A Study on Fingerprint Image Enhancement Techniques

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Abstract – Fingerprints have ridges and valleys on the surface of the finger. Segments on the top skin layer are the ridges and the bottom skin layers are valleys. Minutia points are designed by ridges. The fingerprint is identified uniquely by the pattern of the ridges and minutiae points. There are 5 categories of patterns available in a fingerprint: arch, tented arch, left loop, right loop and whorl. Sensor captures several images of finger under different Illumination conditions that include different wavelengths, different illumination orientations, and different polarization conditions. The output contains information about both the surface and subsurface features of the skin. The finger print image used for matching must be of good quality and it must be without of any type of noise. Reduce the amount of noise in finger print image gives more accurate results. Reducing noise in finger print image is not an easy process. Because of this the fingerprint image gives inopportune minutiae results. Therefore the fingerprints must be improved to mine the minutiae and get entire features of the fingerprints. There have been different image enhancement technique approaches and filters were developed to enhancement the fingerprint images. There are three main techniques of enhancement. Pixel wise Enhancement Techniques, Contextual Filter Enhancement Techniques and Multi Resolution Enhancement Techniques. This paper focuses on these various Fingerprint Enhancement Techniques.

Keywords – ***Biometric identification, minutiae, fingerprint enhancement, Pixel wise Enhancement, Contextual Filter, Multi Resolution Enhancement, etc.***

1. INTRODUCTION

Fingerprint authentication option is introduced by International Systems Research Co. (ISR) for its cloud authentication and access control service, CloudGate. Touch ID-equipped iOS devices can be used by CloudGate consumers to enable this option immediately. When fingerprint authentication option is enabled, CloudGate consumers will get prompt on their iOS devices to validate their login requests initiated via PC browsers. With the right user ID and Touch ID fingerprint, CloudGate consumers can securely access Cloud services such as Google Apps for Work and Office 365 without memorizing and typing in passwords. This feature works with Touch ID-equipped iPhones out-of-box, with no additional devices needed.

The Demand of Passwordless and Non-Password Authentication

Login using ID and Password is a commonly used mechanism in authentication for corporate information systems. However, authentication by validating traditional fixed passwords that the user memorizes and keeps undisclosed always suffers from the risks of fail to recall passwords or pinched passwords. One-time password authentication using USB tokens or mobile apps is one of the solutions to the liability of password authentication. However, this solution brings extra burden to the users who would have to carry additional device(s) and enter extra dynamic passcode(s).

Most of the enterprise IT systems are still using conventional password authentication for implement in their IT systems. Authentication mechanism has not been changed much. Ever since Cloud services started to catch up in the enterprise IT systems requires the daily user login process to be carried out over the Internet, thus calls for healthy and simple authentication that can solve the problem of choosing between security and convenience.

Fingerprint Authentication in CloudGate

- No fingerprint scanning device is required. CloudGate only needs a Touch ID-equipped iOS device to implement fingerprint authentication
- It provides additional security when the user logins in Cloud services via Personal Computer browsers.
- Apple's Touch ID is used in Fingerprint authentication which is more reliable and secure.

The new system of authentication will reduce the stress of daily login for IT administration and end users. And also it boost the security and reduce the helpdesk workload if the passwordless authentication is in place. With fingerprint authentication option, ISR is devoted to making its one safe login cloud service secure and reliable, and accessible to more and more users. Reliable personal authentication has become an essential human computer interface activity. E-commerce, access to computer networks and National Security are some examples where establishing a person's identity is very important. The fingerprint is the most widely used entity since they are unique and do not change over life time and even not at all need to be remembered.[4] Reliable extraction of features from poor quality fingerprint is the most challenging problem faced in the area of fingerprint recognition. Fingerprint image enhancement is the first step in every Automatic Fingerprint Identification System (AFIS), which improves the quality of the fingerprint image by removing noise and blur, thereby escalating the reliability of fingerprint recognition. The following Figure 1 represents the various patterns of Fingerprint.

Figure 1: Pattern of Fingerprint

2. BACKGROUND

Fingerprint is an impression left by friction ridges on a surface. There are two types of fingerprint namely online fingerprint and offline fingerprint. If it is occupied by direct imaging (e.g. by putting the finger directly on a scanner), it is called an online fingerprint on the other hand if the impression is taken on any other surface, then it is called offline fingerprint. A fingerprint pattern consists of ridges and valleys. A ridge is a narrow elevated skin which looks like a line on a finger surface and

the valleys are the furrows which separate the ridges. Figure 2 shows the general fingerprint identification system.

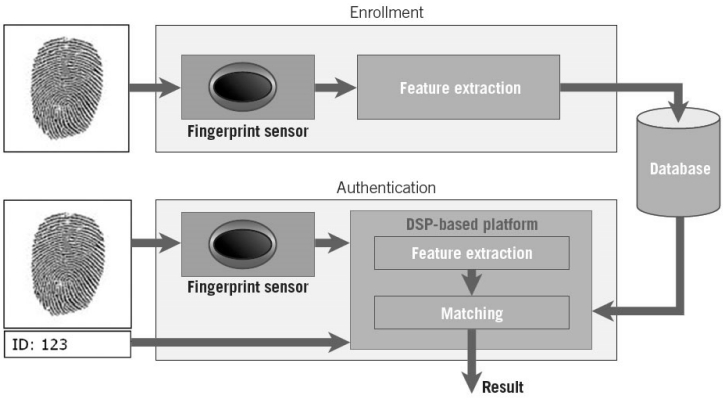

Figure 2: Fingerprint Identification System

There are three physical structural levels in a fingerprint which are discussed below:

2.1. Global Pattern Level

The overall pattern of a fingerprint is represented in Global Pattern Level. For example, in a fingerprint, ridges may enter from bottom-right and then after looping around the center, they may exit from the bottom right again. According to Henry [1] classification of fingerprints, it is called right loop. Similarly, there are other such global patterns and Henry's classification in this respect is exclusive and almost exhaustive. This structure is mainly used for fingerprint classification and/or indexing.

2.2. Local Ridge Pattern Level

Most of the identification algorithms are designed on the basics of this pattern. Ridges may not be continuous in a fingerprint. Some ridges split into two ridges known as bifurcations while some end at some point termed as ridge endings. Such positions are important in a fingerprint. All these are called minutiae points. Minutiae are points which are combination of ridge ending and bifurcation. In addition to this, there are three more special points in a fingerprint (called singular points), core point and delta point. If the innermost ridges of a finger print turns, it is called core point. If two ridges running side-by-side diverge, it is called delta point. Every fingerprint need not have core or delta point while some may have more than one such point. There are generally more than 75 minutiae points in a complete fingerprint of a fingertip.

2.3. Low Level Features

The sweat pores which appear as white holes in the ridges may presented in the fingerprint. This can be obtain by using very high resolution scanners. So these features are used by very sophisticated fingerprint matching systems.

3. MOTIVATION

The necessity to identify an individual for security is raised; the minutiae extraction has a vital role in fingerprint authentication system. The bogus minutiae points presented in the extracted result

will reduce the accuracy of the system. Fingerprint enhancement to get better superiority of fingerprint along with extract minutiae points is become a mandatory. Minutia extracted from the fingerprint greatly depends on quality of input fingerprint. For extracting the exact Minutiae from the fingerprint it is necessary to remove noise from the input image and for that there is need of enrichment algorithm for accuracy.

4. FINGERPRINT ENHANCEMENT TECHNIQUES

Image enhancement is the process of digitally improving a stored image using software program. Many different kinds of tools are used for image enhancement which includes filters, image editors and other tools for changing various properties of an entire image or parts of an image [2]. The main three types of Fingerprint enhancement techniques having two or more subtypes of each are described as follows [1]:

4.1. Pixel-wise enhancement

i. Histogram Equalization
ii. Contrast Enhancement
iii. Normalization
iv. Wiener Filter, etc.

In this pixel based fingerprint image processing function the new value of each pixel only depends on earlier value and a few universal parameters (not depend on the value of the neighbor pixels). Pixel based techniques don't give a good and ultimate results for fingerprint enhancement. Still, contrast stretching, histogram manipulation, normalization and Wiener filtering had given away to be helpful as initial processing steps in added sophisticated fingerprint enhancement algorithm.

The relative frequency of the various gray levels of an image is called the histogram of an image. We can get a uniform histogram for the output image by using histogram equalization. Thus this is a technique for the enhancement in the contrast of an image by adjusting the intensity of every gray level of the image. In this technique without touching the global contrast the lower contrast areas gain a higher contrast.

The commonly used image enhancement method is the contrast enhancement. Many methods for image contrast enhancement have been proposed which can be broadly categorized into two methods: direct methods and indirect methods. Among the indirect methods, the histogram modification techniques have been widely utilized because of its simplicity and explicitness in which the histogram equalization (HE) is one of the most frequently used techniques.

Normalization algorithm can be used to address the problem of uneven background in digital fingerprint images. A background normalization algorithm is designed to adaptively adjust the pixel intensity based on an approximation of the background of a document image.

Weiner Filtering method restores the image even in the presence of blur as well as noise. It uses a pixel wise adaptive method for noise reduction.

4.2. Contextual filtering

i. Fourier Transform
ii. Gabor Filter
iii. Bell Shaped Filter, etc.

A popular technique for fingerprint enhancement is Contextual filtering. In this topological filter features are aligned with the local orientation and frequency of the ridges in the fingerprint image. In traditional image filtering just single filter is used for involvedness all the way through the fingerprint image. Within contextual filtering technique, the filter properties modify based on local context. The first method utilizing contextual filter to enhance fingerprint images performed both the filter design and the filtering in the spatial domain. In reality the sinusoidal-shaped wave of ridges and valleys is principally defined by a local orientation, frequency that varies slowly across the fingerprint area. A suitable filter that is tuned to the home ridge frequency and direction can efficiently removes the unwanted noise and preserve the accurate ridge valley arrangement.

The Fourier Transform is the series expansion of an image function in terms of "cosine" image basis functions. Initially our image is in spatial domain. i.e. The components of the image (the RGB components) vary with their intensity in space (x-axis and y-axis). Representation **->f(x,y)**

Fourier transform can be visualized as a transformation of this image in spatial domain to another domain called the **frequency domain** or ***Fourier domain***. Representation -> **F(u,v)** [u - frequency change along x-axis, v-frequency change along y-axis)

A linear filter used for edge detection is known as Gabor filter. Frequency and orientation representations of Gabor filters are similar to those of the human visual system, and they have been found to be particularly appropriate for texture representation and discrimination. In the spatial domain, a 2D Gabor filter is a Gaussian kernel function modulated by a sinusoidal plane wave.

Gaussian filtering is used to blur images and remove noise and detail. It defines a probability distribution for noise or data. It also used as a smoothing operator. The Gaussian smoothing operator is a 2-D convolution operator that is similar to the mean filter, but it uses a different kernel that represents the shape of a Gaussian (`bell-shaped') hump.

4.3. Multi Resolution Enhancement

i. Dimensional Filter

ii. Rotational Filter, etc.

Resolution of an image is an important aspect of an image. The processing of an image is done in order to obtain more enhanced resolution. The details enclosed in an image are defined by the resolution of an image. The higher the resolution, the more image details. One of the generally used techniques for image resolution enhancement is Interpolation. Interpolation in image processing is a method to increase the number of pixels in a digital image. Interpolation has been widely used in many image processing applications such as facial reconstruction, multiple description coding, and super resolution. Bicubic interpolation is more sophisticated than the other two techniques such as Bilinear and Nearest Neighbor interpolation. Multi-resolution enhancement has been planned [3] to remove noise from fingerprints. Decomposing the image into various sub-images allows to pay damages for different noise components at various scales: particularly, at higher levels (low and middle frequency bands) the rough ridge-valley flow is cleaned and gaps are closed, whereas at the

lower levels (upper frequencies) the improved details are conserved. The enhanced image bands are then recombined to gain the ultimate fingerprint image.

An image is a picture or photograph and is usually a numeric representation of a two dimensional function. An image is represented by intensity at a particular point whose spatial coordinates are on generally x and y axis coordinates. It is a two dimensional collection of pixel values. The resolution or dimension is often used for a pixel count in digital imaging. In this technique the image is enhanced from a lower resolution (dimension) to a higher resolution (dimension).

5. CONCLUSION

This study of Fingerprint Enhancement can be conclude that biometric identification is having very much importance in today's digital world. International Systems Research Co. (ISR) announced that it started to offer fingerprint authentication option in its cloud authentication and access control service, CloudGate. Nowadays The Pixel wise enhancement techniques are not used in most of the new system since it has very basic and older functionalities. While the Contextual fingerprint enhancement techniques are quite superior to the previous one and they are widely used. In future also the most advanced techniques of the fingerprint enhancement that is Multi resolution fingerprint enhancement will come into picture and it will produce fruitful results.

REFERENCES

[1] Davide Maltoni, Dario Maio, Anil K. Jain, Salil Prabhakar "*Handbook of Fingerprint Recognition*", Second Edition, Springer, 2009.

[2] https://www.techopedia.com/de_nition/26314/imageenhancement

[3] Er.Nishi Madaan, Er.Arun Begill, "*A Comprehensive Review of Various Image Enhancement Techniques*", International Journal of Advanced Research in Computer Engineering Technology, pp.1181-1185, April 2014.

[4] Arun Kavi Arasu, Mohamed Nizar, Prabhakaran D, "*Review of Image Contrast Enhancement Techniques*", International Journal of Engineering Research Technology, pp.473-480, November 2013.

[5] Prasanna Krishnasamy, Serge Belongie, David Kriegman "*Wet Fingerprint Recogniotion: Challenges and Opportunities*", IEEE Conference Publications, pp. 1-7 (978- 1-4577-1357-6), 2011.

[6] Shlomo Greenberg, Mayer Aladjem and Daniel Kogan "*Fingerprint Image Enhancement using Filtering Techniques*", Elsevier Science Ltd, pp.226-236, 2002.

[7] G.Sambasiva Rao, C. NagaRaju, L. S. S. Reddy and E. V.Prasad "*A Novel Fingerprints Identification System Based on* the Edge Detection", *i*nternational Journal of Computer Science and Network Security, vol. 8, pp. 394-397, 2008.

[8] Robert Hastings "*Ridge Enhancement in Fingerprint Images Using Oriented Diffusion",* IEEE Computer Society on Digital Image Computing Techniques and Applications, pp.245-252, 2007.

[9] Raju Sonavane and B. S. Sawant "*Noisy Fingerprint Image Enhancement Technique for Image Analysis: A Structure Similarity Measure Approach",* Journal of Computer Science and Network Security, vol. 7 no. 9, pp. 225-230, 2007.

[10] Eric P. Kukula, Christine R. Blomeke, Shimon K. Modi, and Tephen J. Elliott "*Effect of Human Interaction on Fingerprint Matching Performance, Image Quality, and Minutiae Count",* International Conference on Information Technology and Applications, pp. 771-776, 2008.

[11] L. Lam S. W. Lee, C. Y. Suen "*Thinning Methodologies-A Comprehensive Survey",* IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 14, pp. 869-885, 1992.

[12] Mana Tarjoman, and Shaghayegh Zarei "*Automatic Fingerprint Classification using Graph Theory",* Proceedings of World Academy of Science, Engineering and Technology, vol. 30, pp. 831-835, 2008.

[13] Bhupesh Gour, T. K. Bandopadhyaya and Sudhir Sharma *"Fingerprint Feature Extraction using Midpoint Ridge Contour Method and Neural Network*", International Journal of Computer Science and Network Security, vol. 8, no, 7, pp.99-109, 2008.

[14] Hartwing Fronthaler, Klaus kollreider, and Josef Bigun *"Local Features for Enhancement and Minutiae Extraction in Fingerprints*", IEEE Transactions on Image Processing, vol. 17, no, 3, pp. 354-363, 2008.

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