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An Enhanced Technical Approach for Quality of Images Using Directional Filters

Manasa K Chigateri[1], Manjuvani K M[2], Prashanth Keni[3], Manjunath K M[4]

Assistant Professor, ECE Department, RYMEC, Bellary, Karnataka, India[1, 2, 3, 4]

Abstract: The main aim of this project is that implemented image enhancement aspect of guided image filtering techniques. Principle objective of Image enhancement is to process an image so that result is more suitable than original image for specific application. Digital image enhancement techniques provide a multitude of choices for improving the visual quality of images. A survey on directional filter, which defines the splitting of the input image into eight parts and reconstruction in to a single image after image enhancement. It generates the filtering output by considering the content of a guidance image, which can be the input image itself or another different image. This project will provide an overview of underlying concepts, along with algorithms commonly used for image enhancement.

Keywords: 1D Gabor filter, 1D Gaussian filter, DMF, DFB, and STFT.

1. INTRODUCTION

Digital images are widely used in computer applications. Image enhancement improves the quality (clarity) of images for human viewing. It basically improves the interpretability or perception of information in images for human viewers and providing `better' input for other automated image processing techniques. The principal objective of image enhancement is to modify attributes of an image to make it more suitable for a given task and a specific observer. During this process, one or more attributes of the image are modified. The choice of attributes and the way they are modified are specific to a given task. Moreover, observer-specific factors, such as the human visual system and the observer's experience, will introduce a great deal of subjectivity into the choice of image enhancement methods. Removing blurring and noise, increasing contrast, and revealing details are examples of enhancement operations. For example, an image might be taken of an endothelial cell, which might be of low contrast and somewhat blurred. Reducing the noise and blurring and increasing the contrast range could enhance the image. The original image might, have areas of very high and very low intensity, which mask details.

An adaptive enhancement algorithm reveals these details. Adaptive algorithms adjust their operation based on the image information (pixels) being processed. In this case the mean intensity, Contrast and sharpness (amount of blur removal) could be adjusted based on the pixel intensity statistics in various areas of the image. There exist many techniques that can enhance a digital image without spoiling it. The Image enhancement is a preprocessing technique to make the image clearer than the original image, for further operations. Since the fingerprint images, acquired from sensors or other media are not always assured with perfect quality, in fingerprint recognition system, the enhancement methods are needed, to increase the contrast between ridges and furrows and for connecting the false broken points of ridges due to insufficient amount of ink etc. The general purpose image enhancement techniques are not very useful due to the any stationary nature of a fingerprint. In many cases, a single fingerprint image contains regions of good, medium, and poor quality, where the ridge pattern is very noisy and corrupted. When it uses a single filter convolution on the entire fingerprint image, it creates significant number of spurious minutiae, a large number of genuine minutiae are missed and large error in the location (position and orientation) of minutiae is introduced.

However, techniques such as gray-level smoothing, contrast stretching, histogram equalization can be used as pre-processing steps before a sophisticated fingerprint enhancement algorithm is applied. The estimation of orientation field plays an important role in the fingerprint enhancement. Good fingerprint enhancement techniques obtain a relatively good estimate of orientation field even if the quality of input fingerprint image is poor. Most of the fingerprint enhancement techniques use contextual filter or multi-resolution filter.

2. EXISTING METHODS

Several types of filters in both spatial and frequency domains have been proposed in the literature. The purpose of the filters is to fill small gaps (low-pass effect) in the direction of the ridge and to increase the discrimination (band-pass effect) between ridge and valleys in the direction orthogonal to the ridge[1]. Hong et. al. [2] introduced a new fingerprint enhancement algorithm which decomposes the input fingerprint image into a set of filtered images.

A set of band pass filters can efficiently remove the undesired noise and preserve the true ridge/valley structure. Gabor filters [3] have both frequency–selective and orientation-selective properties and have optimal joint resolution in both spatial and frequency domains. Therefore, it is beneficial to use Gabor filters as band pass filters to remove the noise and preserve true ridge/valley

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structure. One of the heuristics to detect the spurious minutiae resulting from these cracks is based on observation.
Biometrics is the science of uniquely recognizing humans based upon one or more intrinsic physical or behavioral traits. Fingerprints are the most widely used parameter for personal identification amongst all biometrics. Fingerprint identification is commonly employed in forensic science to aid criminal investigations etc. A fingerprint is a unique pattern of ridges and valleys on the surface of a finger of an individual.

•Fingerprints are the patterns formed on the epidermis of finger.
•The fingerprint is composed of ridges and valleys. The interleaved pattern of ridges and valleys are the most evident structural characteristic of a fingerprint.
•Individual epidermal ridges and furrows have different characteristics for different fingerprints.

2.1 Fingerprint recognition:

- The human fingerprint is comprised of various types of ridge patterns.
- Loops make up nearly 2/3 of all fingerprints, whorls are nearly 1/3, and perhaps 5-10% is arches.
- These classifications are relevant in many large-scale forensic applications, but are rarely used in biometric authentication.

Among biometrics, fingerprint systems have been one of most widely researched and deployed. Fingerprints are one of the first biometrics to be widely used. It is popular because of their easy access, low price of fingerprint sensors, non-intrusive scanning, and relatively good performance. In recent years, significant performance improvements have been achieved in commercial automatic fingerprint recognition systems. The fingerprint of every individual is considered to be unique. No two persons have the same set of fingerprints. This property makes fingerprints an excellent biometric identifier. So it is one of the popular and effective means for identification of an individual and used as forensic evidence.

3. SYSTEM ARCHITECTURE AND METHODLOGY

The quality of images is improved based on the methods that can broadly be divided in to the following two categories:

1. Spatial Domain Methods
2. Frequency Domain Methods

In spatial domain techniques, we directly deal with the image pixels. The pixel values are manipulated to achieve desired enhancement. In frequency domain methods, the image is first transferred in to frequency domain. It means that, the Fourier Transform of the image is computed first. All the enhancement operations are performed on the Fourier transform of the image and then the Inverse Fourier transform is performed to get the resultant image. These enhancement operations are performed in order to modify the image brightness, contrast or the distribution of the grey levels. As a consequence the pixel value (intensities) of the output image will be modified according to the transformation function applied on the input values. Image enhancement is applied in every field where images are ought to be understood and analyzed. For example, medical image analysis, analysis of images from satellites etc. Image enhancement simply means, transforming an image f into image g using T. (Where T is the transformation. The values of pixels in images f and g are denoted by r and s, respectively. As said, the pixel values r and s are related by the expression, $s = T(r)$ (1) Where T is a transformation that maps a pixel value r into a pixel value s.
The results of this transformation are mapped into the grey scale range as we are dealing here only with grey scale digital images. So, the results are mapped back into the range [0, L-1], where L=2k, k being the number of bits in the image being considered. So, for instance, for an 8-bit image the range of pixel values will be [0, 255]. We will consider only gray level images. The same theory can be extended for the color images too. A digital gray image can have pixel values in the range of 0 to 255.Many different, often elementary and heuristic methods are used to improve images in some sense. The problem is, of course, not well defined, as there is no objective measure for image quality. Here, we discuss a few recipes that have shown to be useful both for the human observer and/or for machine recognition.

Fig1. Showing the effect of Image Enhancement

These methods are very problem-oriented: a method that works fine in one case may be completely inadequate for another problem. In this paper basic image enhancement techniques have been discussed with their mathematical understanding. This project will provide an overview of underlying concepts, along with algorithms commonly used for image enhancement. The project focuses on spatial domain techniques for image enhancement, with particular reference to point processing methods, histogram processing.

These enhancement methods (either in frequency domain or in spatial domain) could not meet the needs for real-time AFIS in improving valley clarity and ridge flow continuity. The performance of most enhancement

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techniques relies heavily on the local ridge orientation. We propose an integrated method, which utilizes both the advantages of anisotropic filter. The fingerprint images are first convolved with anisotropic filter, and then are filtered by DMF. The pore in fingerprint ridge is completely removed (currently, pore features does not have practical application perspectives because it requires very high quality fingerprint images), small to medium artifacts are almost cleared out, as well as broken ridges in most clear regions are perfectly joined.

3.1 Anisotropic Filter: Anisotropic filter plays similar role in reducing Gaussian-like noise as Gabor filter in Hong's [7] work. Greenberg [4] modified anisotropic filter by shaping the filter kernel to process fingerprint image. It is essentially adapting filter shape to the local features (local intensity orientation) of fingerprint image.

3.2 Directional Median Filter: According to Gonzalez [5] and Shapiro [3] median filter is performed as replacing a pixel with the median value of the selected neighborhood. In particular, the median filter performs well at filtering outlier points while leaving edges intact. The two-dimensional (2*D) standard median filter is defined as follows:

Definition : Given a gray-level image IM of size M X N with random impulse noise distribution n, the observation OIM of original image defined as,

$$\mathbf{OIM = IM + n}$$

A median filter mask with suitably pre-selected window W of size (2k + 1) (2l + 1) operates on the position OIM(i; j), such that

Y (i; j;W) = Median f {OIMik;jl; :::;OIMi;j ; :::;OIMi+k;j+lg}

where i = 1; :::;M; j = 1; :::;N, Y is the filtered output.

3.3 Methodology: There are two approaches for fingerprint recognition. They are

- Image based approach,
- Texture based approach and
- Minutiae based approach.

In image based matching: the image itself is used as the template. It requires only low resolution images. Matching is done by optical correlation and is extremely fast. It is based on the global features of a whole fingerprint image. However it requires accurate alignment of the fingerprint samples and is not favorable for changes in scale, orientation and position.

The texture based approach: It uses texture information for matching and performs well with poor quality prints. However like image based matching it requires accurate alignment of the two prints and not invariant to translation, orientation and non-linear distortion.

Minutiae-based approach: is the last approach. Here the ridge features called minutiae are extracted and stored in a template for matching. It is invariant to translation, rotation and scale changes. It is however error prone in low quality images. The minutiae based approach will be applied. Usually before minutiae extraction, image preprocessing is performed. In our project we will focus mainly on the preprocessing and extraction stage. Fingerprint enhancements techniques will be used to reduce the noise and improve the clarity of ridges against valleys.

The image preprocessing consists of the following stages [4]. They are field

- Orientation,
- Ridge frequency estimation,
- Image segmentation and
- Image enhancement thinning.

It is followed by a minutiae extraction algorithm which extracts the main minutiae features required for matching of two samples.

3.4 Algorithm of Image Enhancement: -Image enhancement techniques are employed to reduce the noise and enhance the definition of ridges against valleys. The performance of minutiae extraction algorithms and other fingerprint recognition techniques relies heavily on the quality of the input fingerprint images. In an ideal fingerprint image, ridges and valleys alternate and flow in a locally constant direction. This leads to problems in minutiae extraction. In order to ensure good performance of the ridge and minutiae extraction algorithms in poor quality fingerprint images, an enhancement algorithm to improve the clarity of the ridge structure is necessary.

1. Segmentation
2. Normalization.
3. Minutiae extraction
4. Thinning.

3.4.1 Segmentation

•It is used to locate objects and boundaries like lines, curves in images.

•The image is divided into blocks. For each block gray scale variance is calculated. If the value is lower than the global threshold it is assigned to the background (left out) else it is assigned to the foreground. Let V (k) be the variance for a block of size WxW [6].Then

$$V(K) = \Sigma\Sigma(I(i, j)M(k))$$

The remaining regions are untouched.

If the threshold value is too large, foreground regions may be incorrectly assigned as back ground regions. Conversely, if the threshold value is too small, background regions. Conversely, if the threshold value is too small, background regions may be assigned as part of the fingerprint foreground area .A variance threshold of around 100 has been found to give optimal results in terms of difference between foreground and background regions.

3.5 Normalization

It is the next step in the enhancement algorithm. Normalization is done so that the gray level values lies within a given set of values. The fingerprint image is normalized to have a predefined mean and variance. This is required as the image usually has distorted levels of

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gray values among the ridges and the valleys. Normalization allows standardizing the distorted levels of variation in the gray scale values. Normalization involves pixel-wise operations and does not change the ridge and valley structures. Normalization is a linear process. Suppose the intensity range of the image is 50 to 180 and the desired range is 0 to 255 the process entails subtracting 50 from each of pixel intensity, making the range 0 to 130. Each pixel intensity is multiplied by 255/130, making the range 0 to 255.

3.6 Minutiae Extraction
After the enhancement of the fingerprint image, the image is ready for minutiae extraction. For proper extraction, however, a thinning algorithm is applied to the enhanced image [8, 9, and 10]. It produces a skeletonized representation of the image.

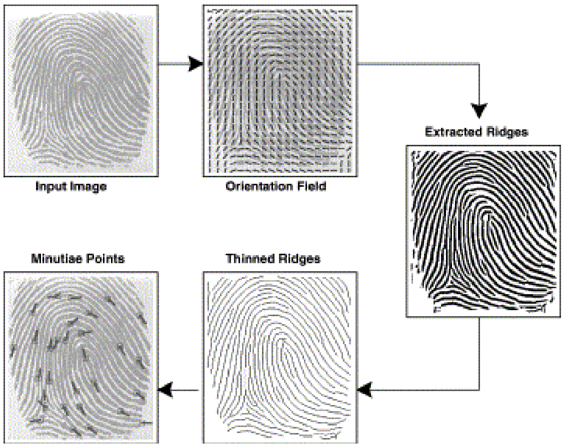


Fig2: Flowchart of the minutiae extraction algorithm

Further, study into the statistical theory of fingerprint minutiae. In particularan approach can be investigated to determine the number of degrees of freedom within a fingerprint population. These result scan then be used to help us better understand the statistical uniqueness of fingerprint minutiae.

3.7 Thinning
Thinning is a morphological operation that is used to remove selected foreground pixels from binary images. It is used to eliminate the redundant pixels of ridges till the ridges are just one pixel wide. Thinning is normally only applied to binary images, and produces another binary image as output. It is the final step prior to minutiae extraction. It uses an iterative, parallel thinning algorithm. Any point that has more than one foreground neighbor is deleted as long as doing so does not locally disconnect the region containing that pixel. Iterate until convergence. The requirements of a good thinning algorithm are

Step1: The thinned fingerprint image obtained should be of single pixel width.
Step2: Each ridge must be thinned to its center pixel.
Step3: Noise and singular pixels must be eliminated.

- Sobel operator is applied to reduce the threshold output of the edge detector.
- The image is set at a particular gray level to obtain a binary image.
- The thinning iteration is applied until all lines are one pixel.

3.8 Image Acquisition: Image acquisition is the first step in the approach. It is very important as the quality of the fingerprint image must be good and free from any noise. A good fingerprint image is desirable for better performance of the fingerprint algorithms. Based on the mode of acquisition, a fingerprint image may be classified as off-line or live-scan. An off-line image is typically obtained by smearing ink on the fingertip and creating an inked impression of the fingertip on paper. A live-scan image, on the other hand, is acquired by sensing the tip of the finger directly, using a sensor that is capable of digitizing the fingerprint on contact. Live-scan is done using sensors. There are three basic types of sensors used [5]. They are optical sensors, ultrasonic sensors and capacitance sensors.

3.9 Grey Scale Manipulation The simplest spatial domain operations occur when the neighborhood is simply the pixel itself. In this case T is referred to as a grey level transformation function or a point processing operation. Point processing operations take the form shown in equation (1)

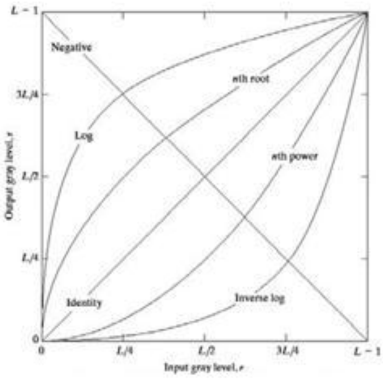
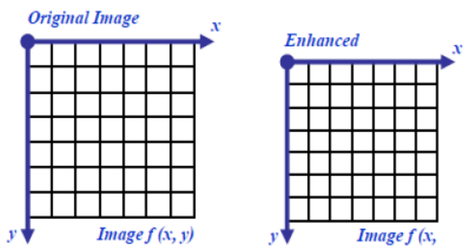


Fig3: Showing basic grey level transformations.

3.10 Logarithmic Transformations: The general form of the log transformation is s = c * log (1 + r). The log transformation maps a narrow range of low input grey level values into a wider range of output values. The inverse log transformation performs the opposite transformation. Log functions are particularly useful when the input grey level values may have an extremely large range of values. In the following example the Fourier transform of an image is put through a log transform to reveal more detail.



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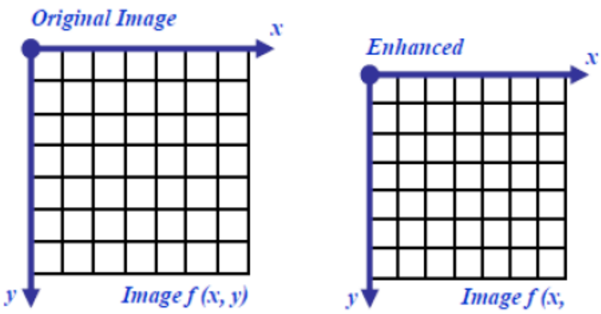
3.11ThresholdingTransformations: Thresholding transformations are particularly useful for segmentation in which we want to isolate an object of interest from a background as shown in figure above.



3.12 Histogram Equalization: Histogram equalization is a common technique for enhancing the appearance of images. Suppose we have an image which is predominantly dark. Then its histogram would be skewed towards the lower end of the grey scale and all the image detail is compressed into the dark end of the histogram. If we could `stretch out' the grey levels at the dark end to produce a more uniformly distributed histogram then the image would become much clearer.

The histogram of a digital image with intensity levels in the range [0, L-1] is a discrete function: -h (ark) = nk Histograms are frequently normalized by the total number of pixels in the image. Assuming an M x N image, a normalized histogram is related to probability of occurrence of rkin the image. p(rk) = , k=0,1…….L-1

3.13 Low Pass Filtering: Low pass filtering involves the elimination of the high frequency components in the image. It results in blurring of the image (and thus a reduction in sharp transitions associated with noise). An ideal low pass filter would retain all the low frequency components, and eliminate all the high frequency components. However, ideal filters suffer from two problems: blurring and ringing. These problems are caused by the shape of the associated spatial domain filter, which has a large number of undulations. Smoother transitions in the frequency domain filter, such as the Butterworth filter, achieve much better results.

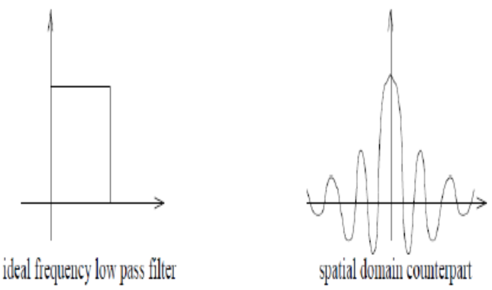


Fig4: Transfer function for an ideal low pass filter.

3.14 Homomorphic Filtering: Images normally consist of light reflected from objects. The basic nature of the image F (x, y) may be characterized by two components: the amount of source light incident on the scene being viewed and the amount of light reflected by the objects in the scene. These portions of light are called the illumination and reflectance components, and are denoted i(x, y) and r(x, y) respectively. The functions i and r combine multiplicatively to give the image function F:- F (x, y) = i(x, y)r(x, y), where $0 < i(x, y) < \infty$ and $0 < r(x, y) < 1$.

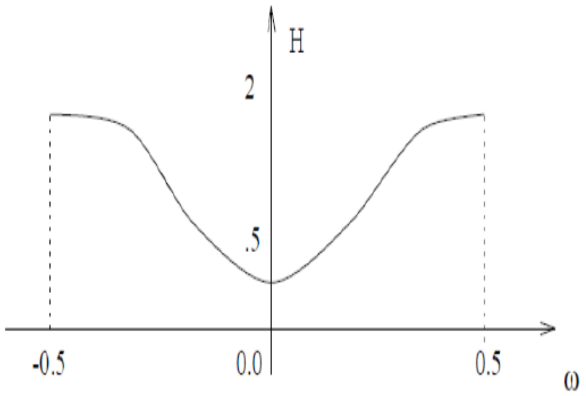


Fig5: Transfer function for homomorphic filtering.

4. IMPLEMENTATION AND BLOCK DIAGRAM

Directional Filter is one of the enhancement techniques which is familiar in multi-resolution enhancement method. The Multi-resolution analysis has been proposed to remove noise from fingerprint image by decomposing the image into different frequency bands (or sub-images).

This allows compensating for different noise components at different scales: in particular, at higher levels (low and intermediate frequency bands) the rough ridge-valley flow is cleaned and gaps are closed, whereas at the lower levels (higher frequencies) the finer details are preserved. The enhanced image bands are then recombined to obtain the final image. Generally, in directional filter bank, the fingerprint image is divided into eight parts according to the orientation of the ridge structure. The eight orientations of ridge flow structure are defined as shown in figure.

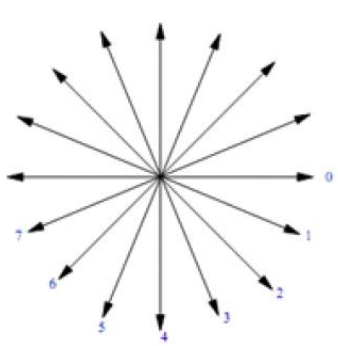


Fig6: Orientation of image ridge flow

The corresponding directional template are shown in figure with width of about 3 pixels, length of about 5-7 pixels and parallel with the local ridge direction.

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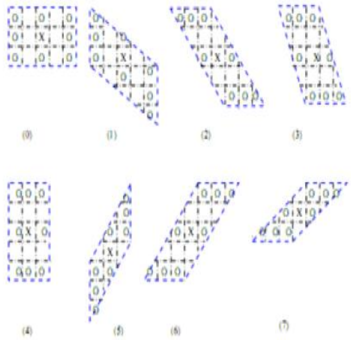

Fig7: Eight Directional Templates

Eight Directional median filter templates, with suitably pre-selected window size W, adopt different flow-like topological shapes, following their respective orientations. When one point in the image is over the focus point of the template kernel with the same orientation, the chosen median filter convolves with the current point; it generates W input samples, i.e., IM1... IMW in the specified window. Then, the output of the median filter is given by

Y (i, j; W) = Median { IM1,…..,IMW}

where i = 1,...,M; j = 1,…,N, Y is the filtered output, W is the suitable pre-selected window size. The length of filter windows must be carefully chosen so that filtering can achieve optimal results. Too small a window might fail to reduce noise adequately; too large a window might produce unnecessary distortions or artifacts. Also directional median filter shapes must follow local orientations appropriately, and select more relative points to enhance ridge-flow continuity.

The window size should be selected based on the image features. Directional Median Filter (DMF) possesses recursive property. The DMF window of size W replaces some of the old input samples with some previously derived output samples. With the same amount of operations, the DMFs with recursive feature usually provide better smoothing capability and completion of interrupted ridges.

Directional filtering can be implemented with fan - type band-pass filters (as shown in fig.1) and the filter is embodied by filter banks. A directional filter bank is a collection of digital filters with a common input or output. The Directional filter is composed of an analysis filter bank and a synthesis bank. The analysis bank of the Directional Filter splits the original image into eight directionally passed sub band images while the synthesis bank combines the sub band images into one image as shown in fig.

In the analysis section of the Directional Filter Bank (DFB), the original image is split into 2 directional sub band images and then two more times into 23 directional sub band images. At this point, the output is used as the input for the next stage. In the synthesis bank, the directional sub band images are combined into a reconstructed image in the reverse order of the analysis stage. An original image and its decomposed sub band images.

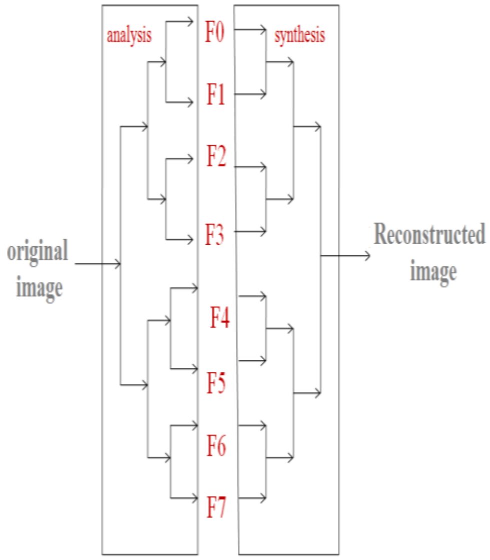

Fig8. Analysis and synthesis process in DFB.

4.1. Directional Image

Directional image are obtain by applying all directional filters, constructed in above section. These directional images can be regarded as decomposition of the original image in eight pieces based on direction [8, 13, 14]. Directional image contain features, associated with global direction rather than local directions. By creating directional images, we have divided noise of the original image into eight different directions.

4.2. Noise Removal

Noise removal is accomplished by first calculating the block based directional energy of each directional image [14]. The directional energy of a block (X,Y) including the pixel (x,y) from the Kth directional image is calculated as:

$$E_k(X,Y) = \sum_{x=0}^{m_k} \sum_{y=0}^{n_k} |f_k(X,Y;x,y)|$$

Where, fk is the directional image. The noise free directional images represented by

Ak are obtain by the equation:

$$A_k = \begin{cases} f_k(X,Y;x,y) \text{ if } E_k(X,Y) > T \\ f_k(X,Y;x,y) \text{ if otherwise} \end{cases}$$

Here, T represents the threshold.

4.3. Reconstruction of the enhanced image

The enhanced image is constructed form the directional image, according to the following equation:

$$f_{hf}(X,Y) = \max_{1 \le i \le 8} f_i(X,Y)$$

Where, fhf is high frequency output image from directional filter bank and fi represent ith directional image. For every block (X, Y) of the original image, a replacement is selected, from the eight directional image base, on maximum directional energy. Comparing the result with the original image. All have observed that all the ridge structures are intact, while the spatial noise has been removed substantially.

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Algorithm of fingerprint image enhancement

The flow chart of the proposed algorithm is shown in figure below. The main steps of the algorithm compress:

Step1. FFT: Compute the Fast Fourier Transform of the acquired image I.

IF =FFT (I)

Step2. LGF Design: Design a Log-Gabor Filter (LGF).

Step3. Frequency Domain Enhancement: Apply LGF on Fourier Transformed image.

TI = IF *LGF

Step4. Inverse Transform of FFT: Perform inverse transform of the image which is derived from step 3.

I `= (TI)-1

Step5. Output of Enhanced Image: Obtain the processed and Log-Gabor enhanced image.

Image acquisition is the preliminary step1followed while implementing the proposed algorithm.

The first step of the algorithm is performing the Fast Fourier Transformation on the image in order to enhance the frequency domain using eqns. 1and 2. The Fourier Transform produces a complex number valued output image which can be displayed with two images, either with the real and imaginary part or with magnitude and phase. More often, only the magnitude of the FFT is displayed in image processing due to the reason of the magnitude which contains the most of the information of the geometric structure of the spatial domain image.

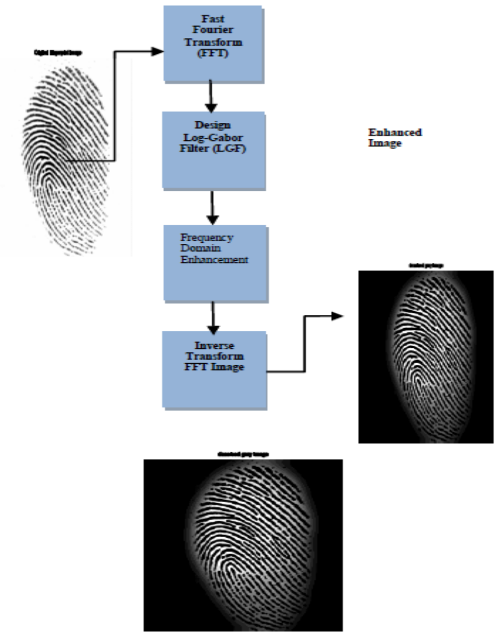

Fig9. Flow chart of the proposed fingerprint enhancement algorithm

The Fourier domain image has much greater range than the image in the spatial domain. Hence, its values are generally calculated and they are stored in float values. To retransform the Fourier image into the correct spatial domain after Log-Gabor filtering in the frequency domain, both the magnitude and the phase of the Fourier Image must be preserved. Meanwhile shifting also performed before the reverse transformation to transform the output of the FFT by moving the zero frequency components into the center of the array. It is very useful to visualize a Fourier transform with the zero-frequency component in the middle of the spectrum. After that the retransformation is accomplished.

5. RESULTS AND DISCUSSION

We implement image enhancement aspect of guided image filtering. We also show comparisons with other linear and nonlinear filters use various performance measures to depict the comparison result in tabular form. Principle objective of Image enhancement is to process an image so that result is more suitable than original image for specific application. When we compare image enhancement using guided filter with other linear and nonlinear filters for gray scale images we find that the guided filter is both effective and efficient and the MSE and PSNR parameters also shows that guided filter performs well as compared to others. Moreover, the guided filter has a fast and non-approximate linear-time algorithm, whose computational complexity is independent of the filtering kernel size.

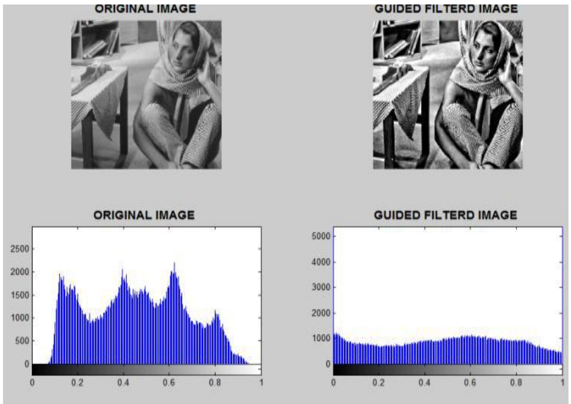

Fig10. Image Enhancement Using Guided Filter

5.1 Guided Filter Algorithm:-

step1: Read the image say I (gray scale image), it acts as a guidance image.

step2: Make p=I, where p acts as our filtering image (gray scale image).

step3: Enter the values assumed for r and eps, where r is the local window radius and eps is the regularization parameter.

step4: Compute the mean of I, p, I*p.

step5: The compute the covariance of (I,p) using the formula:-

cov_Ip = mean_Ip - mean_I .* mean_p;

step6: Then compute the mean of (I*I) and use it to compute the variance using the formula:-

var_I = mean_II - mean_I .* mean_I

step7: Then compute the value of a, b. where a,b are the linear coefficents.

step8: Then compute mean of both a and b.

step9: Finally obtain the filtered output image q by using the mean of a and b in the formula

q = mean_a .* I + mean_b;

step10: Display the output along with the input image, compare the output with other linear and nonlinear filters.

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5.2 Output in Matlab: By using DFB Imafe enhancement results are shown below.Writing the matlab code in editior windowinput image is taken as fingerprint image and saved on matlab window then compling the programme, if there s any errors in the programme it can be debugged untilthe desired solution is obtained, finally run the programme and output is displayed on matlab window.

Fig11. Taking Leena image as example

Here,lena image of (256*256) standard is used for image ehancement which is based on different rotations of angles.The lena image is taken as input,by using directional filters it changes its orientation depending on rotation and desired output as shown above and below

Fig12.Output of image enhancement using DBF

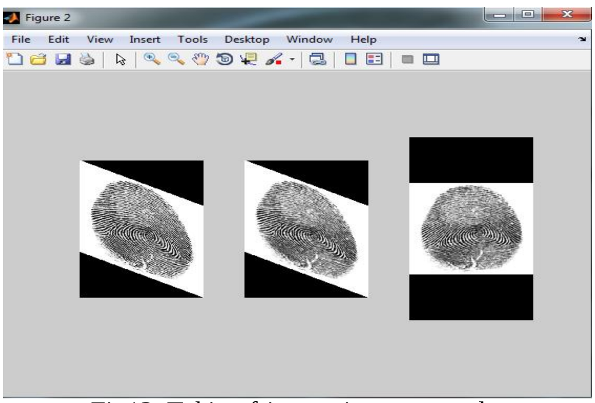

Fig13. Taking fringerprint as example

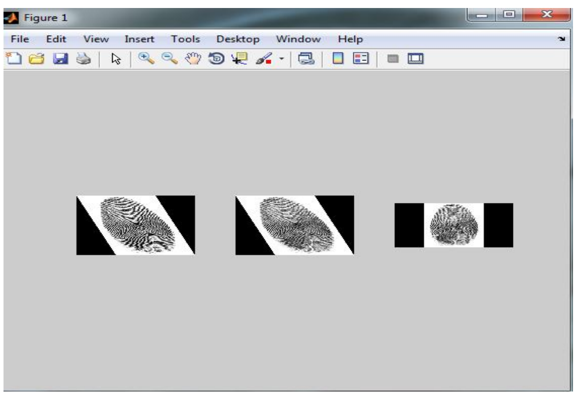

Fig14.Matlab output using DBF

Here, fingerprint image is taken as input and by using directional filters; it can changes its direction of orientation depends on rotation. Finally output image of fingerprint is shown above.

6. CONCLUSIONS

Image enhancement algorithms offer a wide variety of approaches for modifying images to achieve visually acceptable images. The choice of such techniques is a function of the specific task, image content, observer characteristics, and viewing conditions. The fingerprint enhancement method using directional filter is effective in both dry fingerprint images and wet fingerprint images. It removes noise in between the ridge and filling the white hole in the ridge. After the successful implementation of proposed method we can expect obtaining the noise free fingerprint images from the fingerprint scanners and this will increases the efficiency of the security system in which fingerprint scanners are used because sometimes noise in the image affects results of image comparison due to which sometimes fingerprint recognition devices gives wrong output.

7. SCOPE OF ENHANCEMENT

However, some problems need to be solved in the future. This algorithm may fail when image regions are contaminated with heavy noises and orientation field in these regions can hardly be estimated. Therefore, segmentation of these unrecoverable regions from the original image is necessary. An investigation into a filter whose primary aim is to specifically enhance the minutia points. This project has followed the approach adopted by most previous work where the emphasis is on enhancing the ridge structures using Gabor, or Gabor-like filters. However, while the ridge structures are enhanced, this approach has shown to be less effective in enhancing areas containing minutiae points, which are the points of main interest.

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