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Enhanced Preprocessing Filter for Biometric Images Applications with PSNR Mitigation

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ABSTRACT: Biometric system scrutinizes the uniqueness of individuals based on physical and behavioral characteristics. In the biometric system, Fingerprint plays a significant role as a human recognition system. To do this in an advanced manner, several automatic fingerprint detection systems were implemented. Such systems extract the minutiae from the captured fingerprint image which is significant for authentication. The image quality plays the main role in the minutiae extraction. In most of the situations, fingerprint images are affected by noise. To retrieve the enhanced image, noise reduction is performed by wiener filter technique. In this paper, digital image processing based segmentation is performed to get the enhanced fingerprint image. Several mathematical operations were performed such as normalization, thinning in order to get the enriched fingerprint image. Matlab Simulation is used as a front-end engine to visualize the performance of proposed work. At each level of processing, image enrichment is shown in this paper.

Keywords: AFIS, Wiener filter technique, pattern recognition, minutiae and image enrichment.

I. INTRODUCTION

In many fields, security is the most important one that needs to be continuously monitored. Biometrics are used in various fields for security purposes. Because of high accuracy and reliable information, fingerprint is chosen [1, 2, 3] and provides a creditable proof of each and every person. Fingerprints are used in vote polling, online examination, and in offices etc. To get the best authentication result, fingerprint image enrichment is done by image processing [13]. Compared with other biometrics such as face, iris and voice, fingerprint authentication provides a good result. Fingerprint authentication has wide variation where no one will have identical print. There may be a scale variation in fingerprint authentication, but not in a relative appearance. Because of inexpensive and convenient use of the fingerprint detecting device, it is chosen for authentication purpose. The quality of images is essential for better authentication. The captured image cannot be used directly. It has to be preprocessed for removing noise by using wiener filter technique [16] and several operations were performed to get the quality image and to provide a good result. Features in the fingerprint show uniqueness in type and position from one fingerprint to another and it is categorized into local and global features. The global features in the fingerprint can be observed by a naked eye. It retrieves global spatial relationships in the fingerprint. It includes ridge pattern, type, position and orientation. In local features, minutia point is spotted by using complex filtering technique [7].

The challenges in the biometric fingerprint identification system are listed below:
(1) Physical distortion Mismatch due to finger injuries and cuts in the fingers.
(2) Displacement or rotation Mismatch during scanning of the finger.
(3) Unauthorized access due to finger plasticity or clay printing.
(4) Impression variation of the similar finger due to skin condition or noises in the sensor.

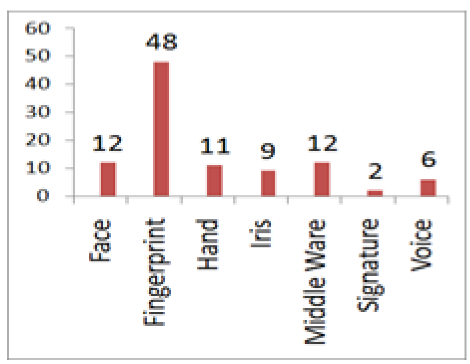
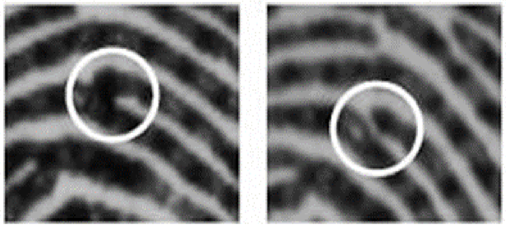


Fig. 1. Performance comparison with other biometrics.

It is retrieved not only by their position, but also by its direction. To extract the ridge orientation and reliability in fingerprint, linear symmetry description is used [6, 10]. In ridge pattern, two different notions of the same image were shown in Fig. 2.



(a) Bifurcation (b) Ridge ending

Fig. 2.

II. LITERATURE SURVEY

Gnanasivam *et al.,* [4] presented two levels of procedure for fingerprint picture improvement. In the first level, Gabor filter is used to enhance the fingerprint and in the next level ridges is refined by three levels of Morphology filter succeeded by the thinning procedure. Bilinear incorporation resizes the picture to the general size. The picture is renormalized and divided by the Morphology filter. The improvement process consists of normalization, division and channeling. Neethu *et al.*, [5] utilizes Fourier change by duplicating the FFT squares by its amplitude for number of times. This method controls the edges thickness and skeletonise. The researcher expresses that if the amplitude of the FFT is squared, powered or cubed, the picture will still be better. The improvement step includes differentiation, histogram evening out, binarization and afterward at long last sifted by utilizing FFT. Borra *et al.,* [8] proposed a technique by utilizing three methods. In the main method the unique mark is dependent upon de-noising process utilizing Wave Atom change, at that point in the subsequent module picture is improved utilizing an enhancement calculation in particular Modified Cuckoo search. Zhao & Tang [9] built up a technique that improves the unique finger impression utilizing versatile thresholding and diminishing pursued by detail extraction. Chaurasia [11] built a method by incorporating standardization, division and picture de-noising Directional Weighted Median channel. The improvement like binarization, focal line diminishing, enlargement, refining pursued by channeling. Selia & Parthiban [12] presented a procedure using histogram evening out for differentiation and Wiener channel and Gobar channel for clamor decrease. The unique mark picture is improved by applying binarization and versatile thresholding. Rajkumar and Hemachandran [14] proposed a Directional channel procedure to expel the commotion from the unique finger impression picture by disintegrating the picture into a few recurrence groups or sub pictures.

Greenberg *et al.*, [15] developed a quick unique finger impression upgrade calculation dependent on an anisotropic sifting. The upgrade includes histogram leveling, wiener separating, binarizarion pursued by morphological sifting.

III. PROPOSED FINGERPRINT IMAGE ENRICHMENT METHOD

Fingerprint Image Enrichment is an essential ingredient to get highly accurate and reliable information. In most of the situations, extracted images bear a noise. Noise reduction is to be performed to get accurate image. The well enriched image shows a clear variation between the real and the factitious feature. The factitious features are those minutiae points generated due to noise.

To get an enhanced image, steps to be performed are (i) Image segmentation (ii) Noise removal (iii) Image localization (iv) Image filtering (v) Image binarization.

While performing segmentation, two sections are to be focused clearly are the front and back view of the fingerprint. The front view involves ridges and valleys as shown in Fig. 3. The figure represents black and white region. The black region represents the ridges and the white region indicates the valley. The Foreground region is indicated as Region of Interest. Mostly the outermost region is said to be the background region where noise gets originated. These noises are reduced by using a filtering technique so as to obtain a clear and enriched image to obtain better result.

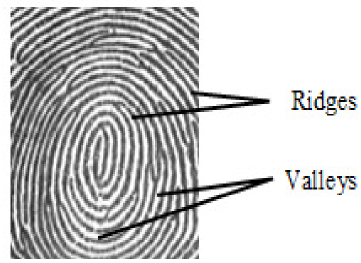


Fig. 3. Ridges and valleys on a fingerprint image.

Initially the image is splitted into equal sections of size N*N, then in each block the variance V(k) is received by computing V(k) and M(k) :

$$V(k)=\frac{1}{N^2}\sum_{i=1}^{n}\sum_{j=1}^{n}(I(i,j)-M(K))^2 \quad (1)$$

$$M(k)=\frac{1}{N^2}\sum_{a=1}^{n}\sum_{b=1}^{n}J(a,b) \quad (2)$$

I(i, j) and J(a, b) are the grey-level value for pixel (i, j) and (a, b) respectively.

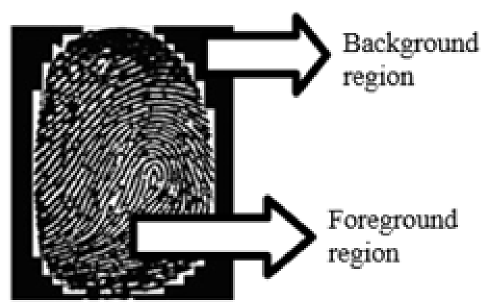


Fig. 4. An image with foreground and background regions.

IV. WIENER FILTER TECHNIQUE

The image which is captured by a fingerprint device usually holds a noise. It should be removed for further better processing. These noises are reduced by using wiener filter technique.

Initially the image is divided into 256×256 samples. The Weiner filtering technique is chosen because of its two performing tasks. One is inverse filtering and the other one is smoothening of noise. To implement this technique, the power spectra and the additive noise found in the image are needed to be figured out. The input image is taken and then the blurring operation is done by a low pass filter and de-convolution is performed by inverse filtering and finally removes the noise using compression operation.

A. Local Normalization

After segmentation and noise removal, Normalization technique is done to get a standardized level of modification in the grey values. To improve the contrast and brightness in the image, the grey level value is made to come around certain range. To implement normalization, the initial step is to split the image into N×N blocks and proceed comparison among them. Normalized value N (i, j) is computed by

$$\text{N (i, j)} = \begin{cases} M_o + \sqrt{\frac{V_0(I(i,j)-M)^2}{V}} & \text{if } I(i,j) > M \\ M_o + \sqrt{\frac{V_o(I(i,j)-M)^2}{V}} & \text{otherwise} \end{cases} \quad (3)$$

Where, M_0 represents the desired mean and V_0 is the desired variance.

B. Image Filtering

The image which is captured cannot be used directly for processing. Image filtering is performed for image enrichment. It includes removal of noise, detection of edge and image smoothening. The Least Square Mean (LSM) algorithm was carried out in this paper after slight modifications to get the enriched image via the following steps.

Orientation estimation: In fingerprint image filtering technique, the ridge which is presented in the image gets diverged in various positions. The position of ridge pixel of the fingerprint is shown in Fig. 6.

(a) Initially, the normalized fingerprint image was split into equal size of S x S.

(b) The gradient values (p, q) were evaluated in X and Y directions for each element of an image.

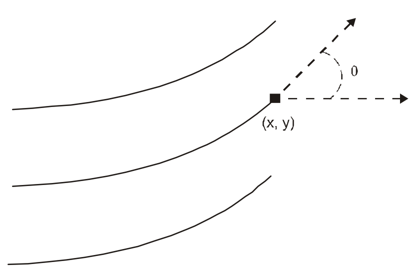


Fig. 5. The position of a ridge pixel is shown in an image.

The gradient value is computed by using Sobel operators in horizontal and vertical format.

$$\begin{bmatrix} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 1 & 0 & -1 \end{bmatrix} \qquad \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$$

Horizontal Sobel Operator   Vertical Sobel Operator

(c) In fingerprint image, local orientation of a pixel was calculated by using S x S neighborhood in Eqns. [8]-[9]. The local orientation I (i, j) is computed by,

$$V_x(i,j) = \sum_{p=i-\frac{s}{2}}^{i+\frac{s}{2}} \sum_{q=j-\frac{s}{2}}^{j+\frac{s}{2}} 2\,\partial_x(p,q)\,\partial_y(p,q) \quad (4)$$

$$V_y(i,j) = \sum_{p=i-\frac{s}{2}}^{i+\frac{s}{2}} \sum_{q=j-\frac{s}{2}}^{j+\frac{s}{2}} \partial_x{}^2(p) - \partial_y{}^2(p,q) \quad (5)$$

$$\theta(i,j) = \frac{1}{2}\tan^{-1}\frac{V_y(i,j)}{V_x(i,j)} \quad (6)$$

where Θ(i, j) indicates least square estimate of the local orientation .

(d) The position of an image is converted into vector field and it was computed by,

$$\varphi_x(i,j) = \cos(2\theta(i,j)) \quad (7)$$

$$\varphi_y(i,j) = \sin(2\theta(i,j)) \quad (8)$$

where φ_x and φ_y represents the *x* and *y* components of the vector field respectively.

(e) Smoothing technique is then applied on the vector field as follows:

$$\varphi_x(i,j) = \sum_{p=-\frac{s\varphi}{2}}^{\frac{s\varphi}{2}} \sum_{q=-\frac{s\varphi}{2}}^{\frac{s\varphi}{2}} G(p,q)\varphi_x(i-ps, j-qs) \quad (9)$$

$$\varphi_y(i,j) = \sum_{p=-\frac{s\varphi}{2}}^{\frac{s\varphi}{2}} \sum_{q=-\frac{s\varphi}{2}}^{\frac{s\varphi}{2}} G(p,q)\varphi_y(i-ps, j-qs) \quad (10)$$

where G indicates Gaussian low-pass filter.

(f) Finally, smoothening is performed on the orientation field O of the block centered at pixel (i, j) as,

$$O(i,j) = \frac{1}{2}\tan^{-1}\frac{\varphi'_y((i,j)}{\varphi'_x((i,j)} \quad (11)$$

Ridge Frequency Estimation: To achieve final enhanced image, Ridge Frequency Estimation is used. This technique is performed to obtain the orientation of the ridges. It is performed with a view to ascertain the number of ridges within a unit length. The extraction of the ridge map includes the following steps:

(a) Calculation of the consistency level of orientation field in the local neighborhood of a pixel (p, q) is given by,

$$C_o(p,q) = \frac{1}{n^2}\sqrt{\sum_{(i,j)€W} |\,\theta(i,j)-\theta(p,q)|^2} \quad (12)$$

$$|\,\theta(i,j)-\theta(p,q)\,| = \begin{cases} d & \text{if } d < 180 \\ d-180 & \text{otherwise} \end{cases} \quad (13)$$

$$D = \theta(i,j) - \theta(p,q) + \text{mod } 360 \quad (14)$$

(b) While computing, if the level of uniformity is below a certain threshold value Fc, then it is again re-estimated until the value of uniformity raises above Fc. After acquiring the orientation field, the following two filters are applied to the image:

$$h_t(p,q,i,j) = \begin{cases} \frac{-1}{\sqrt{2\pi\delta}} e^{\frac{-1}{\delta^2}}, & \text{if } i = l(j) - d, j€\rho \\ \frac{-1}{\sqrt{2\pi\delta}} e^{\frac{-1}{\delta^2}}, & \text{if } i = l(j), j€\rho \\ 0, & \text{otherwise} \end{cases} \quad (15)$$

$$h_b(p,q,i,j) = \begin{cases} \frac{-1}{\sqrt{2\pi\delta}} e^{\frac{-1}{\delta^2}}, & \text{if } i = l(j) + d, j€\rho \\ \frac{-1}{\sqrt{2\pi\delta}} e^{\frac{-1}{\delta^2}}, & \text{if } i = l(j), j€\rho \\ 0, & \text{otherwise} \end{cases} \quad (16)$$

$$l(j) = j\tan(\theta(p,q)) \quad (17)$$

$$d = \frac{Y}{2\cos(\theta(p,q))'} \quad (18)$$

$$\rho = Y\left[\left|\frac{\sin(\theta(p,q))}{-2}\right|\left|\frac{\sin(\theta(p,q))}{2}\right|\right] \quad (19)$$

C. Image Binarization/Thinning

The Image binarization technique is performed on the image after wiener filtering technique. In this technique, the threshold value is set for each cluster. To evaluate the actual value of T, the following steps are done on fixing values of threshold:

(a) Initially, according to a threshold value, the pixel is split into two clusters.

(b) In each cluster, the mean value is taken.

(c) Squaring is performed on the difference between the mean values.
(d) Determination of the product of the number of pixels in one cluster and the other.
The optimal threshold maximizes the between-class variance and minimizes the within-class variance. For each cluster, the within-class variance is computed as follows,

$$\sigma^2_{\text{within}}(T) = n_B(T)\sigma^2_B(T) + n_o(T)\sigma^2_o(T) \quad (20)$$

$$n_B(T) = \sum_{i=0}^{T-1} p(i) \quad (21)$$

$$n_o(T) = \sum_{i=T}^{N-1} p(i) \quad (22)$$

$\sigma^2_B(\mathrm{T})$ isthe variance of pixels in the (below)threshold
$\sigma^2_o(\mathrm{T})$ is the variance of pixels in the background (above) threshold
p(i) represents the value of pixel, N indicates the intensity level and [0, N – 1] is the range of intensity. The total variance is computed by,

$$\sigma^2_{\text{between}}(T) = \sigma^2 - \sigma^2_{\text{within}}(T) \quad (23)$$

$$n_B(T)[A] + n_o(T)[B] \quad (24)$$

$$\mathrm{A} = (\mu_B(T) - \mu)^2 \quad (25)$$

$$\mathrm{B} = (\mu_o(T) - \mu)^2 \quad (26)$$

where σ^2 indicates the integrated deviation, μ_B (T) and μ_o(T) represents the associated mean of background and foreground threshold of cluster T respectively and μ is the integrated mean. The between-class variance is computed by substituting $n_B(T)[A] + n_o(T)[B]$ in Eqn. 24 and the result is:

$$\sigma^2_{\text{between}}(T) = n_B(T)n_o(T)[(\mu_B(T) - \mu_o(T))^2] \quad (27)$$

$$n_B(T+1) = n_B(T) + p \quad (28)$$

$$n_o(T+1) = n_o(T) - p \quad (29)$$

$$\mu_B(T+1) = \frac{\mu_B(T)\mathrm{n}_B(T) + pT}{n_B(T+1)} \quad (30)$$

$$\mu_o(T+1) = \frac{\mu_o(T)\mathrm{n}_o(T) - pT}{n_o(T+1)} \quad (31)$$

V. EXPERIMENTAL RESULTS

A transformed version of the fingerprint enrichment algorithm was proposed by using MATLAB 2013 on the Windows Vista Home Basic operating system. Two types of images namely synthetic and original image were used to evaluate the performance of the algorithm. Several artificial noises were introduced into the synthetic image by using MATLAB m-noise function and the original image is kept in the FVC2004 fingerprint database with four different datasets.

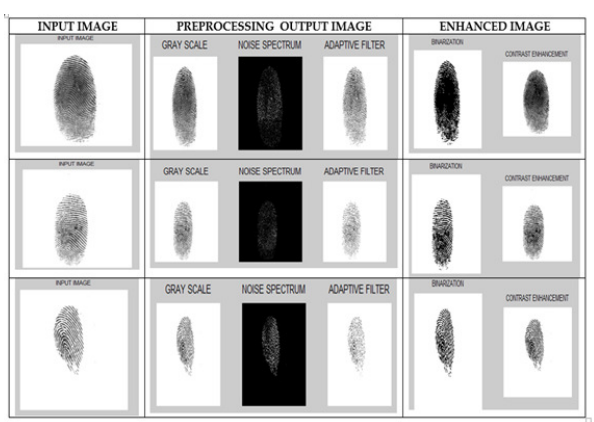


Fig. 6. Simulated results for finger print system using proposed approach for FVC2004 data set 1.

In this paper, wiener filter technique is performed to remove the noise and to get the high accurate result. Several operations such as image segmentation, image binarization and image filtering were performed with slight variations to get enriched image. In image filtering, Orientation estimation and ridge frequency orientation is performed. Experimental analysis is performed between the synthetic image and original image to show the variation and with good result in the original image.
The Figs. 6 to 8 shows the results of proposed Weiner filter system for the dataset FVC2004 database from 1 to 3. Weiner filter suppresses the noise more effectively, also increases the contrast. The binarization step increases the resolution of the image.

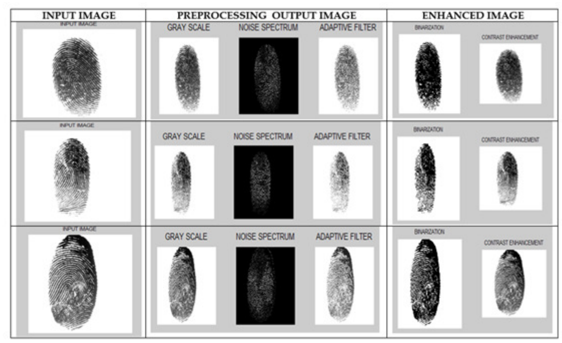


Fig. 7. Simulated results for finger print system using proposed approach for FVC2004 data set 2.

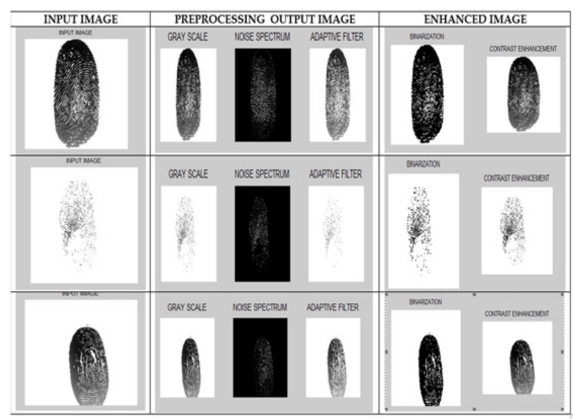


Fig. 8. Simulated results for finger print system using proposed approach for FVC2004 data set 3.

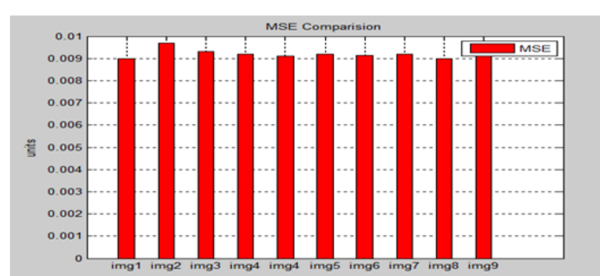


Fig. 9. MSE comparison for the input images.

The Fig. 10 shows the comparison of PSNR values for the above dataset images. The proposed Weiner filter effectively suppresses the Peak Signal to Noise ratio in the input images.

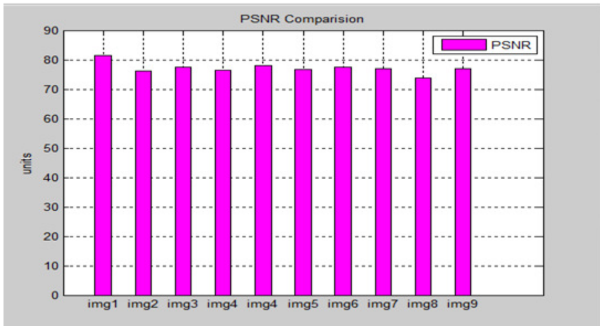


Fig. 10. PSNR comparison for the input images.

The Fig. 11 shows the PSNR comparison for the above dataset images with Gaussian and Weiner filter. The proposed Weiner filter is effectively reducing the PSNR compared with Gaussian filter.

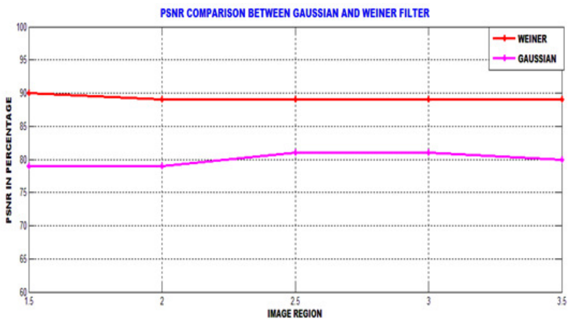


Fig. 11. PSNR comparison with Gaussian and Weiner filter.

VI. CONCLUSION

In this paper, Digital Image Processing based novel image segmentation for biometric authentication is proposed. Because of its high accuracy and reliability, fingerprint data are chosen. Noise removal is performed before image segmentation to get the quality image. Noise is removed by using wiener filter technique. Several mathematical operations such as binarization, filtration and local normalization technique are slightly changed to get the enriched image. In security purpose, Image enhancement is an essential one needed for performing authentication. Experimental analysis is performed between synthetic and original images to evaluate the performance, and in each operation high accurate images are generated in authentication process.

There is much scope available in this field to enhance the biometric identification performance.

(1) Using image processing methods to enhance the images to a better level so that features can be extracted more precisely without any lose of information.

(2) A better algorithm may be provided to reduce the mismatch because of physical distortions & displacements and so on.

(3) By merging various fingerprint recognition methods, a new algorithm with better resolution rate and matching techniques could be developed for biometric fingerprint recognition.

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