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Finger Vein Recognition Algorithms for Security Application

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***Abstract*- With advent of technology, security becomes a potential issue. To overcome this, finger print recognition is widely used. But it poses some issues, which make it to think of new methods for security. Research is moving in the direction of human finger veins image recognition. Several extracting methods were proposed, namely, using mathematical morphology, valley detection, matched pixel ratio, and Region- based axis projection to achieve the veins features extraction. This article investigates various algorithms, benefits and issues related to various benchmarks. This human finger veins image recognition will play a key role in security in this technological era.**

***Keywords*: Finger-vein, Featureextraction, Personal Identification**

I. INTRODUCTION

In this globalized world, there has been a steady increase in the use of consumer electronics which poses serious security issues. To achieve higher security of data, biometrics has been widely used in many applications. Finger vein recognition uses the unique patterns of finger veins under the skin's surface to identify individuals at a high level of precise. Finger Vein recognition is a method which gets individual's finger pattern by passing near-infrared LED (light- emitting diode) light to finger and it is mapped on to previously stored data in database. This provides a contrast pattern because hemoglobin in the blood absorbs near-infrared LED light. The camera records the pattern as a image and the raw data is digitized, certified and sent to a database of registered the vein pattern of individuals. The stored data can be used further for comparison for authentication. By utilizing the principle, blood vessel patterns are unique to each individual, we are approaching this method. Unlike some biometric systems, blood vessel patterns are almost impossible to fakebecause they are located under the skin's surface [1].

The finger vein patterns are preprocessed, features are extracted by applyingGradient boosted feature algorithm technique and labeled using SVM classifier and they are used for authentication purpose [2].An efficient finger-vein extraction algorithmbased on random forest training and regression with efficient local binary pattern feature. By integratingwith a vein pattern matching method which is robust to finger misalignment, we achieved state-of-the-art fingerveinrecognition.

Local Binary Pattern (LBP) is a very efficient pixel operator which labels the pixels in the image bysetting the threshold value for the neighborhood pixel and considers the result as a binary value [3]. Due to advantages like selective power and computational simplicity, LBP pixel operator has been popularly used in vein extraction for authentication.

SDUMLA-HMT, a finger vein database in which, the device used to capture finger vein images is designed by Joint Lab for Intelligent Computing and Intelligent Systems of Wuhan University [4]. There are two types of errors inmatching results. The first is false rejection, which claims a genuine pair as impostor, and the second is false acceptance, which claims an impostor pair as genuine. This system achieves a FRR of 20.0% and FAR of 0.0% for database containing around 150 images.

Finger-vein recognition system (FVRS) [5] is implemented on an embedded platform and equipped with a novel finger-vein recognition algorithm. The system consists four hardware modules: radio frequency identification system, image acquisition module, embedded main board, and human machine communication module. RFID[6] module will start the very initial communication between the user and the device. The finger-vein images of the user are acquired by the image acquisition module of the hardware. The finger-vein recognition algorithm is coded and embedded to the main board. Thismodule communicates with the user through keyboard and displays like LCD or LED as well as voice message. The RFIDmodule improves the security and credibility of the whole system by giving short message service (SMS) through GSM technology to the actual user about the time of authentication. [7] Explores the IR based finger vein capturing device and different algorithm for feature extraction of finger vein used for authentication. The highlighted the finger-vein authentication process, [3,7] its recognition performance parameter i.e. false acceptance rate (FAR) [8] and false rejection rate (FRR).

The vein vessel network is a very important vein pattern for finger vein recognition in the matching stage, the matched pixel ratio (MPR) [9], Hamming distance (HD) and the mismatched ratio are commonly used as the matching algorithms to evaluate the similarity between two finger vein images. But thesematching algorithms are calculated pixel by pixel, they are sensitive to the imagetranslation and rotation.

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A novel matching strategy regionbasedaxis projection (RAP) [9] is first divide the vein pattern into small regions, then concatenate the projection of the vein distribution curves on the x-axis and y-axis of each region, and finally evaluate the similarity by calculating the projections of the whole vein pattern. Resulting an efficient recognitionperformance where the equal error rate [10] (EER) was 0.9803%with total processing time of 0.6362s.

An algorithmbased on Support Vector Machine for finger vein recognitionpresents three advantages and contributions compared to other algorithms. The local information of the finger veins is extracted based on a LBP (Local Binary Pattern) [3, 11]without segmenting accurate finger vein regions. Second, the global information of the finger veins are extracted based on Wavelet transform. Third, two score values by the LBP and Wavelet transform were combined by the SVM (Support Vector Machine). Based on this method the EER (Equal Error Rate) was 0.011% and the total processing time was 98.2ms.

The Minutiae Extraction [12] and Curve Analysis model has been developed using the combination of minutiae point extraction along with curve analysis which has 94% accuracy. Elastic distortion [13] of fingerprints is the major causes for false non-match. To overcome this problem possessor confirmation and encryption key generation usingbiometric imprison, figure presetting, key generation and figure encryption [14] are performed on the identical hidden platform adding an important portability and diminishing the execution time.Liveness detection [15] technique is more efficiency and less searching cost. In this searching technique optimal technique is used instead of block by block searching.ComputationalIntelligence Techniques [16] algorithm for finger vein authentication. Results FFR and FAR are 0.575% and 1.70% respectively with an execution time of 194 milliseconds.

Local Graph Structure (LGS) [17], Symmetric Local Graph Structure (SLGS) , a Difference Symmetric Local Graph Structure (DSLGS) algorithm and A four-layered CNNwith fusion of convolution and subsampling layersare implemented to overcome the shortcomings of the traditional methods[18],[19]. Segmentation processes and noise filtering are not required for this method.

There are usually a lot of parameters analysedin Finger vein recognition algorithms [20, 21], and an extracting method based on gray valley-shapedregion using the profile curve was developed and implemented in DM6437 platformfor better execution time [22]. Furthermore, the execution time of the optimized algorithm can be used to the engineering applications.

II. Algorithms And Its Evaluation For Vein Detection

There are various algorithms for finger vein detection which is discussed below.

Feature extraction algorithm using mathematical morphology

Step 1:

The algorithm has some basic operations like dilation, erosion, opening and closing. Let f(x,y) be the gray scale of pixel at (x,y) and k(i,j). The dilation and erosion are defined as follows

$$(f \oplus k)(x,y) = \max\{f(x-i, y-j) + k(i,j)\} \quad (1)$$

$$(f \Theta k)(x,y) = \max\{f(x+i, y+j) - k(i.j)\} \quad (2)$$

$$\text{Opening:} \quad f \circ k = [(f \Theta k) \oplus k](x,y) \quad (3)$$

$$\text{Closing:} \quad f \bullet k = [(f \oplus k) \Theta k](x,y) \quad (4)$$

Step 2:

In the next step black top-hat transformation and white top-hat transformations are done. White top-hat image contains local peaks of bright feature and black top-hat image contains local valley of black feature. The mathematical expression are given as:

$$\text{White top-hat:} \quad f_{wth}(x,y) = (f - f \circ k)(x,y) \quad (5)$$

$$\text{Black top-hat:} \quad f_{bth}(x,y) = (f \bullet k - f)(x,y) \quad (6)$$

Step 3:

Let image be I. i(x,y) is the grayscale pixel at (x,y). p be the boundary points of the image i. starting from a boundary point p , scan image in 0,45,90,135 degrees in forward direction (rightward and downward).

Step 4:

SE(structuring element) Si,j(j=1,2,3,4) is defined as pixels in four directions. Multi-scale top-hat transformations to extract the valley Vi,j from Si,j. disk SE with radius 3 is used in white top-hat , then line SE of 1*8 is used in black top-hat transformation.

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Step 5:

The obtained image will be I(x,y)= 1 if Vi,j (x,y)<0 and if 0, Vi,j (x,y)>=0.

Step 6:

If the image has already scanned in all four direction then break
Else i=i+1, and goto to step 1.

Step 7:

Label 8-connected objects in binary image. Then second threshold (N) segment is done. N=60 is better threshold for accurate feature extraction.

Step 8:

To optimize the binary image by morphologic method. Thinning and deburring operations are done.
DM6437 PLATFORM (valley detection)

Step 1:

First step in this algorithm is image acquisition, gray level normalization and filtering. The image is normalized by bilinear interpolation. Let the image be rectangular area M×M with (I,j) center and s(I,j) set constituted by all the pixel values.

Step 2:

Next step is venous segmentation. In the image the gray level distributionof veins is valley shaped. Analyze the gray level profile curve which is perpendicular to the finger. By these characteristics of all direction gray curve. Gray pixel in valley shaped region is determined.

One dimensional gray profile array at d as direction (90°, d=2) are extracted

S(I,j) = { gray(i+k,j)|k = -p,……,-1,0,1,…….p}

In which p= (M-1)/2

Step 3:

Property of center point if there is p meeting the

Gray(i-p,j)<gray(I,j)

Gray(I,j)<gray(i+p,j) and

Where p= 0,1,…..,(M-1)/2

Set gray scale at 255, then the point (I,j) can be determined in valley shaped region.

Step 4:

Repeat steps 2 and 3 for all four directions in the image.

Step 5:

Stack up the results of all direction and finally finger vein segmentation is mapped.

A novel matching strategy (MATCHED PIXEL RATIO)

Step 1:

First step in this algorithm is image acquisition, normalization and filtering.

Step 2:

White parts and vein vessel network of the image are denoted as 0 and 1respectively.

Step 3:

Next stage is matching stage, patterns are matching by binary matched pixel ratio. Let S be the MPR between the input binary image I and template t.

$$S = 2\frac{\sum_{x,y} i(x,y)\cdot t(x,y)}{\sum_{x,y} i(x,y) + \sum_{x,y} t(x,y)}$$

Step 4:

An enrolled pattern t is overlapped with input vein image i. the values of overlapping are compared pixels by pixels. A pair of pixel one in vein and another one is background are counted such a pair is called mismatch.

Step 5:

Let Rm be mismatched ratio .it is the ratio of number of mismatched pairs to the total number of vein pixels.

$$R_m = \frac{\sum_{x,y} t(x,y) \otimes i(x,y)}{\text{sizeof(t)}}$$

Step 6:

The final image of finger vein is produced without any mismatch.

A novel matching strategy (Region- based axis projection)

Step 1:

First step in this algorithm is image acquisition, normalization and filtering.

Step 2:

White parts of image is denoted as vein vessel network and black parts are denoted as background, as 1 and 0 respectively.

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Step 3:

The next step Is dividing the pattern into small regions. Shape and size of the region are determined based on gathered samples.

Step 4:

Here B represent selected region. B_h and B_V are the statistics of the frequency of 1 in jth column and ith row.

$$Bh(k) = \sum_{j=1}^{L} B(i,j) \qquad 1 \le j \le L$$

$$Bv(k) = \sum_{i=1}^{L} B(i,j) \qquad 1 \le i \le L$$

Step 5:

The parameter T (static step length) is added to the equation to diminish the impact of image transformation and rotation. Then the frequency is calculated based on T not by (column to column) or (row to row).

$$Bh(k) = \sum_{j=(k-1)*T+1}^{j+T} \sum_{i=1}^{L} B(i,j) \qquad 1 \le k \le L/T$$

$$Bv(k) = \sum_{i=(k-1)*T+1}^{i+T} \sum_{j=1}^{L} B(i,j) \qquad 1 \le k \le L/T$$

Step 6:

It can be interpreted as a discrete distribution curve projection on the x-axis and same way as y-axis. By this we get histogram like distributed graph.

Step 7:

By concatenate the x-axis and y-axis projection of each region together and evaluate similarities by histogram intersection.

Step 8:

The final image of finger vein is produced without any mismatch.

The results from the above algorithms can effectively extract the finger vein features. The first parameter acquired from these observations is processing time. By implementing feature extraction algorithm and mathematical morphology the processing time is around 214.75 and 200.37 seconds respectively. In digital media platform the processing time has drastic reduction to 0.5 seconds. So, we came to know that digital media processor platform has a low processing time.

The important parameter is average error rate of the feature extraction algorithm is 3.233.Algorithm using mathematical morphology, matched pixel ratio and region axis projection methods the average error rate is reduced as 1.296, 0.1509 and 0.0561 respectively. From the evaluation results to achieve higher performance based on error rate region based axis projection method is better and to achieve higher performance based on processing time implementing valley detection algorithm in digital media platform gives the better results.

III. Conclusions

In this article, we investigated various algorithms for finger vein recognition. Based on the binary vein patterns, in the matching stage, this method can better utilize the vein vessel network distribution information and the divided regions are independence with each other, so it is robustness to the image translation and rotation. Results from various articles shows uniqueness in the following bench marks.

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