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Noise Elimination in Fingerprint Image Using Median Filter

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---ABSTRACT---

Fingerprint recognition is a promising factor for the Biometric Identification and authentication process. The quality of the fingerprint is obtained by the noise free image. To get a noise-free fingerprint image, the pre-processing techniques are applied on image. In this paper, we described the finger print classifications, characteristics and preprocessing techniques. We applied the histogram on 256 gray scale finger print image with the default threshold value; then the histogram-equalized image is obtained. Next, histogram-equalized image is given under the binarization process. Finally the binarized fingerprint image is filtered with the implementation of the Median filtering technique in order to produce the noise free image. The comparison of the median filtered image with the original noisy image shows the depth of the noise spread in the original image. The experimental result shows the noise rate which was eliminated in the input fingerprint image and quality of the filtered image using the Statistical –Correlation tool.

Keywords**: Authentication, Binarization, Histogram, Identification, Median filter.**

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1. Introduction

While biometric identification and authentication provides considerable convenience and also some security benefits over token-based or password-based methods, other security and privacy concerns unique to biometrics must also be taken into account. These include identity theft, cross matching, and the exposure, often irrevocable, of sensitive private information, as well as trace-ability of individuals. This has stimulated research on the protection of stored biometric data in recent years, primarily focusing on preventing information leakage. Fingerprint recognition is a gifted feature for the Biometric identification and authentication systems. The field of biometric is still in its formative years, it’s unavoidable that biometric systems will play a significant role in the security [1]. A biometric system is fundamentally a pattern recognition system that functions by obtaining biometric data from an individual, extracting a feature set from the obtained data, and evaluating this feature set against the template set in the database [2]. The biometric data comprises of fingerprints [3], facial features [4], iris [5], hand geometry [6], voice [7], and signature [8]. Biometrics is extensively employed in forensics, in criminal identification and prison security to quote a few of the instances, and has the prospective to be employed in a wide variety of civilian application areas. The primary focus of this research article is to perform the fingerprint image preprocessing cum image enhancement using the median filter.

The rest of this paper is organized as follows: Section 2 describes the classifications and characteristics of fingerprint. Section 3 shows the implementation of median filter on the fingerprint image. Section 4 describes the experimental result like the noise rate and the performance of the median filter.

2. Fingerprint

Fingerprints were accepted formally as valid personal identifier in the early twentieth century and have since then become a de-facto authentication technique in law-enforcement agencies worldwide. The FBI currently maintains more than 400 million fingerprint records on file. Fingerprints have several advantages over other biometrics, which are as following [11]:

- High universality
- High distinctiveness
- High permanence
- Easy collectability
- High performance
- Wide acceptability

At the age of seven months, a fetus' fingerprints are fully developed. The characteristic of the fingerprint does not change throughout the lifetime except for injury, disease, or decomposition after death. However, after a small injury on the fingertip, the pattern will grow back as the fingertip heals [11]. It is supposed that fingerprints are distinct across individuals and across the fingers of a particular individual [9]. It has been established that even identical twins with identical DNA possess different fingerprints. Since many existing fingerprint authentication systems are based on minutiae points, which are feature points extracted from a raw fingerprint image. A fingerprint can be defined as a pattern of ridges and valleys on the tip of the finger. A fingerprint is therefore described by the distinctiveness of the local ridge features and their relationships. Minutiae points denote these local ridge characteristics that appear either at a ridge ending or a ridge bifurcation. The point where the ridge comes to an abrupt end is known as ridge ending and the ridge bifurcation is denoted as the point where the ridge divides into two or more branches.

Fingerprint usage can be divided into three different areas:

- Security as identification of individuals.
- Forensics, also as an identification method.
- Personal characteristics and dermatoglyphics, often involved with horoscopes and similar non-scientifically proven prophecies.

The first two are by far the greatest areas. Fingerprint-based systems, used for security reasons, are so popular today that they have almost become the synonym for biometric systems.

2.1. Fingerprint characteristics

You have probably looked at your own fingerprint at some point in your life and noticed the *papillary lines* on it. In fingerprint literature, the terms *ridges* and *valleys* are used to describe the higher and lower parts of the papillary lines. The reason we have ridges and valleys on our finger, is the frictional ability of the skin. The formation of the ridges and valleys is a combination of genetic and environmental factors. The DNA gives directions in the formation of the skin of the foetus, but the exact formation of the fingerprint is a consequence of random events [12]. This is also the reason why the fingerprints on different finger on the same individual are different, and why identical twins have different fingerprints. The Fingerprint features or patterns are of two types namely local and global Features (see Figure 1). The local features are Ridge termination, Ridge Island or dot, Lake, Spur and Crossover (Table I). The global features are Core and the Delta points of fingerprint (see figure 2).

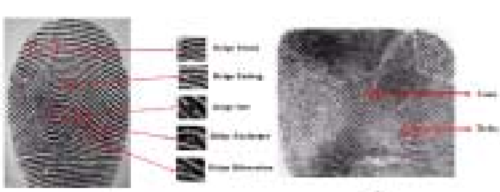
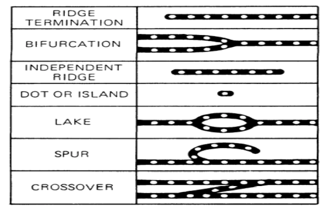


Figure 1 a) Local Features: Minutia b) Global Features: Core and Delta

TABLE I LOCAL FEATURES REPRESENTATION



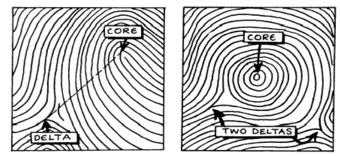


Figure 2 Core and delta points marked on sketches of the two Fingerprint patterns loop and whorl.

2.2. Classifications and pattern types

Fingerprints can be divided into the three major pattern types are arches, loops, and whorls, depicted in figure 3. Loops are the most common fingerprint pattern. These major pattern types can appear in different variations. For example, you can find plain or tented (narrow) arches, right or left loops, and spiral or concentric circles as whorls. Also, the different pattern types can be combined to form a fingerprint, e.g. a double loop, or an arch with a loop [11].

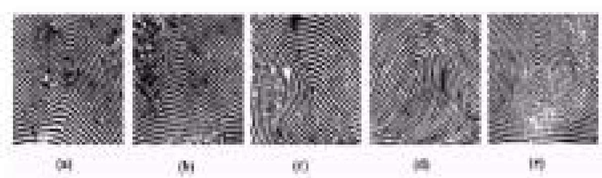


Figure 3 Fingerprint classes: a) Tended Arch b) Arch c) Right Loop d) Left Loop e) Whorl

2.3. Structure of Fingerprint Verification system

The general structure of the fingerprint verification is shown in figure 4. The structure includes the fingerprint image input, preprocessing, fingerprint enhancement, feature extraction and matching with the stored data for authentication or identification purpose. The system describes the each and every phase followed in the verification process. The fingerprint image is given as the input; that is the image is captured from the scanner. The fingerprint image is preprocessed in order to produce a good quality image (noise-free image). Further, the quality fingerprint image is enhanced for accuracy. Next, the minutiae features are extracted from the enhanced fingerprint image. Finally, the extracted minutiae are matched with the stored data. If the input image is matched then authentication is identified; otherwise authentication is denied. Apart from correlation-based, a Minutia based fingerprint matching technique is also widely used [10]. We focus on the fingerprint pre-

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processing phase of the verification system, which is described in the next section.

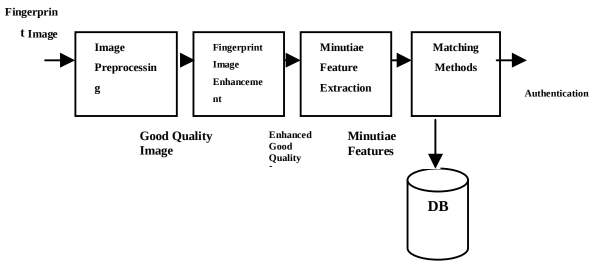


Figure 4 Fundamental Structure of the Fingerprint Verification system

3. Fingerprint Image Preprocessing

Recognition of Fingerprint becomes a complex computer problem while dealing with noise or low quality images [9]. Fingerprint image preprocessing is an essential task to get a good quality image for further process. The Fingerprint preprocessing results the noise-free image that gives the accuracy. The aim of the preprocessing is to improve the image data that suppresses the undesired distortions or enhances some image features, which are important for further processing. Since preprocessing is very useful to suppress information that is not relevant to the specific image processing or analysis task. The preprocessing steps include the following:

- Image Histogram Equalization
- Binarization
- Median Filtering

The algorithm for the preprocessing using Median filter is given below:

1. Read the fingerprint image (I).
2. Generate histogram for the Original Image (H).
3. Binarize the Gray-scale image to get binary image that is black and white image (BI).
4. Implement the **Median Filter** in the Binarized image [QI=MF (BI)].
5. Get a Noise Filtered image as an output (QI).

Procedure to compute the brightness histogram is shown below:

Procedure for **Histogram**:
1. Assigns zero for all elements of the array (H).
2. For all pixels (x, y) of the image I, increment H [I(x, y)] by 1.

3.1. Image Histogram

The brightness transformation modifies pixel brightness of the input image is named as histogram. The transformation depends on the properties of a pixel itself. There are two classes of pixel brightness transformations:

- Brightness corrections: It modifies pixel brightness, taking into account; its original brightness and its position in the image.
- Gray-scale Transformations: Changes brightness without regard to position in the image.

In our experiment we find the histogram of the input fingerprint image. Figure 5 shows the original and their histogram, which get the increased brightness than the original image for the better understating of the individual pixels.

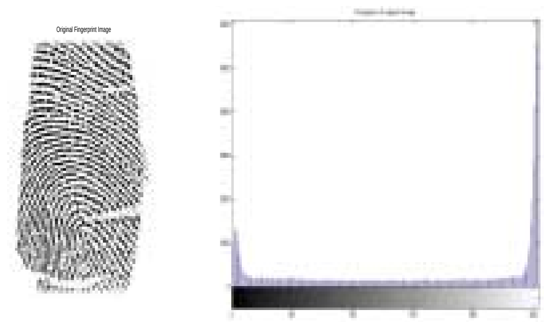


Figure 5 a) Original Fingerprint Image b) Histogram of the Original Image

3.2. Binarization

The captured fingerprint image is as a gray-scale image [range 0 – 255]. Binarization is the process of transforming the Gray-scale image into the binary image [0,1]. The gray-scale transformations do not depend on the position of the pixel in the image. A transformation T of the original brightness P from scale [P_0, Pk] into brightness q from a new scale [q_0 ,q_k] is given by

$$q = T(P). \quad (1)$$

The most common gray-scale transformations are shown figure 6. The straight line 'a' denotes the negative transformation; the dashed line is linear function 'b' enhances the image contrast between brightness value P1, P2. The function 'c' is called brightness threshold and results in a black-and-white image (Binarized image). The binarized image is shown in the figure 7.

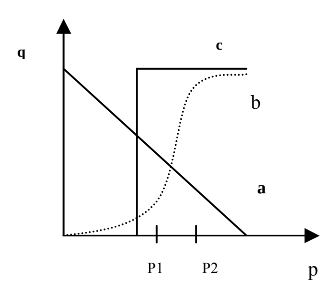
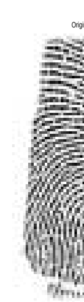


Figure 6 some gray scale transformations



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(c)

Figure 7 a) Original Gray-scale Image b) Binarized Image (c) Histogram after Binaraization

3.3. Median Filter

De-noising algorithms might be better if they involve not only the noise, but also the image spatial characteristics [13]. Median Filter is a non-linear smoothing method that reduces the blurring of edges, in which the idea is to replace the current point in the image by the median of the brightness in its neighborhood. Individual noise spikes do not affect the median of the brightness in the neighborhood and so median smoothing eliminates impulse noise quite well. In our experiment, the median filter was applied and got the median filtered fingerprint image as a good quality image for the further enhancement. The median filtered image is shown in the figure 8.

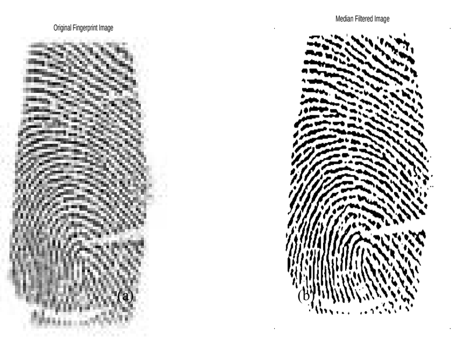

Figure 8 a) Original Fingerprint Image b) Median Filtered Image

4. Experiment Results

This section describes the experimental steps and results obtained. Preprocessing and median filtering were implemented using the MATLAB 7.10. We obtained the input fingerprint image (356 x 328 x 3) from the live-fingerprint reader, which occupies 350304 bytes that was under the histogram equalization (We have generated ten fingerprint images for our experiment; but this paper shows only the result of the single fingerprint image). Further the histogram equalized gray-scale [0-255] image is converted into the binary [0,1] image (356x328). Finally, the binarized image was filtered using a non-linear median filter which results the median filtered image (356x328) with 116768 bytes. The final output could be obtained with as a purified cum filtered image which uncovers the noise. The original captured image, binarization, and median filtered image are shown in the figure 9. Compared the noise ratio between original and the median filtered image through the statistical-correlation factor.

Figure 9 a) Original fingerprint image obtained from External Fingerprint Reader b) Binarised Image c) Median Filtered Image

The correlation factor is calculated using the following procedure.

$$R = \frac{\sum_{m}\sum_{n} (A_{mn} - A`)\,(B_{mn} - B`)}{\sqrt{\sum_{m}\sum_{n} (A_{mn} - A`)^2\,(B_{mn} - B`)^2}} \qquad (2)$$

Where A= Original (Noisy) Image, B= Filtered Image, m, n = size of the Images; A`= Mean (A) and B`= Mean (B).

RESULT 1: Correlation Factor

The correlation value for each fingerprint image which is obtained in our experiment is shown in the table II.

TABLE II CORRELATION BETWEEN ORIGINAL NOISY IMAGE AND THE MEDIAN FILTERED IMAGE

FINGERPRINT IMAGE #	CORRELATION FACTOR
1	0.8658
2	0.8881
3	0.8753
4	0.8594
5	0.8589
6	0.9068
7	0.8988
8	0.8795
9	0.8868
10	0.9044

Result1 show that the changes made in the original image while implementing the median filter. The performance analysis of median filter for ten fingerprint images is shown in figure 10.

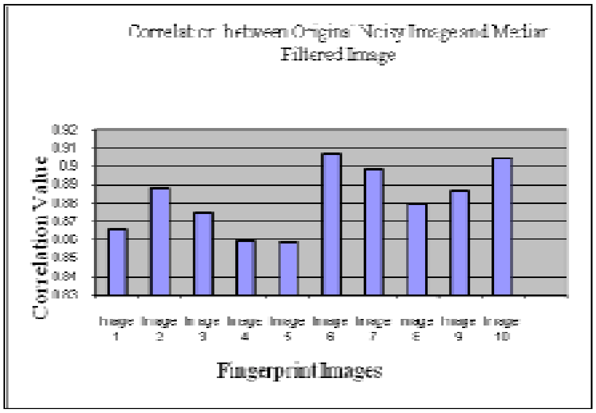

Figure 10 Performance Analysis chart

RESULT 2: Computational time

The performance of the Median filter is identified using the correlation factor; and the computational time is calculated with 0.00000004s clock precision and 2805 MHz clock speed. The computational time of the Median filter is listed in the table III and the performance analysis chart is shown in figure 11.

TABLE III COMPUTATIONAL TIME OF THE MEDIAN FILTER

Fingerprint Image #	Total Recorded Time	Computational Time for Noise Removal
1	0.37s	0.01500000s
2	0.44s	0.01500000s
3	0.38s	0.01600000s
4	0.38s	0.01600000s
5	0.36s	0.01500000s
6	0.37s	0.01500000s
7	0.36s	0.01600000s
8	0.38s	0.01600000s
9	0.39s	0.01600000s
10	0.34s	0.01600000s

The table IV shows the images with their size, bytes and their class. By comparing the original image and the Binarized cum median filtered image, the size of the image is 116768 bytes only.

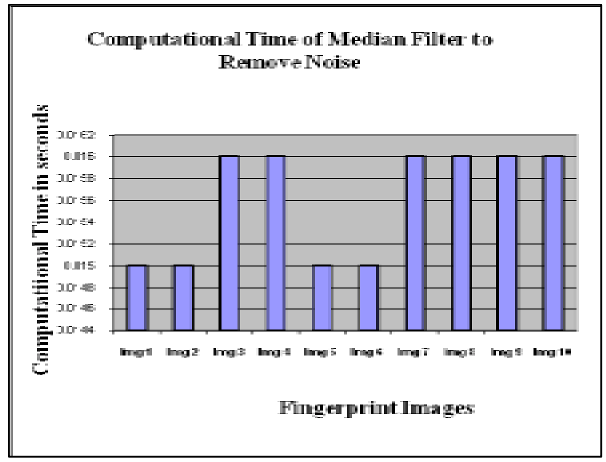

Figure 11 Computational time of Median Filter of ten fingerprint images with 0.00000004s clock precision and 2805 MHz clock speed

TABLE IV COMPARISON OF ORIGINAL AND MEDIAN FILTERED IMAGE STATUS BEFORE AND AFTER NOISE REMOVAL

IMAGE TYPE	SIZE	BYTES	CLASS
Original image (I)	356*328*3	350304	Uint8 Array
Median Filtered Image (MFI)	356*328	116768	Logical Array

5. Conclusion

The need of fingerprint verification system leads the quality factor. The fingerprint characteristics, classifications and basic structure of fingerprint verification system were discussed. The preprocessing techniques were applied on the captured image using an external fingerprint scanner. We obtained a noise free image by implementing the median filter using the MATLAB 7.10Tool; and we have measured the correlation value for ten fingerprint images with less computational time.

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Authors Biography

Dr.E.Chandra received her B.Sc., from Bharathiar University, Coimbatore in 1992 and received M.Sc., from Avinashilingam University, Coimbatore in 1994. She obtained her M.Phil, in the area of Neural Networks from Bharathiar University, in 1999. She obtained her PhD degree in the area of Speech recognition system from Alagappa University Karikudi in 2007. At present she is working as a Director in Department of Computer Applications at D. J. Academy for Managerial Excellence, Coimbatore. She has published more than 28 research papers in National, International journals and conferences. She has guided for more than 30 M.Phil, research scholars. At present, she is guiding 8 PhD research scholars. Her research interest lies in the area of Data Mining, Artificial intelligence, neural networks, speech recognition systems and fuzzy logic. She is an active member of CSI, Currently management committee member of CSI, Life member of Society of Statistics and Computer Applications.

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