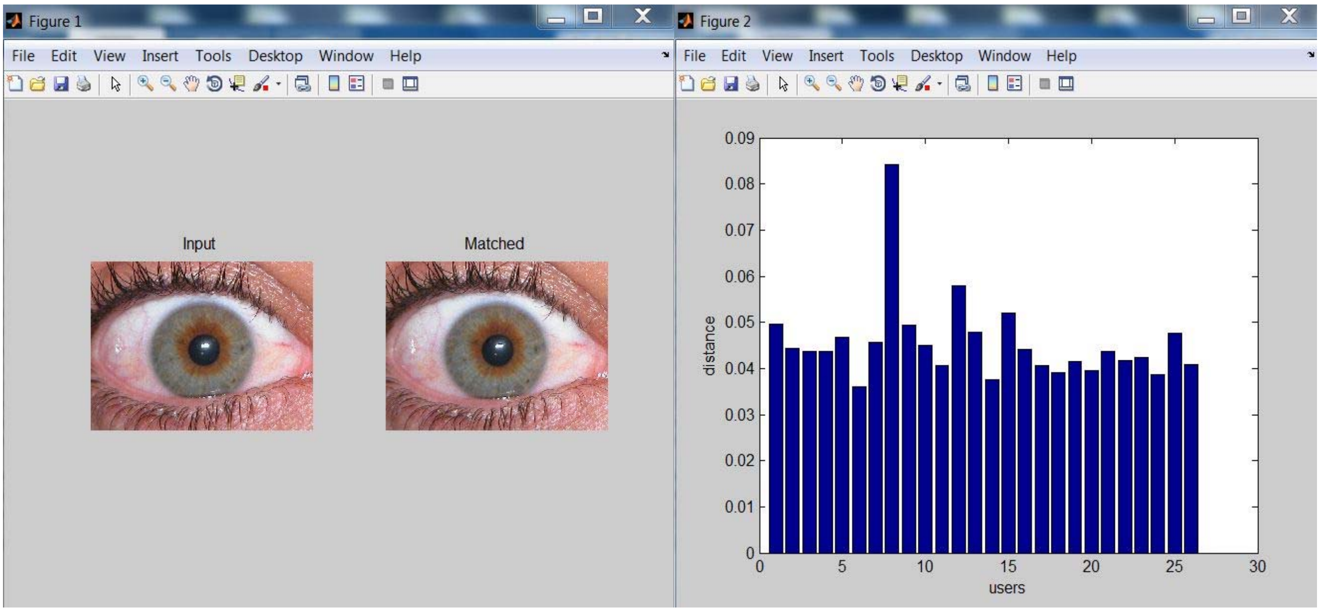

Fig. 10 Matching result of normal eye

The performance of the system cannot be affected by the poor quality images. Here the system can identify the low quality images like off angle, motion blur and lighting. The images which are not the frontal looking image they are of also available for testing. To judge the effect of off angle images, train the recognition system on frontal view images and test on the off angle image. When there is any arbitrary rotation of eye images, then the identification is possible with the proposed feature extraction method called interpolation technique. This feature extraction method extracts feature of the converted polar image and this feature brings the system as rotation invariant. The rotation variant problem is a crucial situation for recognition. For this transformation the image from rectangular or Cartesian image to the polar form, then the feature from the images are extracted. These feature vectors are invariant to the cyclic shifts of the input vector. Thus, this method gives good result of invariant rotations of input image. Fig. 11 shows the identification result of off angle image and its distance measure. From the graph, the image 14 is the correctly identified person in the database.

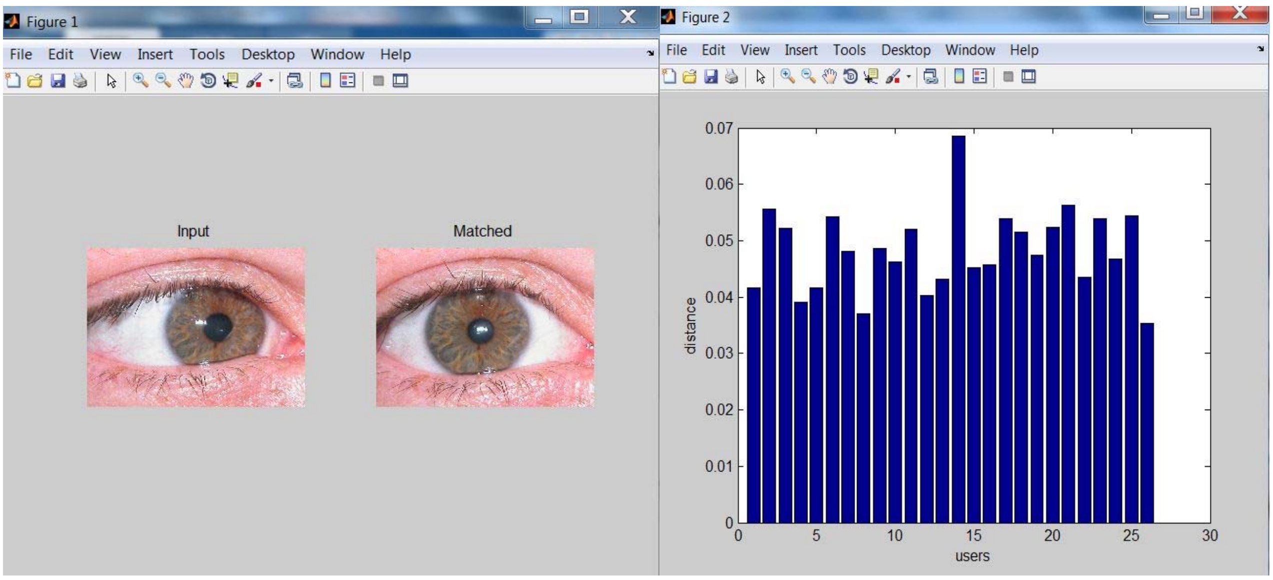

Fig. 11 Matching result of off angle image

Motion blur can result either from the relative motion of an object or relative motion of the camera during exposure time. The Fig. 12 shows the recognition of image in motion blur, which means the movement of the upper eyelid that causes blurred images. In that case a diminished share of the sclera is visible in the picture. Then also perfect identification is possible with these feature extraction techniques. The graph shows the image 4 in the database is the recognized person which has the maximum value.

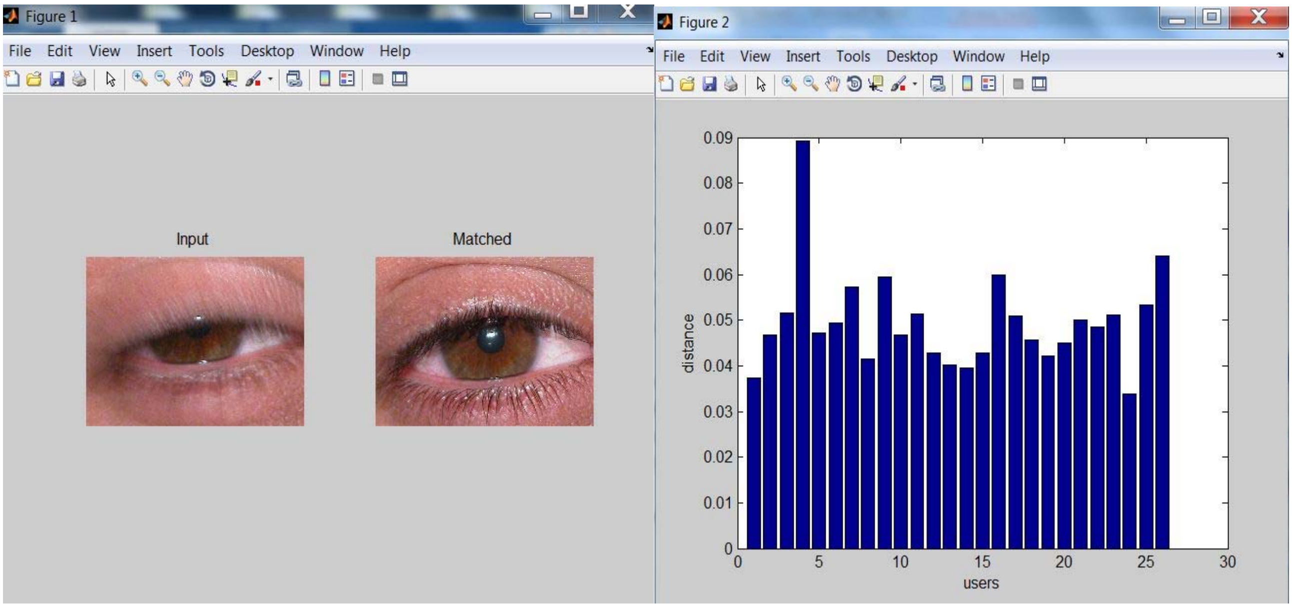

Fig. 12 Matching result of motion blurred image

Sclera recognition under varying lighting conditions is a challenging problem. In order to eliminate these effects, need of illumination invariant features is necessary. The Histogram of Oriented Gradients (HOG) can work out these troubles. The illumination normalization is performed with the help of these features. Train the images in the database. The beginning measure of training involves preprocessing. Only in this case the preprocessing step is totally wiped out by the HOG process. It normalizes the illumination effect in its process itself. The remaining steps are the feature extraction from the trained image and store it in a new file. The testing also has same steps. The preprocessing stage is eliminated from it and extracts the features of the input image for recognition. Fig. 13 shows the matching result under various lighting conditions and its matching is shown by the maximum value. The image 4 is the recognized person from the database.

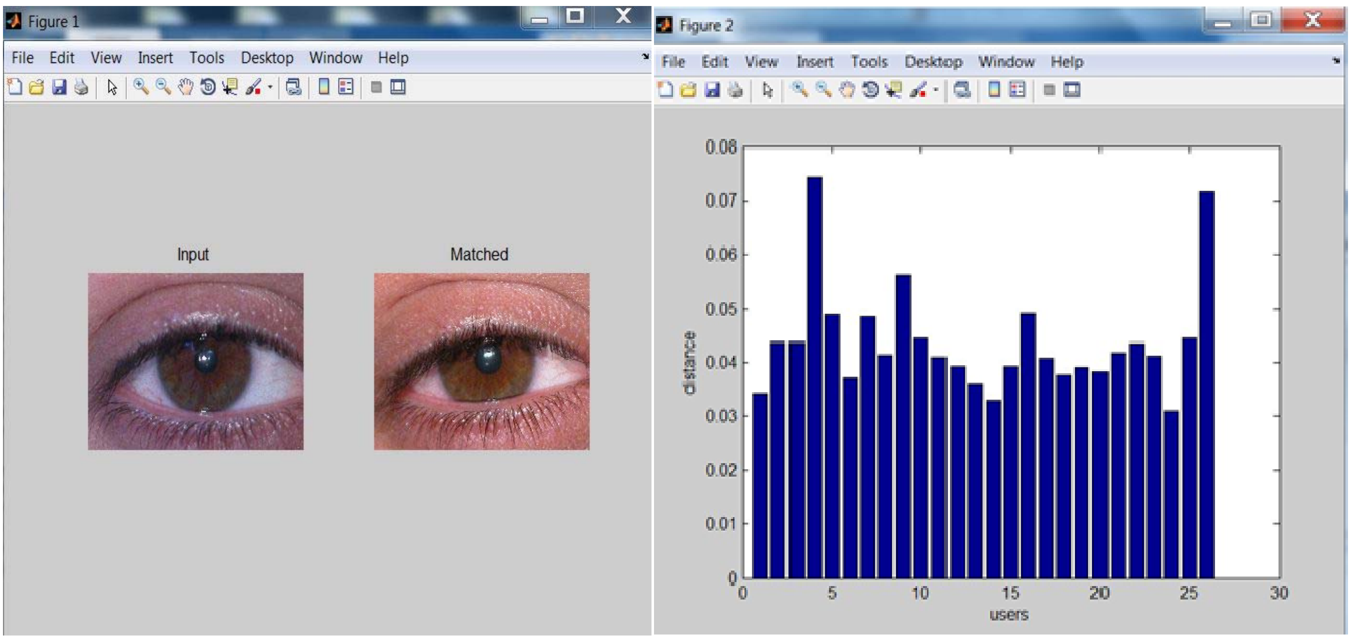

Fig. 13 Matching result under different lighting

The drawbacks of the existing system are rectified using the new feature extraction and matching methods. The existing system considering only about the frontal looking eye images. This drawback is eliminated by the proposed system and from the small portion of the sclera region itself the identification is done perfectly with the few detected veins. This builds it as a promising biometric for human recognition. All the experiments are done with the images in the database of UBIRIS.

V. Conclusion

In this work, a completely automated system is developed that can accurately authenticate individuals based on their sclera vein patterns. The proposed method outlooks the perfect identification when a diminished region of sclera vein pattern is visible. The existing system focused only on the frontal looking sclera recognition; where off angle iris image segmentation and recognition are challenging topic. These two problems in the existing system are rectified using the proposed system. When an image is captured for testing, it will not be the same image as the images in the database. The location of the iris may change. So off angle recognition of the image is also an important task. Sometime, only one portion of the sclera is visible and the other part is covered with the iris, so segmentation is possible only for one portion and from that area the vein patterns are extracted. With these vein patterns recognition is possible. This proves the system is rotation invariant. The images acquired in the recognition process are from the UBIRIS database. These types of images are captured in visible light. This will increase the usable range of biometric systems in surveillance and non-compliant situations. The normalization of images is possible in the extraction of features using Histogram of Oriented Gradients (HOG). Thus, preprocessing step is totally rejected in this scheme and the system becomes illumination invariant. The experimental result shows that the suggested scheme can improve the accuracy of recognition and make the sclera recognition a viable choice for non-compliant recognition applications.

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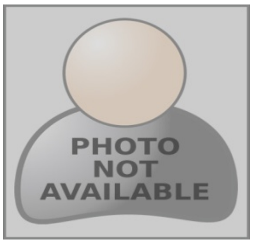

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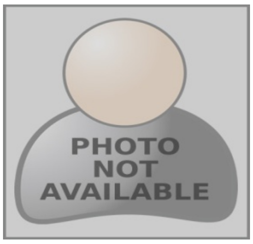

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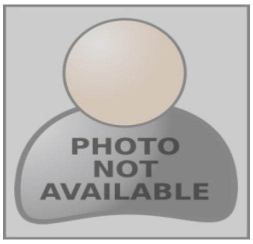

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