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Feature Analysis on Retinal Blood Vessels for Human Authentication

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Abstract*: Security plays a crucial role in protecting the important documents and systems from imposters. A biometric system extracts from the desired person the physiological or mannerism-based characteristics on which the system chooses whether to authorize or deny access. Even though the biometric modalities like fingerprint, face and voice are widely used, there is a demand for high security in certain fields like military and operation centers. This paper takes the datasets from kaggle and presents an idea about to authentication of a person using retinal blood vessels and template matching method based on user IDs and performance analysis is made. Also a scope to authenticate the retinal blood vessels of the person using the geometrical features like fractal dimensions, tortuosity, width, length, bifurcations etc is given and the performance analysis is done.

Keywords— Retina, User ID, Template Matching, Retinal Recognition and Geometric Characteristics.

I. INTRODUCTION

Starting from personal computers at home to super computers at control facilities, there is a great concern for security of files and databases. It is always important to confirm that the person accessing the confidential data is authorized one. This confirmation can be made possible by means of any efficient authentication methods. Person identification can be done based on three criterions; first is what a person knows, second is what a person has and third is what a person is[1]. Commonly used criterion is the first one, what a person knows, password or any personal information. Second criterion is accomplished by the means of smartcards and tokens. The last one stands for use of biometric technology, which is based on morphological characteristics of a person. The most common physical attributes that are used in biometric technology are, Fingerprint scan , 2. Voice recognition, 3. Facial recognition, 4. Iris scan and 5. Retinal scan among which retinal scanning is the most stable one since it cannot be modified through any surgeries unlike the others.

The remaining part of the paper contains related work in section 2, authentication using retinal blood vessels in section 3, results and analysis in section 4 and section 5 concludes the work and gives the future enhancement.

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II. RELATED WORK

Niemeijer et al., proposed a DRIVE dataset approach to blood vessel segmentation. They used 20 pix for each check and schooling Units containing 7 pathological photos and 33 ordinary photos (total 40 non-mydriatic photos). The Floor reality photographs annotated with the aid of two human observers. Device used to capture is TOPCON TRV-50 fundus camera. They again used ROC microaneurysm data set out of which 50 images are used for training and testing sets (total 100 images). Using general reference, the function of microaneurysms specified through the school set is stated. Digital camera “Canon CR5-45NM and TOPCON NW100” was used as a capturing device. In case of STARE dataset, total 400 ordinary and pathological pics. The ground reality images cited through human observers. Capturing tool used is “Canon CR5 non-mydriatic 3CCD camera” [2].

Marco Foracchia, Grisan, and Ruggeri used Messidor dataset out of which 1,200 pictures are pathologically distinct and 800 pictures are mydriatic. The grading of DR and probabilities of macular edema are completed according to the general reference. 3CCD camera with model TOPCON TRC NW6 is used to capture the images in their study. Kauppi et al., made a study on hundred thirty photographs of DIARETDB0 in which everyday snap shots are 20 and pictures with diabetic retinopathy are 110. And on 89 pictures of DIARETDB1 wherein five are regular and 84 of proliferative diabetic retinopathy. Hemorrhages, microaneurysms, soft and hard exudates are characterized by 4 experts. Digital fundus digital camera is used to capture the pictures [2].

Carmona, Rincon, García-Feijoo and Martínez-de-Los Angeles-Casa used one hundred and ten colored virtual retinal photographs of 53-year-old patients including 46% male and 53.8% female patients; all of them were Caucasian, whereas 23.1% of glaucoma patient pix and 70% of hypertensive retinopathy patient snap shots were Caucasian. By using a common gold, two specialists trace the implied contours for each image. The retinal images are captured using a color analog fundus digital camera and a HP picture intelligent high-resolution scanner. “DRIONS-DB” dataset is used here. Al-Diri et al. used 16 snap shots plus 193 annotated segments of retinal vessels with 5,066 factor profiles. The vessel's diameter is evaluated by 3 observers manually and the prevalent reference is calculated by taking its average. For shooting the retinal pictures, digital fundus digital camera is used [2].

ARIA online dataset was considered for the study among which 59 diabetic retinopathy pictures, 61 control group pictures and 92 AMD (age-related macular degeneration) pictures were used. For blood vessel tracing, reference well-known is used and experts labeled the place of the fovea and the optical disk. Capturing device used was Zeiss FF450+ fundus camera. VICAVR dataset has a total 58 images at distinctive radii. Calculated vessel quality via optical disk and type of ship is categorized by 3 experts. Device used for shooting is TOPCON nonmydriatic digital camera NW-a hundred models. CHASE_DB1 dataset having twenty-eight non-mydriatic pictures taken from multi-ethnic kids are used, 20 pictures being tested and eight pictures being tested for training purposes. Ground fact snap shots are marked with the aid of Human observers and experts have labeled the width and are drawn from their well-known reference common. Digital fundus digital camera is used for shooting the retinal photographs.

Odstrcilik et al., used HRF dataset. Regular pictures in this database are 15, diabetic retinopathy is 15 and glaucomatous affected person's snap shots are 15 (general forty five pix) the ground fact is marked by using a collection of professionals. A “CANON CF 60 UVi” camera provided with “CANON EOS 20D” is used for taking pictures the images [2].

III. AUTHENTICATION USING TEMPLATE MATCHING

It was shown that the template matching without the user IDs provided, gives a lower accuracy. Therefore user IDs based template matching is done which is shown in Fig 1. Firstly the user IDs are nothing but the first 2-5 characteristics of the name of the images that are stored as datasets and there will be two IDs for two retinal images (right and left) of an individual and based on this user IDs the template matching is done in faster rate than the template matching without user IDs.

The dataset here is collected from Kaggle. Preprocessing includes histogram equalization (CLAHE) and noise removal from the raw images. Edge based segmentation is used here for segmentation of blood vessels from the retinal images. Canny edge detection is applied here. John Canny took the mathematical problem of designing an optimal smooth filter, which can satisfy the criterion like, detection localization and minimizing the multiple responses of a single edge. He proved that this optimal filter can be sum of four exponential terms and thus approximated well by the Gaussian first order derivatives. He extended his study in applying non-maximal suppression, where in the edge points are only those which posses the gradient magnitude is maximum in the gradient direction. This assumption helps in suppressing the spurious response of an edge [3][4].

A. Template matching

Template matching aims at increasing the probability of a true match to achieve authentic identification and reducing the false match for unauthenticated users. Matching is done by examining the two retinal templates by checking the similarities in their feature vector. This means, the retinal image of the same person taken at different times should be identified as images belonging to the same person and the different retinal images should be treated as images belonging to different persons [10].

Hamming distance based matching is employed by Daugman for bit patterns in codes. It compares the two patterns and represents the different number of bits among those two patterns. Larger the hamming distance more the differences in the codes. In other words, hamming distance between any two feature vectors is nothing but the minimum substitutions needed to turn one into other. If the value of the hamming distance of retinal query image and the template is smaller than the threshold, then it can be noted that the retinal image is identified as coming from the same person as before.

If the hamming distance of retinal query image and the template is greater than the threshold, then the query image is considered as imposter. To get the performance analysis the retinal image that is being taken for query has to be compared with every other template that is stored as template maps of the database. Here the threshold is in terms of block size. This means, an optimal size of 250×250 is chosen for division of blocks for comparison between template and query image similar to that of bits in the code theory and the hamming distance is calculated, based on which ‘match found’ or ‘no match found’ is declared[7] [8] [9] [10].

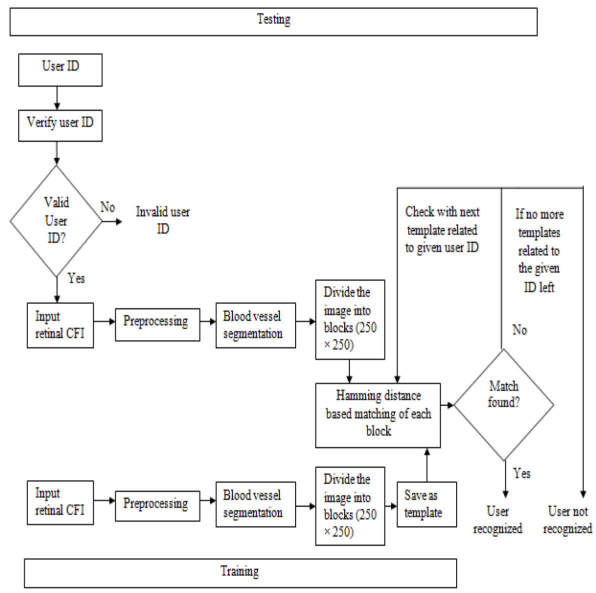

Fig 1. Authentication based on retinal blood vessels of a person using template matching

For two strings X and Y, |X|=|Y|=n, the Hamming distance, $ham(X,Y)$, between X and Y is defined as shown in equation(1),

$$ham(X,Y) = \sum_{i=0}^{i=n-1} \delta(X[i],Y[i]) \text{ where } \delta(X[i],Y[i]) = \begin{cases} 1 & \text{if } X[i] \neq Y[i] \\ 0 & \text{otherwise} \end{cases} \quad .....(1)$$

The retinal recognition scheme is categorized into two groups, conscription and recognition. The obtained retinal images will be pre-processed and improved during the conscription phase. The improved pictures are transferred to the extraction scheme of characteristics, which extracts the characteristics of geometry. For future processing operation, both of these extracted features are stored in the database. The retinal picture of the user is obtained during the identification stage and the picture is done with the previous operations such as pre-processing, extraction of the function. The vector of the so-called function matches the function vectors in the database. If the vectors of the function match each other, access to the scheme is given to the user and vice versa [5].

By using distance measurement, this job simplifies the matching method. Euclidean distance is used as the measure of distance, which compares the user-formed feature vector with the database feature vector. The distance from Euclidean is calculated as shown below

$$E_{dis} = \sqrt{\sum_{i=1}^{n} (U_i - DB_i)^2}$$

The Euclidean range comparison is described as shown in equation (2)

$$com = dis_{min}\left(U_{fv}, DB_{fv}\right) \quad ....(2)$$

U_{fv} is the function vector created from the user's information and DB_{fv} is the function vector in the database. dis_{min} is the minimum distance between the user's function vector and the one in the database. If the vector of the function matches each other, the access will be provided. Since this work is based on both geometric characteristics, it is sensible to perform the job [5].

IV. RESULTS AND ANALYSIS

The optimal block size is chosen by reducing and increasing the block size and noting down the time taken for matching process. If the block size is chosen to be large more time is consumed to match the template with the query image template and vice versa and is shown in Table 2. Accuracy here is calculated based on the Table 1, which means the accuracy is the ratio of number of observed outputs matched with the expected outputs to the total number of outputs. As shown in equation (4)

$$Accuracy = \frac{\text{number of observed outputs matched with the expected outputs}}{\text{total number of outputs}} \quad ...(3)$$

Table 1 Test details for a trial of 20 images

Image Name	Expected output	Observed output
1. 8424_left.jpeg	Match found	Match found
2. 8424_right.jpeg	Match found	Match found
3. 8479_left.jpeg	Match found	No Match found
4. 8479_right.jpeg	Match found	Match found
5. 8490_left.jpeg	No match found	No match found
6. 8490_right.jpeg	No match found	No match found
7. 8543_left.jpeg	Match found	Match found
8. 8543_right.jpeg	Match found	Match found
9. 8610_left.jpeg	Match found	Match found
10. 8610_right.jpeg	Match found	Match found
11. 8622_left.jpeg	No match found	No match found
12. 8622_right.jpeg	No match found	No match found
13. 980_left.jpeg	Match found	Match found
14. 980_right.jpeg	Match found	Match found
15. 985_left.jpeg	Match found	No Match found
16. 985_right.jpeg	Match found	Match found
17. 990_left.jpeg	No match found	No match found
18. 990_right.jpeg	No match found	No match found
19. 992_left.jpeg	Match found	Match found
20. 992_right.jpeg	Match found	No Match found

Table 2 Performance analysis for template matching

	Block Size in pixels	Average Time Taken in Seconds (s)	Accuracy in %
Retina based user authentication without using user ID	250 x 250	101.7629986	95.5%
	750 x 750	210.3578422	97%
	500 x 500	110.24896	96%
	100 x 100	92.3569775	85%
	50 x 50	59.29745	80%
Retina based user	250 x 250	20.2567811	100%
	750 x 750	16.128955	100%

authentication using user ID	500 x 500	18.2354786	100%
	100 x 100	12.246111	100%
	50 x 50	2.11188889	100%
Retina based user authentication using geometric features	250 x 250	27.2567811	75.3%
	750 x 750	19.128955	68.%
	500 x 500	20.2354786	63.4%
	100 x 100	15.246111	62.6%
	50 x 50	8.11188889	52.6%

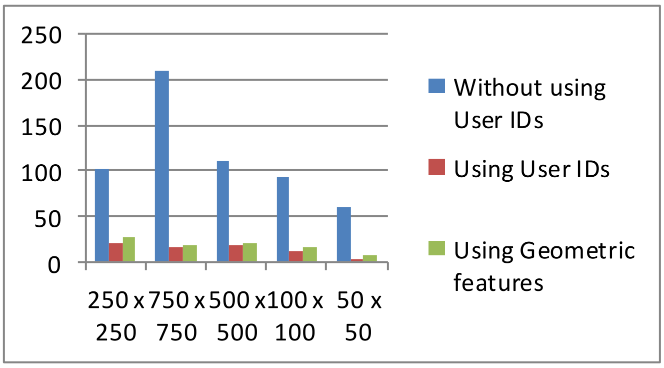

Fig 2. Block size v/s Time taken in seconds (s)

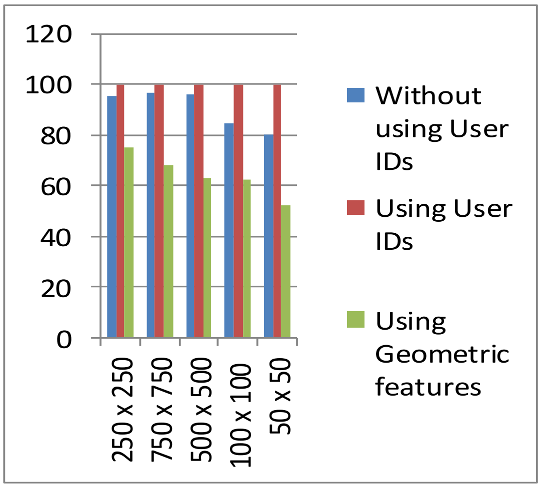

Fig 3. Block size v/s Accuracy (%)

The major factors that decide the optimal sizes for the template are, average time taken and the accuracy calculated at that time for at least 20 images. If a smaller block size is selected, accuracy may not be high as shown in the Fig 3 so even if we want time taken to be less we cannot choose the smaller block size and bigger block size take much time as shown in Fig 2. So an optimal size is chosen based on both the average time taken for the matching process as well as the accuracy acquired. Here matching is also dependent on the thresholds that are given for Hamming distance.

V. CONCLUSION AND FUTURE WORK

The marketplace packages are extremely restricted for retinal recognition, taking all of this into consideration. Consequently, retinal reputation is often used in accessing packages in the body, where extraordinarily excessive levels of safety are needed. This comprises of installations and bases of the military, nuclear installations and laboratories where very excessive pleasant study and enhancement takes place. Government is based mainly on apps for privacy to a favorable extent that it also uses retinal reputation. One of the great examples of this is the state of Illinois, where this method has been used to identify welfare recipients to reduce fraud (while a person may use countless aliases to obtain more than one bill) [6].

In future there is a scope for retinal authentication using the geometric features like bifurcation points, vessel width and many others. The techniques for estimation of the geometrical parameters, which might shape the basis for a computerized device for measuring the geometric parameters of biomedical pictures, should be developed. The system that can permit the goal of quantitative consequences to be derived and extends the capabilities of the existing scientific methods should be evolved using machine learning techniques.

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