IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)
e-ISSN: 2278-2834,p- ISSN: 2278-8735.
PP 28-33
www.iosrjournals.org

A Two Stage Algorithm based on MRT for The Enhancement of Low Quality Fingerprint Images

Ratheesh P.M.[1] , Rajin R[2]
[1]*Department of Instrumentation, Cochin University of Science And Technology Cochin-682022, India*
[2]*Department of Computer Science and Engineering College of Engineering, Vadakara*
Kozhikode- 673105, India

Abstract— *Out of a number of biometric identification systems, the most commonly used and the oldest method of identification is the fingerprint-based identification that has been effectively used in a diversity of applications. Brightness and Contrast enhancements have a significant role in fingerprint identification systems. Generally, the low contrast images are enhanced in spatial domain followed by other image processing methods in the transform domain. In this paper we are proposing a new simple, yet powerful method in fingerprint enhancement that uses a two stage image enhancement technique in spatial and transform domain for addressing low contrast and brightness problems in gray-scale and color images and is more efficient than existing methods. A new technique is being proposed that incorporates ridge compensation filter in spatial domain and sequency based MRT in transform domain. The brightness and contrast is controlled by changing the statistical parameters in the SMRTtransform domain.*

Keywords— *Image Enhancement, Spatial Domain, Transform Domain, Sequency based Mapped Real Transform(SMRT).*

I. Introduction

Image enhancement is one of the main preprocessing step in many biometric identification systems. R.C. Gonzalez and R.E. Woods [1] have explained in his book that there's no general theory of image enhancement. The low quality of image may due to wrong settings of lens aperture at the time of acquisition, lack of dynamic range in image sensor or even due to poor illumination. Brightness variation and contrast stretching are used for improving the visual appearance of an image. The brightness of an image can be varied by changing its mean without changing histogram whereas the contrast is determined from its dynamic range, which is defined as the difference between highest and lowest intensity level present in the image. Contrast enhancement stretches the histogram to distinguish more details, generally not visible. Hence histogram stretching can be used to enhance low contrast images.

Spatial domain methods and transform domain methods are the two major categories for increasing the contrast and brightness of low quality fingerprint images. Direct manipulation of pixels is done in spatial domain techniques and can be carried out on the whole image or on a local region selected on the basis of image statistics. Image averaging, histogram processing, nonlinear filtering and sharpening edges are examples of some spatial domain techniques [2], [3], [4]. In transform domain, the forward transform coefficients are first computed and they are manipulated as proposed by the algorithm. Then to reproduce the spatial domain representation
i.e. the enhanced image, the inverse transform coefficients are evaluated [5], [6], [7].
Spatial domain process can be denoted by the expression:

$$g(x, y) = T[f(x, y)] \quad (1)$$

where, f (x, y) is an input image, g (x, y) is an output image and T is an operator defined over the neighborhood of (x, y).
As an example of frequency domain process DFT is illustrated here. For a given digital image f (x, y), of size M x N, the basic filtering equation in which we are interested has the form:

$$g(x, y) = \tau^{-1}[H(u, v)\, F(u, v)] \quad (2)$$

Where, $^{-1}$ is the IDFT, F (u, v) is the DFT of the input image f (x, y), H (u, v) is the filter function and g (x, y) is the filtered output image. Specification of H (u, v) is simplified considerably by using functions that are symmetric about the center. This is accomplished by multiplying the input image by -1^{x+y} prior to computing its transform [1].

Fingerprint is one among the main guaranteeing approaches among biometric techniques and has been used for individual authentication since nineteenth century. The two fundamental grounds on that fingerprint recognition relies are: fingerprint details are persistent and fingerprints of people are unique. A fingerprint is made of a group of curves. The fingerprint pattern displays different features at different levels. At level 1, the important distinct structural characteristic of fingerprint can be a pattern of the lines (ridges) flowing in varied patterns. This level is also referred to as international level of fingerprint analysis. At this level fingerprint pattern exhibits one or a lot of regions wherever ridge lines are characterized by high curvature and frequent termination. These regions or singular regions are generally used for distribution a fingerprint to a group of five unique classes (arch, tented arch, left loop, right loop, double loop and whorl) with the goal of simplifying search and retrieval. At level 2 fingerprint images are characterized by discontinuity of ridges. Ridge termination and ridge bifurcation are the two most prominent ridge characteristics.

II. Requirement of Fingerprint Image Enhancement

Enhancement is frequently conducted on either binary ridge images or gray-scale images. Binarization before enhancement can generate additional false minutiae structures and miss some important original fingerprint information. Totally different techniques for gray- level fingerprint image enhancement are observed in the literature, assuming that the local ridge frequency and orientation are often consistently estimated. Pixel oriented enhancement schemes like Wiener filtering, histogram equalization, Mean and Variance Normalization [8], improve the appearance of the fingerprint without altering the ridge structure. The very motive for doing enhancement is to eliminate the noise within the fingerprint images, enlighten the parallel ridges and valleys and protect actuality pattern of them. [9].

The method proposed in [10] is well accepted for fingerprint enhancement, which is based on a directional Gabor filtering kernel. A properly oriented Gabor kernel that has frequency- selective and orientation-selective properties is used in this algorithm to accomplish the enhancement. These properties allow the filter to be adjusted to offer maximal response to ridges at a specific orientation and frequency within the fingerprint image. However, Gabor elementary functions has the problems like that they do not form a tight frame and they are biorthogonal bases and there is no strictly admissible reason for choosing the Gabor kernel over various directionally selective filters, like directional derivatives of Gaussian or steerable wedge filters[11].

S.Chikkerur et al. proposed fingerprint image enhancement using STFT analysis [12]. After acquiring the block frequency through the STFT analysis it estimates the local ridge orientation. To enhance the fingerprint image in blocks, a directional band pass filter is employed, not all of the irretrievable regions of the fingerprint will be recovered clearly, because it is tough to accurately estimate some parameters of the filters through a simple STFT analysis. Thus, the algorithm must be improved to enhance the irretrievable regions of low-quality images.

Rajesh Cheriyan Roy developed a new transform for 2-D signal representation called MRT (Mapped Real Transform) [13], [14]. The redundancies presented in the MRT calculation is addressed in [15] by Bhadran V and a new approach called UMRT (unique MRT) is developed to remove redundant elements present in MRT representation and arranges the N^2 unique coefficients in an $N \times N$ matrix. Jaya V.L. presented a new approach for representing the N^2 MRT coefficients in the order of sequency along horizontal, vertical and diagonal directions and are represented by matrix S [16].

III. Mrt, Umrt, And Smrt

2-D MRT (Two-Dimensional Mapped Real Transform) coefficients, $^{(p)}_{k1,2}$ of an image $x n1n2$, $0 \leq n1$, $n2 \leq N-1$ is expressed [13] as

$$Y^{(p)}_{k1,k2} = \sum_{\forall(n1,n2)|z=p} x_{n1,n2} \qquad {}_{\forall(n1,n2)|z=p+M} \qquad {}_{(n1,n2)}$$

for $0 \leq k1$, $k2 \leq N-1$, $0 \leq p \leq M-1$ & $M=N/2$. (3)
where $z=((n1k1+n2k2))N$

2-D MRT maps an $N \times N$ matrix into M matrices of the same size. Hence MRT in the raw form will have $N^3/2$ coefficients and is highly redundant. Unique MRT (UMRT) [14] is developed to eliminate surplus elements present in MRT representation and arranges the N^2 unique coefficients in an $N \times N$ matrix. A new efficient placement for UMRT coefficients is developed known as sequency based unique MRT (SMRT) for N, a power of 2 in which the coefficients are arranged in the order of sequencies along row, column and diagonal directions and are represented by matrix S. The new approach is computationally very fast as the size of the data increases in comparison with UMRT placement.

The first coefficient, S(0,0) called the dc coefficient of the SMRT matrix is found in terms of the input image as sum of all image pixel values. This coefficient is gives an indication of the image mean and restrains most of the image energy. The remaining (N^2-1) coefficients represent the intensity values of the image pixels in various patterns and can be characterized as ac coefficients.

IV. Proposed Algorithm

The existing algorithms are not satisfactory in enhancing and segmenting low quality fingerprint images. To overcome the shortcomings of those approaches we are proposing a new and effective scheme using two consecutive stages as shown in Fig.1.

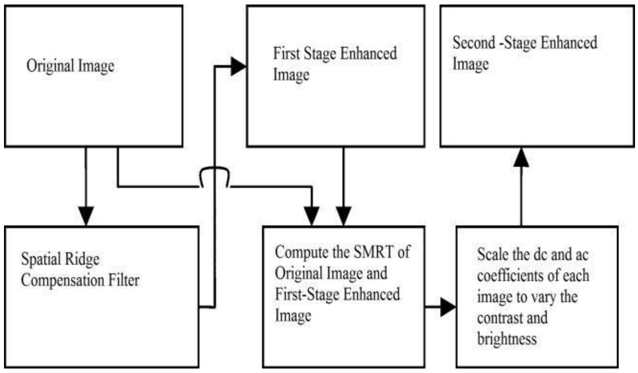


Fig. 1. Proposed SMRT based two-stage enhancement scheme

Using the spatial ridge compensation filter, the algorithm first enhances the images in the spatial domain and, then, enhances the images in the frequency domain using the very fast and efficient real transform SMRT.

Ridge compensation is done along the ridges in the spatial field in the first stage which enhances the fingerprint's local ridges using the neighbor picture elements in a small window with a weighted filter mask throughout the orientation of the local ridges. Every pixel in the fingerprint is substituted with its weighted neighbor sampling pixels in a small window and with the regulated contrast parameters along the orientation of the local ridges, and the filter enhances the gray-level values of ridges pixels throughout local ridge orientation, while reducing the non-ridge pixels' gray-level values; hence, it is able to connect the broken bars and remove the stains in the fingerprint image. The compensation filter uses weighted constant values to control the contrast parameters. Even though not fully enhancing the fingerprint, the processing enhances the ridge contrast and preserves the ridge structures.

A. First-Stage Enhancement: Spatial Domain

The first stage enhancing scheme consists of three steps: local normalization, local orientation estimation, and local ridge- compensation filtering.

1). Local Normalization: This step is used to scale back the local variations and standardize the intensity distributions so as to systematically estimate the local orientation [17]. The clarity of the ridge and furrow structures is not changed by the pixel wise operation, but reduces the variations in gray-level values along ridges and furrows, which smooths the subsequent processing steps.

2). Local Orientation Estimation: This step controls the dominant direction of the ridges in several parts of the fingerprint image. Gradient technique for orientation estimation and an orientation smooth out technique using Gaussian window is used to correct the estimation [18].

3). Local Ridge-Compensation Filter: The final step compensates the ridge artifacts applying a local ridge-compensation filter with a rotated rectangular window to match the local orientation.

B. Second Stage: SMRT Based Image Enhancement

In this stage, dc as well as ac SMRT coefficients of the image are scaled using scaling factors c_{dc} and c_{ac} respectively. Investigational findings reveal that if c_{dc}>1 the histogram moves ahead and if it is less than one, the histogram moves behind with-out changing its shape. Hence, the brightness of the image can be increased as shown in Fig. 2 by scaling, S(0,0) without any change in contrast.

From the results of experimental findings, it can be shown that the contrast and SD of an image can be altered by scaling ac SMRT coefficients while maintaining the image mean. When the scaling factor c_{ac} is greater than unity, the histogram is stretched and when c_{ac} is less than unity it is compressed and thereby modifying the image contrast. Fig.3 shows changes in contrast of the image and the corresponding histograms for different values of c_{ac}

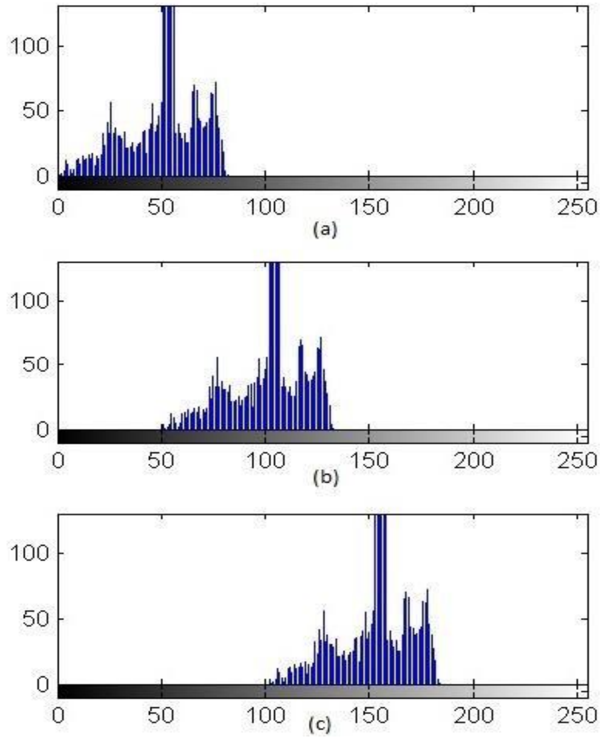


Fig.2. Fingerprint Image Histograms (a) Original Image Histogram (b) dc SMRT coefficient scaled with c_{dc} =3 (c) dc SMRT coefficient scaled with cdc=4

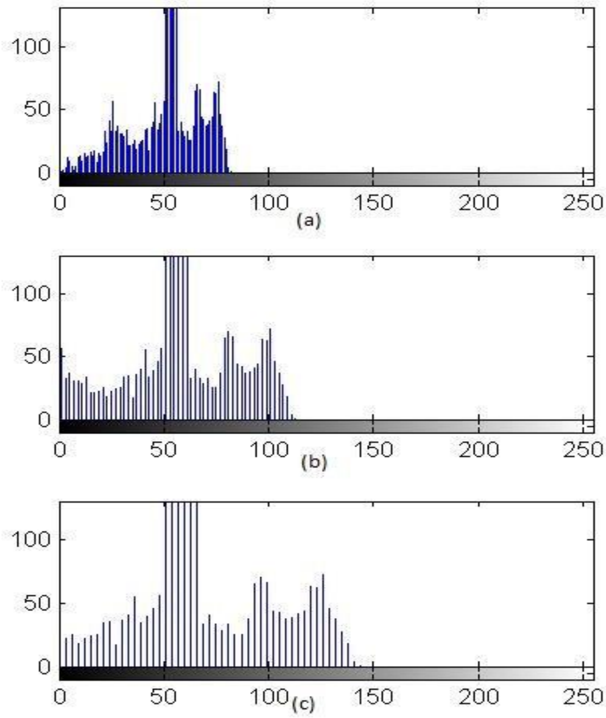


Fig.3. Fingerprint Image Histograms (a) Original Image Histogram (b) ac SMRT coefficients scaled with cac=3 (c) ac SMRT coefficients scaled with cac=4.

The new SMRT matrix that corresponds to the brightness and contrast adjusted image can be expressed as

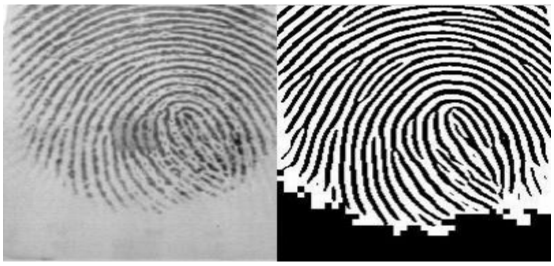
$$\tilde{S}(i,j) = \begin{cases} C_{dc} S(i,j), & if\ i = j = 0 \\ C_{ac} S(i,j), & otherwise \end{cases} \quad \ldots$$

It can be shown that, when a large value of C_{ac} is used, the histogram enlarges and widens to both ends. When C_{ac} value is very much higher, the histogram splits and departs to both ends, then it becomes a black and white image.

The image mean or center of the image histogram is first brought to the center of the range of the histogram by scaling S(0,0) for achieving maximum enhancement. After brightness is adjusted, similar procedure is followed to maximize the contrast.

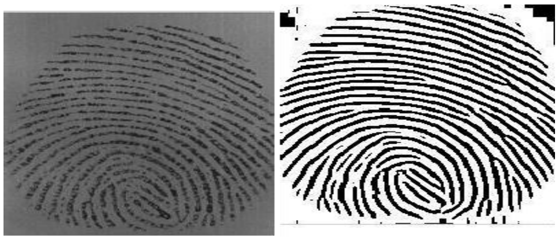
V. Experimental Results

The results obtained from the first stage (Ridge compensation filter) is compared in each case with the output of the second stage. Also the proposed technique is compared with the other enhancement methods. The images on the left side of each of the figures (a) are the original finger prints from FVC 2004 database and that shown on the right side (b) are the enhanced images using the two stage algorithm. The codes are written in MATLAB and runs on Intel core i5 system with 8 GB RAM.



(a) (b)

(a) (c)



(b) (d)

(a) (e)

Fig 4. Results of the proposed two stage enhancement algorithm that is applied to fingerprints from four FVC2004 databases DB1–DB4. (a)Original images. (b), (c), (d), (e) enhance images using the two stage algorithm.

VI. Conclusion

The major aspects of biometry using fingerprint is the enhancement of low quality fingerprint images. Here we developed an efficient and simple two stage fingerprint enhancement technique that is based on a new computationally fast transform called SMRT. The Ridge compensation filter gives a first stage enhanced image, which is then applied to the input of the SMRT section, that manipulates the SMRT coefficients and hence varies the brightness and contrast of the fingerprint image. The output of the proposed technique is compared with the other methods also and better results are obtained.

References

[1] R. C. Gonzalez and R E. Woods, Digital Image Processing. Englewood Cliffs, NJ: Prentice-Hall, 2004.
[2] Faisel G. Mohammed, Huda M. Rada and Sega G. Mohammed, "Contrast and Brightness Enhancement for Low Medical X-Ray Im- ages", International Journal of Scientific & Engineering Research, vol. 4, Issue 5, May 2013.
[3] R. Pushpavalli, and G.Sivaradje, "Switching Median Filter for Image Enhancement", International Journal of Scientific & Engineering Re- search, vol. 3, Issue 2, Feb 2012.
[4] Ashwini Sachin Zadbuke, "Brightness Preserving Image Enhance- ment Using Modified Dualistic Sub Image Histogram Equalization", International Journal of Scientific & Engineering Research, vol. 3, Issue 2, Feb 2012.
[5] Narasimhan K, Sudarshan C R, Nagarajan Raju, "A comparison of contrast enhancement techniques in poor illuminated gray level and color images," International Journal of Computer Applications, vol. 25, pp.17– 25, 2011.
[6] Grigoryan A.M., Agaian S.S, "Transform-based image enhancement algorithms with performance measure," Advances in imaging and Elec- tron Physics, vol.130, pp.165-242, 2004.
[7] Aghagolzadeh. S, Erosy. O.K., "Transform image enhancement," Optical Engineering, vol. 31, pp. 614–626, 1992.
[8] S Greenberg, M Aladjem, D Kogan, and I Dimitrov, "Fingerprint image enhancement using filtering techniques," ICPR, pp. 326-329, 2000.
[9] K. Srinivasan, C. Chandrasekar, An Efficient Fuzzy Based Filtering Technique for Finger-print Image Enhancement, AJSR,ISSN 1450- 223X,no.43, pp. 125-140, 2012.
[10] L. Hong, Y. Wang, A. Jain, Fingerprint Image Enhancement: Algorithm and Performance Evaluation, IEEE Trans. Pattern Analysis Machine Intelligence, Vol. 20, no.8, pp.777-789, 1998.
[11] E. P. Simoncelli and H. Farid, "Steerable wedge filters for local orientation analysis," IEEE Trans. Image Process., vol. 5, no. 9, pp. 1377– 1382, Sep.1996.
[12] S. Chikkerur, A. N. Cartwright, and V. Govindaraju, "Fingerprint enhancement using STFT analysis," Pattern Recog., vol. 40, no. 1, pp. 198–211, 2007.
[13] Rajesh Cherian Roy, R Gopikakumari, "A new transform for 2-D signal representation (MRT) and some of its properties," Proc. IEEE international conference on signal processing and communica- tions(SPCOM'04), pp.363–367, 2004 (http://www.ieeexplore.ieee.org).
[14] Rajesh Cherian Roy, "Development of a new transform MRT," Ph.D Dissertation, Cochin University of Science and Technology, Kochi, 2009.
[15] Bhadran.V, "Development and implementation of visual approach and parallel distributed architecture for 2D-DFT and UMRT computation". Ph.D Dissertation, Cochin University of Science and Technology, Kochi, 2009.
[16] Jaya V L, Preetha Basu, R Gopikakumari, " SMRT: A new placement approach of 2-D unique MRT coefficients for N a power of 2," Annual IEEE India conference (INDICON2012), pp. 233 –237, 2012.
[17] Jucheng Yang, Naixue Xiong and Athanasios V. Vasilakos, Two Stage Enhancemet Scheme for Low-Quality fingerprint images by learning from images, IEEE Transactions on Human Machine System, Vol. 43, no.2, March, 2013.
[18] L. Hong, Y. Wang, A. Jain, Fingerprint Image Enhancement: Algorithm and Performance Evaluation, IEEE Trans. Pattern Analysis Machine Intelligence, Vol. 20, no.8, pp.777-789, 1998.
[19] G. Eason, B. Noble, and I.N. Sneddon, "On certain integrals of Lipschitz- Hankel type involving products of Bessel functions," Phil. Trans. Roy. Soc. London, vol. A247, pp. 529-551, April 1955. (references)