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Fingerprint Image Thinning by applying Zhang – Suen Algorithm on Enhanced Fingerprint Image

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***Abstract*—** Image enhancement and thinning are very important pre-processing steps of biometric fingerprint recognition system. This reduction is accomplished by two preprocessing steps. The overall performance of the fingerprint recognition system is highly depended on image enhancement phase of recognition process. The image enhancement is a very important phase in fingerprint recognition for improving the image quality by removing the noise, connecting broken ridges and making smooth image. Then after obtaining the skeleton of the image using skeletonization is known as thinning. The enhanced image will be thinned and all ridges will be coming 1 pixel breadth. The performance of the fingerprint minutiae extraction is highly depending on the thinning process of the enhanced image. Thus, the overall performance of the fingerprint recognition system is highly affected by the image enhancement and the image thinning phase of recognition process. It is the precondition of minutiae extraction. In this paper, Image enhancement of fingerprint image is done using Gaussian Mask and Sobel Convolution and then after we propose to apply a Zhang - Suen Thinning algorithm on fingerprint image for better performance. This will give efficient results in terms of image quality and thinning speed. The implementation of research work is done in .Net platform using custom fingerprint database of 100 images of 25 users.

***Keywords*—** Fingerprint Recognition, Fingerprint Image Enhancement, Fingerprint Image Thinning, Skeletonization.

I. INTRODUCTION

Security has always been a major concern for authentication over networking. Fingerprints are one of the biometrics which plays an important role in identifying a person based on some minutiae features [1]. There are three types of Authentication technologies are available. First one is knowledge base authentication, second technique is token based authentication and third technique is biometric based authentication. A biometric system is an identification system, which identify the person by determining the authenticity of specific physiological or behavioral characteristics of a user [2]. Now a day's Biometric based authentication is used rapidly from last few decades. Different physiological biometrics modalities like Fingerprint, Face, Iris, Retina, Hand geometry etc and behavioral biometrics modalities likes Voice, Dynamic Signature, Keystroke dynamics, Gait/Body recognition are used for authentication purpose.

Fingerprint recognition is very popular authentication among others biometric authentication. In general, the fingerprint recognition consists of six main steps:

(a) Pre-processing steps.
(i)Image Enhancement
(ii)Ridge extraction
(iii)Binarization
(iv)Thinning
(b) Post processing.
(v) Minutiae extraction
(vi)Matching and recognition

When noisy and low quality image of fingerprint is available then recognition of fingerprint is a complex biometric authentication problem [3-5]. Minutiae extraction cannot be done from the poor quality fingerprint image. Preprocessing algorithm is required to improve the quality of the fingerprint image, so genuine minutiae extraction can be performed for performance improvement [6]. In this proposed work, we are working for the improvement of quality of noisy fingerprint image and then enhanced Image is used for image binarization and thinning processes for fingerprint recognition for performance improvement. In our research the combination of Gaussian Mask and Sobel Convolution is used for fingerprint image enhancement. Then we use Zhang

– Suen thinning algorithm for image thinning. The resulted images are getting using dot net platform.

II. LITERATURE REVIEW

In [7] the author proposes a new algorithm of thinning which combines sequential and parallel approaches. And these approaches come under iterative approach. The thinning algorithm uses three stages. The first and second stage is used to extract the skeleton of the input image and the last stage is used for optimizing the skeleton into one-pixel width. And the experimental result shows that the proposed skeletonization algorithm produces better, effective results than the previous thinning algorithms.

In [8] the author proposes two new iterative thinning algorithms for thinning images. Here Input image must be a binary image. The first thinning algorithm of binary images is done using two operations first is edge detection and second is subtraction. The second thinning algorithm is depends on peeling the pixels until a skeleton of the image is obtained from the binary image as input. The results descibe that edge based and subtraction based iterative thinning algorithm is time- consuming as compared to optimized skeletonization algorithm.

In [9] the author introduced a new technique for making thinning algorithms robust against noise in sketch images and also having fast computation time. The framework estimates the optimal filtering scale automatically and adaptively to the input image. Experimental results showed that this framework is robust against typical types of noise which exists in sketch images, mainly contour noise and scratch.

In [10] the author proposes an algorithm based on morphological operators with the use of hypergraph and also describes its application like Biometric authentication, Signature verification for thinning algorithms. These operators are used prevent errors and irregularities in the skeleton. These operators using hypergraph such as dilation, erosion etc. is a new approach of thinning in image processing and these operators act as a filter for the removal of the noise and also remove the errors from the images.

In [11] the author proposes an algorithm which is combining two thinning approaches that is parallel and sequential which are further categorized under iterative approach. This is widely used approach for thinning of the image. The result of thinning of image is giving much better results when comparing with other thinning techniques. This method is applicable for any shape with any rotation.

In [12] the author briefly, describes an open CV based java platform using Zhang and Suen thinning algorithm. It describes that the proposed implementation for the thinning of the image with the existing implementations of Zhang and Suen thinning algorithm using Matlab platform, C++ and it compares the performance parameters like computation time for the skeleton of the image, thinning rate, removal of noise with others. This experimental results achieved by openCV based java platform. It is faster in terms of computation time and better removal of noise from the image when compared to Matlab and C++.

III. PROPOSED WORK

In this proposed research work we used Gaussian Mask and Sobel Convolution for fingerprint image enhancement. Then we apply Zhang – Suen thinning algorithm on resulted fingerprint image for improvement the performance of fingerprint recognition system.

Fingerprint image enhancement using Gaussian Mask and Sobel Convolution

We proposed composite algorithm for Image enhancement. We use Gaussian Mask for making smooth image and then use two 3*3 Sobel convolution mask for finding edges. The following 5x5 mask is applied on input fingerprint image and then the resulted image is further processed using Sobel convolution.

$$\frac{1}{115}\begin{bmatrix} 2 & 4 & 5 & 4 & 2 \\ 4 & 9 & 12 & 9 & 4 \\ 5 & 12 & 15 & 12 & 5 \\ 4 & 9 & 12 & 9 & 4 \\ 2 & 4 & 5 & 4 & 2 \end{bmatrix}$$

Sobel Edge Detection [13]

2-D spatial gradient measurement on an image is performed by the Sobel operator. It is used to get the approximate absolute gradient magnitude at each point in an input grayscale image.Use a pair of 3x3 convolution masks, one to estimate the gradient in the x direction (columns) and the other to estimate the gradient in the y (rows) direction.3x3 mask is very smaller than the actual image. Because of this, the mask is moved over the image and at the same time manipulates a square of pixels.The example of actual Sobel masks is given below in Figure 1:

-1	0	+1
-2	0	+2
-1	0	+1

Gx

+1	+2	+1
0	0	0
-1	-2	-1

Gy

Figure 1. Example of actual Sobel masks

An approximate magnitude is calculated using following equation.

$|G| = |Gx| + |Gy|$ [12]

The mask is slide over the area of input image and it changes the pixel value and it shift one pixel to the right direction and continue to right direction until it reaches to end of row. Then it goes over to next row. In the following Figure 2 shows an example in which the mask is slide over the top left portion of the input image is shown by green outline. A particular pixel in the output image would be calculated by the formula. The centre of the mask is placed over the pixel you are manipulating in the image. For example pixel a22 have corresponding m22 mask value. It is also notice that pixels in the first and last rows, as well as the first and last columns cannot be manipulated by a 3x3 mask. This is because when the mask is placed on a pixel in the first row, the mask is outside the boundaries of the image.

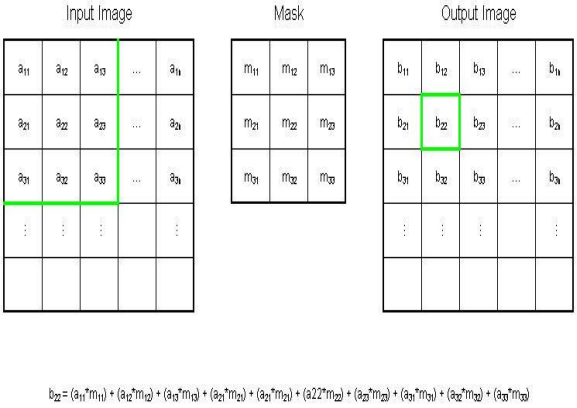

Figure 2. Sobel edge detection example [14]

ZHANG - SUEN THINNING – THE ALGORITHM WE WOULD LIKE TO USE

The algorithm I prefer to use is called Zhang-Suen Thinning algorithm, which introduced in "A Fast Parallel Algorithm for Thinning Digital Patterns" written by T.Y. Zhang and C.Y. Suen.

In this algorithm, a 3X3 matrix is introduced as a mask of original binary image. The layout of the matrix showed as below:

This method for extracting the skeleton of a picture consists of removing all the contour points of the picture except those

P_9 $(i-1, j-1)$	P_2 $(i-1, j)$	P_3 $(i-1, j+1)$
P_8 $(i, j-1)$	P_1 (i, j)	P_4 $(i, j+1)$
P_7 $(i+1, j-1)$	P_6 $(i+1, j)$	P_5 $(i+1, j+1)$

Figure 3. The layout of 3X3 matrix in Zhang-Suen algorithm[15]

points that belong to the skeleton. In order to preserve the connectivity of the skeleton, we divide iteration into two sub-iterations[16].

In the first sub-iteration, the contour point P1 is deleted fromthe digital pattern if it satisfies the following conditions:

(a) 2 _< B(P1) -< 6
(b) A(P1) = 1
*(c) P2*P4*P6 = 0*
*(d) P4*P6*P8 = 0*

Where *A(P1)* is the number of 0-1 patterns in the ordered set P2, P3, P4, … P8, P9 that are the eight neighbors of P1, and *B(Pi)* is the number of nonzero neighbors of P1,that is:
B(P1) = P2 + P3 + P4 + … + P8 + P9.
If any condition is not satisfied, e.g., the values of P2, P3, P4 … P9 as shown in figure on the left, then A(P1) = 2.

Therefore, P1 is not deleted from the picture.

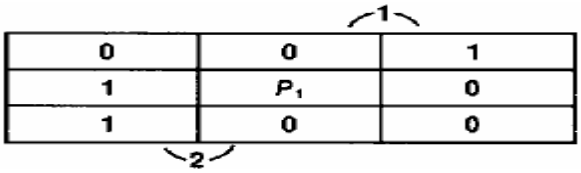

Figure 4. A 3X3 matrix with two 0-1 patterns[16]

This method for extracting the skeleton of a picture consists of removing all the contour points of the picture except those points that belong to the skeleton. In order to preserve the connectivity of the skeleton, we divide iteration into two sub-iterations [16]

In the first sub-iteration, the contour point P1 is deleted from the digital pattern if it satisfies the following conditions:

(a) 2 _< B(P1) -< 6
(b) A(P1) = 1
(c) P2*P4*P6 = 0
(d) P4*P6*P8 = 0

And the rest remain the same.

By conditions (c) and (d) of the first sub-iteration, it will be shown that the first sub-iteration removes only the south-east boundary points and the north-west corner points which do not belong to an ideal skeleton. Similarly, it can be proved that the point P1 deleted in the second sub-iteration might be a north-west boundary point or a south-east corner point [17].

By condition (a), the endpoints of a skeleton line are preserved. Also, condition (b) prevents the deletion of those points that lie between the endpoints of a skeleton line. The iterations continue until no more points can be removed [17].

A flowchart of Zhang-Suen thinning algorithm is below.

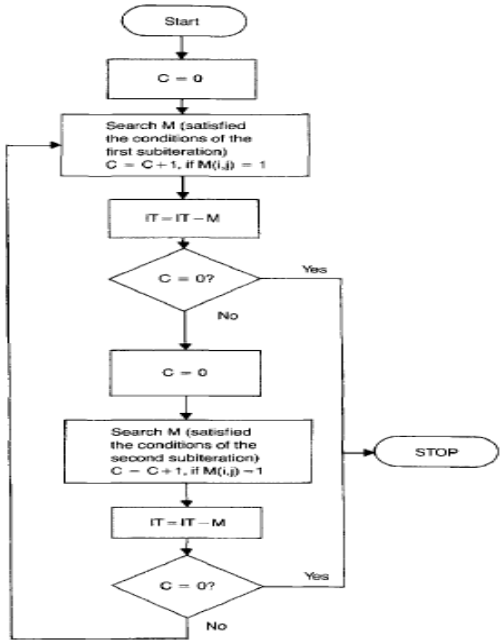

Figure 5. The flowchart of Zhang-Suen thinning algorithm[17]

Initially, the original binary image is stored in matrix *IT* and a counter C is set to 0. The result of the processed image is stored in matrix *IT* as well.

The Zhang-Suen algorithm is very easy to understand and has high precision because it uses two sub-iterations to examine each pixel. The short spurs containing in the processed image are much less than iteration parallel morphological thinning.

Those distinct advantages made me to choose the Zhang-Suen algorithm as thinning method in this fingerprint Paper.

IV. IMPLEMANTATION

The implementation of research work is done in .Net platform using custom fingerprint database of 100 images of 25 users.

The following result is obtain by applying Gaussian Mask for making smooth image and then use two 3*3 Sobel convolution mask .

Table 1. Image quality of proposed enhanced algorithm Using Gaussian Mask and Sobel Convolution

Original Image	Enhanced Image
	
101_01_Original	101_01_Enhanced Image
	
102_01_Original	102_01_Enhanced Image
	
103_01_Original	103_01_Enhanced Image
	

104_01_Original	104_01_Enhanced Image
	
105_01_Original	105_01_Enhanced Image
	
106_01_Original	106_01_Enhanced Image

The following result is obtain by applying Zhang-Suen thinning algorithm on enhanced image which is get by Gaussian Mask and two 3*3 Sobel convolution masks .

Table 2. Thinning Image Using Zhang-Suen thinning algorithm

.

Enhanced Image	Thinned Image
	
101_01_Enhanced Image	101_01_Thinned Image
	
102_01_Enhanced Image	102_01_Thinned Image
	
103_01_Enhanced Image	103_01_Thinned Image

	
104_01_Enhanced Image	104_01_Thinned Image
	
105_01_Enhanced Image	105_01_Thinned Image
	
106_01_Enhanced Image	106_01_Thinned Image

V. CONCLUSION AND FUTURE SCOPE

The research paper shows the implementation of composite algorithm of Gaussian mask and Sobel convolution. The Gaussian mask is used for making smooth images and 3*3 Sobel convolution for detecting edges. Then after Image thinning is carried out by applying Zhang-Suen thinning algorithm on enhanced images. The experiment result shows that noise is removed from the original image by using Gaussian mask and Sobel convolution. The thinned image also provide skeleton fingerprint image so genuine minutiae extraction can be performed for performance improvement of fingerprint recognition system.

REFERENCES

[1] S.Suri, "Biometric based on fingerprint" International Journal of Computer Sciences and Engineering (ISSN: **2320-7639**), Vol-**6** Issue-**5** June **2018**.

[2] V.K. Jain, N Thripathi "Speech Features Analysis and Biometric Person Identification in Multilingual Environment" International Journal of Scientific Research in Network Security and Communication (ISSN: **2321-3256**),Vol-**6** Issue-**1** Feb **2018**.

[3] J. Fierrez-Aguilar, L.-M. Munoz-Serrano, F. Alonso-Fernandez, and J. Ortega-Garcia. On the effects of image quality degradation on minutiae and ridge-based automatic fingerprint recognition. In IEEE Intl. Carnahan Conf. on Security Technology ICCST, Las Palmas de Gran Canaria, Spain. IEEE Press, October **2005**.

[4] H. Fronthaler, K. Kollreider, and J. Bigun. Automatic Image Quality Assessment with Application in Biometrics. In IEEE Workshop on Biometrics, in Association with CVPR-**06**, New York, pages **30–35**, June **2006**.

[5] D. Maio, D. Maltoni, R. Cappelli, J. Wayman, and A. Jain. FVC **2004**: Third Fingerprint Verification Competition. In International Conference on BiometricAuthentication (ICBA**04**), Hong Kong, pages **1–7**, July **2004**.

[6] M. B. Patel, R. B. Patel, S. M. Parikh and A. R. Patel, "An improved O'Gorman filter for fingerprint image enhancement," **2017** International Conference on Energy, Communication, Data Analytics and Soft Computing (ICECDS), Chennai, **2017**, pp. **200-209**.

[7] Abu-Ain W, et al. "Skeletonization Algorithm for Binary Images" The 4th International Conference on Electrical Engineering and Informatics (ICEEI **2013**) pp.**704-709**.

[8] Padole G.V, Pokle S. B. "New Iterative Algorithms For Thinning Binary Images" Third International Conference on Emerging Trends in Engineering and Technology IEEE **2010** pp. **166-171**

[9] Chatbri et al. "Using scale space filtering to make thinning algorithms robust against noise in sketch images" Pattern Recognition letters **42(2014)** pp. **1-10.**

[10] Prakash, R. P., Keerthana S. Prakash, and V. P. Binu. "Thinning algorithm using hypergraph based morphological operators." Advance Computing Conference (IACC), **2015** IEEE International. IEEE, **2015**.

[11] Abu-Ain, W., Abdullah, S.N.H.S., Bataineh, B., Abu-Ain, T. and Omar, K., **2013**. Skeletonization Algorithm for Binary Images. Procedia Technology, **11**, pp.**704-709**.

[12] Saudagar, Abdul Khader Jilani, and Habeeb Vulla Mohammed. "OpenCV Based Implementation of Zhang-Suen Thinning Algorithm Using Java for Arabic Text Recognition." Information Systems Design and Intelligent Applications. Springer India, **2016. 265-271**.

[13] Vincent. O. R. and Folorunso. O., "A Descriptive Algorithm for Sobel Image Edge Detection", Proceedings of Informing Science & IT Education Conference (InSITE) **2009**.

[14] Shrivakshan, G. T., &Chandrasekar, C. **(2012)**. Comparative Study Among Sobel, Prewitt And Canny Edge Detection Operators Used In Image Processing, Journal of Theoretical and Applied Information Technology, Vol.**96**. No **19**, Oct-**2018**.

[15] T.Y. Zhang and C.Y. Suen, A Fast Parallel Algorithm for Thinning Digital Patterns, Communication of the ACM, Vol.**27** No.**3**. pp **236**, Mar **1984**.

[16] T.Y. Zhang and C.Y. Suen, A Fast Parallel Algorithm for Thinning Digital Patterns, Communication of the ACM, Vol.**27** No.**3**. pp **237**, Mar **1984**.

[17] T.Y. Zhang and C.Y. Suen, *A Fast Parallel Algorithm for Thinning Digital Patterns*, Communication of the ACM, Vol.**27** No.**3**. pp **238**, Mar **1984**.

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