Biometrics Detection and Recognition Based-on Geometrical Features Extraction

Azmi Shawkat Abdulbaqi
Dept. of Comp. Science
College of Computer & InfoTech-
University of Anbar
Anbar, Iraq
azmi_msc@yahoo.com

Reyadh Hazim Mahdi
Dept. of Comp. Science.
College of Science-University of
Mustansiriyah
Baghdad, Iraq
reyadh.hazim@uomustansiriayh.edu.

Abd Ibrahim Mosslah
College of Islamic Science-
University of Anbar
Anbar, Iraq
alaesawy24@yahoo.com

***Abstract*—Recently, the biometric detection and recognition have been more interest by people with the progress of technology nowadays. The human fingerprint is an ideal source of data for negative person identification. Fingerprint structure over time does not change, this feature is a good visible candidate solution. The fingerprint can be considered as distinctiveness, collectability, universality, and permanence satisfies biometric characteristic. A new method for fingerprint detection and recognition based geometrical features extraction such as curvature of lines has been presented. The process in this paper passes through pre-processing phase by using same images size. Active contour model (ACM) of Euclidean distance transformation used to detect the fingerprint edges. The median filter was applied in order to image enhancement and denoising after converting the image into the binary system. After then, Sobel edge detection makes some enhancement on the images and extract the features of images. Finally, classified the feature extracted by using absolute error distance and nearest neighbor. This method proved by results that the proposed algorithm shows the accuracy and efficiency almost 97%.**

Keywords—*Sobel Edge Detection, Fingerprint Biometrics, Euclidean Distance Transformation (EDT).*

I. INTRODUCTION

All lately, biometric has been receiving an interest from all. Biometric identified individuals based on their behavioral characteristics and physiological. The biometric systems are systems called biometrics traits, used behavioral and anatomical characteristics to recognize individuals automatically. The biometric will become the main element for any personal identification. Biometrics can be classified into physiological and behavioral classes [1]. The physiological classes depend on external physical features measurements like a fingerprint, body shape, skin color, height, weight, etc. The behavioral classes depend on measure behaviors learned to like, speech, heartbeat, body posture, blinking eye, writing, gait, etc. Biometrics for any human being can carry the following characteristics:

a. Collectability: features can be measured quantitatively.
b. Uniqueness: no two individuals have same features.
c. Permanence: the features are stable over time.
d. Universality: every individual should have it [2].

Identification process takes more time because involves comparing individuals biometric information corresponding to users in the huge database, this based on the size of the database.

978-1-5386-3540-7/18/31.00$©2018 IEEE

The verification process includes comparing individuals templates corresponding to the database, this takes short time due to the comparing includes one to one. Any healthy fingerprint consists of ridges and valleys as shown in fig. (1). the grouped families of fingerprints are classified into two solid-state fingerprint readers (the manual method by ink and regular paper), and optical fingerprint readers (such as fingerprint scanner) [3].

The process of fingerprint capturing by using sensors consists of a touch screen with a specific sensing area to sensing a finger when touching the screen, which according to the physical principle in use captures the difference between valleys and ridges in the fingerprint. The main benefits of the fingerprint as a source of important data are [4]:

a. The fingerprint does not change since the birth until to death.
b. High robustness and high reliability
c. The fingerprint can be captured at a scene of the crime.

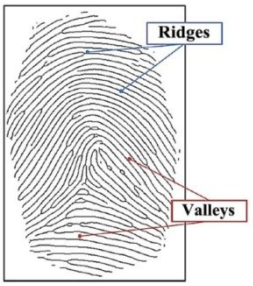

Fig. 1. Show Valleys and Ridges in a Fingerprint Image.

II. RELATED WORK

Wherever there are many types of research have been proposed to gain unique features of the fingerprint in order to identify individuals based on this features. Recently, according to the developments in a person biometrics recognition, led to improvements in the reliability and accuracy. Below, some of the related work on fingerprint detection and recognition.

P. Dh. and Ms .N. M., the researchers presents a study the impact of a fingerprint on person recognition systems and developed this system to overcome the challenges faced by partial fingerprint matching by using MATLAB [5].

Z. F. Gao, X. G. You, L. Zhou, and W. Zeng, present a method for fingerprint by using neighboring local graphical structure to match the pattern points in a global corresponding to overcome of noisy data problem [6].

Z. M. Win and M. M. Sein used a correlation based on fingerprint model. The model uses the Gabor filters for fingerprint feature extraction. The test results of accuracy reported 94% [7].

Zhu Le-Qing, present a proposed a knuckle print recognition model based on SURF algorithm (Speeded-Up Robust Features). The test results show the accuracy of 96.91% depend on Poly U FKP database [8].

J. C. Yang, N. X. Xiong, A. V. Vasilakos and Zh. J. Fang proposes a secure method for fingerprint based on a set of assembled geometric moment and Zernike moment. The results show EER=2.27%, average enroll time=1.77s and average match time=0.19s depend on FVC2002 database [9].

A. K. Jhal, S. Narasimhan, S. Sreedhar, Krishna, and V. P. M. Pillah, proposed artificial neural network based model for the fingerprint. The results test f show recognition quotient of 0.937 and less than 0.5 for another different fingerprint [10].

S.Malathi and C. Meena, develop a novel methodology for partial fingerprint matching based on pores corresponding to their Local Binary Pattern (LBP) features. The result is tested and the best match score is obtained depend on NIST SD30 database [11].

G. Danese, M. Giachero, F. Leporati, and N. Nazzicari, presented a parallel architecture for a fast fingerprint matching technique based on BLPOC (Band Limited Phase Only spatial Correlation). The experimental results show low false acceptance rate and false rejection rate depend on FVC2002 database [12].

Y. Yang and J. Mi built an ATM terminal based on the fingerprint. The model uses Gabor filter for image enhancement. The model ensures enhanced security for stability and reliability [13].

III. Fingerprint Dataset

In this paper, the dataset used for training is NIST-4 database that consists of 4000 various types of images, size 512x512 with 500 dpi resolution. in the dataset, each fingerprint image is numbered from F0001 to F2000 and from S0001 to S2000. The figure below shows a sample of the fingerprint with details.

IV. Geometrical Features Extraction (GFE)

GFE is a comprehensive technology that combines machine learning and computer vision to solve visual tasks. They create a set of representative features from a geometrical shape to represent an object by combining the geometrical features of images and learning them using effective automated learning methods. To solve computer vision problems, researchers simulated people's ability to recognize objects by making several attempts. To solve optical tasks that give a quick response by extracting cognitive parameters from objects seen by humans around it. The methods of engineering learning feature can not only solve recognition problems but also solve prediction problems by analyzing a set of sensory images with serial inputs. Through learning, some hypothesis is given the following procedure, and according to the probability of each hypothesis gives the most likely procedure. The technique is widely used in artificial intelligence[18].

V. Active Contour Model (ACM)

ACM can be defined as a framework of computer vision (CV) to delineating an object into the noisy 2D image. The ACM is public in CV, and more used in the applications such as edge detection, object tracking, segmentation, shape recognition, and etc. In CV, any contour models are used to describe the edges of shapes in the 2D images. ACM designed to solve the problems by the approximate shape of the boundary is known [14].

VI. Fingerprints Acquisition

There are two types of fingerprint acquisition, online and offline. In the offline acquisition, this type of fingerprints are called rolled fingerprint, the method is done by staining fingertip using certain ink and placing a fingertip on paper to taking the fingerprint. Next, the digitization step, by using an optical scanner or high-resolution camera. In the online capturing, the fingertip acquired directly through inkless fingerprint sensor (scanner). The image's resolution must be at least (500dpi) because of the quality of images is very important to determine the fingerprints boundaries [15].

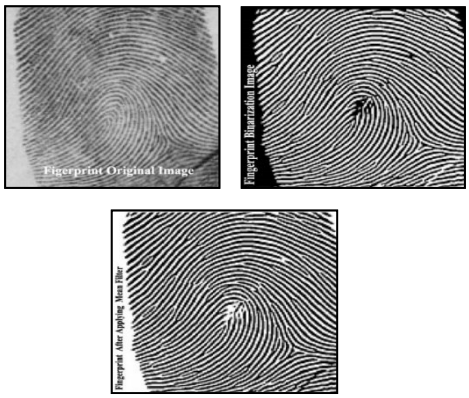

Fig. 2. Fingerprint images ((1) Original Images (2) Binarization Image and (3) Image After Applying Median Filter)

VII. Fingerprint Image Normalization

The goal of the image normalization step is to reduce the dynamic range of the grayscale image between the valleys and edges of the image to facilitate the processing of subsequent phases. The image normalization shown in fig. 3. The processing of fingerprint normalization can minimize the variance in the values of the gray-level along ridges and valleys by means of adjusting values of the gray-level to the predefined constant mean and variance. And normalization can eliminate the effect of sensor noise and the deformations of the gray-level. Let I(i,j) refer to the value gray-level of pixel (i,j) in acquired fingerprint image, the size of fingerprint image is (mxn), M and V are the predicted mean and variance of input fingerprint image,

sequentially, and N(i, j) refere to the value of the normalized gray-level at the pixel (i, j). The normalized image is described as follows equation 1 and 2:

$$\boldsymbol{N(i,j) = M_0 + \sqrt{\frac{V_0}{V}(I(i,j) - M)(I(i,j) - M)}\ if\ I(i,j) > M}\text{……..(1)}$$

or

$$\boldsymbol{N(i,j) = M_0 - \sqrt{\frac{V_0}{V}(I(i,j) - M)(I(i,j) - M)}\ if\ I(i,j) < M}\text{……..(2)}$$

where M_0, and V_0 are the values of the assumed mean and variance, sequentially. Normalization is a pixel-wise operation that does not change the structures of the ridge and valley in the fingerprint images.

Fig. 3. (1) The LEFT image before normalization (2) The RIGHT Image after normalization

VIII. Fingerprint Image Binarization

In this step, if the pixel values are less the threshold level 127, then set the pixel values equal to 255, otherwise, set the pixel values equal to zero according to equation 3[17].

$$P(x,y)=\begin{cases} 0 & if\ G(x,y) > T \\ 255 & if\ G(x,y) \leq T \end{cases} \text{……..(3)}$$

IX. The Proposed model

Recently, the biometric measure will become a necessary and important element of personal identification an easily. Biometrics determine individuals based on behavioral characteristics and physiological characteristics. Preferred to using the biometric systems for personal identification due to the traditional systems have a lot of disadvantages and suffer from weakness such as passwords, specific keys, identification cards etc. and due to the weakness, biometrics systems were used. The fingerprint may be considered as a perfect candidate solution for person identification because of a fingerprint not change over time.

The proposed algorithm consists of the below steps:

a. Image acquisition Process through big database or fingerprint scanner device.
b. Pre-Processing
c. Image Noise removal Process.
d. Fingerprint detection
e. Post Detection
f. Edge detection Process
g. Feature Extraction Process
h. The Classification Process

The above steps described in details by fig.3

1. The Pre-processing Step:

Re-sizing all entire images to the size [272 x 204] pixels in this step. This size is same images sizes in the actual database. In this step, using a median filter to de-noising images according to the below equation(4):

$$G(x,y) = \frac{1}{2\mu\sigma^2} exp^{-\frac{x2+y2}{2\sigma^2}} \text{……..(4)}$$

Where σ^2 represent the standard deviation, and x, y is represents the both coordinate.

2. Fingerprint Detection

In order to specify a fingerprint edges accurately, ACM is used. The following steps are a description of how to determine fingerprint edges detection.

- Using ACM.
- Point manually the first position of ACM. This is done by selecting to main control points of images.
- Determine main ACM parameters by:
- Beta parameter(β)
- Gamma parameters (γ)
- Kappa parameters (κ)
- Wt (Edge): weight of edge factor based on probable range.
- Wt (E-term): weight of edge factor based on cut off the probable range.
- Wt(E-line): weight of edge factor for density based on probable range.
- Determine the no. on iterations for which contours location is to be calculated.

3. Edge detection process

There are several points to describe this step:

- Applying (5x5) mean filter for images denoising.
- Convert the inputted images binarization images.
- Apply Prewitt filter for edge detection by searching on local max I.
- There are two kinds of edges in fingerprints images, weak and strong edges. In order to detect both edges, applying two thresholds if the weak edges in the output only connected with strong edges.

4. Post-processing process

A method was proposed to improve the fingerprint images. This method is based on rules to strengthen enhancement process. The method rejects a candidate bifurcation if:

- The end points and the bifurcation points through minimum distance 8 pixels.

- Through minimum distance and two bifurcation points 8 pixels. Through edge detection in images, there are some edges break. To connect edges, applying equation 5. After that, to ending the contours, applying Equation 6.

$$X \oplus H = U_h \epsilon_H X_h \quad \text{.....(5)}$$
$$X.H = (X \oplus H)_\theta H \quad \text{.....(6)}$$

Where X represents the input image, H is the element structure.

X. The Feature Extraction Process

In binary images, the boundaries of these images are extracted, the fingerprint is extracted from the image and get the minimum Euclidean distance between all pixels according to equation 7 below:

$$D(X,Y) = \sqrt{(x2-x1)^2 + (y2-y1)^2} \quad \text{.....(7)}$$

XI. Fingerprint Images Classification

There are three kinds of fingerprint images classification are used:

a. K-nearest neighboring.
b. Nearest neighboring.
c. The Naïve classification.

According to above description, below is an outline of the proposed algorithm in order to fingerprint image identification and recognition:

1. Input the acquired Image I (i, j) - (from scanner or data set images)
2. Image Re-sizing 272 ×204 (database images standard)
3. Image denoising using a MEDIAN filter.
4. Fingerprint edges detection using ACM model.
5. Image Isolation (Separate the fingerprint from the background).
6. Object(fingerprint) (I,j)= I(I,j) * M(I,j)
7. Smooth image by apply MEAN filter
8. Fingerprint image binarization (converting finger print image to binary image).
9. Fingerprint edge detection using sobel operator.
10. Noise removal by eliminates small noisy objects in images.
11. Connect the broken edges to become closed counter, get edges fingerprint.
12. Apply euclidean distance between every pixel.
13. Get the maximum value as a feature value to the distinction between fingerprint images. The flowchart of above algorithm can be summarized as below:

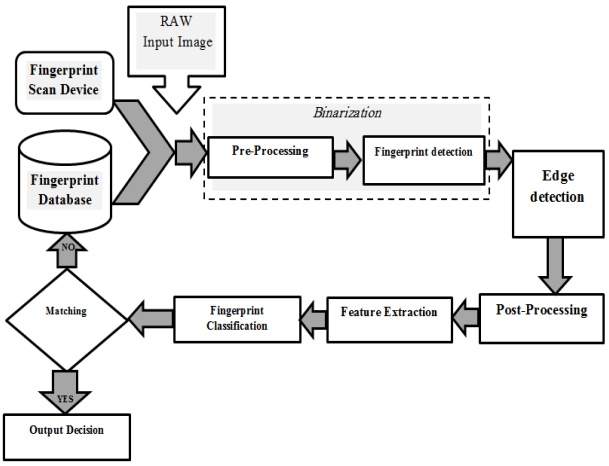

Fig. 4. A Complete Proposed Block Diagram

XII. Experimental Results

In this paper, NIST-4 database of fingerprints images, 2 images for 40 individuals have been presented. In the training phase, using 50 fingerprints images with 25 images for testing, then the algorithm based on training fingerprint images equal to 50 and testing fingerprint images equal to 25. In the classification, the phase is achieved by using more classifier with one nearest neighboring with sum absolute difference distance that gives high accuracy, fingerprint images classified true equal to 47 and fingerprint images classified false equal to 3. Then Accuracy= 97% when used the sum of absolute distance with K nearest neighboring classifier showing in table I.

TABLE II. CLASSIFIERS USED AND ACCURACY

publication	Method	Data base	Fingerprint Sample Test	Genuine Acceptance	False rejection rate(%)	False acceptance rate(%)
The Proposed	GFE	NIST-4	50	97 %	0 %	3.3 %
Marasco and Sansone[2012]	FT	WVU04	50	90 %	0.4 %	7.7 %
Galbally et al. [2009]	WT	BSL	40	86 %	0 %	14 %
Ghiani [2013]	Angular Increment (AngInc)	CAS	30	84 %	0 %	13 %
Espinoza et al. [2011]	Delaunay Triangulation	Clarkson 10 - #1	40	83.7 %	0 %	13 %

TABLE II. ACCURACY OF EUCLIDEAN DISTANCE WITH SUM OF ABSOLUTE DIFFERENCE

Classifier	Accuracy
Naïve	78%
Euclidean distance	93%
Sum of absolute difference	97%

The following figure (5), shows the sequence of fingerprint image operations processing.

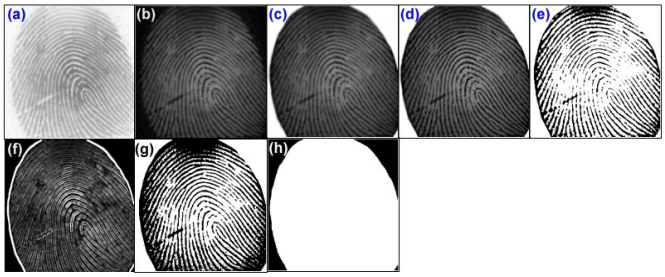

Fig. 5. (a) Original image (b) Edge detection image (c) Image isolated (e) Image after applied median filter (f) Image binarization (g) Detect the largest object (h) Image thresholding (i) Image fingerprint after separation.

XIII. CONCLUSION

In this paper, a novel algorithm for fingerprint detection and recognition using GFE has been introduced. There are many values for features extracted, mean of a fingerprint, four various distances from the matrix which contain Euclidean distance between every pixel in the fingerprint image, the centroid of coordinate x and centroid of coordinate y.

There are attempts to increase the values of distances taken to increase the vector feature that will be more representative. There is no effect on run-time because feature vector is still small but representative. K-nearest neighbor used in the classification process because it confers the highest resolution required for representation. The experimental results proved that the proposed method conferred better results in terms of accuracy and efficiency by 97%.

REFERENCES

[1] V.G. et al., "A Systematic Approach for Feature Extraction in Fingerprint Images", International Conference on Biometric Authentication (ICBA), 2004.

[2] A.K et al., "Longitudinal Study of Fingerprint Recognition," Proceedings of the National Academy of Sciences", Vol. 112, No. 28, p.p. 8555–8560, 2015.

[3] Z.C et al.," A Novel Composite Framework for Large-Scale Fingerprint Database Indexing and Fast Retrieval", in Proc. Hand-Based Biometrics, IEEE, p.p. 1-6, 2011.

[4] W.Y et al.," Fingerprint Enhancement in the Singular Point Area" Signal Processing Letters IEEE, Vol. 11, p.p. 16-19, 2004.

[5] Ms. N. M. and P. Dh.," Design & Implementation of Enhancement, Feature Extraction and Matching of a Fingerprint Image", IJETT (International Journal of Engineering Trends and Technology) – V.13 No. 4, ISSN: 2231-5381,p.184, Jul 2014

[6] Zh. Gao et.al.,"A novel matching technique for fingerprint recognition by graphical structures", in Proc. the Wavelet Analysis and Pattern Recognition, Guilin, IEEE, July 10-13, 2011.

[7] M. M. Sein and, Z. M. Win", Fingerprint Recognition System for Low-Quality Images", Presented at the SICE Annual Conference, University of Waseda, Tokyo, Japan, Sep. 13-18, 2011.

[8] L. Q. ," Finger Knuckle Print Recognition Based on SURF Algorithm", in Proc. Eighth International Conference on Fuzzy Systems and Knowledge Discovery, IEEE, 2011.

[9] Jucheng Yang et al., "A fingerprint Recognition Scheme Based on Assembling Invariant Moments for Cloud Computing Communications", IEEE Systems Journal, vol. 5, No.4, Dec. 2011.

[10] Avinash Kumar Jha et al., " A Neural Network Based Approach for Fingerprint Recognition System", International Congress on Ultra-Modern Telecommunications and Control Systems and Workshops, 2010.

[11] S. Malathi et al. ," An Efficient Method for Partial Fingerprint Recognition Based on Local Binary Pattern", in Proc. CCCT (Communication Control and Computing Technologies), p.p. 569-572, IEEE, 2010.

[12] G. Danese et al. , "A Multicore Embedded Processor for Fingerprint Recognition", in Proc. 13th Euromicro Conference on Digital System Design: Architectures, Methods, and Tools, IEEE, p.p. 779-784, 2010.

[13] Yun Yang and JiaMi,"ATM Terminal Design is Based on Fingerprint Recognition, IEEE, 2010.

[14] O. B. et al., "Best Practice Fingerprint Enrollment Standards-European Visa Information System", in NIST International Biometric Performance Testing Conference, 2010.

[15] AJ.," Survey on Fingerprint Liveness Detection", In Proceedings of the IEEE International Workshop, 2013.

[16] L.G. et al. ,"Fingerprint Liveness Detection using Binarized Statistical Image Features", In Proceedings of the IEEE 6th International Conference on Biometrics: Theory, Applications, and Systems, 2013.

[17] F.A et al. , " A High-Performance Fingerprint Liveness Detection Method Based on Quality Related Features", Future Generation of Computer Systems (FGCS),p.p. 311–321, 2012.

[18] The free encyclopedia Wikipedia, https://en.wikipedia.org/wiki/Geometric_feature_learning.