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RESEARCH ARTICLE

FINGERPRINT IMAGE ENHANCEMENT USING FILTERING TECHNIQUES.

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Abstract

Detecting whether a fingerprint is present in an image is of fundamental importance in capture devices and in the maintenance of existing fingerprint-based biometric systems. Biometric systems and fingerprint recognition systems have become very widespread in the recent years, both in mobile devices and through increased usage in border controls, electronic national identification systems, controlled work duration time and so on. Any biometric system is that the quality of the data that enters the system is of the highest possible quality to facilitate ease. But the system error rates are sensitive to the quality of the enrolled sample due to subsequent interactions with the biometric system, results in a comparison being made against the enrolled sample. If the enrolled sample is of poor quality then the comparisons are more likely to result in a false non-match. We present a fingerprint enhancement algorithm, which can adaptively improve the clarity of ridge and furrow structures of input fingerprint images based on the estimated local ridge orientation and frequency. In this research shows the Gaussian, Median, Mean, Minimum, Maximum and Variance filtering techniques, Canny, Robert, Prewitt, Log and Fuzzy edge detection methods, enhancement Sharpen techniques, Morphological thinning methods, combined their methods and some experiment results in fingerprint images. The enhancement, Sharpen techniques, Canny edge detection, Gaussian filter and morphological thinning methods combined gave the good result and much more reduced noise, increased edges, lightning and enhanced fingerprint image. The morphological thinning method gave the good result our experiments fingerprint images.

Introduction:-

Fingerprint identification is one of the most important biometric technologies which has drawn a substantial amount of attention recently. Everyone has unique fingerprints in birth. The uniqueness of a fingerprint is exclusively determined by the local ridge characteristics and their relationships (E. Newham, 1995).

The two most prominent ridge characteristics, called minutiae, ridge ending and 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

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diverges into branch ridges. A good quality fingerprint typically contains about 40-100 minutiae (L. Hong etc., 1996). Automatic fingerprint matching depends on the comparison of these local ridge characteristics and their relationships to make a personal identification (Henry. C. Lee & R. E. Gaensslen, 1991). A critical step in fingerprint matching is to automatically and reliably extract minutiae from the input fingerprint images, which is a difficult task. The ridge structures in fingerprint images are not always well defined, and therefore, an enhancement algorithm, which can improve the clarity of the ridge structures, is necessary (Lin Hong, Yifei Wan & Anil Jain, 1998). Most of the minutiae detection methods which have been proposed in the literature are based on image binarization, while some others extract the minutiae directly from gray scale images (Daria Mario & Davide Maltoni, 1997). Concerning these two approaches, this work proposes three methods for fingerprint image enhancement. The first one is carried out using various filtering methods for direct grayscale enhancement. The second method use to edge detection techniques and morphological thinning methods. Finally fingerprints the results of a comparative study of our approaches and the methods described in this paper.

Methods:-

Filtering techniques:

Six different filtering techniques methods and various edge detectors were selected for comparison. Elimination of noise is done by image processing, as noise leads to the error in the image (H S Shukla, Narendra Kumar & R P Tripathi, 2014). A digital filter is used to remove noise from the degraded image (Anil K. Jain, 2006). As any noise in the image can be result in serious errors. Noise is an unwanted signal, which is manifested by undesirable information (Jong-Sen Lee, 1980). Thus, the image which gets contaminated by the noise, is the degraded image and using different filters that is used to filter this noise and used for image enhancement linear or nonlinear filters (Herbert Taub & Donald L. Schilling, 1986). In these types of filters, the values of the pixels of an image are advantages and disadvantages showed table 1.

Table 1:-Types of filtering methods

Filter techniques name	Basic principle	Advantages	Disadvantages
Median	The median filter is a sliding-window spatial filter. The median filter is normally used to reduce noise in an image, somewhat like mean filter.	Easy to implement. No need to generate new pixel value. Since the median is less sensitive than the mean to extreme values, those extreme values are more effectively removed.	Not good for all types of noise, it is very good only for removing salt and pepper noise. Computational complexity, non-linear filter.
Gaussian	Gaussian filtering is used to blur images and remove noise and detail. It is used in mathematics and smoothing operator.	The weights give higher significance to pixels near the edge. Gaussian smoothing is very effective for removing Gaussian noise, computationally efficient and rotationally symmetric.	It takes reduced details. Takes time.
Mean	Take the average of intensity values in an mxn region of each pixel (usually m=n). Take the average as the new pixel value, the normalization factor m, n preserves the range. Of values of the original image.	Simple filter the same for all types of noise.	It takes blurs image, detail is lost.
Sharpen	Sharpen techniques improve the clearness of digital images by enhancing the marks of the objects which are present in the scene.	This improves their borders and their details, giving to the images greater neatness and depth.	If the coefficient is not selected adequately, then grain effect and noise are produced also in flat regions, where edges are absent.
Maximum	These filters are used to find the brightest and darkest points in the	The maximum filter finds the light-colored points in the	This filter is unable to find out the black or dark

	image. The maximum filter replaces the pixel value with the brightest point and the minimum filter replaces the pixel with the darkest point.	image.	colored pixels in an image.
Minimum		Minimum filter is used to find the dark colored points in the image.	The minimum filter cannot locate the light or white colored points in an image.

Edge detection techniques:

Edge detection is a basic tool used in image processing, basically for feature detection and extraction, which aim to identify points in a digital image where brightness of image changes sharply and find discontinuities (G. Ganchimeg, 2015). The purpose of edge detection is significantly reducing the amount of data in an image and preserves the structural properties for further image processing. In a gray level image, the edge is a local feature that, with in neighborhood separates regions in each of which the gray level is uniform with in different values on the two sides of the edge (G. Ganchimeg, 2014). Edge detection makes use of differential operators to detect changes in the gradients of the gray level. Edge detection techniques divided into two main categories: Gradient based operator and Laplacian based operator. In this paper we studied various edge detection techniques as Canny, Prewitt, Robert, Sobel, Log and Fuzzy operators. Robert, Sobel, Prewitt are classified as classical operators which are easy to operate but highly sensitive noise and gradient based operator (G. Ganchimeg, 2014). Robert operator firstly computes the sum of the squares of the difference between diagonally adjacent pixels through discrete differentiation and then calculate approximate gradient of the image. It is uses following 2x2 two kernels. Sobel operator is a discrete differentiation operator used to compute an approximation of the gradient of image intensity function for edge detection. At each pixel of an image gives either the corresponding gradient vector or normal to the vector. Sobel operator convolves the input image with kernel and computes the gradient magnitude and direction. Sobel and Prewitt operators uses following 3x3 two kernels (Rashmi, M Kumar & R Saxena, 2013). The function of Prewitt edge detector is almost same as of Sobel operator but have different value kernels. Canny edge detector an optimal edge detection technique to provide good detection, clear response and good localization (John Canny, 1986). Log (Laplacian of Gaussian) operator is based on a second-order derivative of the Laplacian. Log operator works on a zero-crossing method and uses both Gaussian and Laplacian operator so that Gaussian operator reduces the noise and Laplacian operator detects the sharp edges (David Marr, Ellen Catherine Hildreth, 1980). Fuzzy logic is used to perform the edge detection on an image. The algorithm is based on the selection of a set of four pixels of the image.

Binarization and Morphological Thinning:

Human fingerprints are rich in details called minutiae, which can be used as identification marks for fingerprint verification. To achieve good minutiae extraction in fingerprints with varying quality, preprocessing in form of image enhancement and binarization is first applied on fingerprints before they are evaluated (Lin Hong, Yifei Wan & Anil Jain, 1998). Many methods have been combined to build a minutia extractor and a minutia matcher. Minutiae, in fingerprinting terms, are the points of interest in a fingerprint, such as bifurcations (a ridge splitting into two) and ridge endings (Mayank Tripathi & Deepak Shrivastava, 2015). Fully convolutional network is used to map raw fingerprints to a minutia-score map with a fixed stride. Minutia score map generates proposals in pixel level through a given threshold (Yao Tang, Fei Gao & Jufu Feng, 2017). The fingerprint binarization is an algorithm producing a 1-bit type image, with 0 as ridges which are tinted with black and 1 as valleys which are tinted with white (Biometrics History, 2006). However, the adaptive binarization method is based on a threshold t, with gray level pixels lower than t assigned to 0 and the others to 1. It is known that dissimilar fingerprint images have special contrast and intensity, and therefore, a unique threshold t is not proper for a general fingerprint image analysis (Sangram Bana & Davinder Kaur, 2011). Thinning is the last step of the fingerprint image enhancement before feature extraction, and it is used to clarify the endpoints and the bifurcations in each specific pixel, subject to the numbers of pixels belonging to these features in the original fingerprints (Lin Hong, Yifei Wan & Anil Jain, 1998). Different thinning algorithms and techniques have been developed but they are based on thinning the neighborhood of the pixels that have maximum values in a sequential process obtaining a characteristic pixel value for each feature at each step (David Maltoni, etc., 2009). Thinning algorithm is a Morphological operation that is used to remove selected foreground pixels from binary images. It preserves the topology of the original region while throwing away most of the original foreground pixels. A total of one hundred and fifty different local ridge characteristics, called minute details, have been identified. These local ridge characteristics are not evenly distributed.

Methodology:-

The performance of a minutiae extraction algorithm relies heavily on the quality of the input fingerprint images. We can good quality live scan fingerprint image. But, in practice, due to variations in impression conditions, ridge

configuration, skin conditions, acquisition devices, and non-cooperative attitude of subjects, significant percentage of acquired fingerprint image is of poor quality and we need enhancement fingerprint images.

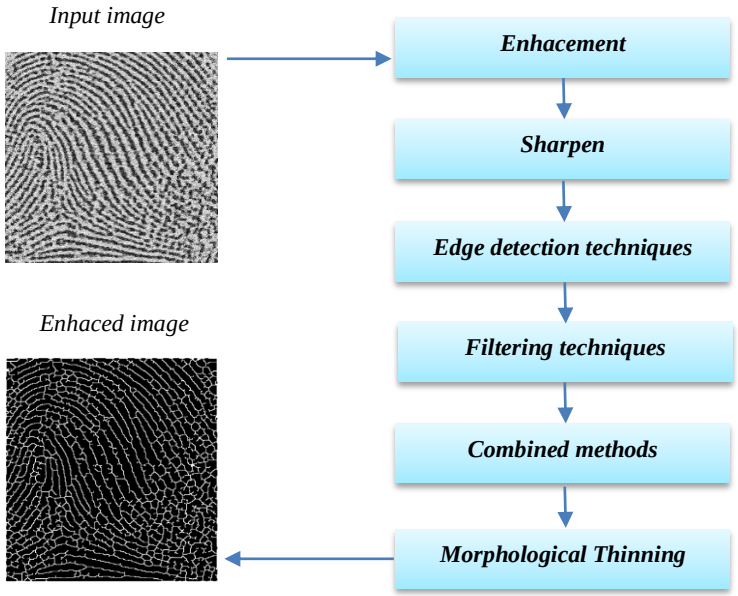


Figure 1:- A flowchart of the proposed fingerprint enhancement method

The ridge structures in poor quality fingerprint images are not always well defined and hence they cannot be correctly detected (G. Ganchimeg & H. Leopold, 2019). Our methodology is trained enhancement filtering methods, correct edge detection method chooses and combined morphological thinning methods (figure 1).

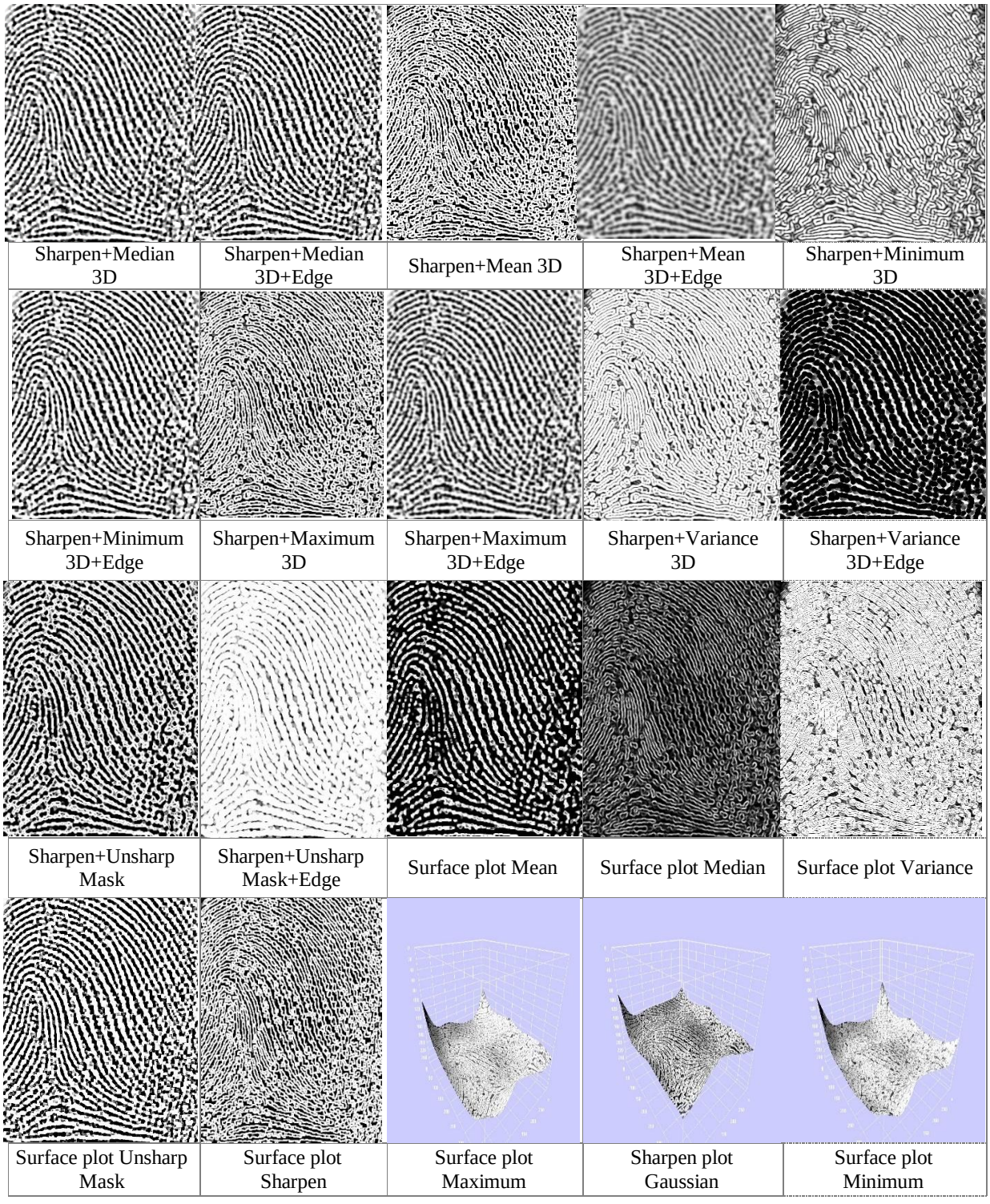
Results and Discussion:-

The goal of an enhancement algorithm is to improve the clarity of ridge structures of fingerprint images in a recoverable region and to remove the unrecoverable regions. A fingerprint enhancement algorithm should not result in any spurious ridge structures. This is very important because spurious ridge structure may change the individuality of input fingerprints. This research used to Mongolian one biggest supermarket workers (hundred more) fingerprint images. This company-controlled work duration (work start and finish time) time and used to fingerprint scanner device. Sometimes scanner panel was blurred and need to enhancement fingerprint image. We trained various filtering techniques, edge detection methods and morphological thinning methods combined and shows an example result image (figure 2 to 4).

I) Filtering Techniques Results

In this section we compare the enhancement results conducted on grayscale images by six different filtering methods. The results obtained with edge detection methods are also compared here. The techniques based on direct gray scale enhancement perform better than approaches which require filtering techniques and morphological thinning as all steps.

Enhancement image	Sharpen	Sharpen+Edge	Sharpen+Gaussian Blur 3D (x, y, z, R=2)	Sharpen+Gaussian Blur 3D+Edge


Sharpen+Median 3D
Sharpen+Median 3D+Edge
Sharpen+Mean 3D
Sharpen+Mean 3D+Edge
Sharpen+Minimum 3D
Sharpen+Minimum 3D+Edge
Sharpen+Maximum 3D
Sharpen+Maximum 3D+Edge
Sharpen+Variance 3D
Sharpen+Variance 3D+Edge
Sharpen+Unsharp Mask
Sharpen+Unsharp Mask+Edge
Surface plot Mean
Surface plot Median
Surface plot Variance
Surface plot Unsharp Mask
Surface plot Sharpen
Surface plot Maximum
Sharpen plot Gaussian
Surface plot Minimum

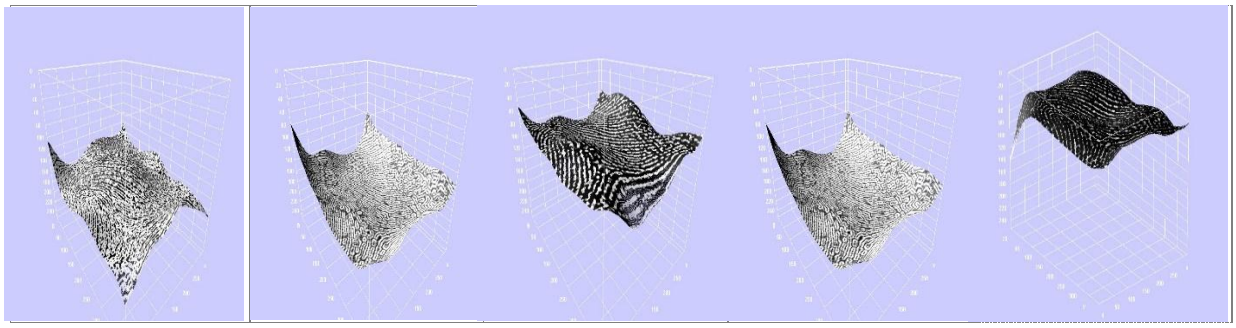


Figure 2:- Filtering techniques some result images

A fingerprint image enhancement algorithm receives an input fingerprint image, applies a set of intermediate steps on the input image, and finally outputs the enhanced image. In practice, the Gaussian filter is blurred images and remove noise detail much more but not increase radius 2. Sharpen technique is increased improve the clearness enhancement image and lightning edges. Maximum and minimum filtering techniques combined sharpen technique trained result gave the brightest and darkest points much more increased in the fingerprint image. In practice, this assumption is not valid for fingerprint images of poor quality, which greatly restricts the applicability of variance, mean, median filtering techniques. These techniques also combined sharpen and edge detection techniques not gave the good result and much more noise not removed. We show an example surface plot various filtering technique used to the same radius (x, y, z, R=2) not combined other methods. But these single filtering methods is not giving the good result (figure 2).

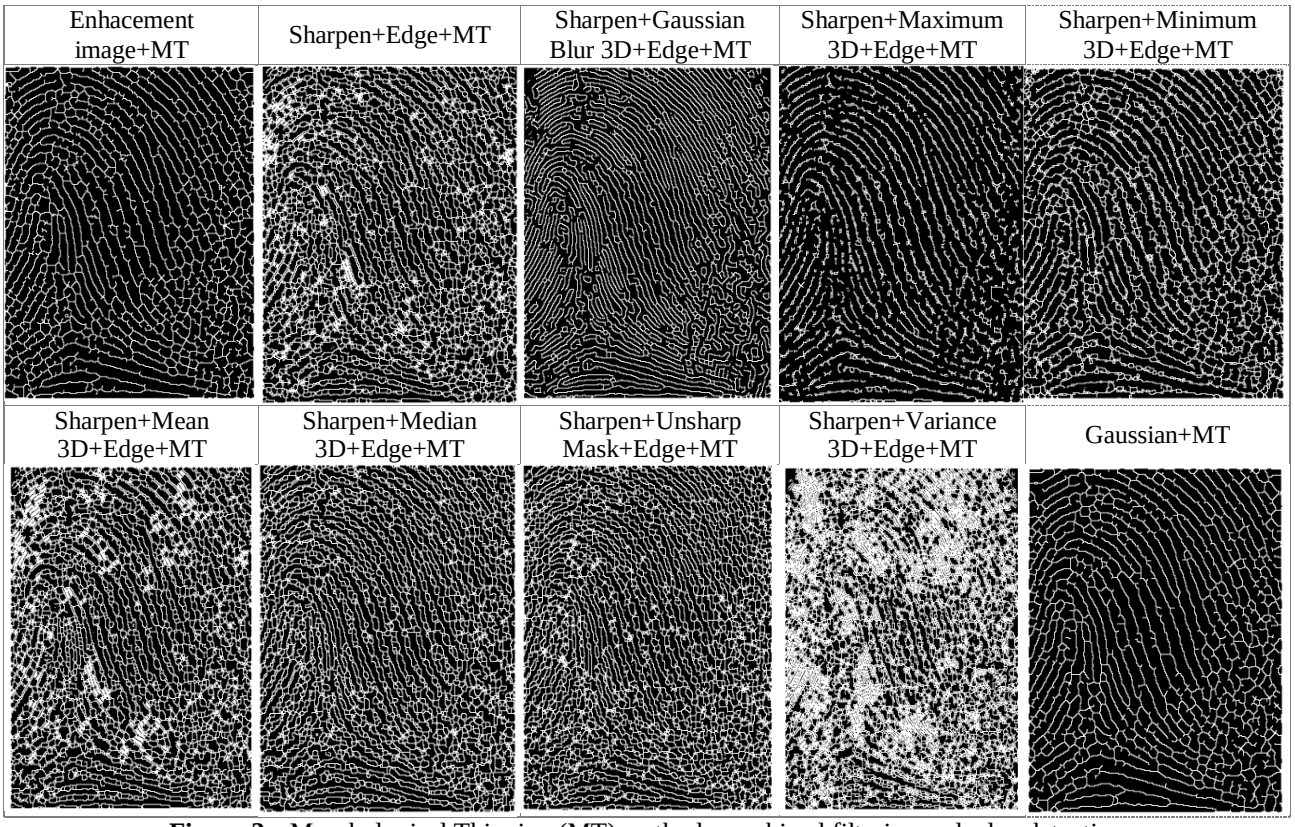


Figure 3:- Morphological Thinning (MT) methods combined filtering and edge detection techniques some result of images

The configurations of parallel ridges and furrows with well-defined frequency and orientation in a fingerprint image provide useful information which helps in removing undesired noise. In practice, enhancement, Sharpen techniques, Canny edge detection, Gaussian filter and Morphological thinning methods combined gave the good result and

much more reduced noise, increased edges, gave the lightning and enhanced fingerprint image (figure 3). Also thinning method is the last step of the fingerprint image enhancement. The morphological thinning method gave the good result our experiments fingerprint images.

II) Edge Detection Combined Morphological Thinning Techniques Results

In this section, we compare the various edge detection images combined Morphological thinning methods.

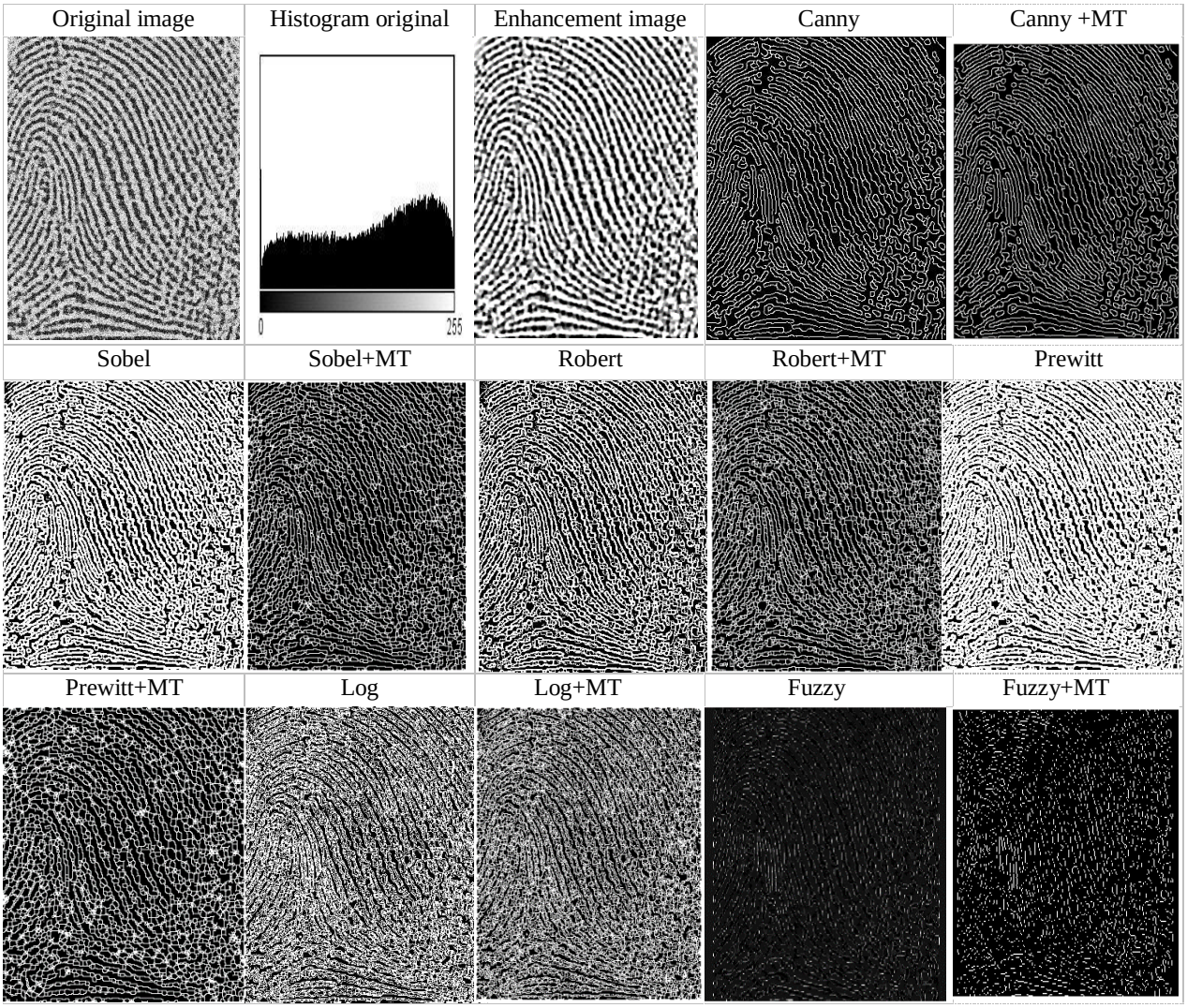


Figure 4:- Various Edge Detection Images combined +MT

The output from experiment images gave the various result (figure 4). Robert operator is its simplicity but having a small kernel (2x2) it is highly sensitive to noise not and not much compatible. But the morphological thinning method combined Robert operators gave the resulting noise much more reduced. Sobel operator convolves the input image with the kernel and computes the gradient magnitude and direction. Sobel operator as having a larger mask, errors due to effects of noise are reduced by local averaging within the neighborhood of the mask. Sobel edge operator gives better performance than that of Prewitt operator. Prewitt operators are simpler to the operator as compared to Sobel operator but more sensitive to noise in comparison with Sobel operator. The Log operator, however, suffers two main limitations. It generates responses that do not correspond to edges and the localization error may be severe at curved edges and not reduced noise. The Canny operator is less sensitive to noise, adaptive in nature, resolved the problem of streaking, provides good localization a detects sharper edges as compared to others and gave the good results. In this paper, using the fuzzy logic a very simple and very efficient edge detection method

is developed. Also, the morphological thinning method combined all edge detection methods gave the good result noise much more reduced.

Summary:-
A fingerprint image is possible to develop an enhancement algorithm that exploits these visual clues to improve the clarity of ridge structures in corrupted and enhancement. In general, for a given digital fingerprint image, the region of interest can be divided into the following three categories: well-defined region, recoverable corrupted region, and unrecoverable corrupted region.

We trained a fast enhancement algorithm which can adaptively enhance the ridge and furrow structures, a computationally efficient filtering the Gaussian, Median, Mean, Minimum, Maximum and Variance filtering techniques, Canny, Robert, Prewitt, Log and Fuzzy edge detection methods, enhancement Sharpen techniques, Morphological thinning methods and combined their methods and some experiment results in fingerprint images. The enhancement, Sharpen techniques, Canny edge detection, Gaussian filter and morphological thinning methods combined gave the good result and much more reduced noise, increased edges, gave the lightning and enhanced fingerprint image. The morphological thinning method gave the good result our experiments fingerprint images. The techniques based on direct gray scale enhancement perform better than approaches which require filtering techniques and morphological thinning as all steps. The morphological thinning method combined all edge detection methods gave the good result noise much more reduced.

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