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Retina registration for biometrics based on retinal feature points

Z. Nougrara*, N.E. Berrached

Department of Mathematics, University of Science and Technology, U.S.T.O-MB, BP 1505, El M'naouer, 31000 Oran, Algeria

Corresponding Author Email: nzrecherche@yahoo.fr

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ABSTRACT

The retina blood vessel pattern characterizes each individual and it is almost impossible to forge that pattern in a false individual. The registration stage is necessary since the position of the retinal vessel structure change between acquisitions due to the movements of the eye. Nodes registration plays an extremely important role as it is often the essential step for various applications such as identification of different images of the same individual. The image registration process concerns feature detection, feature matching and transformation model. In this paper, we present a methodology for retina registration based on retinal feature points which are the nodes of the blood vessels network. We present also some experiments to test retinal images from the publicly available Drive fundus image database. The proposed methodology achieves good results for registration.

1. INTRODUCTION

T Reliable authentication of each individual is a growing demanding service in many fields, not only in police or military environments but also in civilian applications, such as access control or financial transactions [1]. In fact, determining the identity of a person is becoming critical in our vastly interconnected information society. As increasing number of biometric-based identification systems are being deployed for many civilian, biometrics and its applications have evoked considerable interest.

The identity of a person can be categorized into two fundamentally distinct types of problems with different inherent complexities: (i) verification (authentication) and (ii) recognition (identification). Verification refers to the problem of confirming a person's identity and identification refers to the problem of establishing a subject's identity [2]. Biometrics deals with identification of individuals based on fingers¸ hand geometry, voice, face, iris, ear and signature for examples.

A biometric can also be defined as any measurable, robust, distinctive physical characteristic or personal trait that can be used to identify, or verify the claimed identify of an individual [3]. The robustness of a biometric is a measure of the extent to which the characteristic or trait is subject to significant changes over time. Changes can occur as a result of age, chemical exposure, etc. For example, the iris which changes very little over a person's lifetime is more robust than a voice.

The applications of biometrics can be divided into the following three main groups [4]: (i) Commercial, applications such as computer network login, credit card, cellular phone, etc. (ii) Government, applications such as national ID Card, passport control, social security, etc. And (iii) Forensic, applications such as criminal investigation, terrorist identification, etc.

Some of the limitations imposed by unimodal biometric systems can be overcome by using multiple biometric modalities like face and fingers of a person. Such systems, known as multimodal biometric systems, are expected to be more reliable due to the presence of multiple independent pieces of evidence.

A biometric system [5] is essentially a pattern-recognition system that recognizes a person based on a feature vector derived from a specific physiological or behavioral characteristic that the person possesses. That feature vector is usually stored in a database after being extracted.

A simple biometric system consists of four basic components: (i) Sensor module which acquires the biometric data, (ii) feature extraction module, (iii) matching module: feature vectors are compared against those in the template and (iv) decision-making module: the user's identity is established or a claimed identity is accepted or rejected.

Retina may provide higher level of security due to its inherent robustness against imposture [6]. The main features of retina images were defined as the optic disk, fovea, and blood vessels [7]. The retina blood vessel pattern is a unique pattern in each individual and it is almost impossible to forge that pattern in a false individual [7] and [8]. The retina biometrics' advantages [5] and [9] include high distinctiveness, universality, and stability overtime of the blood vessel pattern.

Image registration is a vital problem in medical imaging. It has many potential applications in clinical diagnosis [3] and [10]. It is a process of aligning two images into a common coordinate system thus aligning them in order to monitor subtle changes between these images.

Registration algorithms consist to set correspondence between the two images. The reference and the referred image could be different (taken at different times, using different devices and different angles).

In this paper, we propose an approach for registration of retina images. This work is a continuation of our previous work [11] which its main objective is the extraction of blood vessels and their bifurcation and crossover points from retinal images.

This paper is structured as follows: in Section 2, we present an overview of the literature. In Section 3, we describe the proposed approach. In Section 4, results and comparisons are presented on retinal images of the Drive database. Finally in Section 5, conclusion and possible directions for future research are given.

2. LITERATURE OVERVIEW

Several works concerning biometrics field have been exploited, for example the paper [7] proposed a method for recognition retina in biometrics system. This method uses the set of geometrical and texture features of the complex vessel structure of the retina to determinate the feature vector for the human recognition. Another work [9] represents the retina vessel network as a spatial relational graph. The retina graph is not just sets of nodes and edges, but sets of other substructures that are commonly present in it. Such substructures must be robust to missing or spurious nodes and edges which result from the graph extraction process. In [3], the authors explored the various methods of biometric identification that have evolved over the years and the features used for each modality. Ortega [12] presented an automatic system for personal authentication using the retinal vessel tree as biometric pattern. Also Ortega et al. [1, 8] showed that the biometric pattern of the system for person's authentication is a set of feature points representing landmarks in the retinal vessel tree. Feature points are a robust biometric pattern allowing defining metrics that offer a good confidence band. Pattern matching problem is reduced to a point pattern matching problem and the similarity metric is defined in terms of matched points. The proposed method in [13] uses facial region in the immediate vicinity of the eye. Global and local information are extracted from the facial region using texture and point operators resulting in a feature set that can be used for matching. The effect of fusing these features sets is also studied. In [6] features of human retinal images are used for blood vessel segmentation, feature generation and feature matching. The work [14] presents an innovative touch-less palm print recognition system. The proposed system permits to automatically detect and locate the region of interest of the palm in real-time video stream. The discriminative palm print features are extracted based on a new method that applies local binary pattern texture descriptor on the palm print directional gradient responses. The study [15] presents the performance of different normalization techniques and fusion rules in the context of a multimodal biometric system based on face, fingerprint, and hand-geometry traits of a user. In [4], a brief overview of the field of biometrics is given and some of its advantages, disadvantages, strengths, limitations, and related privacy concerns are summarized. In [9], a brief overview of biometric methods and their advantages and disadvantages are presented. The study in [16] concerns information fusion in biometric verification systems by combining three biometric modalities (face, fingerprint and hand geometry). Finally, [17] presents a novel authentication method which employs the retinal vessel tree as the biometric parameter, with a prior registration stage needed to align the template image and the acquired image. A multi-resolution feature-based registration method has been employed, taking the creases extracted by means of a robust and accurate method as the reference features. After this extraction, a registration stage is necessary since the position of the retinal vessel structure could change between acquisitions due to the movements of the eye.

3. METHODOLOGY

The basic idea of our methodology is mainly derived from our previous work on [18]. The present algorithm concerns only the information obtained by the extraction of retinal blood vessel network with bifurcations and crossover points [11]. This algorithm improves our previous algorithm by incorporating a priori information provided by the extracted retinal blood vessel network with its nodes (bifurcations and crossovers points). The use of these nodes represents the decision criterion to have a best registration.

Also the retina is composed by some features like optic disk and macula-fovea. These features are used as support points in our proposed algorithm of registration. Optic disk is a bright disk area and all major blood vessels and nerves originate from it. Macula is an important vessel-free area near center retina; at the center of the macula is the fovea, which is responsible for sharp central vision. Figure 1 represents the main processing steps described in more details in the following subsections.

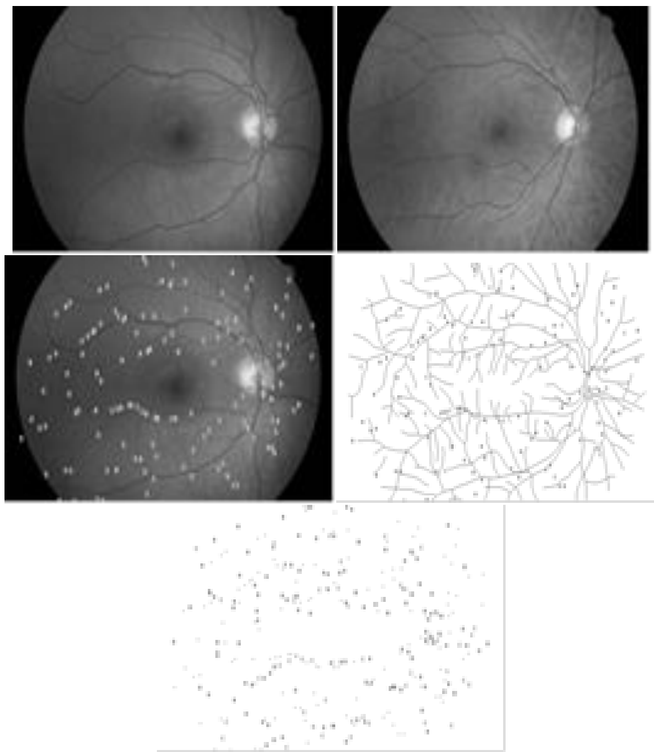


Figure 1. Main steps of the method

From left to right and top to bottom: grayscale retinal images (green channel) which represent respectively original and test images; superposition of new calculated nodes of the test image on the original image; superposition of new calculated nodes of the test image on the vessel network of the original image; superposition of new calculated nodes of the test image on the nodes of the original image.

3.1 Principle of registration

NN: number of nodes of a test retina image.

For each node, we calculate its new coordinates in the original image.

The algorithm is defined as follows:

For i=1 to NN
x = a*z + b*t + c
y = (-b)*z + a*t + d
end

The parameters a, b, c and d are determinate by the use of the two support points: optic disk and fovea.

3.2 How to know if there are two identical images or two different images

To calculate the new coordinates of the test image's nodes by the algorithm defined in Section 3.1

To calculate the report between the number of the new obtained nodes which are superposed on the nodes of the original image and the total number of nodes of this image.

If R is this report, R=NS/TN with NS number of the superposed nodes and TN number of the total nodes.

If R is a little value, we confirm that the two images (test image and original image) are different; else these images are identical (R is very great).

4. EXPERIMENTAL RESULTS AND DISCUSSION

In this section, some experiments which test the proposed methodology are described.

4.1 Experimental results

4.1.1 Data sets

The publicly available Drive database was used for testing our proposed approach. Figure 2 shows an example (green channel) taken from this database with the associated segmentation.

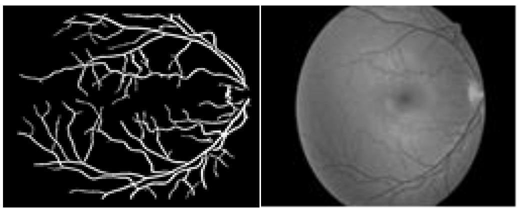
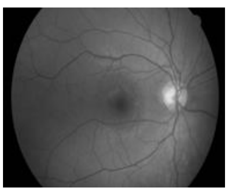


Figure 2. Example of a digital retinal image (right) and associated ground truth segmentation (left) from the Drive database

4.1.2 Results



Original image

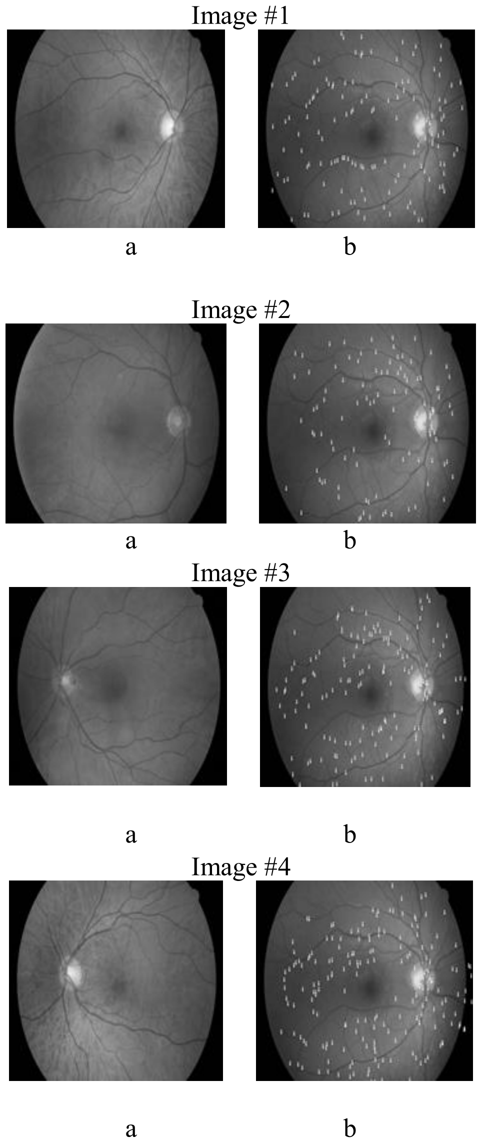


Figure 3. (a) Test image. (b) Registration of new calculated nodes with the proposed method on the original image

4.1.3 Evaluation results

In these experiments, four retinal images from the Drive database have been tested (see figure 3). The results were first qualitatively evaluated by superposition of the calculated nodes on the original image. Quantitative evaluation was performed by computing the report between correctly overlapping nodes of the test image and all nodes of the original image. Table 1 shows the different values of this report for the four tested retinal images.

We note that the obtained results used two set of nodes: the first set of nodes is obtained by the algorithm [11]. The second set of nodes represents the decision criterion to have a best registration; these nodes are obtained by the algorithm of subsection 3.1.

Table 1. Values of report for the four tested images

Images	Report (%)
Image # 1	4.2
Image #2	4.2
Image #3	9.0
Image #4	9.6

The proposed methodology achieves good results for registration of retina images. In fact, all images of the Drive database are not identical and this proposed method achieves impressive results in terms of report. To more validate our proposed algorithm (to measure the accuracy of the algorithm), we have changed the original image (its position: the angle). Figure 4 shows both images and the superposition of the new calculated nodes on the original image.

a *b* *c*

Figure 4. (a) Original image. (b) The tested image. (c) New calculated nodes of image (b) superposed on image (a)

The report value is 75.90%. So we confirm that these two images are identical. And effectively are identical because we have used the same image.

In comparison to other approaches in literature, the main advantage of our method is its ability to identify identical and not identical images and its simplicity. The other approaches present a difficulty especially in thin vessels registration and in the use of several principles (steps of their proposed methodology). The obtained results by our proposed method were good. In fact, they show that the use of simple ideas can more efficiently identify different images than the multiple or complex algorithms. However, the main drawback resides in the loose of information concerning the nodes of each image and in this case; it is difficult to have an exact value of report. Also, in the case of defective images like diabetics image, the algorithm's evaluation is not clear.

4.2 Discussion

The mentioned algorithm achieved good degree of success according to the level of registration.

Our proposed methodology advantage's is its ability to identify identical and not identical images. It presents clear ideas, few principles and not complicates algorithms to obtain results.

However, this proposed methodology needs other factors to consider for retinal image registration like the contrast, illumination, and brightness of the image. Therefore, this paper requires more experiments, under varying conditions, in experimental results section. So we propose to develop this work in the future.

5. CONCLUSION

The changes in retinal blood vessels structure and progression of diseases have been the subject of several large scale clinical studies. Moreover, retina is one of the most secured, reliable, trustworthy sources of biometric information for individual authentication with unique features such as blood vessel structure and associated bifurcations and crossover points that are distinctive enough for each individual. Having the feature points of the retinal vessel tree allows an objective analysis of the diseases that cause modifications in the vascular morphology avoiding in this way a manual subjective analysis.

The main interest of this work is retinal images registration. We have proposed an approach for nodes registration (bifurcation and crossover points) from retinal fundus images and tested it on the publicly Drive retinal database. Its originality lies in the use of features concerning the extracted blood vessels which are the nodes: the points of intersection between blood vessels. The obtained results were in general satisfactory.

Future work will include the development of the algorithms to treat other pattern for biometrics such as hand veins. Also this work can be developed by varying factors such as the contrast and illumination of the image to consider for retinal image registration. Finally, we suggest to test the proposed method on a larger databases containing defective images like diabetics image.

REFERENCES

[1] Ortega M, Penedo MG, Rouco J, Barreira N, Carreira MJ. (2009). Retinal verification using a feature points-based biometric pattern. EURASIP Journal on Advances in Signal Processing, New York, NY, United States. https://doi.org/10.1155/2009/235746

[2] Jain A, Bolle R, Pankanti S. (1998). Biometrics personal identification in networked society. Book published by Springer Science+Business Media. Inc. 233 Spring Street, New York, NY 10013, USA.

[3] Adeoye OS. (2010). A survey of emerging biometric technologies. International Journal of Computer Applications 9(10): 1-5. https://doi.org/10.5120/1424-1659

[4] Jain AK, Ross A, Prabhakar S. (2004). An introduction to biometric recognition. IEEE Transactions on circuits and systems for video technology 14(1): 4-20. https://doi.org/10.1109/TCSVT.2003.818349

[5] Delac K, Grgic M. (2004). A survey of biometric recognition methods. 46th International Symposium Electronics in Marine. Zadar Croatia, pp. 184-193. https://doi.org/10.1109/ELMAR.2004.1356372

[6] Farzin H, Abrishami-Moghaddam H, Moin MS. (2008). A novel retinal identification system. EURASIP Journal on Advances in Signal Processing, pp. 1-10. https://doi.org/10.1155/2008/280635

[7] Choras RS. (2012). Retina recognition for biometrics. IEEE.

[8] Ortega M, Penedo MG, Rouco J, Barreira M, Carreira MJ. (2009). Personal verification based on extraction and characterization of retinal feature points. Journal of Visual Languages and Computing 20: 80-90. https://doi.org/10.1016/j.jvlc.2009.01.006

[9] Arakala A, Davis SA, Horadam KJ. (2011). Retina features based on vessel graph substructures. IEEE. https://doi.org/10.1109/IJCB.2011.6117506

[10] Wyawahare MV, Patil PM, Abhyankar HK. (2009). Image Registration Techniques: An overview. International Journal of Signal Processing. Image Processing and Pattern Recognition 2 (3): 11-27.

[11] Nougrara Z, Kihal N, Meunier J. (2016). Semi-automated extraction of retinal blood vessel network with bifurcations and crossover points. Paper for Participation in IEEE International Conference on Biometrics, FL, USA. https://doi.org/10.1007/978-3-

319-50832-0_33
[12] Ortega M. (2009). Automatic system for personal authentication using the retinal vessel tree as biometric pattern. PhD thesis, CORUNA University.
[13] Park U, Ross A, Jain AK. (2009). Periocular biometrics in the visible spectrum: a feasibility study. IEEE. https://doi.org/10.1109/tifs.2010.2096810
[14] Michael GKO, Connie T, Teoh ABJ. (2008). Touch-less palm print biometrics novel design and implementation. Image and Vision Computing 26: 1551-1560. https://doi.org/10.1016/j.imavis.2008.06.010
[15] Jain A, Nandakumar K, Ross A. (2005). Score normalization in multimodal biometric systems. Pattern Recognition 38: 2270-2285. https://doi.org/10.1016/j.patcog.2005.01.012
[16] Ross A, Jain A. (2003). Information fusion in biometrics. Pattern Recognition Letters 24: 2115-2125.
[17] Marino C, Penedo MG, Penas M, Carreira MJ, Gonzalez F. (2006). Personal authentication using digital retinal images. Pattern Anal Applic 9: 21-33. https://doi.org/10.1007/s10044-005-0022-6
[18] Nougrara Z. (2017). Registration of the roads with the use of a satellite image and a road map: application to road map update. AMSE Journals-AMSE IIETA Publication-2017-Series: Advances B 60(4): 646-656.