

Addressing Biometric Sensor Interoperability using Gabor Filter

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Abstract: Biometric authentication using fingerprint is one of the unique and reliable methods of verification processes. Biometric System suffers a significant loss of performance when the sensor is changed during enrollment and authentication process. In this paper fingerprint sensor interoperability problem is addressed using Gabor filter and classifying images into good and poor quality. Gabor filter play an important role in many application areas for the enhancement of various types of fingerprint images. Gabor filter can remove noise, preserve the real ridges and valley structures, and it is used for fingerprint image enhancement. Experimental results on the FVC2004 databases show improvements of this approach.

Keywords: Biometrics, fingerprint Sensor, Sensor Interoperability, Gabor filter.

1. Introduction:

Biometric means identity verification of persons according to their physical or behavioral characteristics. Many physical body parts and personal features have been used for biometric systems: fingers, hands, irises, faces, ears, voices, gaits, odors, feet, signatures, and DNA [1, 2]. A biometric system contains mainly a sensor module, a feature extraction module and a pattern matching module. A Sensor module acquires the raw biometric data of a person. Feature extraction module improves the quality of the captured image. Database module stores the biometric template information of enrolled Persons. Pattern matching module compares the present input with the stored template, which in-turn generates match score [1].

Fingerprint-based identification is one of the most important biometric technologies. Humans have used fingerprints for personal identification and the validity of fingerprint identification has been well established. Segmentation is an important pre-processing step in fingerprint recognition system. The segmentation is partitioning the fingerprint image into multiple segments. Gabor functions play an important role in biometric recognition. The most prominent two steps are [3]:

- **Foreground Segmentation**
The Gabor response is only computed in the foreground and, hence, foreground segmentation is required. Foreground region corresponds to the area containing ridges and valleys.
- **Pixel-based Gabor response analysis**
Thresholds are defined for the Gabor responses to associate a quality with each block. Similarly, thresholds are defined to classify the pixel into good and poor quality depending on the neighboring region [4, 5].

They are employed for many physical or behavioral traits including iris, face, speech, gait, handwriting, palm print and fingerprint recognition. Fingerprint recognition Gabor filterbank are used for the segmentation [6] and improve the quality of databases and evaluate the performances of fingerprint sensors and classification and fingerprint matching based on Gabor features. The Gabor filter is used for fingerprint image enhancement [7].

Gabor-based Quality Classification:

The Gabor-based quality classification aids in classifying images into good and poor quality images [8]:

- **Good image:** clear ridges/valley contrast, easily-detected ridges, easily segmented.

- **Poor image:** The poor quality images are also classified into dry (broken ridges, tiny parts of ridges can be separated) and smudged (not well separated ridges) on basis of the nature of the prints.

Fingerprint Sensors:

Fingerprint sensors come in various shapes and sizes, but generally into two categories [9]:

- Touch sensor: The user hold the finger on the sensor surface
- Swipe sensor: The user slides a finger vertically over the sensor surface.

There is the various acquisition technologies used in fingerprint sensors: optical, capacitive, thermal, and ultrasonic [10, 11].

1. **Optical sensor:** It capturing the digital image formed by the reflection of light from the points where ridges touches the sensors touch surface. Optical finger impression followers contain of a light sensor, touch surface and a capture device which can be a Charge Coupled Device.
2. **Capacitive Sensor:** Capacitive sensor is the solid state sensor. Fingerprint sensors consist of an array of capacitive plates on a silicon chip. One plate of capacitor is formed by the finger; other plate holds a tiny area of metallization on the chip.
3. **Ultrasonic Sensor:** It uses high frequency sound waves to monitor the finger surface. . Ultrasonic method of acquiring fingerprint is based on sending ultrasonic signals towards the finger and finds the echo.
4. **Thermal sensor:** Fingerprint sensors are made from the silicon die tiled by pixels of pyro-electric material that is sensitive to detect temperature differences. This sensor scans the surface of the finger, measuring the heat transferred from sensor to fingerprint.



Figure 1: Fingerprint Sensors

Sensor Interoperability:

Sensor interoperability is the ability of a biometric framework to adapt to the raw data obtained from a variety of sensors. Practically biometric frameworks would intended with look at information originated starting with the same sensor, but fail to give a good performance when the acquisition device is changed between the enrolment and the authentication phase [12]. Fingerprint sensor interoperability is the process of matching fingerprints collected from different sensors.

2. Related Work:

Lugini et al. [14] statistically analyzed how match scores change across different optical devices. Results of the Kendall's rank correspondence test pointed out that there is a significant difference between sensor pairs and that those change will not symmetric when inverting those two devices.

Marasco et al. [15] [16] proposed a learning-based approach to improve cross-device performance. They extracted quality and intensity-based characteristics of fingerprint images acquired using four different commercial optical devices and scanned ink rolled prints. The defined set of characteristics was concatenated with the match score into a feature vector used for training a pattern classifier. Later, they investigated the impact of age and gender across different optical devices and matching algorithms.

Satish et. al. [17] discussed fingerprint authentication using Gabor filter which is used to extract features of fingerprint images. FVC 2000 and DBIT fingerprint databases are used to evaluate the algorithm and it achieves the average efficiency of 82.95 % and 89.68% respectively.

Lu Yang et. al.[19] proposed a super pixel based finger vein region of interest (ROI) extraction with sensor interoperability in biometric systems. Finger boundaries were firstly determined by tracking super pixels. Then the middle points of detected finger boundaries were used to adjust the finger directions. Finally, internal tangents of finger boundaries were used to localize ROI. It was found that this method extracts ROI accurately from the images acquired using multiple sensors.

3. Proposed Framework:

A fingerprint sensor is to obtain a good quality image of the ridge pattern. The quality of a fingerprint image depends on sensor characteristics and the condition of the finger surface (i.e. good, dry). Sensing mechanism of each device is different and images with different sizes, resolution, feature distribution, gray level are produced.

In this work, a Novel approach to address sensor interoperability using Gabor filter is presented. This approach avoids the requirement to change the model when the sensing devices changes. The approach follows procedures that enhances segmentation process of quality images and apply on Gabor filter. Gabor filter is used for fingerprint image enhancement. The fingerprint image enhancement is to improving the clarity of the ridge and valley structure.

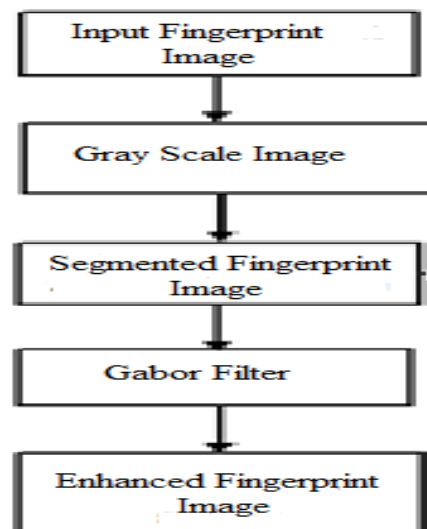


Figure 2: Architecture of proposed scheme

Database:

The database used is an FVC2004 database. The analysis for this study was conducted using fingerprints collected from three different fingerprint sensors. The three fingerprint sensors are V300 Cross match, Digital Persona U.are.U4000, and Atmel Finger Chip FCD4B14CB. The V300 Cross match and Digital Persona U.are.U4000 sensors are optical sensors and Finger Chip FCD4B14CB is a thermal sensor. Table 1 shows the database, sensors and specifications for the three fingerprint sensors:

Table 1.FVC 2004 Fingerprint Database:

Database	Sensor Type	Sensor Name	Image Size	Resolution
DB1	Optical	V300 Cross match	640x480 (307K Pixels)	500dpi
DB2	Optical	Digital Persona U.are.U4000	328x364 (119K pixels)	500dpi
DB3	Thermal	Atmel FCD4B14CB	300x480 (144K pixels)	512dpi

4. Results:

In this proposed framework there are 2 fingerprint images of different optical sensors one is V300 Cross match and other is of Digital Persona U.are.U4000. This approach follows a procedure that enhances and segments the quality image then applies on Gabor filter

A. Gray-Scale:



Figure 3: Original fingerprint image taken from DB1



Figure 4: Original fingerprint image taken from DB2

B. Segmentation

Fingerprint segmentation technique can improve the accuracy in collecting clear fingerprint area and mark noise areas. The segmented images of good and poor quality fingerprint are illustrated in figure below:



Figure 5: Original fingerprint of good quality taken from DB1 and Segmented image of good quality

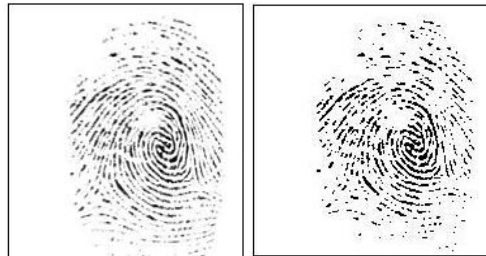


Figure 6. Original fingerprint of Poor quality taken from DB1 and Segmented image of poor quality



Figure 7: Original fingerprint of good quality image taken from DB2 and Segmented image of good quality



Figure 8: Original fingerprint of poor quality image taken from DB2 and Segmented image of poor quality

C. Gabor Filter:

Gabor filter is used for enhance the segmented fingerprint image for better result. The images are illustrated in figures below:



Figure 9: Segmented fingerprint of good quality image taken from DB1 and Gabor filter image of good quality

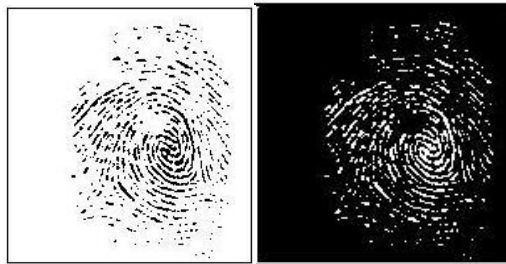


Figure 10: Segmented fingerprint of Poor quality image taken from DB1 and Gabor filter image of poor quality



Figure 11: Segmented fingerprint of good quality image taken from DB2 and Gabor filter image of good quality



Figure 12: Segmented fingerprint of poor quality image taken from DB2 and Gabor filter image of poor quality

D. Histogram:

Histograms of original image, segmented image and Gabor filter Image of good and poor quality were constructed. It is found that histograms of the Gabor filter images are similar and intensities lie in the range 0-1 as shown below:

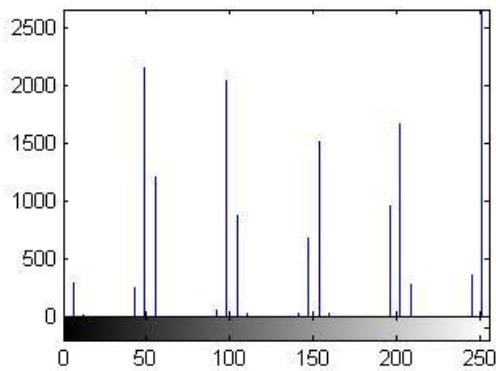


Figure 13: Histogram of original image of good quality taken from DB1

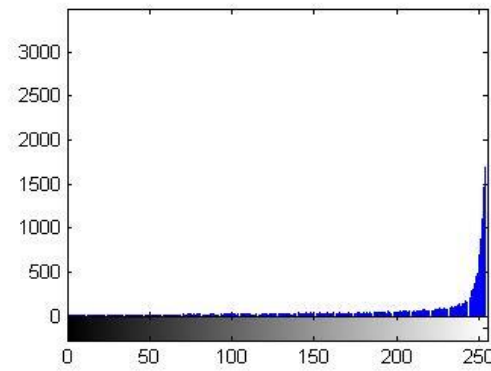


Figure 14: Histogram of original image of poor quality taken from DB1

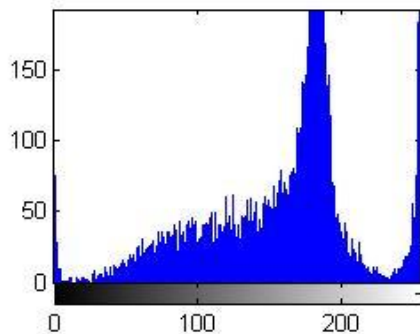


Figure 15: Histogram of original image of good quality taken from DB2

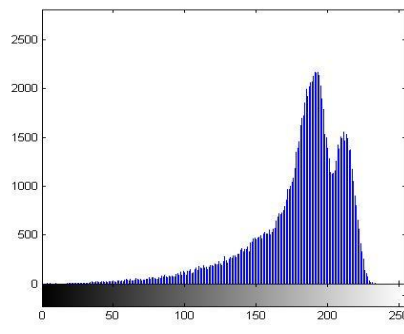


Figure 16: Histogram of original image of poor quality taken from DB2

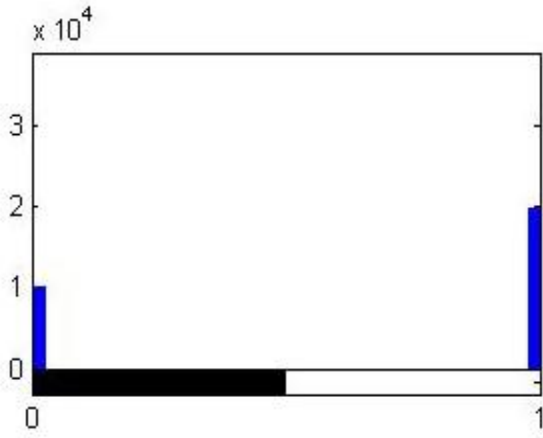


Figure 17: Histogram of segmented image of good quality taken from DB1

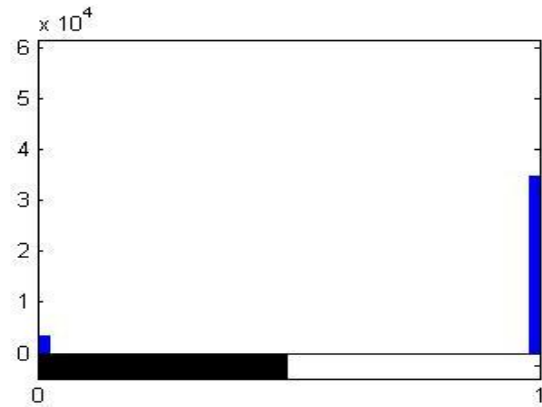


Figure 18: Histogram of segmented image of poor quality taken from DB1

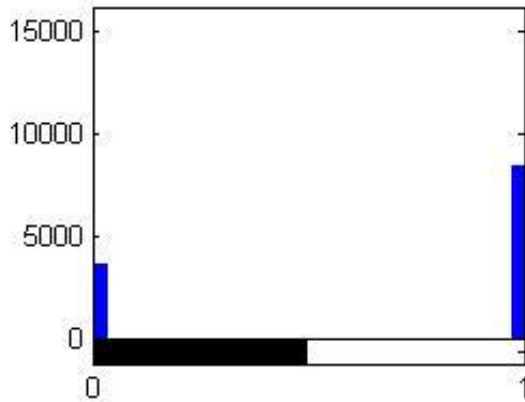


Figure 19: Histogram of segmented image of good quality taken from DB2

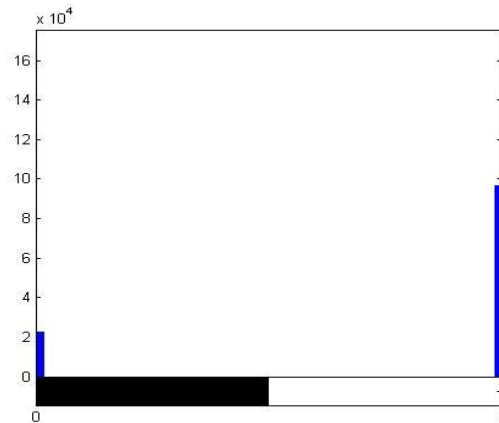


Figure 20: Histogram of segmented image of poor quality taken from DB2

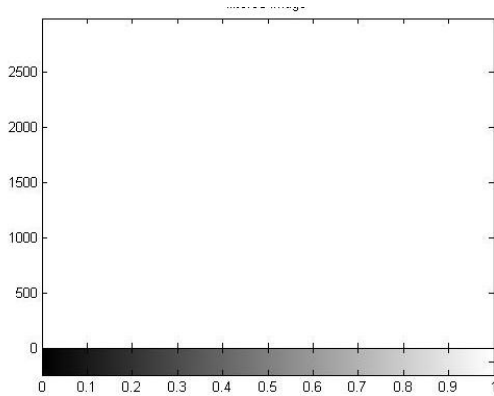


Figure 21: Histogram of Gabor filter image of good quality taken from DB1

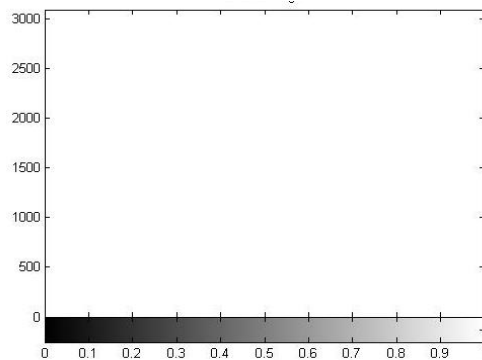


Figure 22: Histogram of Gabor filter image of poor quality taken from DB1

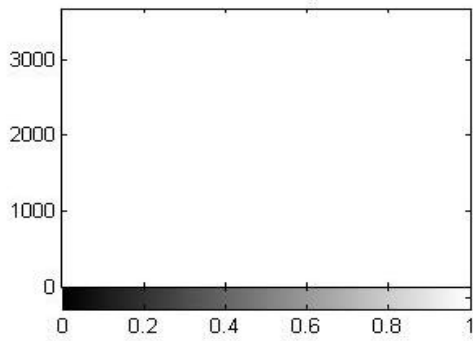


Figure 23: Histogram of Gabor filter image of good quality taken from DB2

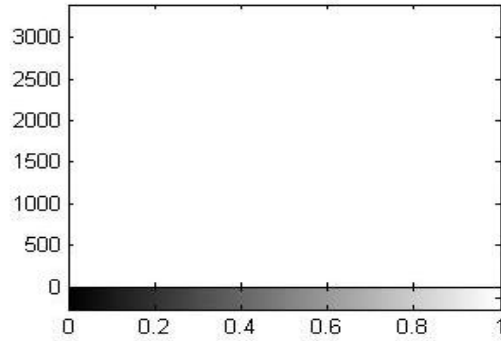


Figure 24: Histogram of Gabor filter image of poor quality taken from DB2

5. Conclusion:

In this work, the proposed technique improves sensor interoperability in fingerprint sensors by using a Gabor filter. The Proposed approach is used for enhance the segmented fingerprint image of good quality and poor quality. It improves sensor interoperability in fingerprint sensors. In this paper, a gabor filter approach is presented to enhance the segmented images accurately when the image is captured using various sensors. In future, it will applicable on any type of biometric sensor.

6. References:

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