Sclera Vein Recognition Using Different Matching Techniques

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ABSTRACT

The vein structure in the sclera, the white and opaque outer defensive covering of the eye, is anecdotally stable over time and unique to each and every person. As a result, it is well-matched for use as a biometric for human apperception. In this paper, we propose a new method for sclera recognition with the following contributions: First, we elaborating a color-based sclera region computation scheme for sclera segmentation. Second, we designed a Gabor wavelet based sclera pattern augmentation method, and an adaptive thresholding scheme to underscore and binarize the sclera vein patterns. Third, we proposed a line descriptor based registration, trait extraction, and matching routine that is scale-, orientation-, and distortion-invariant, and can moderate the multi-layered deformation effects and tolerate segmentation error. It is objectively proved using the IUPUI multi-wavelength databases and UBIRIS that the proposed method can perform accurate sclera recognition. In furthermore, the identification results are compared to iris recognition algorithms, with very similar outcomes.

Index terms: opaque, anecdotally, UBIRIS, IUPUI, sclera recognition

1. INTRODUCTION

Biometrics is the detection of humans using intrinsic physiological, biological, or behavioral features, traits and habits. Biometrics have the potential to provide this desired ability — to unambiguously and discretely identify a person's identity— more accurately and conveniently than other options. Examples of biometric modalities embrace face, iris, hand, fingerprint, gait, typing, speech, and others. For users, biometric systems can reduce or eliminate the need to retain a key or remember a password, can speed up user throughput, and can be less intrusive. For example, at a border or security turnpike, a biometric system could provide a high-buoyancy identification of a user while they walk through a checkpoint rather than requiring them to stop, produce some detection, and be interviewed by security personnel. From a system standpoint, biometric systems can check much larger databases than are realistic with traditional security systems, are more harmonious, do not have ethnic or personal biases, and can be cheaper to operate.

2. SCLERA VEIN RECOGNITION

Sclera recognition is identification of a human using the sclera, the 'white of the eye.' It offers several benefits over other eye-based biometrics that makes it well-suited for non-compliant recognition situations. The sclera completely mounts the eye, and is made up of four layers of tissue — the episclera, stroma, lamina fusca, and endothelium [2]. The conjunctiva is a clear mucous membrane, made up of epithelial tissue, and comprise of cells and casual basement membrane that covers the sclera and lines the inside of the eyelids[3]. In general, the conjunctival vascular is hard to see with the naked eye at a distance. For young children, the blood vessels in sclera area are to be blue, but for adults, the blood vessels are in red color. The composition of the blood vessels in the sclera are well suited to be used as a biometric — they are an internal organ that is visible with no undue difficulty and they are anecdotally stable over time and unique for each person [2],[4]. Therefore, the vein patterns in the sclera could be used for positive human identification. In previous works, identification of users using the sclera region has been referred to as 'conjuctival vasculature perception' [5]. However, as the conjunctiva is the top-most transparent layer of the sclera and images of the sclera region capture more than just this top-most layer, it is more precise to refer to the system as performing 'sclera recognition.'

3. SCLERA RECOGNITION DATABASES

Sclera vein archetype are not readily visible under near-infrared illumination, the normal illumination for iris perception algorithms, only iris vision databases that are assimilated under visible light illumination are potentially useful for sclera vein recognition applications. In this research, two databases are used – the UBIRIS databank and the IUPUI multi-wavelength databank.

3.1. UBIRIS Database

The UBIRIS database [6] is a publicly available database with iris images acquired in color. The databank consists of 1877 images acquired from 241 users acquired in two sessions. The images are predominately frontal stare. The database is available with multiple image decree, with the maximum image decree being 800by 600 pixels. In first session, noise was minimized and the images were attempted to be acquired in focus. However, in second session, noise effects were not lessen, precinct light was not standardized, and a substantial number of the images have very poor focus. In both sessions, the images are generally cropped such that the eye is predominately pivoted and the eye province well-cropped in the images.The main focus of the UBIRIS database is to minimize the requirement of user collaboration, i.e., the analysis and proposal of approaches for the automatic recognition of individuals, using images of their vision captured at-a-distance and minimizing the required degree of cooperation from the users, most likely even in the covert mode. In the first session database, the primary difference between good and poor quality images is image focus and/or eyelid occlusion. For some images, the iris and sclera region are very poorly focused, which reduces the visual clarity of the image and in many cases makes the sclera vein patterns difficult, or impossible, to reliably identify by either automatic or manual methods. For the second session database, the images are of very poor quality for sclera recognition. The overall image quality is much worse, and much less consistent than in the first session database. In particular, the focus on the sclera region is very inconsistent, which makes the Second session database very poor for sclera recognition.

3.2. The IUPUI Multi-Wavelength Database

The IUPUI multi-wavelength database is an internally acquired database of video images of user's eye and the surrounding regions with different eye gaze-angles, illumination wavelengths, and ambient illumination levels. The database is composed of 45 users, with two videos acquired of each user with at least 1 week of time between acquisitions. For each session, 32 videos were acquired – 8 different illumination wavelengths (420, 470, 525, 590, 610, 630, 660, and 820 nm), with and without ambient illumination, and both the user's left and right eyes. For each video, the user was asked to direct their gaze to 6 different gaze locations (centered, up, left, left-up, right, and right-up) during the video. Each image was acquired at a resolution of 1280 by 1024 pixels, with the eye generally centered in the image. In general, the eye regions are around 1000 pixels in width, about 200 pixels more than the UBIRIS database's maximum eye width. Users were asked to limit their movement of head, but no restraints were used to otherwise limit their movement.

4. SCLERA MATCHING

The proposed sclera matching method uses a RANSAC-type registration algorithm to register the sclera vein descriptors, and the proposed sclera template matching method. The proposed sclera matching method is capable of matching the sclera vein patterns even in the presence of noise and deformations.

5. MATCHING SCHEMES

Many matching schemes have been proposed and used for previous biometric and pattern recognition applications. Some historical examples of matching schemes are presented, along with justification for their use or disuse.

5.1. Hamming Distance

Hamming distance is a distance measure for binary strings that measures the amount of similarity between two strings by measuring the number of bits that must be changed to make the two strings equivalent [7]. It is a common distance metric for biometrics, for instance Daugman's iris recognition algorithms. However, for this work, it is not used, because the feature vectors used are not binary.

5.2. Euclidean Distance

Euclidean distance is the distance among two vectors, and is commonly used as a simple metric for how similar two vectors are [8]. In this work, it is used as the primary measure of how similar two features are.

5.3. Spectral Angle Measure

Spectral angle measure is a commonly used measure of similarity in hyper spectral and multiple spectrum imaging that measures the similarity between hyper spectral signatures [9].

5.4. Information Distance

Information distance, or mutual information, is a measure of the dependence between two random variables [10], and can also be used as a distance metric for feature vectors.

6. SCLERA MATCHING TECHNIQUES

6.1. Sclera Template Registration

When acquiring the eye images, the eyelids can have distinct shapes, the iris location can differ, the pupil size can be different, and the eye may be tilted with respect to the camera. The camera-to-object distance and camera zoom can also fluctuate. All of these factors could affect the size, the location, and the observed patterns of the acquired sclera region in the image. It is important to take these variances into account in a sclera matching algorithm. Therefore, the first step is to perform Sclera region-of-interest, or ROI, registration to achieve global rendition, revolution and scaling-invariance. In addition, due to the complex deformation that can occur in the vein archetype, it is desirable to have a registration scheme that is robust and exhaustive, but does not unduly introduce false accepts by over-fitting. The sclera vascular patterns deform non-linearly with the movement of the eye, eyelids, and the contraction/dilation of the pupil. As a result, the segments of the vascular patterns could move individually, and this must be accounted for in the registration scheme.

A new method based on a RANSAC-type algorithm was developed to estimate the best-fit parameters for registration between the two sclera vascular pattern descriptors. RANSAC, or random sample consensus, is an iterative model-fitting method that can robustly fit to a model, even given noise [11]. To limit potential false accepts due to over-fitting, the patterns are registered as a set of points – the centers of the line segments that make up the template. The optimal registration used is the one that minimizes the minimum distance between the templates. This reduces artificially introduced false accepts because it does not register the patterns using the same parameters used for matching, so the optimal registration and optimal matching can, and probably will, be different for templates that should not match. For the registration algorithm, it randomly chooses two points – one from the test template, and one from the target template. It also randomly chooses a scaling factor and a gyration value, based on apriori knowledge of the database.

6.2 Sclera Template Matching:

It is important to design the matching algorithm such that it is tolerant of segmentation errors. In general, the edge areas of the sclera may not be segmented accurately; therefore the weighting image is created from the common regions of the two registered sclera masks — i.e., only regions that are included in the segmented sclera regions of both images are used for matching. Then, the interior pixels of the mask are set to 1, pixels within some distance of the boundary of the mask to .5, and pixels outside the mask to 0.

This allows for a contrasting value between two segments to be between 0 and 1, and allows for weighting the contrasting results based on the segments that are near the mask's boundaries. This reduces the effect of dissection slip, in particular for under segmentation of the boundary between the sclera and eyelids. For this work, the width of the boundary of the mask was set to the average width of the lower eyelid boundary in the database, in an attempt to reduce the effect of mis-segmented results near the boundary.

After the templates are itemized, each line segment in the test stencil is compared to the line segments in the target template for matches.

7. COMPARISON TABLE FOR SCLERA VEIN RECOGNITION

S.NO	TECHNIQUES	ADVANTAGE	DISADVANTAGE	EVALUATION
1	Sclera template registration	A new method based on a RANSAC-type algorithm was developed to estimate the best-fit parameters for registration between the two sclera vascular pattern descriptors.	It is desirable to have a registration scheme that is robust and exhaustive, but does not unduly introduce false accepts by over-fitting.	One could calculate the expected variance of the sclera size using the stand-off distance and capture volume. Using these values, it calculates a robustness value for the registration using these parameters.
2	Sclera template matching	It reduces the amount of segmentation errors and also it allows for overlapping vein patterns, multiple independent vein patterns are to be matched even as they change Independently.	The edge areas of the sclera may not be segmented accurately. The matching schemes that retain and use the 'crossing points' of the patterns could be problematic with this type of deformation.	The total matching score, , is the sum of the individual matching grooves divided by the maximum matching groove for the minimal set between the test and target template

8. ADVANTAGES

- Eye vein patterns are unique to each person [1]
- Patterns do not change over time, and are still readable with redness [1]
- Works with contacts and glasses
- Resistant to false matches

9. DISADVANTAGES

- Phone must be held close to face
- Not supported on devices with no cameras, nor on adult smart phones

10. CONCLUSION

A completely automated system was developed that can accurately identify individuals using their sclera vasculature patterns, with potential implementations as either a uni-modal configuration or as a multi-modal configuration with another biometric modality. The system can use visible light acquired images — which can be acquired at longer distances and in more varied operational environments than traditional iris recognition systems. The biometric system has the potential to expand the operational range of biometric systems in surveillance and non-compliant situations. These types of implementations could significantly increase the ability to maintain public security while being unobtrusive and user-friendly.

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The system uses a biometric modality, the sclera vasculature, which is well-suited to non-compliant situations — it is easily imaged in the visible frequencies, is difficult to hide or disguise, is difficult to forge, and is highly unique.

REFERENCES

[1] Derakhshani, R.; Ross, A. (2007). "A Texture-Based Neural Network Classifier for Biometric Identification using Ocular Surface Vasculature". International Joint Conference on Neural Networks (IJCNN, Orlando, FL, USA). doi:10.1109/IJCNN.2007.4371435. Retrieved 2014-03-22.

[2] C. W. Oyster, The human eye : structure and function. Sunderland, MA: Sinauer Associates, 1999.

[3] J. Daugman, "Probing the Uniqueness and Randomness of IrisCodes: Results From 200 Billion Iris Pair Comparisons," Proceedings of the IEEE, vol. 94, pp. 1927-1935, 2006.

[4] P. C. Y. Chen and B. W. Zweifach, "Network reorganization - human bulbar conjunctiva in aging and disease," Microcirculation, an update : proceedings of the Fourth World Congress for Microcirculation, vol. 2, 1987.

[5] R. Derakhshani, A. Ross, and S. Crihalmeanu, "A New Biometric Modality Based on Conjunctival Vasculature," Proc. of Artificial Neural Networks in Engineering, 2006.

[6] H. Proença and L. A. Alexandre, "UBIRIS: A noisy iris image database," 13th International Conference on Image Analysis and Processing, vol. Springer LNCS 3617, pp. 970-977, 2005.

[7] R. Hamming, "Error Detecting and Error Correcting Codes," Bell System Technical Journal, vol. 26, pp. 147-160, 1950.

[8] R. O. Duda, P. E. Hart, and D. G. Stork, Pattern Classification. New York: John Wiley & Sons, 2001.

[9] Y. Du, C.-I. Chang, H. Ren, C.-C. Chang, J. O. Jensen, and F. M. D'Amico, "New hyperspectral discrimination measure for spectral characterization," Optical Engineering, vol. 43, pp. 1777-1786, 2004.

[10] T. Cover and J. Thomas, Elements of Information Theory. Wiley-Interscience, 1991.

[11] M. A. Fischler and R. C. Bolles, "Random sample consensus: a paradigm for model fitting with applications to image analysis and automated cartography," Commun. ACM, vol. 24, pp. 381-395, 1981.

