Human Identification Using Finger Vein and Texture Matching

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***Abstract*:** In this paper, the finger images obtained from the database are separated into finger vein and finger texture images. These two images are processed separately as per the concept presented in paper. The process involved in matching are divided into image preprocessing, image enhancement, feature extraction and feature matching. For feature extraction we have used Gabor filter and for matching we have implemented score level combination as holistic and nonlinear fusion. Finger vein and finger texture matching system has more advantage than the existing security systems. The vein pattern is not visible to human vision without any special device and it will not produce any trace in any object.

Keywords—*Image Preprocessing, Image Enhancement, Feature Extraction, Matching.*

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I. INTRODUCTION

Automated human identification using physiological and/or behavioral characteristics, biometrics, is increasingly mapped to new civilian applications for commercial use. The tremendous growth in the demand for more user-friendly and secured biometrics systems has motivated researchers to explore new biometrics features and traits [1]. The anatomy of human fingers is quite complicated and largely responsible for the individuality of fingerprints and finger veins. The high individuality of fingerprints has been applied to the random imperfections in the friction ridges and valleys, which are commonly referred to as minutiae or level-2 fingerprint features [2].

The acquisition of such minutiae features typically requires imaging resolution higher than 400 dpi. The conventional level-1 fingerprint features, which illustrate macro finger details such as ridge flow and pattern type, can be extracted from the low-resolution fingerprint images. Such features are useful for fingerprint classification, although the commercially available automated fingerprint identification systems barely utilize such level-1 features. The utility of such features, which can be more conveniently be acquired from the low-resolution (webcam) images or at a distance, deserves attention for its possible use in personal identification for civilian and/or forensic applications [3].The images at such low resolution typically illustrate friction creases and also friction ridges but with varying clarity. Several biometrics technologies are susceptible to spoof attacks in which fake fingerprints, static palm prints, and static face images can be successfully employed as biometric samples to impersonate the identification. Therefore, several liveness countermeasures to detect such sensor-level spoof attacks have been proposed [1], e.g., finger response to electrical impulse [4], finger temperature and electrocardiographic signals [5], time-varying perspiration patterns from fingertips [6], and a percentage of oxygen-saturated hemoglobin in the blood [7].

II. PROPOSED METHOD

A new approach for personal identification that utilizes simultaneously acquired finger-vein and finger surface (texture) images are presented. Our experimental results illustrate significantly improved performance. Another related contribution of this paper is on the development of new approaches for both the finger-vein and finger texture identification, which achieves significantly Improve the performance over previously proposed approaches. Our finger-vein identification approach utilizes peg-free and more user-friendly unconstrained imaging. Therefore, the steps for the acquired finger-vein image normalization, rotational alignment, and segmentation to effectively minimize resulting interclass variations. Block diagram of proposed method is shown in Fig.1.

Finger texture identification: Input image is finger texture image and by applying preprocessing and feature extraction, we get output as finger texture feature extraction image.

Finger texture matching: Input image is finger texture feature extraction image and it is compared with enrollment database to check whether it is matching or not. The output is finger texture image.

Score combination: Input images are finger vein, finger texture and enrollment database and by applying holistic and nonlinear fusion we get output as whether the fingerprint is genuine or not.

III. MODULE DESCRIPTION

A. Module 1: Finger Vein Identification

1. Image preprocessing:

Finger images are noisy with rotational and translational variations. To remove these variations, it is subjected to preprocessing steps.

a) Image normalization
b) ROI extractor

c) Image enhancement

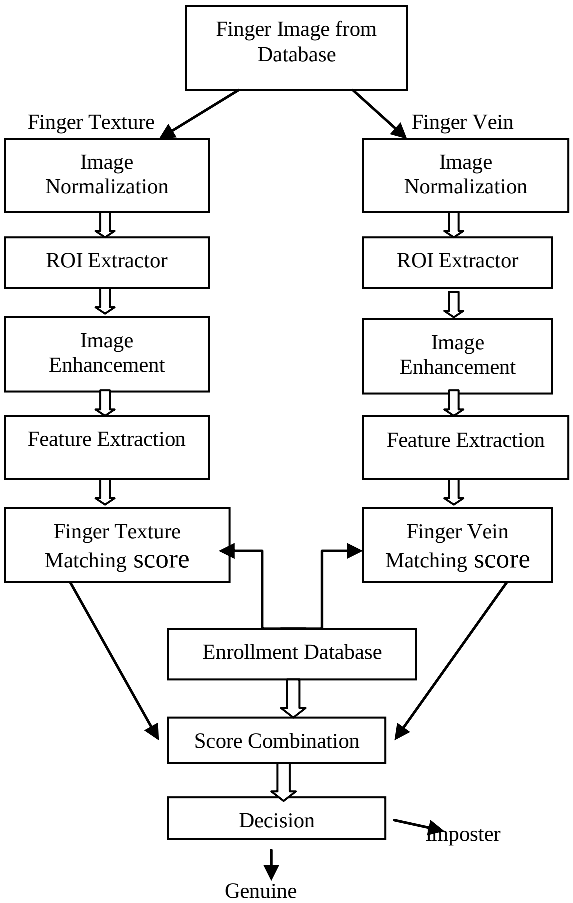

Fig.1. Block Diagram for personal identification using simultaneous finger vein and finger texture matching.

a) *Image normalization:*

Normalization is a process that changes the range of pixel intensity values. In this, the image is subjected to binarization with threshold value of 230. Sobel edge detector is applied to the image to the remove background portions connected to it. Eliminating the number of connected white pixels being less than a threshold, to obtain the binary mask.

Binarization is a method of transforming grayscale image pixels into either black or white pixels by selecting a threshold. Fingerprint Image Binarization is to transform the 8-bit Gray fingerprint image to a 1- bit image with 0-value for ridges and 1-value for furrows. After the operation, ridges in the fingerprint are highlighted with black color while furrows are white. A locally adaptive binarization method is performed to binarize the fingerprint image.

b) *ROI extractor:*

In the finger images, there are many unwanted regions (that cannot be taken for analysis) has been removed by choosing the interested area in that image. The useful area is said to be "Region of Interest". The obtained binary mask is used to segment the ROI (Region of Interest) from the original finger-vein image. The orientation of the image is determined to remove the low quality images that present in finger vein image. This orientation is used for the rotational alignment of the ROI in vein image.

c) *Fingerprint Image Segmentation:*

In general, only a Region of Interest (ROI) is useful to be recognized for each fingerprint image. The image area without effective ridges and furrows is first discarded since it only holds background information. Then the bound of the remaining effective area is sketched out since the minutia in the bound region is confusing with that spurious minutia that is generated when the ridges are out of the sensor. To extract the ROI, a two-step method is used. The first step is block direction estimation and direction variety check, while the second is intrigued from some Morphological methods.

i. Block direction estimation:

The direction for each block of the fingerprint image with W x W in size (W is 16 pixels by default)is estimated. The algorithm is:

I. The gradient values along x-direction (gx) and y-direction (gy) for each pixel of the block is calculated. Two Sobel filters are used to fulfill the task.

II. For each block, following formula is used to get the Least Square approximation of the block direction.

$$tg2\beta = 2\sum\sum(gx * gy)/\sum\sum(gx^2 - gy^2) \qquad (1)$$

for all the pixels in each block.

The formula is easy to understand by regarding gradient values along x-direction and y-direction as cosine value and sine value. So the tangent value of the block direction is estimated nearly the same as the way illustrated by the following formula.

$$tg2\theta = 2\sin\theta\cos\theta/(\cos 2\theta - \sin 2\theta) \qquad (2)$$

After the estimation of each block direction, those blocks without significant information on ridges and furrows are discarded based on the following formulas:

$$E = \{2\sum\sum(gx * gy) + \sum\sum(gx^2 - gy^2)\}/W * W * \sum\sum = (gx^2 + gy^2) \qquad (3)$$

For each block, if its certainty level E is below a threshold, then the block is regarded as a background block.

ii.ROI extraction by Morphological operations:

Two Morphological operations called 'OPEN' and 'CLOSE' are adopted. The 'OPEN' operation can expand images and remove peaks introduced by background noise . The 'CLOSE' operation can shrink images and eliminate small cavities. The bound is the subtraction of the closed area from the opened area. Then the algorithm throws away those leftmost, rightmost, uppermost and bottommost blocks out of the bound so as to get the tightly bounded region just containing the bound and inner area.

d) *Image enhancement:*

The acquired image is thin and it is not clear. So the image is enhanced by using bicubic interpolation for better visualization. Fingerprint Image enhancement is to make the image clearer for easy further operations. Since the fingerprint images acquired from sensors or other Medias are not assured with perfect quality, those enhancement methods, for increasing the contrast between ridges and furrows and for connecting the false broken points of ridges due to insufficient amount of ink, are very useful for keep a higher accuracy to fingerprint recognition. The Method adopted in fingerprint recognition system is Histogram Equalization

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Histogram equalization is to expand the pixel value distribution of an image so as to increase the perceptional information. The original histogram of a fingerprint image has the bimodal type. The histogram after the histogram equalization occupies all the range from 0 to 255 and the visualization effect is enhanced.

B. Module 2: Finger Texture Image Preprocessing

1. Localization and Normalization
2. Image Enhancement

1. Localization and Normalization:

In texture preprocessing, Sobel edge detector is used to obtain the edge map and localize the finger boundaries. This edge map is isolated with noise and it can be removed from the area threshold. Such noise is eliminated from the area Thresholding, i.e., if the number of consecutive connected pixels is less than the threshold. The slope of the resulting upper finger boundary is then estimated.

This slope is used to automatically localize a fixed rectangular area, which begins at a distance of 20 pixels from the upper finger boundary and is aligned along its estimated slope. We extract a fixed 400* 160 pixel area, at a distance of 85 and 50 pixels, respectively, from the lower and right boundaries, from this rectangular region. This 400 *160 pixel image is then used as the finger texture image for the identification.

2. Image Enhancement:

In image enhancement, finger texture image is subjected to median filtering to eliminate the impulsive noise. The resulting images have low contrast and uneven illumination. Therefore obtain the background illumination image from the average of pixels in 10∗ 10 pixel image sub blocks and bicubic interpolation. The resulting image is subtracted from the median-filtered finger texture image and then subjected to histogram equalization.

C. Module 3: Finger Vein Identification Finger Vein and Texture Image Feature Extraction

Gabor filter is used for finger vein and texture image feature extraction. Gabor filters optimally capture both local orientation and frequency information from a fingerprint image. By tuning a Gabor filter to specific frequency and direction, the local frequency and orientation information can be obtained. We have creating the Gabor with specified orientations and these Gabor filter is convolved with the enhanced image to remove the unwanted regions other than the vein and texture regions.

$$G(x,y) = s(s,y)g(x,y) \quad (4)$$

where s(x,y) is complex sinusoid and g(x,y) is 2D gaussian envelope

$$s(x,y) = \exp[-j2\pi(\mu 0x + v0y]) \quad (5)$$

$$g(x,y) = \frac{1}{\sqrt{2\pi\sigma x\sigma y}}\exp[-\frac{1}{2}(\frac{x^2}{\rho x^2} + \frac{y^2}{\sigma y^2})] \quad (6)$$

σ_x And σ_y characterize the spatial extent and bandwidth of along the respective axes, u_o and v_o are the shifting frequency parameters in the frequency domain.

D. Module 4: Finger Vein And Texture Matching:

The general block diagram for matching is given below Fig.2.

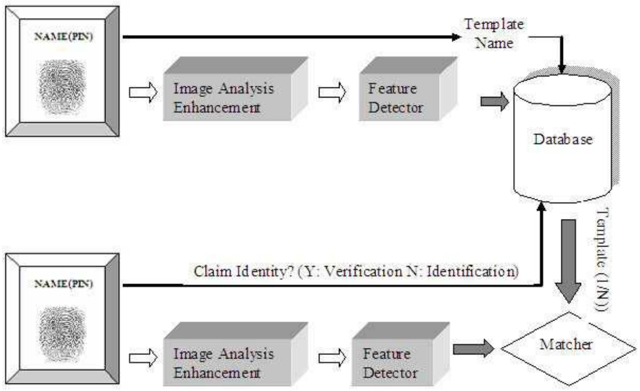

Fig. 2.: Block Diagram For Matching

In that, the matcher block predicts that the vein and texture image is matched with the database. The database contains the features of all vein and texture images.

For matching, two steps has been done

a) Extract features

b) Match features

These two steps are done by using mat lab in built commands. Vein regions extracted from the image are stored in database.

1. Vein matching:

The features extracted from finger vein images are already stored in a database. The features of the input image are matched with all the extracted veins in the database to check whether the input image is matched with any one of the extracted veins.

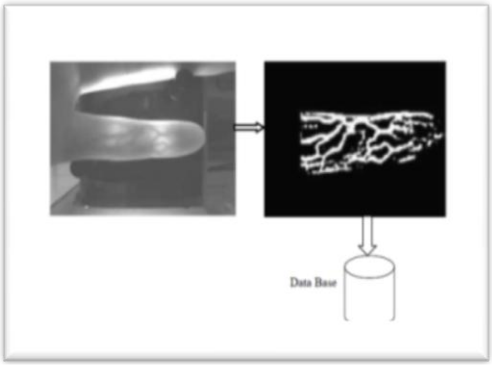

Fig. 3.: Database

2. Texture matching:

The features extracted from finger texture images are stored in the same database. The features of the input image are matched with all the extracted texture in the database to check whether the input image is matched with any one of the extracted textures.

E. Module 4: Score Combination:

In score level combination, two techniques are used.

a) Holistic fusion

b) Nonlinear fusion

These two techniques are used to combine the resultant finger vein and texture images. The result of this fusion is used to check whether the fingerprint is genuine or not.

a) Holistic Fusion:

This approach is developed and investigated to utilize the prior knowledge in the dynamic combination of matching scores. Let s_v, s_t and $\hat{s}$ represent the matching score from finger vein, finger texture, and combined score, respectively, and this holistic rule of score combination is given below:

$$s^{\wedge} = \{\{(s_v * \eta) + (s_t * (1 - \eta))\} + \frac{\{(s_v * \eta) + (s_t * (1 - \eta))\}}{(2 - s_v)} \quad (7)$$

The above equation can also be written as,

$$\hat{s} = \{(s_v * \eta) + ((s_t * (1 - \eta))\} * (1 + \frac{1}{2 - s_v}) \quad (8)$$

By using this equation, the final combined scores have a similar trend as the score from vein matching, i.e., when the score from finger-vein matching is high, the fused score will also become high and vice versa. Factor η is selected to reflect the reliability of each modality or matching score. We choose the matching score from finger vein as the controlling factor since the performance of finger-vein matching is more stable, as compared with that of the texture.

b) Nonlinear Fusion:

This nonlinear score combination attempts to dynamically adjust the combined score according to the degrees of consistency between the two matching scores and is illustrated as below:

$$\hat{s} = \left(\frac{c + s_t}{c + s_v}\right)^{\gamma} * (c + s_v)^2 \quad (9)$$

Where γ is a positive constant and is fixed to 1 and is selected in the range of [1, 2].

IV. Experimental Result

Fig.1. Original Vein Image

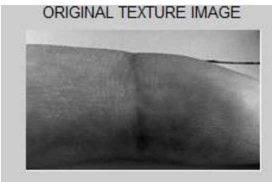

Fig.2.Original Texture Image

Fig.3.Binarised Vein Image

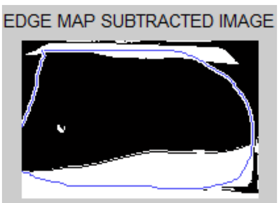

Fig.4.Edge Map Subtracted Image

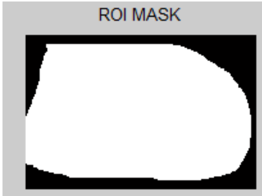

Fig.5.ROI (Region Of Interest) Mask

Fig.6..ROI Finger Vein Image

Fig.7.Enhanced finger vein Image

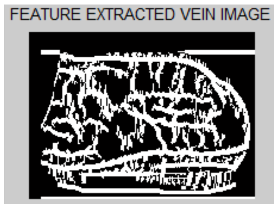

Fig.8.Feature Extracted Vein Image

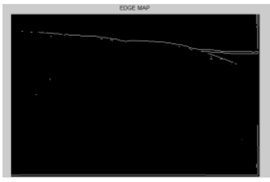
Fig.9.Edge Map

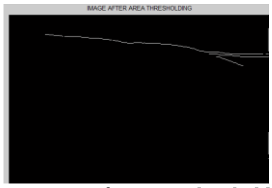
Fig.10. Image after Area Thresholding

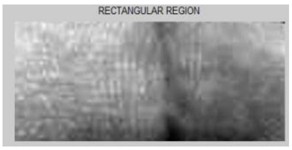

Fig.11.Rectangualar Region

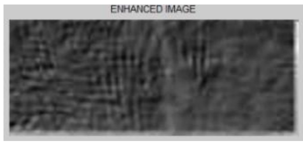

Fig.12.Enhanced Image

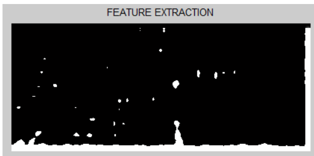

Fig.12.Feature Extraction

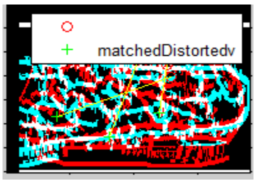

Fig.13.Vein Match

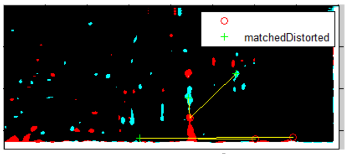

Fig.14.Texture Match

Fig.15.Matching Score

V. Conclusion:

This paper presents a fully automated finger image matching framework by simultaneously utilizing the finger vein and finger texture. Finger-vein identification algorithm is found to be reliable and achieve much higher accuracy. The process involved in matching are divided into image preprocessing, image enhancement, feature extraction and feature matching. Two algorithms have been used namely nonlinear and holistic, for effectively combining simultaneously generated finger-vein and finger texture matching scores.

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