Noisy Fingerprint Image Enhancement Technique for Image Analysis: A Structure Similarity Measure Approach

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Summary
Fingerprint images vary in quality. In order to ensure that the performance of an automatic fingerprint identification system (AFIS) will be robust with respect to the quality of input fingerprint images, it is essential to incorporate a fingerprint enhancement module in the AFIS system. In this paper, we introduce a special domain fingerprint enhancement methods which decomposes the input fingerprint image into a set of filtered images. From the filtered images, the orientation field is estimated and a quality mask which distinguishes the recoverable and unrecoverable corrupted regions in the input image is generated. Using the estimated orientation field, the input fingerprint image is adaptively enhanced in the recoverable regions

A technology for recognizing fingerprints for security purposes is proving as regards as reliable but efficient recognition is depending on the quality of input fingerprint image. Recognition of the fingerprint becomes a complex computer problem while dealing with noisy and low quality images. In this Paper work we are focusing the special domainn biometric System of noisy and low quality images, which will be beneficial for recognition system.

Experimental results show that our enhancement Methods improves the performance of the fingerprint Images makes it more robust with respect to the quality of input.

Keywords
Image Enhancement Technique, Spatial domain methods, Contrast Image enhancement

1. Introduction

Biometrics techniques are divided into two categories i.e. Physiological (fingerprints, face, iris, DNA, retina, voice,hand geometry, palm print, retinal scan etc.) and Behavioral (gait, signature etc). These physiological or behavioral Characteristics are used for human identification on the basis of their universality, uniqueness, permanence and collectability [1]. Fingerprint is the most interesting and oldest human identity used for recognition of individual. In the early twentieth century, fingerprint was formally accepted as valid signs of identity by law-enforcement agencies. Therefore in 1960 the FBI Home office (UK) and Paris Police Department initiated studies on automatic fingerprint identification system [2]. Scientific study on fingerprints was started in sixteenth century, but Sir F. Galton and E.Henry established the foundation of modern fingerprint recognition at the end of nineteenth century [2]. On the basis of this the automatic fingerprint recognition system for authentication and identification developed by the scientist and developers recently. These system merely used in various application and systems where the authentication and identification of human being required, like Defense, law, crime, banking, communication etc. Fingerprint recognition system is based on two basic premises. 1) Persistence: The basic characteristics of fingerprint do not change with time i.e. preserve its characteristics and shape form birth to death. 2) Individuality: The fingerprint is unique to an individual [3]. This area of studies comes under biometric systems. Apart from the fingerprint sign of a human being there are various approaches to develop the biometrics system for above-mentioned applications using other biometrics signs also like hand, iris, face, speech, voice etc.

2. Background

International and National status

In a recently published World Biometric Market Outlook (2005-2008), analysts predict that the average annual growth rate of the global biometric market is more than 28%, by 2007. The technologies that would be included in this are fingerprint technology by 60%, facial & iris by 13%, keystroke by 0.5% and digital signature scans by 2.5%

Basically there are two types of fingerprint Recognition System:

1.AFAS (Automatic Fingerprint Authentication System)
2.AFIS (Automatic Fingerprint Identification/Verification System)

AFAS (Automatic Fingerprint Authentication System)

Components of AFIS are: [11][12[13]

1. Physical Fingerprint required as input.
2. Input is processed by using various image processing tools and databases and Classification of Fingerprints. The basic fundamental steps of these systems (see figure (1)are image acquisition, pre-processing segmentation, enhancement etc), feature extraction, matching along with classification through databases. Authentication or verification systems authenticate the person's identity by comparing the own biometric template(s) stored in database (One-to-One comparison). An identification system recognize by an individual by searching the entire

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templates in database for match (One-to-Many Comparison) [3] [5].

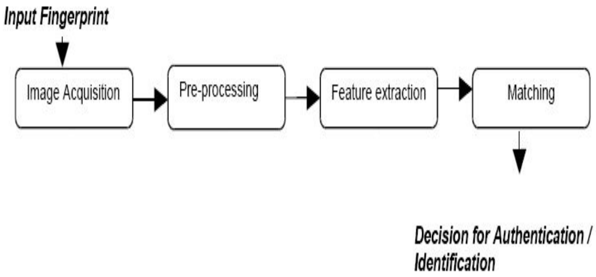


Figure 1: Fundamental steps of Automatic Fingerprint Recognition System

Decision for Authentication /Identification : Fingerprint Structure

Image Acquisition Feature extractor-processing n Matching Eighteen different types of fingerprint *features* are enumerated. The *ridge ending* and *bifurcations* are taken as the distinctive features of fingerprint as shown in figure 2; in this method location and angle of the feature are taken to represent the fingerprint and used in the matching process [6]. On a complete fingerprint image contain near about 50 to 150 minutiae and for automated systems almost 10 minutiae matching are sufficient to establish identity of individual [7].

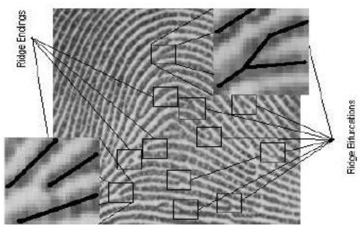


Figure 2: Ridge ending and Bifurcation

Fingerprint contains two special types of features called *core* and *delta points* as shown in following figure 3 and other features like *trifurcation, spur, dots, island, short ridge, ridge, enclosure* etc are shown in figure 4. The *core* and *delta* points are often referred to as Singularity points of fingerprints. The Core point is generally used as a reference point for coding minutiae and defined as the topmost point on the innermost recurving ridge. The core point is generally used as a reference point [8].

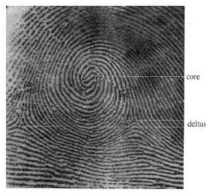


Figure 3: Core and Delta Point

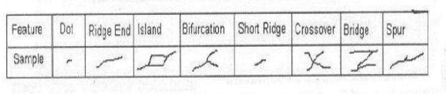


Figure 4: Other fingerprint features

Fingerprint Image pre-processing

The captured fingerprint image in RGB format is first converted to gray scale [0-255] followed by the normalization process. Parallelly, we determine the probable fingerprint region. The adaptive thresholding followed by the morphological processing are performed on the determined probable fingerprint region in order to create the fingerprint binary mask. The normalized image is then multiplied with the fingerprint binary mask. The resulting image is cropped and enhanced by using the STFT based technique that proposed in [14]. Finally, the ridge orientation is calculated and the core point detection is done on the enhanced image. The process flow of the fingerprint preprocessing is shown in Fig. 5.

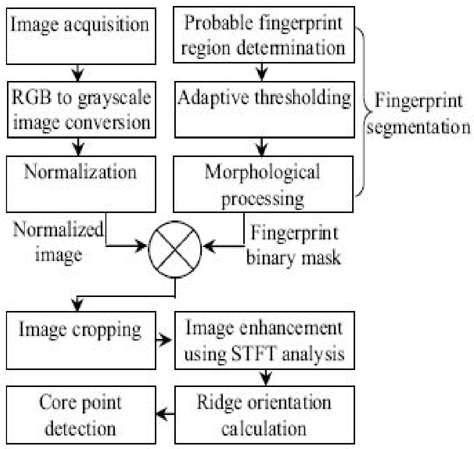


Figure 5 Flow Chart of the Fingerprint Preprocessing

3. Image Enhancement Technique

The aim of image enhancement is to improve the interpretability or perception of information in images for human viewers, or to provide `better' input for other automated image processing techniques. ie. To process an image so that the result is more suitable than the original image for a specific application. Image enhancement techniques can be divided into two broad categories:

1. Spatial domain methods, which operate directly on pixels, and
2. frequency domain methods, which operate on the Fourier transform of an image.

Unfortunately, there is no general theory for determining what is `good' image enhancement when it comes to human perception. If it looks good, it is good! However, when image enhancement techniques are used as pre-processing tools for other image processing techniques, then quantitative measures can determine which techniques are most appropriate.

Image Enhancement Techniques

Spatial domain methods :

The value of a pixel with coordinates (*x,y*) in the enhanced image $\hat{F}$ is the result of performing some operation on the pixels in the neighborhood of (*x,y*) in the input image, *F*. Neighborhoods can be any shape, but usually they are rectangular. It Contains

- Contrast Image Enhancement
- Negative Image Enhancement
- Histogram Image Enhancement etc

Frequency domain methods

Image enhancement in the frequency domain is straightforward. We simply compute the Fourier transform of the image to be enhanced, multiply the result by a filter (rather than convolve in the spatial domain), and take the inverse transform to produce the enhanced image.

The idea of blurring an image by reducing its high frequency components or sharpening an image by increasing the magnitude of its high frequency components is intuitively easy to understand. However, computationally, it is often more efficient to implement these operations as convolutions by small spatial filters in the spatial domain. Understanding frequency domain concepts is important, and leads to enhancement techniques that might not have been thought of by restricting attention to the spatial it contains

- Filtering
- Geometric Transformations etc

The performance of our enhancement methods has been evaluated by conducting experiments by the help of MATHLAB 7.0 On FVC2004 Database containing over 4000 fingerprint images.

Experiment and Analysis

Method of calculation the following parameters

MSSIM (Structure Similarity Measuring)

$$SSIM(\mathbf{x},\mathbf{y}) = \frac{(2\mu_x\mu_y + C_1)(2\sigma_{xy} + C_2)}{(\mu_x^2 + \mu_y^2 + C_1)(\sigma_x^2 + \sigma_y^2 + C_2)}. \quad 1.$$

MSE (Mean Squre Error)

$$\frac{1}{MN}\sum_{j=1}^{M}\sum_{k=1}^{N}(x_{j,k} - x'_{j,k})^2 \quad 2.$$

PSNR (Peak Signal to Noise Ratio)

$$10 \log(255^2 / MSE) \quad 3.$$

NK (Normalized Co-relation)

$$NK = \frac{\sum_{j=1}^{M}\sum_{k=1}^{N} x_{j,k} . x'_{j,k}}{\sum_{j=1}^{M}\sum_{k=1}^{N} x^2_{j,k}} \quad 4.$$

SC (Structured Content

$$SC = \sum_{j=1}^{M}\sum_{k=1}^{N} x_{j,k}^{2} / \sum_{j=1}^{M}\sum_{k=1}^{N} x'_{j,k}{}^{2} \quad 5.$$

NAE (Normalized Absolute Error)

$$NAE = \sum_{j=1}^{M}\sum_{k=1}^{N} | x_{j,k} - x'_{j,k} | / \sum_{j=1}^{M}\sum_{k=1}^{N} | x_{j,k} | \quad 6.$$

In a Contrast technique for enhancing the finger print images taken from FVC2004 database in which we have chosen different images taken from each database is enhanced by this method the quality matrix MSSIM(Structure Similarity Measuring), PSNR (Peak Signal to Noise Ratio), NK (Normalized Co-relation), SC (Structured Content), NAEC (Normalized Absolute Error)

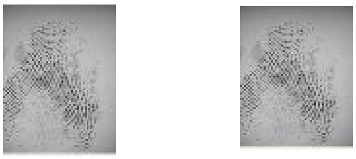
It is clearly seen that the sample from database no 2 image name 25_2.tif is getting the best result through out the samples Image 25_2.tif shows the best results as compare with the others as shown in Fig 5 and graph 2(a),The parameters values obtained are given in Table no 2

25_5.tif Source Enhanced Image

Fig 5 of Contrast Enhancement on FVC2004

In a **histogram technique** for enhancing the finger print images taken from FVC2004 database in which we have chosen different images taken from each database is enhanced by this method the quality matrix MSSIM(Structure Similarity Measuring) , PSNR (Peak Signal to Noise Ratio), NK (Normalized Co-relation), SC (Structured Content), NAEC (Normalized Absolute Error) The results which we have obtained is given in table No 2 and graph no 2(b)Discuss below long with the graphs

It is clearly seen that the sample from database no 3 image name 61_6.tif is getting the best result on scale value **N=100 instead of N=200** as compare with the others as shown in Fig 6 And Table No 2 ,Graph No 2(b)

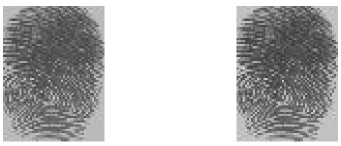


61_6.tif Source Enhanced Image

Fig 6

In a **Negative Image technique** for enhancing the finger print images taken from FVC2004 database in which we have chosen different images taken from each database is enhanced by this method the quality matrix MSSIM(Structure Similarity Measuring) ,PSNR (Peak Signal to Noise Ratio), NK (Normalized Co-relation), SC (Structured Content), NAEC (Normalized Absolute Error)The results which we have obtained is dicussed below along with the graph

It is clearly seen that the sample from database no 4 image name 11_2.tif is getting the best result through out the samples Image 11_2.tif Fig No 7 shows the best results as compare with the others as shown in table no 20 and graph no 19,The parameters values obtained are given in Table no 2 and graph shown in graph no2(c)



Source Enhanced Image

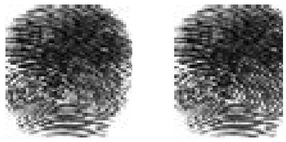
Fig 7 11_2.tif

4. Discussion and Conclusion

It is clearly seen that the Contrast Image enhancement method returns the best results when studied with all available database samples as compare with others as indicated in below figures .

Image 25_2.tif (Fig No 8)shows the best results as compare with the others from FVC2004 Database no. 2

The parameters values obtained are Given in Table no 1 and graph shown in graph no-1



25_2.tif source Enhanced Image

Fig 8

In this research paper, we have studied various Image enhancement techniquessuch as Contrast ,negative ,log transform etc. Using these techniques it is possible to detect the discontinuities and similarities occurred in Images and there quality in overall view of image

In **Contrast Image enhancement** we have observed that as MSSIM (Structure Similarity Measuring), increases PSNR (Peak Signal to Noise Ratio) also increases which yields the quality of the images and same time the NK (Normalized Co-relation)reduced , SC (Structured Content), NAEC (Normalized Absolute Error) are proportionally increases .We have got the image 25_2.tif from the collection of Db2 having a better quality result

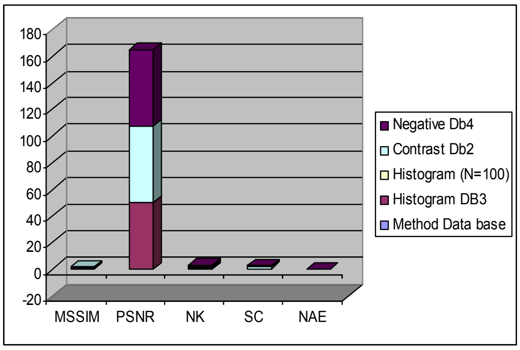
In **Histogram Image enhancement** we have observed that as N(Gray Scale value in number) increases , MSSIM (Structure Similarity Measuring) decreases ,also PSNR (Peak Signal to Noise Ratio) decreases and which yields the bad quality of the images and same time the NK (Normalized Co-relation) increases , SC (Structured Content), NAEC (Normalized Absolute Error) are proportionally decreases .We have got the image 61_6.tif from the collection of Db3 having a better quality result at N = 100

In **Negative Image enhancement** we have observed that as MSSIM (Structure Similarity Measuring), increases PSNR (Peak Signal to Noise Ratio) also increases which yields the quality of the images and same time the NK (Normalized Co-relation)reduced , SC (Structured Content), NAEC (Normalized Absolute Error) are proportionally increases .We have got the image 11_2.tif from the collection of Db4 having a better quality result

Out of these studied methods we are in the position to conclude that the contrast Image enhancement is the one of the best method within the studied techniques as shown in Graph no 1 and fig 9 and Table No 1

MSSIM	PSNR	NK	SC	NAEC
0.9363	58.009	0.9993	1.00	2.8790e-007

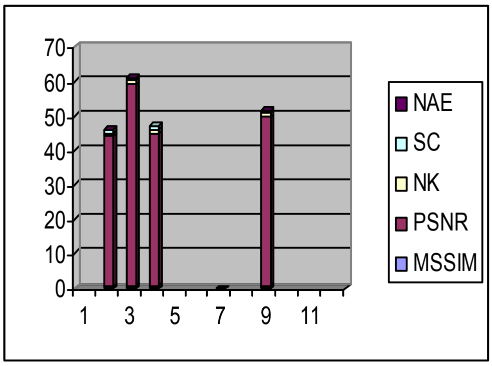
Table No 1



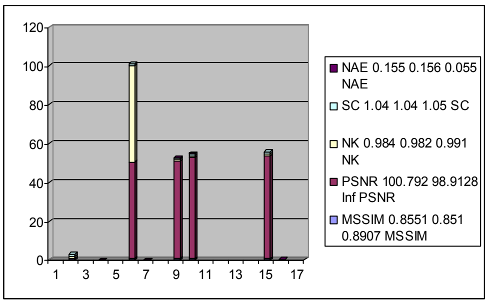
Graph No 1

Histogram Image Enhancement				
MSSIM	**PSNR**	**NK**	**SC**	**NAEC**
0.9136	49.9943	1.033	0.74	0.023
Contrast Image Enhancement				
0.9363	58.009	0.9993	1.00	2.8790e-007
Negative Image Enhancement				
-0.4169	57.0182	1.000	1	0.0015

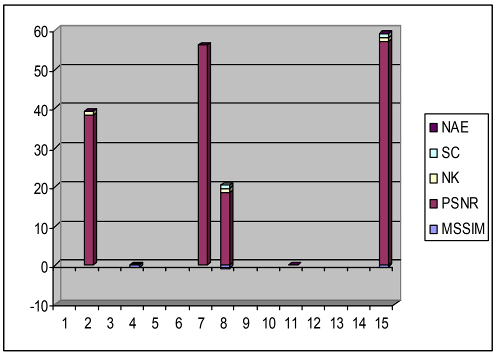
Table No 2



Graph No 2(a)



Graph No 2(b)



Graph No 2(c)

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