A STUDY REPORT ON FINGER PRINT IMAGE ENHANCEMENT METHODS

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ABSTRACT

In this paper Finger print Image Enhancement method in spatial domain and frequency domain using filter is discussed. The state-of-art in the literature is reviewed to provide a foundation for the evaluation of the proposed approaches. Fingerprint enhancement can be conducted on either binary ridge images or gray-scale images. Different techniques for gray-level fingerprint images enhancement have been proposed assuming that the local ridge frequency and orientation can be reliably estimated. A good fingerprint enhancement technique obtains 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 whose parameters depend on the local ridge frequency and orientation.

Keywords: Finger print, Binarization, Filter, Minutiae, Spatial Domain & Fourier Domain.

1. INTRODUCTION

1.1. Need of Finger Print Image Enhancement

A fingerprint is the pattern of ridges and valleys also called furrows in the fingerprint literature (A. Moenssens, 1971) on the surface of a fingertip. Each individual has unique fingerprints. The uniqueness of a fingerprint is exclusively determined by the local ridge characteristics and their relationships (H.C. Lee, 1991 & A. Moenssens, 1971). A total of 150 different local ridge characteristics like Islands, short ridges, enclosure, etc. have been identified (A. Moenssens, 1971). These local ridge characteristics [2] are not evenly distributed. Most of them depend heavily on the impression conditions and quality of fingerprints and are rarely observed in fingerprints. The two most prominent local ridge characteristics, called minutiae shown in Fig. 1, are

1. Ridge ending
2. Ridge bifurcation.

A ridge ending is defined as the point where a ridge ends abruptly. A ridge bifurcation is defined as the point where a ridge forks or diverges into branch ridges. A good quality fingerprint typically contains about 40-100 minutiae.

In an ideal fingerprint image ridges and valleys alternate and flow in a locally constant direction and minutiae are anomalies of ridges i.e. ridge endings and ridge bifurcations.

In such situations the ridges can be easily detected and minutiae can be precisely located from the thinned ridges. However in practice due to variations in impression conditions, ridge configuration, skin conditions (e.g. aberrant formations of epidermal ridges of fingerprints, postnatal marks, occupational marks), acquisition devices, and non-cooperative attitude of subjects etc., a significant percentage of acquired fingerprint images is of poor quality. The ridge structures in poor-quality fingerprint images are not always well-defined and hence they cannot be correctly detected. This leads to following problems:

1. A significant number of spurious minutiae may be created,
2. A large percent of genuine minutiae may be ignored,
3. Large errors in their localization (position and orientation) may be introduced.
Fingerprint images are rarely of perfect quality. In realistic scenario though the quality of a fingerprint image may suffer from various impairments caused by (i) scars and cuts, (ii) moist or dry skin, (iii) sensor noise/blur, (iv) wrong handling of the sensor (e.g. too low/high contact pressure), (v) generally weak ridge-valley pattern of the given fingerprint etc. They may be degraded and corrupted with elements of noise due to many factors including variations in skin and impression conditions as explained above. This degradation can result in a significant number of spurious minutiae being created and genuine minutiae being ignored. A critical step in studying the statistics of fingerprint minutiae is to reliably extract minutiae from fingerprint images. Thus it is necessary to employ image enhancement techniques prior to minutiae extraction to obtain a more reliable estimate of minutiae locations.

In order to ensure that the performance of the minutiae extraction algorithm will be robust with respect to the quality of input fingerprint images, an enhancement method which can improve the clarity of the ridge structures is necessary.

The paper is further organized as follows. Section 1 describes brief overview about fingerprint image enhancement and need of Fingerprint Image enhancement. Finger print image enhancement techniques are described in Section 2. Fingerprint image enhancement process is discussed in Section 3. Fingerprint image enhancement algorithm/research work is discussed in Section 4. Further sub section 4.1 discusses the researches/algorithms in spatial domain filtering while sub section 4.2 have researches/algorithms in frequency domain filtering. Section 5 deals with conclusion on this report.

2. FINGERPRINT IMAGE ENHANCEMENT TECHNIQUE

There have existed a variety of research activities along the stream of reducing noises and increasing the contrast between ridges and valleys in the gray-scale fingerprint images. Some approaches are implemented in spatial domain, others in frequency domain.

The term spatial domain [1] refers to the image plane itself, and image processing methods in this category are based on direct manipulation of pixels in an image. Two principle categories of spatial processing are Intensity transformations and spatial filtering. Intensity transformation operates on single pixels of images, principally for the purpose of contrast manipulation and image thresholding. Spatial filtering deals with performing operations such as image sharpening, by working in a neighborhood of every pixel in an image.

Spatial domain process we discuss above can be denoted by the expression

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

where \( f(x, y) \) is the input image, \( g(x, y) \) is the output image and \( T \) is an operator on defined over a neighborhood of point \((x, y)\). The operator can apply to a single image or to a set of images, such as performing the pixel-by-pixel sum of a sequence of images for noise reduction.

Filtering technique in frequency domain consists of modifying the Fourier transform of an image and then computing the inverse transform [Discrete Fourier Transform (DFT)] to get back to input image. Thus, given a digital image, \( f(x, y) \), of size \( M \times N \), the basic filtering equation in which we are interested has the form:

\[ g(x, y) = \mathcal{F}^{-1}[H(u, v)F(u, v)] \]  

where \( \mathcal{F}^{-1} \) is the IDFT, \( F(u, v) \) is the DFT of the input image \((x, y)\), \( H(u, v) \) is the filter function and \( g(x, y) \) is the filtered output image. The filter function modifies the transform of the input image to yield a processed output \( g(x, y) \). Specification of \( H(u, v) \) is simplified considerably by using functions that are symmetric about the center, which requires that \( F(u, v) \) be centered also.

This is accomplished by multiplying the input image by \((-1)^{x+y}\) prior to computing its transfer.

3. FINGERPRINT IMAGE ENHANCEMENT PROCESS

R.C. Gonzalez and R.E. Woods [1] have explained in his book that there is no general “theory” of image enhancement. When an image is processed for visual interpretation, the viewer is the ultimate judge of how well a particular methods works. Enhancement techniques are so varied, and use so many different image processing approaches, that it is difficult to assemble a meaningful body of techniques suitable for enhancement in one chapter without extensive background development.

The input fingerprint images which are obtained from sensors, scanning or imaging devices may have imperfections or poor quality due to non-uniformity of the ink intensity or non-uniform contact with the sensor, scanning or imaging devices by the users. The quality of a fingerprint image directly affects the performance of a given recognition system.

![Figure 2: Enhancement Process](image)

The fingerprint image enhancement is a preprocessing technique to make the image clearer than the original image, for further operations as shown in Fig. 2. In many cases, a single fingerprint image contains regions of good, medium, and poor quality, where the ridge pattern is very noisy and corrupted. A ‘good’ quality fingerprint image has high contrast and well defined ridges and valleys. A ‘poor’ quality fingerprint is marked by low contrast and ill-defined boundaries between the ridges and valleys.
Fingerprint enhancement can be conducted on either binary ridge images or gray-scale images. Binarization before enhancement will generate more spurious minutiae structures and lose some valuable original fingerprint information; it also poses more difficulties for later enhancement procedure, so it is inherent limitations of this process. Different techniques for gray-level fingerprint images enhancement have been proposed assuming that the local ridge frequency and orientation can be reliably estimated. A good fingerprint enhancement technique obtains 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 whose parameters depend on the local ridge frequency and orientation.

4. RESEARCHES/ALGORITHMS

4.1. Spatial Domain Algorithm

4.1.1. Fingerprint Image Enhancement: Algorithm and Performance Evaluation

L. Hong et al. [2] has incorporated a fingerprint enhancement algorithm in the minutiae extraction module. A fast fingerprint enhancement algorithm, which can adaptively improve the clarity of ridge and valley structures of input fingerprint images based on the estimated local ridge orientation and frequency, was applied. Based on the local orientation and ridge frequency around each pixel, the Gabor filter is applied to each pixel location in the image. The effect is that the filter enhances the ridges oriented in the direction of the local orientation, and decreases anything oriented differently. Hence, the filter increases the contrast. The main stages of this algorithm include normalisation, ridge orientation estimation, ridge frequency estimation and filtering.

The performance of the image enhancement algorithm was evaluated using the goodness index of the extracted minutiae and the accuracy of an online fingerprint verification system. Experimental results show that incorporating the enhancement algorithm improves both the goodness index and the verification accuracy. The algorithm also identifies the unrecoverable corrupted regions in the fingerprint and removes them from further processing.

4.1.2. Fingerprint Image Enhancement Using Filtering Techniques

Extracting minutiae from fingerprint image is one of the most important steps in automatic fingerprint identification and classification. Minutiae is local discontinuities in the fingerprint pattern, mainly terminations and bifurcations. Greenberg et al. [3] propose two methods for fingerprint image enhancement. The first one is carried out using local histogram equalization, Wiener filtering, and image binarization. The second method use a unique anisotropic filter for direct grayscale enhancement. The results achieved are compared with those obtained through some other methods. Both methods show some improvement in the minutiae detection process in terms of either efficiency or time required.

The techniques based on direct gray scale enhancement perform better than approaches which require binarization and thinning as intermediate steps. The average error percentage, in terms of dropped, exchanged and false minutiae, as produced by Greenberg binarization approach is considerably lower than the errors produced by other approaches. The modified Gabor filter performs better than the original scheme proposed by Hong (1998), especially for poor quality images with corrupted ridges and blocks with singular points. The need for estimation of local frequency information, as conducted by Gabor-based filter, is eliminated by using Greenberg unique anisotropic filter.

4.1.3. Quality Measures of Fingerprint Images

Shen et al. [4] propose a Gabor-feature based method for determining the quality of the fingerprint images. An image is divided into N w x w blocks. Gabor features of each block are computed first, then the standard deviation of the m Gabor features is used to determine the quality of this block. Due to the accurate estimation, the results can be further used for foreground/background segmentation and smudginess and dryness computation. Shen also compare his algorithm with the variance method described in experiments.

The Experimental results are compared with an existing model of quality estimation. Shen analysis shows that his method can estimate the image quality accurately.

4.1.4. New Enhancement Algorithm for Fingerprint Images

Kim et al. [5] proposed an improved algorithm for enhancement of fingerprint image on the basis of the image normalization and Gabor Filter. Firstly, the adaptive normalization based on block processing is suggested for improvement of fingerprint images. An input image is partitioned into sub-blocks with the size of K x L at first and the region of interest (ROI) of the fingerprint image is acquired. The parameters for the image normalization are adaptively determined according to the statistics of each block. By utilizing these parameters, the block image is normalized for the next process. Secondly, a new technique for selection of two important parameters of Gabor filter is devised. These parameters are the ridge direction and the ridge
frequency. In this study, the ridge direction of a block image is determined by the probabilistic approach unlike other works. With this ridge direction, the ridge frequency is selected by utilizing the directional projection.

The proposed algorithms are tested with NIST fingerprint images and show significant improvement in the experiments.

### 4.1.5. Fingerprint Image Enhancement and Minutiae Extraction

Fingerprint enhancement methods based on Hong et al [2] have been used by Raymond Thai [6]. He has implemented a series of techniques for fingerprint image enhancement to facilitate the extraction of minutiae like normalisation, orientation estimation, ridge frequency estimation, and Gabor filtering. In addition to these four stages, he has implemented three additional stages that include: segmentation, binarization, and thinning. Experiments were then conducted using a combination of both synthetic test images and real fingerprint images in order to provide a well balanced evaluation on the performance of the implemented algorithm.

The experimental results have shown that combined with an accurate estimation of the orientation and ridge frequency; the Gabor filter is able to effectively enhance the clarity of the ridge structures while reducing noise. Future work which he suggested are: (i) An investigation into a filter whose primary aim is to specifically enhance the minutia points, (ii) To perform the statistical experiments used in his work on a larger sample size, and to conduct a full analysis of the observed results and (iii) Further study into the statistical theory of fingerprint minutiae.

### 4.1.6. Fingerprint Image Enhancement Method Using Directional Median Filter

C. Wu et al. [7] observed that effective methodology of cleaning the valleys between the ridges contours are lacking. He also observed that noisy valley pixels and the pixels in the interrupted ridge flow gap were "impulse noises". Therefore, C. Wu proposed method describes a new approach to fingerprint image enhancement, which is based on integration of Anisotropic Filter and directional median filter (DMF). Gaussian-distributed noises are reduced effectively by Anisotropic Filter, "impulse noises" are reduced efficiently by DMF. Usually, traditional median filter is the most effective method to remove pepper-and-salt noise and other small artifacts, the proposed DMF can not only finish its original tasks, it can also join broken fingerprint ridges, fill out the holes of fingerprint images, smooth irregular ridges as well as remove some annoying small artifacts between ridges. The enhancement algorithm has been implemented and tested on fingerprint images from FVC2002.

Experimental results shows that the proposed method can effectively reduce Gaussian-distributed noises (by anisotropic filter) and impulse noises along the direction of ridge flow (by DMF). He has compared his method with other methods described in the literature in terms of matched minutiae, missed minutiae, spurious minutiae, and flipped minutiae (between end points and bifurcation points).

### 4.1.7. Image Enhancement Method for Fingerprint Recognition System

S. Li et al. [8] in his research work presented fingerprint image enhancement method, by a refined Gabor filter. The method includes ridge orientation estimation, a Gabor filter processing and a refined Gabor filter processing. This enhancement method can connect the ridge breaks, ensures the maximal gray values located at the ridge center and has the ability to compensate for the nonlinear deformations.

Furthermore, this method does not result in any spurious ridge structure, which avoids undesired side effects for the subsequent processing and provides a reliable fingerprint image processing for Fingerprint Recognition System. A refined Gabor filter is applied in fingerprint image processing, with that a good quality fingerprint image is achieved, and the performance of Fingerprint Recognition System has been improved.

### 4.1.8. Adaptive Fingerprint Image Enhancement with Fingerprint Image Quality Analysis

Accurate minutiae extraction from fingerprint images is heavily dependent on the quality of the fingerprint images. Yun et al. [9] proposed an adaptive preprocessing method to improve image quality appropriately. The preprocessing is performed after distinguishing the fingerprint image quality according to its characteristics. It is an adaptive filtering according to oily/dry/neutral images instead of uniform filtering. In the first stage, several features are extracted for image quality analysis and they go into the clustering module. Then, the adaptive preprocessing is applied to produce good quality images. Yun tested the proposed method on NIST DB 4 and a private DB collected with careful consideration of image quality.

Experimental results show that the proposed method is able to improve both quality measurements. In terms of the identification performance, the proposed method is better than the conventional one. Further works are going on to develop image characteristic factors for the identification system in real world.

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

Raju Sonavane et al. [10], introduces 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. In his proposed work, Raju Sonavane have studied various Image enhancement techniques such as Contrast, negative, log transform etc. Using these techniques it is possible to detect the discontinuities and similarities occurred in Images and their quality in overall view of image.

4.1.10. Image Enhancement for Fingerprint Minutiae-Based Algorithms Using CLAHE, Standard Deviation Analysis and Sliding Neighborhood

The purpose of this proposed method [11] is to investigate the performance of a three-step procedure for the fingerprint identification and enhancement, using CLAHE (contrast limited adaptive histogram equalization) together with 'Clip Limit', standard deviation and sliding neighborhood as stages during processing of the fingerprint image. Firstly, CLAHE with clip limit is applied to enhance the contrast of the small tiles existing in the fingerprint image and to combine the neighboring tiles using a bilinear interpolation in order to eliminate the artificially induced boundaries. In a second step, the image is decomposed into an array of distinct blocks and the discrimination of the blocks is obtained by computing the standard deviation of the matrix elements to remove the image background and obtain the boundaries for the region of interest. Finally, by using a slide neighborhood processing, an enhancement of the image is obtained by clarifying the Minutiae in each specific pixel, process known as thinning. Also a combination of filters in both domains, spatial and Fourier is used to obtain a proper enhanced image. Some possible new developments have been carried out especially by applying the standard deviation analysis of the array to each distinct M x N blocks of image in order to remove the background and obtain the region of interest.

4.1.11. An Iterative Fingerprint Enhancement Algorithm Based on Accurate Determination of Orientation Flow

Simant Dube [12] describes an algorithm to enhance and binarize a fingerprint image. The algorithm is based on accurate determination of orientation flow of the ridges of the fingerprint image by computing variance of the neighborhood pixels around a pixel in different directions. He used directional filtering in his enhancement algorithm. He claimed that his filtering is faster as it uses short 1-D Gaussian filter as against 2-D Gaussian or Gabor filters commonly used. Furthermore, he proposed that algorithms for binarization and enhancement fit in the structure of our orientation flow algorithm so that they can be integrated.

Experimental result show that an proposed algorithm which captures the mutual interdependence of orientation flow computation, enhancement and binarization gives very good results on poor quality images.

4.1.12. A Dynamic Enhancement Method for Fingerprint Matching

P. Prasarn et al. [13] propose a dynamic enhancement method for an adaptive fingerprint matching. Directional wavelet transform and Gabor filter are applied. The original fingerprint image is decomposed into approximation and detail sub-images. The Daubechies wavelet (db4) is used to decompose the fingerprint image before directional filtering. To each sub-dimension a directional filter: Gabor filter is applied for tuning up the image features. The filter can play a good impact when its standard derivation is 2-3. After 5, the image is not much improved. Changing in parameters of the filter not only resulted in the changing in line-end positions but also bifurcate positions. These changes can result in minutiae matching score. At some proper positions of these minutiae, the fingerprint pattern can be matched. Hence, effort is believed to improve the successful rate of fingerprint matching.

4.1.13. Contrast Fingerprint Enhancement Based on Histogram Equalization Followed by Bit Reduction of Vector Quantization

M.F. Hanoon et al. [14] in his research work: Contrast Fingerprint Enhancement Based on Histogram Equalization Followed by Bit Reduction of Vector Quantization has used Histogram equalization for contrast enhancement. A low bit rate image coding scheme based on vector quantization is proposed. The block prediction coding techniques are employed to cut down the required bit rate of vector quantization. In block prediction coding neighboring encoded blocks are taken to compress the current block. Hannon has investigated the performance of four steps procedure for fingerprint compression and enhancement using contrast limited adaptive histogram equalization with clip limit (CLAHE), Wiener filtering, image binarization, thinning and Vector Quantization (VQ).

Experimental results show that this algorithm is applied to avoid specific shortfalls. This improvement, in turn, results in an improvement in the quality of input fingerprint images. The procedure follows first the application of CLAHE with Clip Limit in order to enhance the contrast of small tiles, to eliminate the artificially induced boundaries and to avoid over saturation of the image specifically in homogeneous areas. In addition, the wiener filtering is used to obtain a proper enhanced image.

Amjad Ali et al. [15] put forward a novel method of fingerprint image enhancement using a combination of diffusion-coherence filter and spatial domain 2D-Gabor filter. In addition to this a new block overlapping technique is used to remove the blocking artifact in the enhanced image. The proposed algorithm enhances the core region without any distortion, improves the clarity between ridges and valleys, removes the gap between the broken and the scratched ridges and increases the number of correct features which are required to be used in matching algorithms for fingerprint recognition.

The algorithm has been tested on FVC 2002 databases and the experimental results demonstrate the improved performance of the algorithm in the core region and in the plane ridge-valley pattern of the image compared to the diffusion and Gabor-based methods if used disjointedly.

4.2. Frequency domain Algorithm

4.2.1. Algorithm for Enhancing Fingerprint Images

A New method of Finger print image enhancement [16] is described based on non-stationary directional Fourier domain filtering. Fingerprints are first smoothed using directional filter whose orientation is every where matched to local ridge orientation. The enhancement consists of filtering stage followed by thresholding stage. Filtering stage produce directionally smoothed version of the image from which most of the unwanted information has been removed. Thresholding stage yields the binary enhanced image.

The results of enhancements are presented for fingerprint of various pattern classifications. A comparison is made with the enhancement used within AFIS. Use of proposed enhancement methods leads to significant improvement in speed and accuracy of AFIS(Automated fingerprint identification system).

4.2.2. Adaptive Fingerprint Binarization by Frequency Domain Analysis

J.S. Bartunek et al. [17] present a new approach for fingerprint enhancement by using directional filters and binarization. A straightforward method for automatically tuning the size of local area is obtained by analyzing entire fingerprint image in the frequency domain. Hence, the algorithm will adjust adaptively to the local area of the fingerprint image, independent on the characteristics of the fingerprint sensor or the physical appearance of the fingerprints. Frequency analysis is carried out in the local areas to design directional filters.

The proposed adaptive fingerprint binarization algorithm shows a good ability to tune itself to each fingerprint image. This results in an algorithm which is insensitive to variations in sensors, skin etcetera.

4.2.3. Automatic Fingerprint Recognition System Using Fast Fourier Transform and Gabor Filters

The proposed system [18] in this work consists of a combination of two algorithms, the Fast Fourier Transform and Gabor Filters to enhancement and reconstructs the image's information. The system consists of eight steps: Acquisition, Noise Reduction, Enhancement with Gabor Filters, Enhancement with Fast Fourier Transform, Binarization, Minutiae Detection and Recognition. Each one of these steps was evaluated with different fingerprints.

Once the fingerprint is enhanced and processed an algorithm of recognition based on minutiae was developed obtaining good results. The results show an elevated percentage of recognition for an application of regular size. The implementation of a system with these characteristics is very acceptable because it presents a high percentage of recognition and only 0.5% of false acceptance, 1.8% of false rejection is not problem since the user only will have to put his fingerprint again.

4.2.4. A New Fingerprint Ridges Frequency Determination Method

P. Porwik et al. [19] in his research work has explained that in many cases the average fingerprint ridge frequency in the whole fingerprint image should be determined. This parameter is among other things, very important in procedures, where so called fingerprint reference point has to be located. Unfortunately, as far, ridges frequency has been determined a priori, on the basis of anthropological measurement of human population. This parameter is established as 10 pixels, regardless of captured fingerprint image resolution. Until now it is assumed that this resolution is equal to 500 dpi. In practice, scanners obviously work with different resolution. This point of view has been revised and a new method of fingerprint ridge frequency measurement was introduced. This method allows to precisely calculating fingerprint ridges frequency-individually for any fingerprint image.

To evaluate the effectiveness of the proposed method, the 33 randomly selected images were selected and core point was determined. The proposed approach gives the better results of the core point location compared to methods, where fingerprint ridge frequency were globally determined as constant value.

4.2.5. An Effective and Robust Fingerprint Enhancement by Adaptive Filtering in Frequency Domain

In the work, A.M. Raicevic et al. [20] propose an adaptive filtering in frequency domain in order to enhance fingerprint image. To achieve this, the query image is first normalized to have desired mean and variance. The image is then divided into non-overlapping blocks and dominant ridge orientation (direction) is determined for
each block to be used in the subsequent processes. The dominant ridge directions are then smoothed and subsequently the block-direction image is formed. The next step is to estimate the average ridge distance (or frequency). In order to reduce the computational cost, average ridge distance is computed once for the whole input image instead of determining it for each block of the image. The image is then enhanced using the directional filtering method. Two different directional filters (Butterworth and Gabor filter) are proposed where both of them enhance fingerprint ridge-valley structure and attenuate existing noise.

As a result of enhancement process more reliable feature extraction is obtained, less spurious minutiae are extracted, which improves the overall AFIS accuracy. A.M. Raicevic et al. Future work will be focused on effort to filter false minutiae to maximal extent possible.

4.2.6. **Fingerprint Image Enhancement with Second Derivative Gaussian Filter and Directional Wavelet Transform**

K. Sihalath et al.[21] proposed a technique for enhancing the quality of fingerprint images by applying Directional wavelet transform and second derivative of a Gaussian filter. The original fingerprint image is decomposed into approximation and detail sub-images. To each sub-dimension a directional filter: second derivative of Gaussian filter is applied for tuning up the image features.

The experiment results indicate that noise in the image could be reduced significantly. As a result, the ridge (and valley) and core point detection of fingerprint could be improved. With less computational complexity the wavelet transform can be omitted and applying only the second derivative of a Gaussian filtering. The images could also be improved but not as good as that involves the directional wavelet transform.


M.R. Kannan et al. [22] has evaluated three techniques of minutia detection systems which are particularly very much different in the way of enhancing the input image for minutia detection. These are: Histogram Based Image Enhancement, FFT Filter Based Fingerprint Image Enhancement and Gabor Filter Based Fingerprint Image Enhancement They have proposed to use FFT and Gabor Filter based on frequency and orientation image enhancement technique instead of directional convolution and grey scale.

The Experiment is being successfully implemented and evaluated using three different models under Matlab 6.5. The arrived results were significant and more comparable. Among the three evaluated fingerprint image enhancement algorithms, the Gabor Filter based algorithm performed very well. It has performed 5 to 6 times better than the other two algorithms.

In future works, he may address the impact of image enhancement algorithm with the spurious minutia removal algorithms and matching algorithms.

4.2.8. **Fingerprint: DWT, SVD Based Enhancement and Significant Contrast for Ridges and Valleys Using Fuzzy Measures**

In this work D Bennet [23] develop a novel method for Fingerprint image contrast enhancement technique based on the discrete wavelet transform (DWT) and singular value decomposition (SVD). This technique is compared with conventional image equalization techniques such as standard general histogram equalization and local histogram equalization. An automatic histogram threshold approach based on a fuzziness measure is presented. Then, using an index of fuzziness, a similarity process is started to find the threshold point. A significant contrast between ridges and valleys of the best, medium and poor finger image features to extract from finger images and get maximum recognition rate using fuzzy measures.

The experimental results show the recognition of superiority of the proposed method to get maximum performance up gradation to the implementation of this approach.

4.2.9. **Finger Print Image Enhancement Based on Energy Minimization Principle**

Finger print Image Enhancement method [24] using filter is discussed in this work. For this purpose a system design using filters is proposed. Finger Print Images have ridge directions and ridge frequencies due to several peaks and valleys available on the surface of human finger. Both the features of the images are required to be enhanced, so two distinct filters in Fourier domain, one for enhancing ridge frequencies and other for ridge directions, have to be designed. Selecting image features i.e. frequencies and directions which minimize energy function based on energy minimization principle, a very good enhanced image can be produced. The energy function for selecting above image features is defined by intensities of the images obtained by the designed filters and smoothness of image feature is measured in proposed method also. Image features obtained by the above filters which minimize energy function too, can be utilized for many applications.

Experiment result shows that proposed method reduces two -third matching error rate compared with other methods.
5. CONCLUSION ON REVIEW REPORT

Review of literature put forward attention that there are many researches available in spatial domain filtering but very few research work found using filter in frequency domain. Also none of work could be found taking ridge frequency enhancement in review literature process. Though ridge orientation and ridge detection on single pixel found very well in spatial domain filtering. There are few research work reviewed based on fuzzy concept and filter also, but not mentioned in the report. In our proposed work ridge detection and ridge frequency enhancement, both is considered, it is reason two distinct filters one for ridge detection and another for ridge frequency are proposed to be designed

REFERENCES

Spatial Domain


Frequency Domain


