ISSN: 2321-8169
5673 - 5677

Conjunctival Vasculature (CV) as a unique modality for authentication, using Steady Illumination Colour Local Ternary Pattern (SIcLTP)

Noorjahan Khatoon*
Dept. General Science & Computer Engineering,
Advanced Technical Training Centre (ATTC),
Bardang, East Sikkim,INDIA
njk_gtk@yahoo.com

Mrinal K Ghose
Dean (Academics) & Professor
Dept. of Computer Science & Engineering
Sikkim Manipal Institute of Technology
Majitar, East Sikkim, INDIA
mrinal.ghose@smu.edu.in

Abstract**—**it has been proved that a new biometric modality based on the patterns of conjunctival vasculature performs well in visible spectrum. The vessels of the conjunctiva could be seen on the visible part of the sclera; these vessels are very rich and contain unique details in the visible spectrum of light. In this paper we have explored the feature extraction technique for conjunctival vasculature using Steady Illumination colour Local Ternary Patterns(SIcLTP). The concept of LTP as argued in various earlier published papers is that, it is very robust to noise and gives rich information at the pixel level. In this paper before feature extraction the images are converted into YIQ colour space from RGB colour space to do away with the redundant information demonstrated by RGB colour space. Further the image similarity and dissimilarity is found out using zero-mean sum of squared differences between the two equally sized images. The results received with AUC (Area Under ROC Curve) being 0.947, demonstrates the richness of the texture pattern of conjunctival vasculature and robustness of the method being used. It is concluded that this texture pattern is a very promising biometric modality which could be used for identification.

Keywords*- Conjunctival Vasculature, SLcLTP, LTP, LBP, sum of differences, color space.*

*****

I. INTRODUCTION

Biometrics is the study of personal identification using highly unique and permanent physical or behavioural characteristics of human beings [1]. It comprises of acquiring different biometric modalities and it's processing of the relevant data for identification or verification. Biometric systems have proved their accuracy and convenience of use. Ocular biometrics in particular is important due to the reported high accuracies of iris recognition [2] [3] [4] [5]. Most of the ocular biometric methods use textural information at the pixel level from the iris, conjunctival vasculature, and retina for authentication. As far as extracting retinal information is concerned, it has been found out that it is challenging, needs specialized equipment, and attentive user cooperation [6].

The main reason for the success of iris biometrics is the relatively easy access for imaging of the eye and the high stability and uniqueness of the iris patterns over lifetime.

This particular modality has been well studied, has many commercial applications, and new developments continue to improve the performance of iris recognition systems [7]. Most iris biometric systems require NIR illumination and cameras and most of the people with highly-pigmented irises, which reveal their textures much better in NIR. However, the use of the modality including Conjunctival Vasculature in visible spectrum has also been studied and Recently has received a much interest with the advancements of imaging technology [8] [9] [10].

The conjunctival vasculature is also an anterior segment structures of the human eye, which are externally seen and with visible and easy to capture vasculature [11]. To make it brief, the plurality of conjunctival and episcleral vasculature seen on the white of the eye has been coined as conjunctival vasculatures. Conjunctiva is the tissue which lines inside of eyelids, spreads over the anterior sclera (white part of the eye) up to the scleral-corneal limbus [11]. The conjunctiva is covered with a clear mucous membrane and it is vascular in nature. The visible vasculature on the outer surface of the conjunctiva is from its bulbar layer. Due to reflectance of red color wavelengths, it is easy to capture the vasculature in visible spectrum. The unique patterns present provides great amount of textural information, which can be used as a biometric modality. The conjunctival vasculature can complement the iris modality and can compensate for it in images of eyes with off-angle gaze (an extreme left or right gaze direction). Previous work on textural classification of conjunctival vasculature has demonstrated high accuracies that support the usage of conjunctival vasculature as a biometric modality [4] [5].

In this paper, our method has been inspired by [12] [13].We conducted experiment using our module i.e., SIcLTP on self procured database of colour conjunctival vasculature (CV) images of 30 subjects using Nikon digital Camera, model D5200. Ten (10) images of conjunctival vasculature per person (5 left CV + 5 right CV) for 30 person have been procured in different lighting conditions.

Further, the similarity and dissimilarity between the equal sized images have been tested using sum of squared differences between the equal sized images. We demonstrate the effectiveness and uniqueness of this modality and the effectiveness of SIcLTP module for biometric authentication.

The results in the form of ROC curves show that the module/operator shows that it is capable of extracting good features in YIQ colour space which is steady with respect to illumination changes. Also, Conjunctival Vasculature as ocular biometrics, considered at the pixel level, provides better results for biometric authentication.

We have validated our result using LBP (Local Binary Pattern) explained by [14] on the same database, which clearly shows the superiority of SIcLTP over LBP as feature extraction operator which when further subjected to finding out the similarity and dissimilarity between equal sized images produced good results.

II. RELATED WORKS

As discussed by [15]. Besides the iris, human eyes carry other specific and identifiable patterns. One such pattern arises from the vasculature seen on the sclera, the white part of the eye ball. Most notably, when the camera acquires a non-frontal image of the iris, vascular information of the sclera is revealed. They introduce and discuss a new modality for eyeborne personal identification using the patterns of ocular surface vessels residing in the episclera and conjunctiva. Incorporation of this modality in an iris system is also expected to decrease the threat of spoof attacks since it can be difficult to accurately replicate these vessels using physical artifacts.

On the use of multispectral conjunctival vasculature as a soft biometric, [16], argues and demonstrates that, ocular biometrics has made significant progress over the past decade primarily due to advances in iris recognition. When the iris is off-angle with respect to the acquisition device, the sclera (the white part of the eye) is exposed. The sclera is covered by a thin transparent layer called conjunctiva. Both the episclera and conjunctiva contain blood vessels that are observable from the outside. In this work, these blood vessels are referred to as conjunctival vasculature. it is better seen in the visible spectrum. The paper focuses on conjunctival vasculature enhancement, registration and matching. Initial results are promising and suggest the need for further investigation of this biometric in a bimodal configuration with iris.

A Novel Method for Vessel Detection Using Contourlet Transform by [17], interprets that, Vessel detection is an important task for diagnosis of vascular diseases in clinical images. Many diseases such as diabetic retinopathy and hypertension can be detected by retinal vessel map or scanning conjunctival vessels. In the paper they develop an algorithm based on Non-subsampled Contourlet Transform (NSCT) and morphological operations. By combining information from two scales of contourlet and gray scale image, vessel map is extracted. Optic disc border is eliminated by Non-subsampled Contourlet directional information. In addition, circular shapes such as micro aneurysms are removed using morphological operations. Experimental results show significant improvements in achieving high accuracy and decreasing False Positive Rate (FPR) of vessel detection.

In this paper, we propose to use Steady Illumination colour Local Ternary Patterns(SLcLTP) for feature extraction process in the YIQ colour space of the images in consideration. The proposed method in this paper involves three steps. First, RGB images are converted into YIQ colour space, second, feature extraction using SIcLTP and finally, finding the similarity and dissimilarity between the equal size images using zero-mean sum of squared differences.

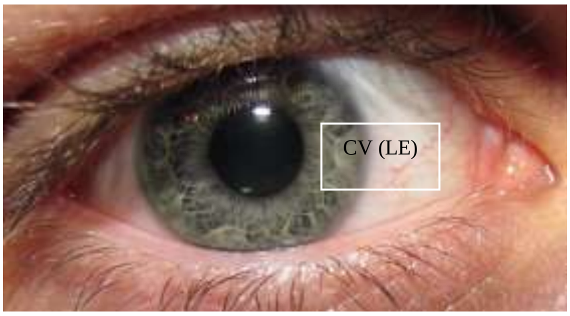


Fig 1: Conjunctival Vasculature (CV) of Right Eye (RE)

III. STEADY ILLUMINATION COLOUR TERNARY PATTERN

A. Local Ternary Patterns

Local Ternary Patterns [18] are derived from Local Binary Patterns. In LTP, the sign function is changed from a binary function to a ternary function.

In this paper we have demonstrated the use of Local Ternary Pattern features for image matching, showing that LTP gives better overall performance than LBP, because it captures rich local and colour texture information while being resistant to variations in lighting conditions. It thus works well for classes that are recognized mainly by their colour textures.

B. *Feature extraction applying Steady Illumination colour Local Ternary Patterns(SIcLTP)*

Local Binary Pattern (LBP) is proved to be a powerful local texture based image descriptor [14]. The encoding is shown in the following Fig 2, which is monotonically invariant to gray scale, transforms.

72	88	53
75	75	37
70	95	85

(75) → Threshold

0	1	0
1		0
0	1	1

Fig 2: LBP Operator

However, the LBP operator is not robust to local image noises [18]. To deal with local noises, they proposed a Local Ternary Pattern (LTP) operator for face recognition. LTP is more robust by introducing a small tolerant value range.

72	88	53
75	75	37
70	95	85

(75-t, 75+t), t=5 → Threshold

0	1	-1
0		-1
0	1	1

Fig 3: LTP Operator

The concept of the Steady Illumination colour Ternary Patterns (SIcLTP) operator for feature extraction is shown below:

72	88	53
75	75	37
70	95	85

[75(1-t), 75(1+t]
t=0.03 → Threshold

00	01	10
00		10
10	01	01

Fig 4: SIcLTP Operator with t=0.03

Given any pixel location (x_c, y_c), SIcLTP encodes it as:

$$SIcLTP^{t}{}_{N,R}(x_c, y_c) = \sum_{b=0}^{N-1} s_t(p_c, p_b) \quad (1)$$

Where, p_c is the colour centre pixel, p_b with 0 to N-1 are the N neighbourhood pixels surrounding a circle of radius R, ^{t} is a scale factor for range comparison, and s_t is a function defined as,

$$s_t(p_c, p_b) = \begin{cases} 01, if p_b > (1+t)p_c \\ 10, if p_b < (1-t)p_c \\ 00, otherwise \end{cases} \quad (2)$$

The advantages offered by this operator are:

1. It is computationally simple and efficient.
2. Introduction of the tolerance ranges makes LTP operator robust to noises.
3. Finally SLcLTP is robust to illumination changes.

C. Procedure for applying SIcLTP

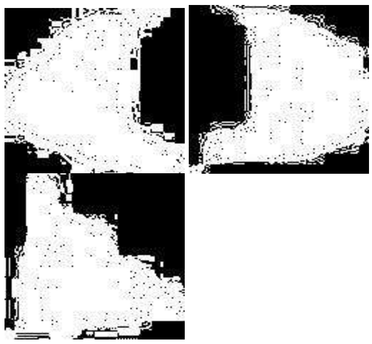
- Input image, or multi images.
- Provide the scale parameter (>0) of SIcLTP
- The radius parameter of SIcLTP is to be provided. It should be a positive integer. (In our experiment it is kept 1)
- The number of neighbouring pixels, which can be 4 or 8 (in our experiment, it is kept 8).

It is important to note that the selection of tolerance value, radius and the number of surrounding pixels needs to be selected carefully, as the end result would differ based on the selection of these values.

The database of conjunctival Vasculature is procured locally using Nikon digital camera, model D5200.

Fig. 5: Few sample Conjunctival Vasculature images of the database being created.

Fig 6: sample of extracted features using SIcLTP



D. *Experimental set up and Process:*

The following steps were undertaken to carry out the proposed experiment using the self procured database of conjunctival
vasculature. The database contains 300 images in total pertaining to 30 subjects.

ISSN: 2321-8169
5673 - 5677

Step 1: Upload Conjunctival Vasculature images.
Step 2: Convert the RGB images to YIQ color space
Step 3: Extract features from the images using SIcLTP
Step 4: Compare the images of the extracted feature to find similarity and dissimilarity between the images using zero-mean sum of squared differences.

The image similarity matching was done at random, picking any image from the database and matching that image with other images in the database at random. The sum of squared differences results in a scalar value which denotes how closely the images compared are similar. The scalar value 0 indicates the exact and symmetrical match and the lowest values indicate the closest and correct matches, While result evaluation the exact symmetrical matches have been excluded.

The experiments were carried out on HP laptop having Intel(R) Core(TM) i5 CPU @2.60GHz with 4 GB RAM including RADEON Graphics. Modules and experiments were performed using MATLAB R2007b.

IV. Result and Discussion

The same locally procured database was used to test the LBP operator. Therefore the results obtained were compared between LBP based and SIcLTP based results. The results obtained were analysed with ROC curves, constructed using Delong's method, which are shown below.

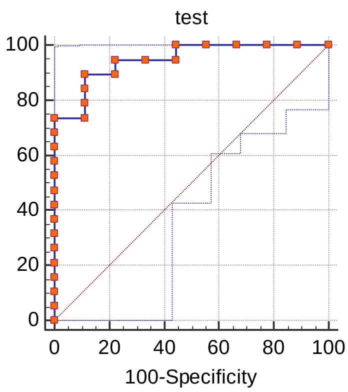


Fig.8: ROC curve obtained applying SIcLTP

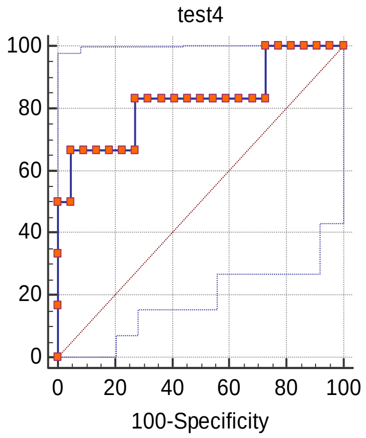


Fig.9: ROC curve obtained applying LBP

TABLE I. COMPARISON TABLE

Method	AUC	Standard Error	Significance Level P(Area=0.5)
SIcLTP	0.947	0.039	<0.0001
LBP	0.826	0.122	0.0078

The accuracy of the test depends on how well the test separates the group being tested into correct matches and incorrect matches. This accuracy is measured by the Area Under the ROC curve (AUC). It can be easily inferred that the accuracy of the module SIcLTP is more than the LBP based result, as AUC for SIcLTP based result is indicating excellent test, with AUC of 0.947, closer to the perfect test value of 1. Sensitivity is the probability that a test result will be positive when there is a correct match. Specificity is the probability that a test result will be negative when there is no correct match. Also, both the curves results are statistically significant as the significant level P is found to be less than the conventional value of 0.5.

V. Conclusion

We have demonstrated the effectiveness of the operator SIcLTP, in combination of zero mean sum of squared differences between the images, capable of producing correct and incorrect match between images.

The colour of the eyes plays a vital role in image acquisition especially in the RGB colour space. The darker eyes did not reveal much rich discriminative textures, in less constrained environment. However, if rather good images of conjunctival vascular are available in visible spectrum, we are confident that much better results could be obtained. Also the image quality could be further enhanced by image processing techniques, which in turn would provide much better result. In future other classifiers to classify the images would be explored.

References

[1] Jain, A. K., S. Pankanti, et al. Biometrics: a grand challenge. Proceedings of the 17th International Conference on Pattern Recognition, Cambridge, UK, August 2004

[2] J Daugman, ."How iris recognition works". International Conference on Image Processing, 2002.

[3] Li, M., T. Tieniu, et al. "Personal identification based on iris texture analysis." IEEE Transactions on Pattern Analysis and Machine Intelligence 25(12): 1519-1533. 2003.

[4] Tistarelli, M., M. Nixon, et al. "Enhancement and Registration Schemes for Matching Conjunctival Vasculature". Advances in Biometrics, Springer Berlin / Heidelberg. 5558: 1240-1249. 2009.

[5] Derakhshani, R. and A. Ross. "A Texture-Based Neural Network Classifier for Biometric Identification using Ocular

ISSN: 2321-8169
5673 - 5677

Surface Vasculature". Proceedings of International Joint Conference on Neural Networks, 2007

[6] Gottemukkula, V., S. Saripalle, et al. "A texture-based method for identificaiton of retinal vasculature". Proceedings of IEEE International Conference on Technologies for Homeland Security, 2011

[7] Bowyer, K. W., K. Hollingsworth, et al. "Image understanding for iris biometrics: A survey." Computer Vision and Image Understanding 110(2): 281-307. 2008.

[8] Proenca, H. "On the feasibility of the visible wavelength, at-a-distance and on-the-move iris recognition". Proceedings of IEEE Workshop on Computational Intelligence in Biometrics: Theory, Algorithms, and Applications. 2009.

[9] Sriram Pavan Tankasala, R. P., Vikas Gottemukkula, Sashi Kanth Saripalle, Venkata Goutam Nalamati, Arun Ross, Reza Derakhshani, "A video-based hyper-focal imaging method for visible spectrum Iris" biometrics.Proceedings of IEEE International Conference on Technologies for Homeland Security (HST),2011

[10] Tankasala, S. P., P. Doynov, et al. Biometric recognition of conjunctival vasculature using GLCM features. Proceedings of International Conference on Image Information Processing. 2011.

[11] T, et al. Distribution of normal superficial ocular vessels in digital images. Contact Lens Anterior Eye, http://dx.doi.org/10.1016/j.clae.2013.07.009

[12] Shengcai Liao, et al., and Stan Z. Li, "Modeling Pixel Process with Scale Invariant Local Patterns for Background Subtraction in Complex Scenes", Center for Biometrics and Security Research & National Laboratory of Pattern Recognition, Institute of Automation, Chinese Academy of Sciences, Machine Vision Group, University of Oulu, Finland,2008.

[13] M. Heikkil¨a and M. Pietik¨ainen. "A texture-based method for modeling the background and detecting moving objects". IEEE Transactions on Pattern Analysis and Machine Intelligence, 28(4):657–662, 2006.

[14] T. Ojala, M. Pietikaeinen, "Multiresolution Gray-Scale and Rotation Invariant TextureClassification with Local Binary Patterns", IEEE Trans. Pattern Analysis and Machine Intelligence, 24 (2005), 971–987, URL http://www.mediateam.oulu.fi/ publications/pdf/6.pdf.

[15] R. Derakhshani, A. Ross, and S. Crihalmeanu, "A new biometric modality based on conjunctival vasculature," in Artificial Neural Networks in Engineering (ANNIE), St. Louis, USA, 2006.

[16] S. Crihalmeanu and A. Ross, "Multispectral scleral patterns for ocular biometric recognition," Pattern Recognition Letters, 2012.

[17] Farnoosh Ghadiri, Seyed Mohsen Zabihi, Hamid Reza Pourreza, Touka Banaee ,"A Novel Method for Vessel Detection Using Contourlet Transform", Machine Vision Lab. Computer Eng. Dept. Ferdowsi University of Mashhad Mashhad, Iran, 2012

[18] Xiaoyang Tan and Bill Triggs," Enhanced Local Texture Feature Sets for Face Recognition under Difficult Lighting Conditions", 3rd International Workshop Analysis and Modelling of Faces and Gestures 4778 ,2007