A Critical Study on Fingerprint Image Sensing and Acquisition Technology

Krishna Prasad K.[1] & P. S. Aithal[2]
[1]Research Scholar, College of Computer and Information Science, Srinivas University, Mangaluru-575001, Karnataka, India
[2] College of Computer and Information Science, Srinivas University, Mangaluru-575001, Karnataka, India
E-Mail: karanikrishna@gmail.com

Type of the Paper: Case Study.
Type of Review: Peer Reviewed.
Indexed In: OpenAIRE
DOI: http://dx.doi.org/10.5281/zenodo.1130581.
Google Citation: IJCSBE

How to Cite this Paper:
Krishna Prasad, K. & Aithal, P. S. (2017). A Critical Study on Fingerprint Image Sensing and Acquisition Technology. *International Journal of Case Studies in Business, IT and Education (IJCSBE)*, 1(2), 86-92.
DOI: http://dx.doi.org/10.5281/zenodo.1130581.

International Journal of Case Studies in Business, IT and Education (IJCSBE)
A Refereed International Journal of Srinivas University, India.

A Critical Study on Fingerprint Image Sensing and Acquisition Technology

Krishna Prasad K.[1] & P. S. Aithal[2]

[1]Research Scholar, College of Computer and Information Science, Srinivas University, Mangaluru-575001, Karnataka, India

[2] College of Computer and Information Science, Srinivas University, Mangaluru-575001, Karnataka, India

E-Mail: karanikrishna@gmail.com

ABSTRACT

Automatic Fingerprint Recognition System (AFIS) mainly depends on the quality of the fingerprint captured during the enrollment process, even though a lot of techniques developed in literature for fingerprint matching, all most all system is influenced or affected by the quality of acquisition method. Automated fingerprint identification system requires fingerprint images in a special format. Normally it can't receive and process the photographic image or photo taken from virtual camera or cell camera. There are many special acquisition or sensing strategies to extract the ridge-and-valley structure of finger skin or fingerprint. Traditionally, in law or regulation enforcement packages, fingerprints were especially received offline. Fingerprint acquisition can be specially classified into groups as an offline and live scan. An offline acquisition technique gets input through inked affect of the fingertip on paper and digitized with the aid of the paper with an optical scanner or video digital camera. The live acquisition is received through the sensor that is having the ability to directly digitize the sensing tip of the finger. As the fingerprint sensing, image processing, signal processing, and communication technology advance, an increasing number of new technologies in this acquisition technology are arriving at the main facet. In this paper, we discuss different types of fingerprint acquisition technologies, which involve optical, ultrasonic, capacitance, passive capacitance, and active capacitance. This paper helps to identify new fingerprint acquisition technology.

Keywords: Fingerprint Sensing Technology, Fingerprint image, Optical fingerprint sensor, Ridge, Valley.

1. INTRODUCTION :

Automatic Fingerprint Identification System requires fingerprint image in particular format. Usually, it cannot accept and process the photographic image or image taken from digital camera or mobile camera. There are many special acquisition or sensing strategies to gain the ridge-and-valley structure of finger skin or fingerprint [1]. Traditionally, in regulation or law enforcement applications, fingerprints had been specially obtained offline. Fingerprint acquisition can be mainly categorized into two groups as an offline and live scan. An offline acquisition method gets input through inked affect of the fingertip on paper and digitized with the aid of the paper with an optical scanner or video digital camera. The live acquisition is obtained through the sensor that is having the ability to directly digitize the sensing tip of the finger. As the fingerprint sensing, image processing, signal processing, and communication technology advance more and more new technologies are arriving at the leading edge.

In recent times, most business and forensic programs receive live-experiment digital photographs acquired by way of directly sensing the finger surface with a fingerprint sensor based totally on optical, solid-state, ultrasonic and other imaging technology. Fingerprint sensors are available numerous sizes and styles but generally fall into two classes; region experiment (or contact) sensor and swipe sensor. With a touch sensor, the user places and holds the finger on the sensor surface and impact transferred from the pad of the final joint of finger or thumb. Touch sensors are used typically in constant systems because of their size and form [2]. Usually, touch sensors are square in shape and occupy more space and also weighs more; used in passport or immigration based applications. In swipe sensor, the user glides a finger vertically over the surface. The size and shape of the swipe sensors make it suitable for portable electronic gadgets like laptop computers and mobile phones [2-3]. However, swipe sensor technology intrinsically restricts their appropriateness for a few programs [4-9]. These sensors require customer education and practice to work consistently and they frequently fail to capture the fingerprint image. However, in each type of sensors, there are some common problems exist, like direct exposure to the surroundings, damage from mechanical results, electrostatic discharge (ESD), thermal surprise, discrimination between liveness and spoof. In this paper, we discuss different types of fingerprint acquisition technologies, which involve optical, ultrasonic, capacitance, passive capacitance, and active capacitance.

2. FINGERPRINT SENSING TECHNOLOGY-REVIEW :

The initial types of fingerprint image have been impersonation in a fine-grained surface and later in a yellowish moldable substance called as wax. Starting from late 19th century to entire period of 20th century, the gaining or acquiring of fingerprint images were particularly carried out via ink-technique. This kind of acquisition method is referred as offline fingerprint sensing through moving in a particular direction-rolling, which remains being utilized in forensic packages and historical past assessments of applicants for highly sensitive jobs.

Later scanning instantaneously or live scanning device were developed, which makes use of technology multi-touch community based on Total Internal Reflection (FTIR), where F stands for Frustrated. The sensors carried out earlier had the disadvantage that they have been not suited for wet or dry arms and had to be wiped clean regularly to save you grease and dust from compromising the photo or image excellent.

Since last 20 years, fingerprint sensing technology has grown tremendously. Witnessing this growth as an instance Multispectral Fingerprint Imaging (MFI) has been introduced by the company Lumidigm, Inc. [10]. In contrast to traditional optical fingerprint sensors, MSI gadgets experiments the subsurface of the skin by using the usage of one-of-a-kind wavelengths of light. The fundamental idea is that distinct functions of skin motive extraordinary absorbing and scattering moves relying on the wavelength of light. Fingerprint snapshots obtained using the MSI technology appear to be of appreciably higher excellent in comparison to standard optical sensors for dry and wet palms. Multispectral fingerprint snapshots have also been shown to be beneficial for spoof detection [10].

Later, in 2006, sensing generation primarily based on the Multicamera device has been added. Those were termed as a touch less imaging and were added by means of TBS, Inc. [11]. Touchless imaging avoids direct touch among the sensor and the pores and skin and, therefore, constantly preserves the fingerprint ground reality without introducing skin deformation throughout photograph acquisition.

One of the maximum crucial traits of a digital fingerprint image is its resolution, which shows the number of dots or pixels per inch (PPI). Normally most of the fingerprint sensing device has resolution 250 to 300 (PPI) is considered to be a minimal requirement for any fingerprint feature extraction algorithm to extract minutiae details. FBI-compliant sensors have to fulfill the 500 (PPI) resolution requirements. However, a good way to capture pores in a fingerprint image, a significantly higher resolution, which is nearly of size 1,000 (PPI).

Even though it isn't yet realistic to layout solid-state sensors with the sort of high resolution due to the cost factor, optical sensors with a resolution of 1,000 (PPI) are to be had commercially. Extra excitingly, optical sensors with resolutions of 4,000-7,000 PPI have also been developed, which are most effective in capturing fingerprint image level 3 features for identification, and also helps to identify pore activities (commencing and final) for spoof detection. Current years have visible a new high-resolution fingerprint device called P3400 [12-14]. That is a small and financially cheaper fingerprint reader brought by Zvetco inc. This device can produce 500 dpi images and is built of great aluminum. It is geared up with a 6-foot USB cable and is highly used with most biometric security access software packages. The compact guardian consists of capabilities which include patented automatic capture capability and ideal rolling era, making it perfect for foolproof fingerprint

acquisition in high-volume processing environments, consisting of visa issuance and border manipulate. The device can collect quality fingerprints at high resolution (500 dpi) in few seconds and meets worldwide requirements that observe government necessities in many nations.
The ten-print MFS-500 stay scanner is high resolution (500 and 1000 dpi) devices designed and built for optical perfection [15]. It may examine aircraft static fingerprints and can also be implemented in the 3D print-pressed rolling scan. A sensor presents the very clean image and stops dry fingerprint problems. A form of fingerprint identity software is brought into the sensor to discover the fingerprint. The fingerprint captured with this scanner will have the highest identification and matching ratio, which is claimed by the manufactures.
Futronic FS80 USB2.0 fingerprint scanner uses a sophisticated CMOS sensor generation and precise optical device to supply high first-class fingerprint image. The finger is illuminated via 4 infra-purple LED's at some stage in scanning and the mild depth is robotically adjusted in step with scanning fingerprint's characteristics (wet, dry, blurred, etc.) to optimize the satisfactory of the captured fingerprint picture. it captures an undistorted uncooked fingerprint photo of 500dpi decision into the computer in 100msec. The scanner can reject fake fingers crafted from silicone rubber and play-doh. It supports fingerprint recognition, verification, authentication, and matching programs.
The sort of scanner used relies on the utility and environment where it is to be applied. in general, it is preferred to have scanners that are merchandise licensed for compliance with the FBI's included computerized fingerprint identity gadget image excellent specs. These forms encompass information concerning fingerprint image resolution, length (place), the number of pixels, geometric accuracy, gray-level quantization and gray variety, spatial frequency reaction, and signal-to-noise (SNR) ratio. The scanners licensed by way of the FBI as examined and in compliance with the FBI's subsequent technology identification (NGI) initiatives and included automatic fingerprint identification system (IAFIS). Table 1List outs features of different types of fingerprint sensing technology.

Table 1: Various Fingerprint Sensing Technology and its Features

Sr. No	Sensing Technology	Features
1	Multispectral Fingerprint Imaging	• Ubiquitously Works for all types of users • Fast method for acquisition • Highly robust and repeatedly images can be taken
2	Touchless imaging	• Highly superior quality image • Highly invariant to fingerprint conditions • Built in accordance with user guidance • Non-intrusive capturing capacity
3	P3400	• Small in size • Most-cost effective fingerprint sensing technology • High resolution image-about 500 dpi • Highly scratch resistant
4	Ten-print MFS-500 stay scanner	• High resolution image-500 to 1000 dpi • High quality 3D image • Very clean image • Stops dry fingerprint problems • Good identification and matching capacity
5	Futronic FS80 USB2.0 fingerprint scanner	• Good quality image due to advanced CMOS technology • Having the capacity to reject false fingerprint from silicone rubber and play-doh • Affective in fingerprint recognition, verification, authentication, and matching programs

3. FINGERPRINT ACQUISITION METHODS

This section narrates different fingerprint acquisition method, which acts as an input or raw image for Automatic Fingerprint Identification System [16-18]. *Optical:* Optical fingerprint scanners are the oldest technique for capturing and evaluating fingerprints. This technique mainly depends on capturing an optical picture, basically a picture, and the use of algorithms to come across unique patterns on the surface, which include a ridge. Optical sensor comprises of the specialized digital camera, touch surface, a light-emitting phosphor layer, and solid state pixels. The specialized digital camera is used to acquire an image of the fingerprint ridge and valley pattern. A digital camera is located on the sensor and it captures the digital image using visible light. The touch surface is nothing but where the finger is kept, which is situated in the top layer of the sensor. Below the layer of touch surface is light emitted phosphor layer, which illuminates the surface of the finger when the finger is kept on the touch surface. The light emitted from the finger reaches to an array of solid state pixels with the aid of phosphor layer. Wound, scratch and dirty finger will cause a negative effect on the quality of the acquired image. The disadvantage of this kind of sensor is the reality that the imaging abilities are suffering from the high-quality of skin on the finger. As an instance, a dirty or marked finger is hard to image well. This sensor has a capacity of acquiring only two-dimensional images, synthetic or good quality image can be used to fool this acquisition device. Live finger detector mechanism should fuse along with this technology to attain more security.
Ultrasonic: Ultrasonic sensor works on the theory of medical ultrasonography with an intention to develop a visual image of the fingerprint. An ultrasonic sensor utilizes very high-frequency sound waves with an intention to penetrate epidermal layer of the skin. The sound waves are produced with the aid of piezoelectric transducers and also in order to measure reflected energy piezoelectric transducers are used. Image of the fingerprint can be generated by the reflected wave measurement due to reason that dermal skin layers show same features of the fingerprint. Due to this fact even though the skin is damaged and dirty it will exhibit same features of the fingerprint or which will not affect the quality of the input image [19].
Capacitance: Capacitance sensor utilizes the technology capacitance to shape fingerprint image. To generate ride and valley structure of the fingerprint capacitance sensor uses electric current. Capacitance sensor comprises a tiny array of cells with one or more semiconductor chips. Every cell includes two conductor plates with parallel plate capacitor and dermal layer and epidermal acts as a dielectric, which is a nonconductor [20].
Passive Capacitance: A passive capacitance sensor is almost similar to capacitance sensor, which forms an image of the fingerprint on the dermal layer of the skin. At every point of the array, a capacitance is measured with the help of sensor pixels. An air gap bridges the volume between the dermal layer and sensing element in valleys, which creates capacitance variance in ridge and valley structure of fingerprint. Two values are already known, which are a dielectric constant of the epidermis and area of the sensing element. Ridge and valley of the fingerprint are differentiated with the help of measured capacitance value [20].
Active Capacitance: In this type of sensor, initially before measurement of the fingerprint takes place, a voltage is applied to the skin with the help of charging cycle. Effective capacitor charges as an application of voltage. The pattern of the ridges in the dermal skin is identified with the help of electric field between finger and sensor. A reference voltage is maintained in discharge cycle in order to calculate the capacitance, by cross-comparing voltage across the dermal layer and sensing element. Later to form the image of the fingerprint the distance values are mathematically calculated. Like the ultrasonic sensor ridge pattern of the dermal layer are taken into considerations for measurement purpose. So this process overcomes the need for a clean surface and undamaged epidermal skin of the fingerprint [20].

4. COMPARISON OF OPTICAL AND NON-OPTICAL SENSORS :

In Table 2 Optical and Non-optical fingerprint scanners are discussed with five parameters. These parameters are Measurements, Advantages, Benefits, Constraints, and Disadvantages.

Table 2: Comparison of Optical and Non-optical Sensors

Parameters	Optical	Non-optical
Measurements	Light	Pressure, Heat, Capacitance, and Ultrasonic

		wave.
Advantages	Specially-strong performance, Physical or electrical durability, Excellent image	Mass production leads to low cost. Compact and low size makes it appropriate for low power applications like a mobile phone or laptop computers.
Benefits	Oldest and well-known method, Good technology support, Applications in the area of Attendance control, entry control, banking service etc.	Positive competition leads to mass production, which in turn leads to cost reduction. Similar to optical can be used for various applications.
Constraints	Difficult to build spoof free or highly secured system	Complex structure, Lack of technical knowledge leads to capture false points of a fingerprint.
Disadvantages	Reduction in size of the image is too costly, Relatively easy to compromise the security	Performance variations with respect to outer changes in temperature and dryness of a finger

5. CONCLUSION :

Fingerprint image sensing technology is meant for capturing fingerprint image in a particular format with various factors like image resolution, length (place), Quantity or number of pixels, Geometric accuracy, Gray-level Quantization and Gray Variety, Spatial frequency and many more, which is utilized by highly powered Automatic fingerprint recognition or identification device for Authentication purpose. As we have discussed in this paper there are many types of sensor devices mainly based Optical and Non-optical devices. In this paper, we have also critically discussed different types of fingerprint acquisition technologies, which involve optical, ultrasonic, capacitance, passive capacitance, and active capacitance. This paper helps to identify new fingerprint acquisition technology.

REFERENCES :

[1] Xia, X., & O'Gorman, L. (2003). Innovations in fingerprint capture devices. *Pattern Recognition*, 36(2), 361-369.

[2] Memon, S., Sepasian, M., & Balachandran, W. (2008, December). Review of finger print sensing technologies. In *Multitopic Conference, 2008. INMIC 2008. IEEE International* (pp. 226-231). IEEE.

[3] Galy, N., Charlot, B., & Courtois, B. (2007). A full fingerprint verification system for a single-line sweep sensor. *IEEE Sensors Journal*, *7*(7), 1054-1065.

[4] Krishna Prasad, K. & Aithal, P. S. (2017). A Conceptual Study on Image Enhancement Techniques for Fingerprint Images. *International Journal of Applied Engineering and Management Letters (IJAEML)*, 1(1), 63-72. DOI: http://dx.doi.org/10.5281/zenodo.831678.

[5] Krishna Prasad, K. & Aithal, P. S. (2017). Literature Review on Fingerprint Level 1 and Level 2 Features Enhancement to Improve Quality of Image. *International Journal of Management, Technology, and Social Sciences (IJMTS)*, 2(2), 8-19. DOI: http://dx.doi.org/10.5281/zenodo.835608.

[6] Krishna Prasad, K. & Aithal, P.S. (2017). Fingerprint Image Segmentation: A Review of State of the Art Techniques. *International Journal of Management, Technology, and Social Sciences (IJMTS)*, 2(2), 28-39. DOI: http://dx.doi.org/10.5281/zenodo.848191.

[7] Krishna Prasad, K. & Aithal, P. S. (2017).A Novel Method to Contrast Dominating Gray Levels during Image contrast Adjustment using Modified Histogram Equalization. *International Journal of Applied Engineering and Management Letters (IJAEML)*, 1(2), 27-39. DOI: http://dx.doi.org/10.5281/zenodo.896653.

[8] Krishna Prasad, K. & Aithal, P. S. (2017). Two Dimensional Clipping Based Segmentation Algorithm for Grayscale Fingerprint Images. *International Journal of Applied Engineering and Management Letters (IJAEML),* 1(2), 51-65. DOI: http://dx.doi.org/10.5281/zenodo.1037627.

[9] Krishna Prasad, K. & Aithal, P. S. (2017). A conceptual Study on Fingerprint Thinning Process based on Edge Prediction. International Journal of Applied Engineering and Management Letters (IJAEML), 1(2), 98-111. DOI: http://dx.doi.org/10.5281/zenodo.1067110.

[10] Nixon, K. A., & Rowe, R. K. (2005, March). Multispectral fingerprint imaging for spoof detection. In *Proc. of SPIE Vol* (Vol. 5779, p. 215).

[11] Parziale, G., Diaz-Santana, E., & Hauke, R. (2006, January). The surround imagertm: A multi-camera touchless device to acquire 3d rolled-equivalent fingerprints. In *International Conference on Biometrics* (pp. 244-250). Springer, Berlin, Heidelberg.

[12] Lockie, M. (2006). Fakta stores go biometric in Denmark. *Biometric Technology Today*.

[13] Esekhaigbe, E. J. (2016). *Contributions to Biometric Recognition: Fingerprint For Identity Verification* (Doctoral dissertation, Cardiff Metropolitan University).

[14] Chao, T. H., & Cammack, J. (2007). *U.S. Patent Application No. 11/654,197*.

[15] Kaye, D. H. (2012). The Report of the Expert Working Group on Human Factors in Latent Print Analysis--Latent Print Examination and Human Factors: Improving the Practice through a Systems Approach.

[16] Kozan, N., Kotsyubinskaya, J., & Zelenchuk, G. (2017). Express Prediction of External Distinctive Features Of Person Using The Program of Dermatoglyphics For Prediction. *Eureka: Health Sciences*, (3), 26-32.

[17] Scheibert, J., Leurent, S., Prevost, A., & Debrégeas, G. (2009). The role of fingerprints in the coding of tactile information probed with a biomimetic sensor. *Science*, *323*(5920), 1503-1506.

[18] Baratelli, P. J. (2001). *U.S. Patent No. 6,325,285*. Washington, DC: U.S. Patent and Trademark Office.

[19] Meghdadi, M., & Jalilzadeh, S. (2005, October). Validity and acceptability of results in fingerprint scanners. In *Proceedings of the 7th WSEAS International Conference on Mathematical Methods and Computational Techniques In Electrical Engineering* (pp. 259-266). World Scientific and Engineering Academy and Society (WSEAS).

[20] Setlak, D. R. (2005). Advances in biometric fingerprint technology are driving rapid adoption in consumer marketplace. *Retrieved December, 08*, 2017.

****