A New Retinal Image Processing Method for Human Identification Using Radon Transform

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Abstract— **The blood vessels of retinal image have a unique pattern, from eye to eye and person to person. We have used this trait for designed a new person identification system. This approach focused on blood vessels around the optical disc instead of extracting total retinal blood to optimize the computational cost. At first, optical disc is localized using template matching technique and uses it to rotate the retinal image to reference position. This process compensate the rotation effects which might occur during scanning process then a circular region of interest (ROI) around optical disc is selected. Next, a rotation invariant template is created from each ROI by a polar transformation. In the next stage, vessels from each template are enhanced. Radon transform is used for feature definition in our method. Finally we employ 1D discrete Fourier transform and Euclidian distance for feature matching. The proposed algorithm was tested on a 200 image from DRIVE database [9]. Experimental results on the database demonstrated an average identification rate equal to 100 percent for our identification system.**

Keywords — **human identification; retinal image; image processing; radon transform; feature extraction**

I. Introduction

Biometrics is the identification of an individual using a distinctive aspect of their biology or behavior. A biometric system provides automatic identification of an individual based on a unique feature or characteristic possessed by the individual [1]. Some commonly identification method include: voice, fingerprint, face, hand geometry, facial thermo gram, iris, retina [2]. Less change in vessels pattern during life, high security, more reliability and stability are important feature which exist in retinal image [2-3]. These traits make retina as robust approach in human identification. Retina biometrics systems are suited for environments requiring maximum security, such as Government, military and banking. Different algorithms have been utilized for human identification. in [4] extract blood vessels pattern and then used 2 level Daubechies wavelet for decomposition and extract wavelet energy as a feature.

In [5] presented an approach based on localizing the optical disc using Haar wavelet and active Contour model and used for rotation compensation and also Fourier-Mellin transform coefficients and complex moment magnitudes of the rotated retinal image have been used for feature definition. In [6] a fuzzy circular Hough transform is used to localize the optical disc in the retinal image. Then, they defined feature vectors based on the ridge endings and bifurcations from vessel obtained from a crease model of the retinal vessels inside the optical disc. For matching, they adopted a similar approach as in [7] to compute the parameters of a rigid transformation between feature vectors which gives the highest matching score. This algorithm is more computationally efficient in comparison with the algorithm presented in [7]. However, the performance of the algorithm has been evaluated using a very small database including only 14 subjects. as mentioned before, preprocessing based on blood vessel extraction increase the computational cost of the algorithm. Thus vessel extraction in our method is applied only for templates that are created for every ROI. This is reduces computational time and complexity.

This article is in 5 sections as follow: section 2 describes Anatomy of the retina in section 3, the method for localization of optic disc and removing rotation effect is discussed. . Section 4, represent selected the ROI around of optical disc and polar transformation. In section 5, the radon transform and feature vector construction is discussed. Experimental results appear in section 6 and we conclude the paper in section 7.

II. Retina Anatomy

The retina is a multi-layered sensory tissue that lines the back of the eye. It contains millions of photoreceptors that capture light rays and convert them into electrical impulses. These impulses travel along the optic nerve to the brain where they are turned into images. Optic disk (OD) is brighter than other parts of the retina and is normally circular in shape and has a diameter of almost 3 mm. It is also the entry and exit point for nerves entering and leaving the retina to and from the brain. Fovea or the "yellow spot" is a very small area at the center of retinal that is most sensitive to light and is responsible for our sharp central vision [5]. Blood vessels are continuous patterns with little curvature, branch from OD and have tree shape on the surface of retina (Fig. 2). The mean diameter of the vessels is about 250 μm.

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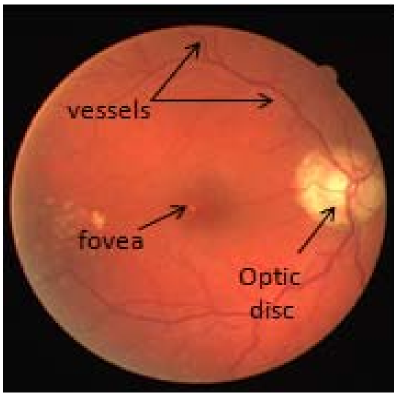

Figure 1. Retinal anatomy

III. COMPENSATION OF UNDESIRED ROTATION

Because of anatomic movement during imaging process, some rotation may occur in retinal images. These rotations cause some problem in feature extraction and matching phase of retinal image recognition. To achieve a robust method, rotation compensation is needed.

To determine the rotation angle of the retinal image, at first, optical disc has been localized by template matching technique. Template matching is a technique in digital image processing for finding small parts of an image which match a template image. The basic method of template matching uses a correlation mask (template), tailored to a specific feature of the search image, which we want to detect. In this case template is optic disc and search image is green part of retinal image. For this purpose green plane of retinal image is used and a template image is considered. The template image is constructed by selection a rectangular region around the optical disc. The template is generated by averaging rectangular region containing OD in our retinal image database [3]. Retinal image is correlated by template image to find most bright region in the retina, as shown in Fig. 2. This point is an approximation of center of optical disc position.

In the second step, the center of optical disc and image center of mass are used to determine the required rotation angle and then the undesired rotation of the scanned image of retina is compensated by applying the opposite rotation. To locate image center of mass for an M×N image the following equation are used (1):

$$\bar{x} = \frac{\sum_{x=1}^{M}\sum_{y=1}^{N} x f(x,y)}{\sum_{x=1}^{M}\sum_{y=1}^{N} f(x,y)} \qquad \bar{y} = \frac{\sum_{x=1}^{M}\sum_{y=1}^{N} y f(x,y)}{\sum_{x=1}^{M}\sum_{y=1}^{N} f(x,y)} \tag{1}$$

After localization of OD and center of mass points, we calculate angle between baseline and the line passing these two points as shown in Fig. 3.

We then compensate for the rotation by applying opposite rotation to input image.

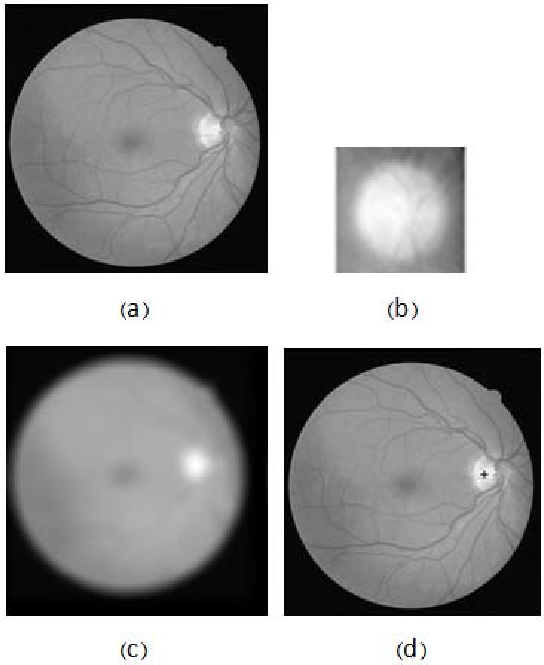

Figure 2. Template matching technique for Optical disc localization (a) original image (b) template (c) correlated image (d) the result of optical disc localized

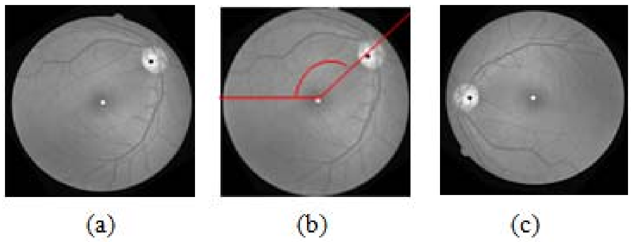

Figure 3. The result of rotation compensation (a) retinal image after localized center of mass and optical disc (b) the calculated angle (c) compensation for image rotation

IV. SELECTED THE ROI AROUND OF OPTICAL DISC AND POLAR TRANSFORMATION

Vessels around OD are more important for identification purposes because their distribution pattern around OD has less randomness within a subject. In other words, as The vessels are farther from OD, they become thinner and Their distribution is more random such that it has less Discriminative property [3] .Thus we focused on vessels around of OD. We used two circular mask with the radius of r1 and r2 (r1 < r2) centered at OD and utilized area between two circles called ROI for feature extraction (see Fig 4.a and b).

After the extraction of ROI from the compensated image, polar transformation is applied on the selected region. Polar image can be constructed by the following transformations from Cartesian coordinates. The point (x,y) in Cartesian coordinates is transformed to the point ($r = \sqrt{(x^2 + y^2)}$, $\theta = arctg(y/x)$) in the polar coordinates. Figure 4 show this transformation. At the next step, the pattern of the blood vessels' in the retina image should be enhanced. There are several vessels enhancement algorithms in the literature. So, in this paper the method presented in [8] is used for blood vessels enhancement. Fig 4.c shows polar transform and vessels enhancement.

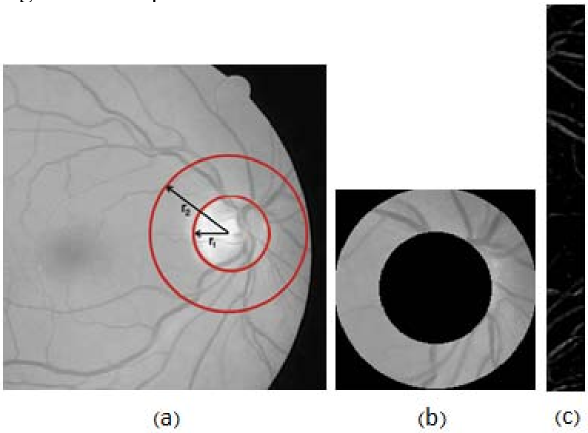

Figure 4. (a) region of interest of vessels images around OD (b) ROI in Cartesian coordinates (c) polar image after enhancement

V. RADON TRANSFORM AND FEATURE VECTOR CONSTRUCTION

To extract features of retina image, we used radon transform. This transform is able to transform two dimensional images with lines into a domain of possible line parameters, where each line in the image will give a peak positioned at the corresponding line parameters. This has lead to many line detection applications within image processing, computer vision.

The Radon transform (RT) of a two dimensional function f(x, y) with compact support that includes the origin is familiar as the set of projections along angles θ, $0 \leq \theta < \pi$

$$Rf \equiv p(\rho,\theta) = \int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} f(x,y)\delta(x\cos\theta + y\sin\theta - \rho)dxdy \quad (2)$$

$$= \int_{-\infty}^{+\infty} f(\rho\cos\theta - \ell\sin\theta, \rho\sin\theta + \ell\cos\theta)d\ell \quad (3)$$

where the δ-function converts the two-dimensional integral to a line integral $d\ell$ along the line $x \cos\theta + y \sin\theta = \rho$ [10].

In other words, the Radon transform is the projection of the image intensity along a radial line oriented at a specific angle (Fig. 5). A projection of a two-dimensional function f(x,y) is a line integral in a certain direction. For example, the line integral of f(x,y) in the vertical direction is the projection of f(x,y) onto the x-axis; the line integral in the horizontal direction is the projection of f(x,y) onto the y-axis. Fig.5 shows horizontal and vertical projections for a simple two-dimensional function.

To construct the feature vector radon transform is applied on the polar image at the specific angle ($\theta=\pi/2$). This feature vector contains both directional and local information and determines the location of the vessel with the straight direction. Radon Feature (RF) has a strong ability to distinguish blood vessels as shown in Fig. 6. The RF of two different blood vessels shown in figure. Fig 7 shows the difference between the components of RF of the polar blood vessels from the same retinas and different retinas. Same retinas are very similar while those from different retinas are quite dissimilar.

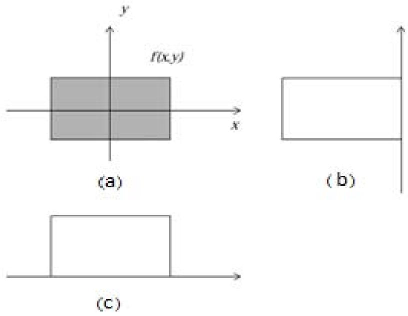

Figure 5. (a) simple two-dimensional function. (b) the line integral of f(x , y) in the vertical direction is the projection of f(x ,y) onto the x-axis (c) the line integral in the horizontal direction is the projection of f(x,y) onto the y-axis.

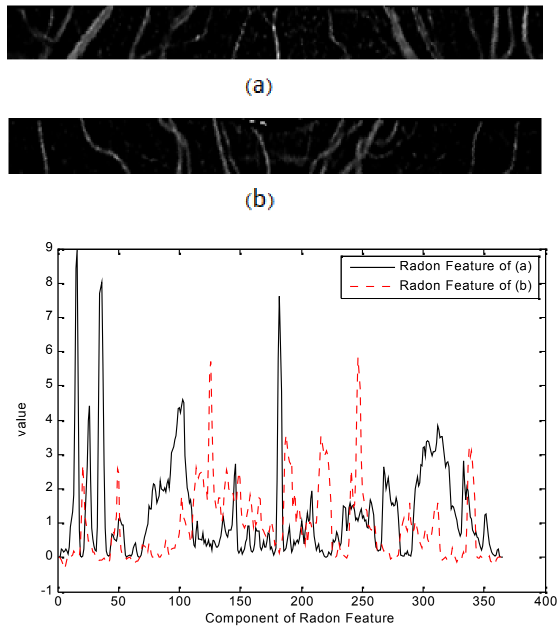

Figure 6. a and b are 2 polar retina images from different persons and c represents corresponding RF vectors.

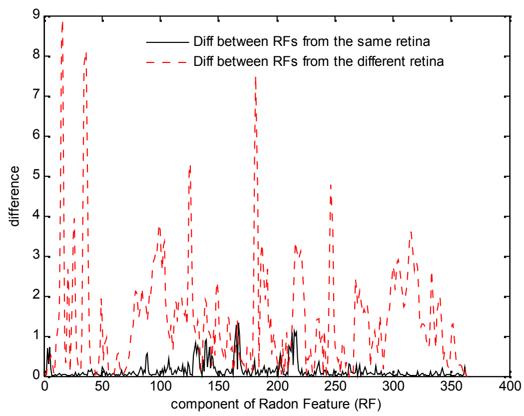

Figure 7. Connected line is difference between RF of

two images captured from same retinas and dash line is corresponding to difference between RF of different retinas.

Retina identification includes two stages. Our proposed identification system includes the following phases. In the registration phase of the persons, a number of images scanned from each person, then after rotation compensation of the captured retinal image, feature vector of all image are extracted and registered in a Feature Data Base. In the test phase, feature vector of each test retinal image is computed, then a method based on 1D DFT is used for feature matching as shown in Fig.8 . First a 1D DFT is applied both on each feature vector registered in data base and the test feature vector and the absolute value (Abs) of each DFT vector is calculated. Based on minimum Euclidean distance classifier, corresponding person to the nearest feature is selected as identified person. 1D FFT and Euclidean distance is selected between different method such as Manhattan distance, Euclidian distance and correlation which are applied on the feature vectors because of its best results.

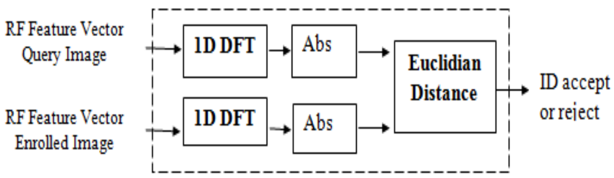

Figure 8. overview of matching stage

VI. EXPERIMENTAL RESULTS

The proposed algorithm tested on a database of 200 retinal images from 40 subjects. To produce test images, each image in the database was rotated 5 times using various random degrees to obtain 200 new test images. Images are green channel of input color image. To employ the proposed method, feature vector has 360 elements. We evaluated the performance of our identification system in three different experiments as follows.

Experiment A:
The first 40 images of DRIVE database were enrolled and 40 images of DRIVE databases with 5 images per subject were entered to the system as queries.

Experiment B:
The first 30 images of DRIVE database were enrolled, and 40images of DRIVE databases with 5 images per subject were entered to the system as queries.

Experiment C:
The last 30 images of DRIVE database were enrolled, and 40images of DRIVE databases with 5 images per subject were entered to the system as queries.

In all of above experiments, we could achieve %100 identification rate.

Fig. 9 shows False Rejection Rate and False Acceptance Rate to determine this system reliability.

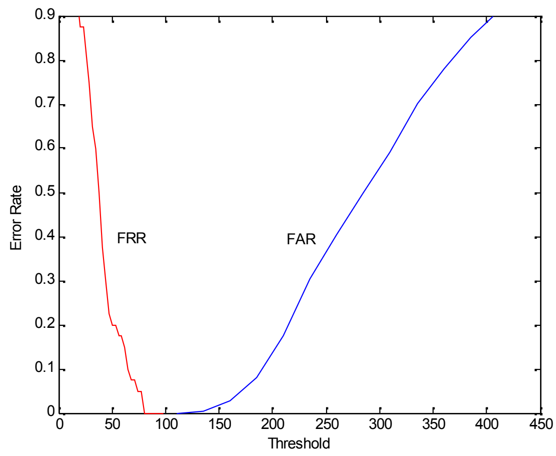

Figure 9. FRR and FAR diagrams

VII. CONCLUSION

In this article, a method for human identification system based on regional image of retina and Radon Transform was proposed. Based on experimental results, this approach is robust to rotation; in addition it's simple and has low computational complexity. Feature vector generated in this method have useful information about vessel diameter and density and vessels direction in the image.

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