ISSN (Print) : 0974-6846
Indian Journal of Science and Technology, Vol 8(19), DOI: 10.17485/ijst/2015/v8i19/61512, August 2015 ISSN (Online) : 0974-5645

An Innovative and Effective Approach for Sclera Detection

S. Athira, Shilpa Gopal, G. H. Gowri Krishna and Shriram K. Vasudevan*

Department of Computer Science and Engineering, Amrita School of Engineering, Amrita Vishwa Vidyapeetham (University), Coimbatore - 641 112, Tamil Nadu, India; athira.sakunthala@gmail.com, shilpag32@gmail.com, gowrihari16@gmail.com, Kv_shriram@cb.amrita.edu

Abstract

Background/Objectives: Providing security to systems is one of the major challenges faced in day-to-day life. Biometrics plays a vital role in ensuring security. Out of the different existing recognition systems available - namely face, finger, gait, retina and so on, sclera recognition system gives out better performance. Sclera is the white part of the eye, which is unique and consistent in nature because of which it is chosen for recognition. In this paper, we analyzed the existing sclera recognition system with both human and animal eye images. **Methods/Statistical Analysis:** In this paper, we compared the performance of the algorithm with both human and animal eye images. The animals we considered for the algorithm analysis include deer, buffalo and lion. Human eyes are the most observable due to the presence of more sclera area. The blood vessel patterns present in the sclera region are stable over lifetime and unique person by person, thus making it appropriate for identification. The results show that the algorithm works better for human eye. **Results/Findings:** In this paper, we compared the extracted input vessel structure with that in the database and verify whether the input is authorized or not. It is observed that the system underperforms for animal eye images, whereas it shows an acceptable performance with human eye images. **Conclusion/Application:** The results prove that the algorithm works satisfactorily for identifying human. It can be incorporated with other recognition systems to build up a multimodal biometric system that can provide better security than the existing systems.

Keywords: Biometrics, Feature Extraction, Sclera, Segmentation

1. Introduction

Biometrics involves identification of humans using their physiological, biological and behavioral features[1]. The two main broad categories of biometrics are static and dynamic. Static biometrics uses physiological features like face, iris, fingerprint which are static in nature whereas dynamic biometrics uses the behavioral traits such as gait, signature, speech which are dynamic in nature. Every biometric has its own merits and demerits. Not all biometrics is perfect. The main challenge faced in facial recognition is the changes that occur in face as years pass by. In the case of fingerprint recognition, the recognition process is restricted to the proximity of the machine which is one of the major drawbacks. Iris recognition is considered to be the mostly accepted recognition system but it requires NIR illumination to capture the images of eye because of which it is not suitable to use in some real time applications in remote areas. Sclera recognition is a new approach which provides comparable accuracy with that of iris. Unlike iris system that uses NIR illumination, sclera recognition system uses visible wavelength illumination for image capturing, making it more efficient.

Sclera, the white part of the eye, which is opaque and fibrous acts as a protective layer for the eye that comprises of collagen and elastic fibers. The representation is shown below in Figure 1.

Over time, the collagen and elastic fibers degrade which results in the dehydration of sclera and the

*Author for correspondence

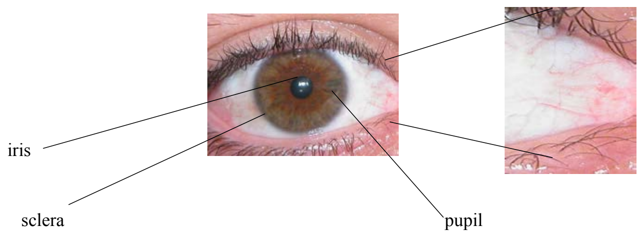

Figure 1. Sclera image.

accumulation of lipids and the other salts like calcium salt, etc. But the blood vessel patterns remain the same throughout. Because of its uniqueness and stability, it is considered as a better metric for human identification.

2. Existing Systems

In Quick Response codes[4], sclera is embedded as an authentication method. These barcodes which are of two dimensional nature hold more data and can be read faster with the help of devices like mobile phones, tablet PCs. These QR codes along with Biometric provide an authentication system which performs very fast. Mobile ticketing is the application where this approach can be suitably applied. For two factor authentication, cancelable sclera templates are incorporated in Quick Response codes.

Since the system uses visible light for image capturing, this system contributes to surveillance systems. It can be also combined with other existing biometric systems to form a much stronger multimodal system.

3. Proposed System

The proposed system includes five phases: sclera segmentation, sclera vessel pattern enhancement, sclera feature extraction, feature matching and matching decision[2]. In sclera segmentation phase, only the required sclera area is segmented from the input image. After enhancing the segmented image, vein patterns are extracted. The vein patterns are chosen as features for the identification purpose. These features are matched with that in the database and the matching decision is made. The architecture of proposed system is presented below in Figure 2.

4. Sclera Segmentation

Segmentation is the technique of dividing the digital image into multiple segments. Here, the input eye image is segmented to obtain the required sclera region. Before

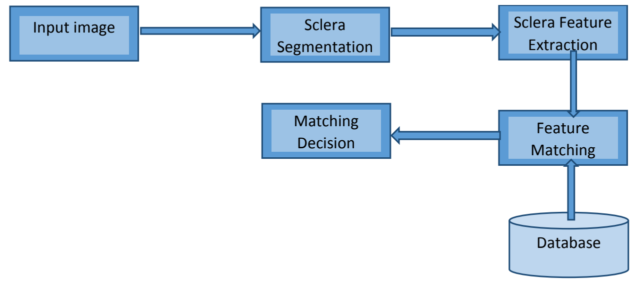

Figure 2. Sclera recognition system.

segmenting the input image, it is recommended to perform glare area detection and noise removal so as to improve the quality of segmentation. Glare area detection can be performed by using Sobel filter and Salt and Pepper algorithm can be used to remove certain noises in the image. Segmentation phase is represented in Figure 3.

In order to estimate the potential sclera areas, color distance map for both natural and flash illuminators are used. For natural illumination, the color distance map is given by:

$$\mathrm{CDM1} = \begin{cases} 1, & \begin{array}{c} R > 95, G > 40, B > 20 \\ \max(R,G,B) - \min(R,G,B) > 15 \\ |R-G| > 15, R > G, R > B \end{array} \\ 0 & else \end{cases}$$

For flash illuminators, the color distance map is given by:

$$\mathrm{CDM2} = \begin{cases} 1, & \begin{array}{c} R > 220, G > 210, B > 170 \\ \max(R,G,B) - \min(R,G,B) > 15 \\ |R-G| < 15, R > B, B > G \end{array} \\ 0 & else \end{cases}$$

The sclera map is used to map the sclera area in the segmented image.
The calculation of sclera map is done by combining the two color distance maps:

Original image | Segmented gray scale image | Segmented color image

Figure 3. Segmentation phase.

$$S1(x,y)=\begin{cases}1, & CDM^1(x,y) \text{ OR } CDM^2(x,y)=0\\ 0, & \textit{else}\end{cases}$$

5. Vessel Pattern Enhancement

Since the sclera area is reflective, the vascular patterns appear to be blurred. So, it is difficult to extract the vein structures from the region. To remove this effect, we use Gabor filters[3].

6. Feature Extraction

In this phase, we extract the features from the enhanced image which is used for further processing. For extracting the feature we considered each vein structure as a line segment.

Templates for vessel structures are created using these line segments. Template is the collection of all segments' descriptors.

Three quantities that describe the segments are:

Angle made by the segment to the iris center

Distance of the segment from the center of the iris

Angular orientation of the line segment

Let S be a descriptor, then it is denoted as $S = (\theta, r, \Phi)^T$ and each component is defined as

$$\Theta = \tan^{-1}\left(\frac{y_a - y_i}{x_a - x_i}\right)$$

$$R = \sqrt{(y_a - y)^2 + (x_a - x)^2}$$

$$\Phi = \tan^{-1}\left(\frac{\delta(f\,\text{line}(x))}{\delta x}\right)$$

where fline (x) is polynomial approximation of the segment, (x_a, y_a) is center of the segment, (x_0, y_0) is the iris center.

7. Feature Matching

Feature matching is the final phase of the system. Based on the feature matching result, we come to a conclusion about the authorization of the person. Initially the system is trained with images in the database. The database used is UBIRIS. While testing with query image, the features extracted are compared with those in the database. Results from the comparison can be used to check the authorization of the subject

8. Database used

The database used is UBIRIS[5] which consists of 1877 colored eye images of 241 users. It consists of two different sessions where the first session comprises of 1214 images and second session contains 663 images. The factors like contrast, reflection, luminosity that cause noise are alleviated in first session. In session 2, the images were taken in natural illumination which led to the appearance of heterogeneous images in accordance with focus related problems, contrast, reflection and luminosity.

Since there is no online database available for animal eyes, we chose Google images. We resized the Google images to match the size of the image in the database (800×600).

9. Flowchart

A flow chart will be handy to represent the working and is presented below in Figure 4.

10. Experimental Results

On applying the algorithm on both human and animal dataset, it is observed that the algorithm performs much better in the case of human eye images.

The screenshot obtained after applying the algorithm on the animal eye image is in Figure 5 and the Figure 6 represents the results for human eye.

The screenshot obtained after applying the algorithm on the human eye image is as follows:

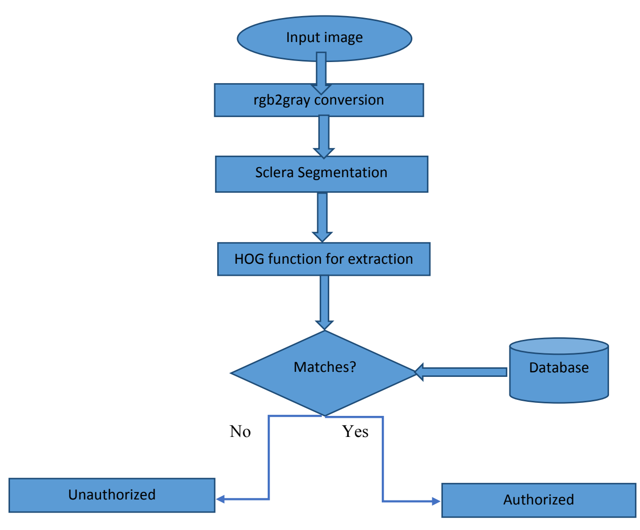

Figure 4. Working of the system.

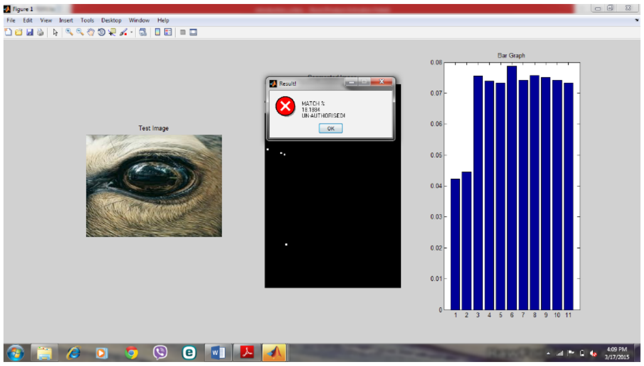

Figure 5. Result obtained for animal eye.

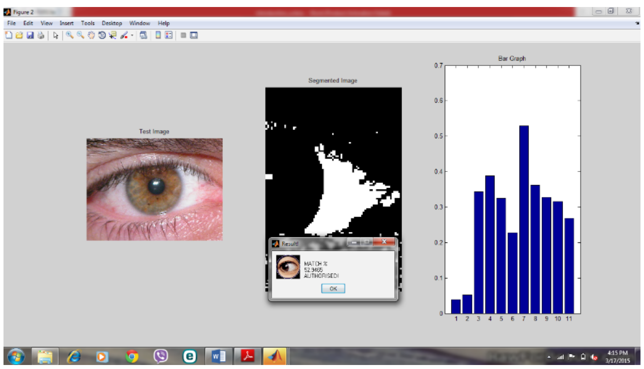

Figure 6. Result obtained for human eye.

11. Conclusion

In this paper, we analyzed the existing sclera recognition algorithm with two different datasets - human eye images and animal eye images. The results shows that the algorithm works acceptably well with human eyes. The performance of the algorithm is very poor with animal dataset as their eyes have less sclera coverage. From the results, we can conclude that the sclera recognition algorithm is a promising approach for human identification.

Currently the system focuses on frontal looking eye images. In future it can be extended by considering the images of eyes gazing at different angles.

12. References

1. Zhou Z, DuEY, Delp EJ. A new human identification method: sclera recognition. IEEE Transactions on Systems, Man and Cybernetics. 2012 May; 42(3):571–83.
2. Maxwell EG, Tripti C. A comparison between contrast limited adaptive histogram equalization and gabor filter sclera blood vessel enhancement techniques. International Journal of Soft Computing and Engineering (IJSCE). 2013 Sep; 3(4):22–5. ISSN: 2231-2307
3. Sreelakshmi KJ, Therese YM, Shanmuganathan KL. Human identification based on the pattern of blood vessels as viewed on sclera using hog and interpolation technique. International Jounal of Advance Research in Computer Science and Management Studies. 2014 Sep; 2(9):285–95.
4. Brindha S, Vennila I, Nivedetha B. Secure user authentication using sclera in quick response codes. International Journal of Engineering and Technology (0975 – 4024). 2013 Oct; 5(5):4199–205.
5. Proenca H, Alexandre LA. UBIRIS: a noisy iris image database. Proceedings 13th International Conference Image Analysis and Process. 2005; 3617: 970–7.
6. Sreelakshmi KJ, Therese YM. Human identification based on the histogram of oriented gradients. International Journal of Engineering Research and Technology (IJERT). 2014 Jul; 3(7): 1611–4.