Retina based Personal Identification System using Skeletonization and Similarity Transformation

Geethu Sasidharan

PG Scholar
Computer Science and Engineering
St. Joseph's College of Engineering and Technology, Palai

***Abstract*— Biometric security has become more important because of the increasing activities of terrorists and hackers. One of the most reliable biometric security systems is retina biometric security system, because no two people have the same retinal pattern. The proposed system consist of four modules viz, retina fundus acquisition, Pre-processing, Detection of bifurcation points and Feature matching. In the pre-processing step retinal blood vessels are enhanced and segmented. From the segmented image bifurcation points are detected, with the help of skeleton process. Using this bifurcation points, it check similarity with bifurcation points of reference images in database using similarity transformation. The proposed system has extremely lower error rate and quick response.**

Keywords— **Retina biometric, Frangi's vessel detection, Skeletonization, Similarity transformation.**

I. Introduction

A biometric system is a pattern recognition system that checks the authenticity of a person using biometric measures. There are two types of authentication: - verification (checking the validity of a given identity) and identification (checking if given pattern is associated with any of the enrolled identities stored in database). Biometric based security systems are the reliable source of security for highly sensitive areas.

The retina is an internal protected organ of the body. Human retina consists of blood vessels which form a unique pattern and the pattern does not change through the individual's life. So it is impossible to forge that pattern. Retina based security system works by tacking an image of an individual's retinal blood vessel network and comparing it to a previously authenticated scan of the same individual. The uniqueness and stability of retina guarantees a strong biometric authentication. Also it is less vulnerable to identity theft.

The primary application for retinal pattern recognition till date has been for physical access entry for high-security facilities such as military installations, nuclear facilities, sophisticated laboratories etc. It is also used in access control systems at high security facilities. There are many advantages of retina biometry:- it has low occurrence of false positives, also offer extremely low (almost 0%) error rates, since no two people have same retinal pattern it is highly reliable and it can provide speedy results that is identity of a person can be verified very quickly.

II. Proposed System

The proposed system is Retina based personal identification system using skeletonization and similarity transformation. The system comprised of four modules viz, retina fundus acquisition, Pre-processing, Detection of bifurcation points and Feature matching. The proposed system is shown in fig 1:

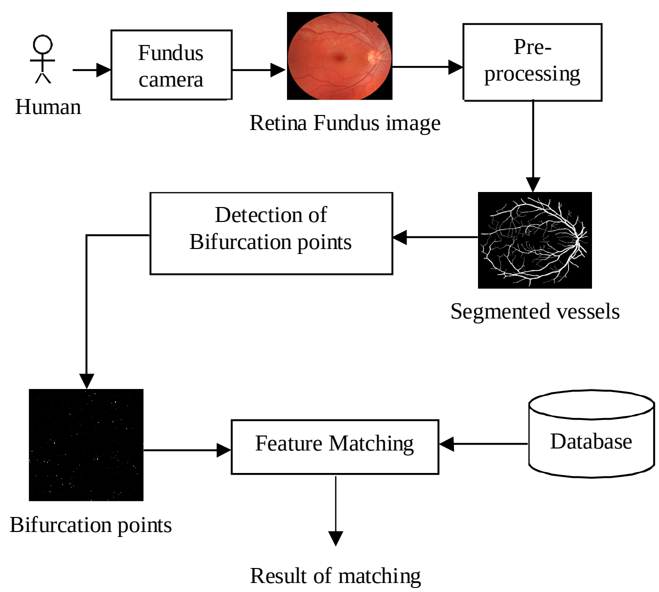


Fig 1: Proposed system

Each of the modules is described below.

A. Fundus acquisition : Devices used to obtain images of the retina were called fundus cameras, which uses low intensity infrared light to illuminate blood vessel pattern of the retina. Once the retinal image is obtained, the blood vessels are identified through further processing. Then from the complex network of blood vessels distinguishing features are extracted and stored in templates, which are later used in the matching process.

B. Preprocessing : In this step, it performs blood vessel enhancement and segmentation that helps to extract the retinal blood vessel pattern from fundus image. For this first of all we extract the green channel of the fundus image, because it provides highest contrast. The preprocessing [1] of fundus image is shown in fig 2. This consists of five stages: resolution hierarchy creation, hessian vesselness extraction, back sampling, Hysteresis thresholding and image fusion.

1) Resolution hierarchy creation : In this step three resolution levels are created from the green channel image. It is obtained by rescaling the image by a factor 0.5.

2) Hessian vesselness extraction : These rescaled images are subjected to hessian vesselness extraction [4]. This step enhances the blood vessels in the fundus.

3) Back sampling : In this stage, the three output images of vesselness extraction are back sampling to original resolution.

4) Hysteresis thresholding : In this stage the vessel tree in all the three resolution levels are identified. It is a double thresholding method, means it uses two thresholds:- a lower threshold and a higher threshold. Pixels above the higher threshold are identified as strong vessel pixels and are marked. Pixels below the lower threshold are suppressed. And pixels whose intensity value lies between highest and lowest threshold are identified as weak vessel pixels. These pixels are added to the output if and only if they are connected to a strong vessel pixel.

5) Image fusion : The final segmented image is generated by applying a pixel-wise OR operator on the binarized images obtained from the different resolution levels.

C. Detection of bifurcation points : Bifurcation are the most reliable and abundant feature in fundus images. The retinal bifurcation points are unique for each person, so they are used for successive process of identification of person. In this paper, it detects bifurcation points with the help of Skeletonization process [2]. According to this process a pixel in image will be removed if satisfies 2 conditions.

Condition I: for pixel I(i, *j*),

1. The number of pixels connected must be equal to *1*.
2. It should have at least 2 near pixels and at the latest *6*.
3. The pixels in location (*i,j+1*), (*i-1,j*) and (*i+1,j*) should be white
4. The pixels in location (*i-1,j*), (*i+1,j*) and (*i,j-1*) should be white.

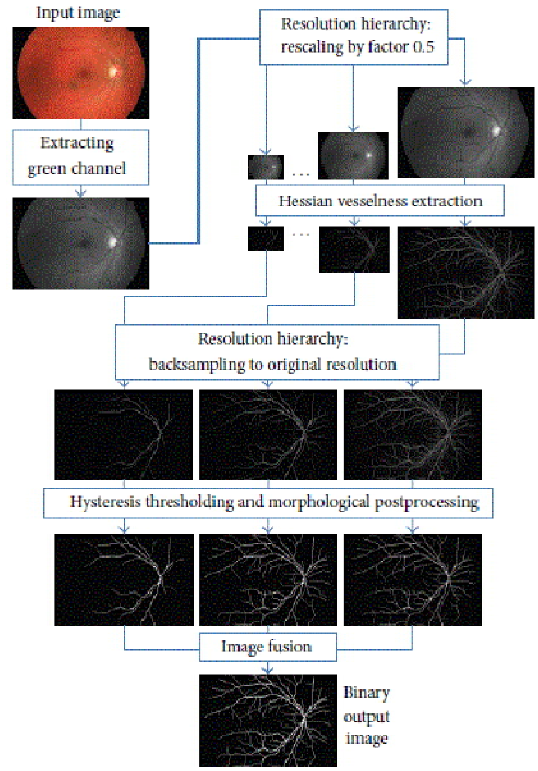
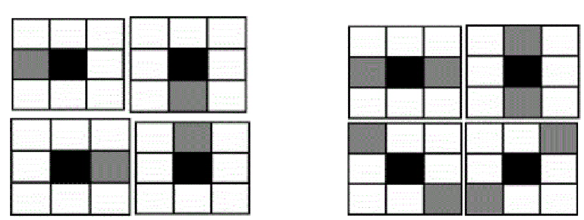


Fig 2: Preprocessing

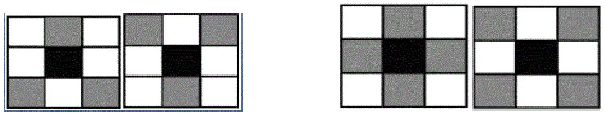
Condition II:

1. The number of pixels connected must be equal to *1*.
2. It should have at least 2 near pixels and at the latest *6*.
3. The pixels in location (*i-1,j*), (*i+1,j*) and (*i,j-1*) should be white.
4. The pixels in location (*i,j+1*), (*i-1,j*) and (*i+1*,j) should be white.

If there is no pixel that satisfies the above two conditions, then the algorithm will be stopped. For detecting bifurcation points, the system count the connectivity number (cn) of each pixels (the number of pixels connected with the candidate pixel) present in skeleton image. The classification of pixels for bifurcation point detection is based on connectivity number (cn) is shown in fig 3.



a) If cn=1; it is an end point b)if cn=2; it is an inside point



c) if cn=3; it is a bifurcation d) if cn= 4; it is a crossover

Fig 3: Pixel classification

If a bifurcation point is found in the direction of another point, then calculate angle (α) between them. The bifurcation points are shown in fig 4.

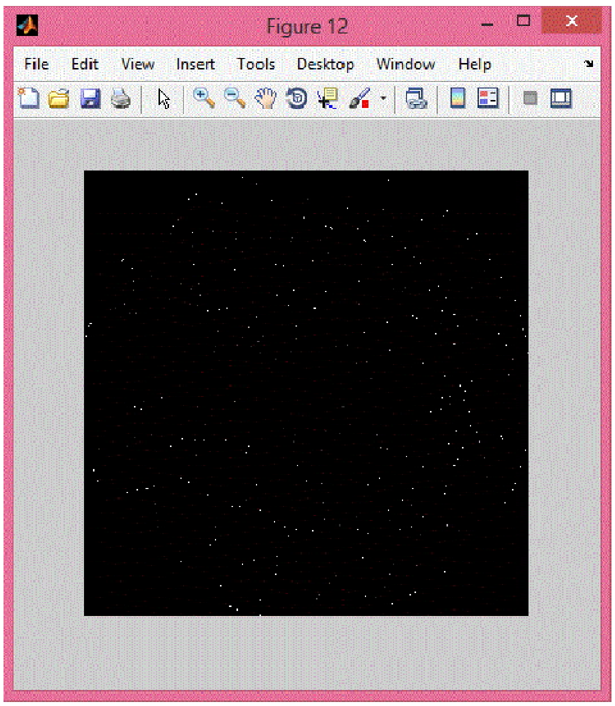


Fig 4: Bifurcation points

D. Feature matching : In the matching stage, the reference pattern, *p*, which is stored in database for the claimed identity is compared to the pattern extracted, *p'*, during the previous stage. Due to the eye movement during the image acquisition stage, it is necessary to align β with α in order to be matched. The movement of the eye in the image acquisition process leads to translation in both axes. So for same individual, the number of bifurcation points of both patters *p* and *p'* are different. So it is necessary to transform the candidate pattern in order to get a pattern similar to the reference one. In this paper Similarity transformation (ST) [3] is used to check similarity between patterns. In this method the transformation with the highest matching score will be accepted as the best transformation. The possible number of transformation *T* is calculated using the equation:

$$T=\frac{(M^2-M)(N^2-N)}{2} \qquad (1)$$

Where, M and N are the total number of feature points in reference pattern and candidate pattern respectively.

In order to check feature points similarity, a similarity value (SV) between points is defined. It indicates how similar two points are. For two points *X* and *Y*, similarity value is calculated using following equation.

$$SV(X,Y)= 1-\frac{Distance\,(X,Y)}{D_{max}} \qquad (2)$$

Where, D_{max} is a threshold. If *Distance* (*X*, *Y*) > D_{max} then *SV* (*X*, *Y*)=0. If two points Y_1, Y_2 both have a good value of similarity with a point *X* in the reference pattern. Then to identify the most suitable matching pair (MP), following equation is used.

$$MP(X_i, Y_j)=\frac{SV\,(X_i,Y_j)^2}{\left(\sum_{i'=1}^{M} SV(X_{i'},Y_j)+\sum_{j'=1}^{N} SV(X_i Y_{j'})-SV(X_i,Y_j)\right)} \qquad (3)$$

Using this equation an *M*x*N* matrix *Q* can be constructed, in which value in position (*i*, *j*) = *MP* (X_i, Y_j). The set of matching feature points *MFP* is calculated using *MP* with the help of a greedy algorithm. An element in position (*i*, *j*) is inserted into *MFP*, if that position in *Q* contains the maximum value. This procedure stops when no more non-zero element can be chose from *Q*. Where, *MFP* is the final set of matched points.

Using these matched points in *MFP*, a similarity metric is calculated. This metric is used to define similarity measures on the patterns. The Similarity Measure (*SM*) between to patterns is given by,

$$SM=\frac{MFP}{f(M,N)} \qquad (4)$$

Where, *MFP* is the number of matched points between patterns. *M* and *N* are matching pattern sizes and the function *f* is given by,

$$f=\sqrt{MN} \qquad (5)$$

III. Conclusion

The proposed Retina based personal identification system using skeletonization and similarity transformation, is a simple and efficient system for identifying authenticity of people. The use of hessian based vessel segmentation method helps to extract the complete retinal vessel tree from fundus image. Thus we can extract almost all features. Skeletonization helps to construct the skeletal structure of retinal vessels. From the result of skeletonization, the pixel classification method detects all bifurcation points in the image. These detected bifurcation points are used as features in matching stage. In the matching stage, the acquired pattern is matched with the reference one stored in database of the system. Here, the degree of similarity is measured using similarity metric.

Thus the proposed system is able to produce an accurate result. Also it offers extremely low error rate. The system requires less computation time. It is a simple and efficient method for checking authentication of user.

REFERENCES

[1] Robust Vessel Segmentation in Fundus Images, A. Budai, R. Bock, A. Maier, J. Hornegger, and G.Michelson. Hindawi Publishing Corporation International Journal of Biomedical Imaging Volume 2013, Article ID 154860, 11 pages http://dx.doi.org/10.1155/2013/154860

[2] A Combined Method to Detect Retinal Fundus Features V. Bevilacqua S. Cambo L. Cariello G. Mastronardi, Politecnico Di Bari (Italy)

[3] Retinal Verification Using a Feature Points-Based Biometric Pattern, M. Ortega, M. G. Penedo, J. Rouco, N. Barreira, and M. J. Carreira, Hindawi Publishing Corporation EURASIP Journal on Advances in Signal Processing Volume 2009, Article ID 235746, 13 pages doi:10.1155/2009/235746.

[4] Alejandro F. Frangi,Wiro J.Niessen, et al. "Multiscale vessel enhancement filtering," Medical Image Computing and computer-Assisted Intervation-MICCAI'98. 1998,1496:130:137.

[5] Digital image processing, third edition, Rafael C Gonzales and Richard E Woods.

[6] Retinal Fundus Biometric Analysis for Personal Identifications, Vitoantonio Bevilacqua, Lucia Cariello, Donatello Columbo, Domenico Daleno, Massimiliano Dellisanti Fabiano, Marco Giannini, Giuseppe Mastronardi, and Marcello Castellano, D.-S. Huang et al. (Eds.): ICIC 2008, LNAI 5227, pp. 1229–1237, 2008.

[7] Retinal Fundus Features Hybrid Detection based on a Genetic Algorithm, Vitoantonio Bevilacqua, Lucia Cariello, Simona Cambo, Domenico Daleno, Giuseppe Mastronardi, DEE Polytechnic of Bari, Via Orabona 4, 70125 Bari, Italy

[8] Bevilacqua ,V., Cariello, L., Introna, F., Mastronardi, G., 2005, A Genetic Algorithm Approach to Detect Eye Fundus Vessel Bifurcation Points, Proceedings of Int. Conference, CIMED'2005, Lisbon ISBN 0-86341-520-2, pp.355-360.

[9] A Survey on Biometric Recognition Techniques, ARULALAN.V, BALAMURUGAN.G, PREMANAND. V, International Journal of Advanced Research in Computer and Communication Engineering Vol. 3, Issue 2, February 2014.

[10] Extraction of the Retinal Blood Vessels and Detection of the Bifurcation Points, Manjiri B. Patwa, Dr. Remesh R. Manza, Yogesh M. Rajput, Dr. Neha K. Despande and Dr. Manoj Saswade. International Journal of Computer Applications (0975 – 8887) Volume 77– No.2, September 2013.