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Segmentation of low Quality Fingerprint Images using SVM

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Abstract-- Fingerprints are the oldest and most widely used form of biometric. Main reason for false recognition is noise, added to fingerprint images during the acquisition step. Hence, the improvement of the enhancement step affects general accuracy of automatic recognition systems. Segmentation is the process of partitioning an image into regions. Region is a group of connected pixels with similar properties. This paper presents a new algorithm for segment low quality fingerprint images. The algorithm uses four features mean, variance, coherence and SVM (Support vector machine) of the image to achieve the fingerprint segmentation. The project is coded in MATLAB.

Keywords: segmentation, Gaussian Filter, Histogram Equalization, SVM (Support vector machine)

I . INTRODUCTION

Fingerprints have been used for over a century and are the most widely used form of biometric identification. Fingerprint identification is commonly employed in forensic science to support criminal investigations and in biometric systems such as civilian and commercial identification devices. Despite this widespread use of fingerprints, there has been little statistical work done on the uniqueness of fingerprint minutiae. In particular, the issue of how many minutiae points should be used for matching a fingerprint is unresolved. The fingerprint of an individual is unique and remains unchanged over a lifetime. A fingerprint is formed from an impression of the pattern of ridges on a finger. A ridge is defined as a single curved segment and a valley is the region between two adjacent ridges. The minutiae, which are the local discontinuities in the ridge flow pattern, provide the features that are used for identification. Details such as the type, orientation, and location of minutiae are taken into account when performing minutiae extraction [11]. Galton [13] defined a set of features for fingerprint identification, which since then, has been refined to include additional types of fingerprint features. However, most of these features are not commonly used in fingerprint identification systems. Instead the set of minutiae types are restricted into only two types, ridge endings and bifurcations, as other types of minutiae can be expressed in terms of these two feature types. Ridge endings are the points where the ridge curve terminates, and bifurcations are where a ridge splits from a single path to two paths at a Y-junction. Figure 1.1 illustrates an example of a ridge ending and a bifurcation. In this example, the black pixels correspond to the ridges, and the white pixels correspond to the valleys.

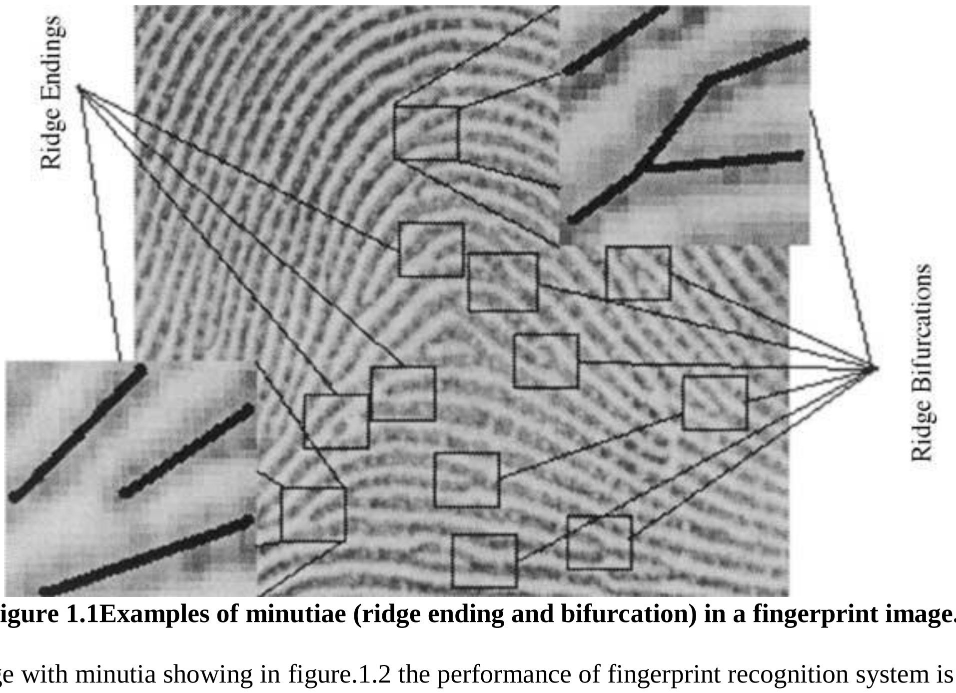


Figure 1.1Examples of minutiae (ridge ending and bifurcation) in a fingerprint image.

Fingerprint image with minutia showing in figure.1.2 the performance of fingerprint recognition system is depends on the quality of fingerprint image [13] [14]. Therefore, most of the efforts required for improving the quality of fingerprint image.

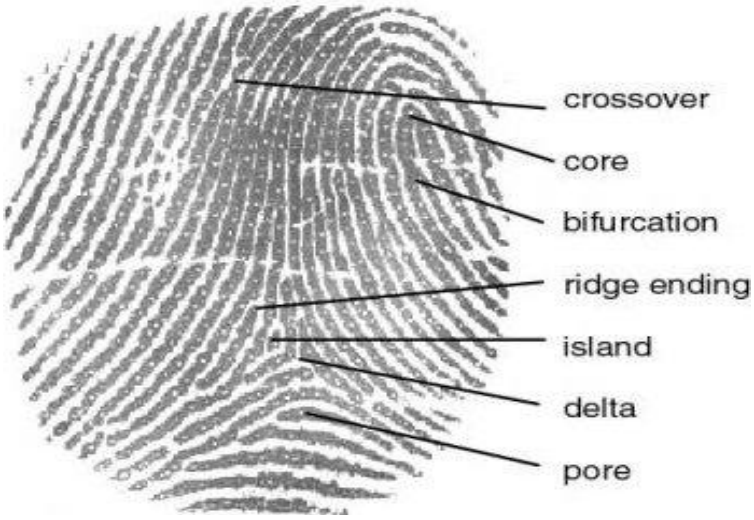


Figure1.2 Fingerprint image with minutia showing

The various biometric modalities can be broadly categorized as-

• Physical biometrics: These involve some form of physical measurement and include modalities such as face, fingerprints, iris-scans, hand geometry etc.

•Behavioral biometrics: These are usually temporal in nature and involve measuring the way in which a user performs certain tasks. This includes modalities such as speech, signature, gait, keystroke dynamics etc.

• Chemical biometrics: This is still a nascent field and involves measuring chemical cues such as odor and the chemical composition of human perspiration.

In this paper, a new Method for the segmentation of low quality fingerprint images is presented. It includes pre-processing, some additional stages and post-processing stages to segment Fingerprint Images. The rest of the paper is organized as follows.

In section II the II. Related Work. In section III the proposed method is illustrated. The proposed algorithm is shown in section IV, the experimental results based on the proposed method are displayed in section V and in section VI the conclusion is presented.

II. RELATED WORK

A.Hasan Fleyeh et.al. "Segmentation of Low Quality Fingerprint Images"

This paper presents a new algorithm to segment fingerprint images. The algorithm uses four features, the global mean, the local mean, variance and coherence of the image to achieve the fingerprint segmentation. Based on these features, a rule based system is built to segment the image. The proposed algorithm is implemented in three stages; pre-processing, segmentation, and post processing. Gaussian filter and histogram equalization are applied in the pre-processing stage. Segmentation is applied using the local features. Finally, fill the gaps algorithm and a modified version of Otsu thresholding are invoked in the post-processing stage [2].

B. Krzysztof Mieloch, Axel Munk et.al. "Improved Fingerprint Image Segmentation and Reconstruction of Low Quality Areas"

One of the main reason for false recognition is noise added to fingerprint images during the acquisition step. Hence, the improvement of the enhancement step affects general accuracy of automatic recognition systems.

In one of our previous publications we introduced hierarchically linked extended features – the new set of features which not only includes additional fingerprint features individually but also contains the information about their relationships such as line adjacency information at minutiae points or links between neighboring fingerprint lines. In this work we present the application of the extended features to preprocessing and enhancement. We use structural information for improving the segmentation step, as well as connecting disrupted fingerprint lines and recovering missing minutiae. Experiments show a decrease in the error rate in matching [4].

C. Jitendra Choudhary et.al. "A New Framework for improving low Fingerprint Images"

Fingerprints are the oldest and most widely used form of biometric identification. A fingerprint image may not always be well defined due to elements of noise that corrupts the clarity of the ridge structures or basic information, which is required for recognition. Noise may occur due to variations in skin and impression condition. Thus, image enhancement techniques are often used to reduce the noise and enhance the structure of ridges and valleys for minutiae detection. in this paper, we present a fingerprint image enhancement method which can adaptively improve the clarity of ridge and furrow structures of input fingerprint image based on the frequency and spatial domain filtering , local orientation estimation , local frequency estimation and morphological operation. There set of operation applied on own database DB-Finger that Improve the quality of fingerprint Image [1].

D. Bian Weixin et.al. "Fingerprint Segmentation Based on Improved Active Contour"

Snake (Active Contour) Model, introduced by Kass in 1987, is a dynamic curve model with energy-minimizing. Snake algorithm, which has advantages in extracting target object from a certain region, is an effective method in image segmentation. Based on the analysis of the snake model and the regional information of the edges of the fingerprint images, an improved active contour for the segmentation of fingerprints is presented in this paper. In this paper the limitations of the segmentation of fingerprint images using the snake as suggested in [5] are pointed out. The authors present a solution to the fingerprint segmentation by replacing the standard external energy in the snake energy balance equation with the difference between peaks in the directional histogram and gray variance, and a new external energy that is applied to control. the snake outward expansion or inward contraction. This method has been tested by a large number of fingerprint images from different sources, and is found to be more accurate and robust.

III. PROPOSED METHOD

Features for Fingerprint Segmentation such as Local mean, local variance and local coherence are used for separation of foreground and background. Foreground is the component that originates from the contact of the fingertip with the sensor contains all important information needed in the automatic fingerprint recognition systems. However, the background is a noisy region that contributes to the extraction of false minutiae in the system which is located at the borders of the image. Fusion of three features of the fingerprint images in one algorithm shows efficiently the distribution of pixels for valleys and ridges in images. In this method the fingerprint image is partitioned in blocks of $w \times w$ pixels. Then, for each block features are obtained. In window *w* around a pixel, local mean and local variance [6] are define as:

$$Mean = \frac{1}{w^2}\sum_{W} I \qquad (1)$$

$$Variance = \frac{1}{w^2}\sum_{w}(1-mean)^2 \qquad (2)$$

Where I is Intensity of each pixel and coherence is defined as

$$Coh = \frac{\sqrt{\left[\left(g_{xx}-g_{yy}\right)^2 - 4\left(g_{xy}\right)^2\right]}}{g_{xx}-g_{yy}} \qquad (3)$$

$$g_{xx} = \sum_{w} G_x^2,\; g_{yy} = \sum_{w} G_y^2,$$

$$g_{xy} = \sum_{w} G_x G_y$$

Where Gx and Gy are corresponding vertical and horizontal gradient components which are given by Sobel operators. The spatial distribution of these three features of this image of fingerprint is shown in figures 3.1, 3.2, 3.3, 3.4, 3.5.

Figure 3.1Fingerprint image

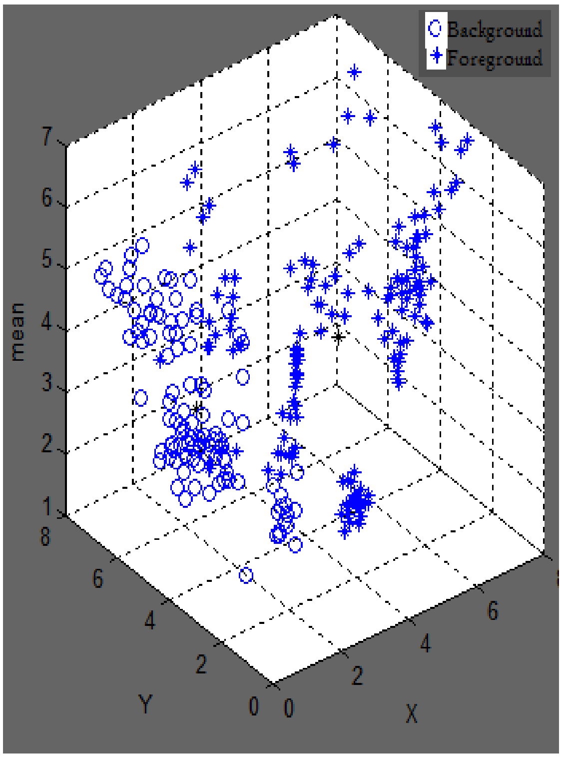


Figure 3.2 Distribution of mean in image

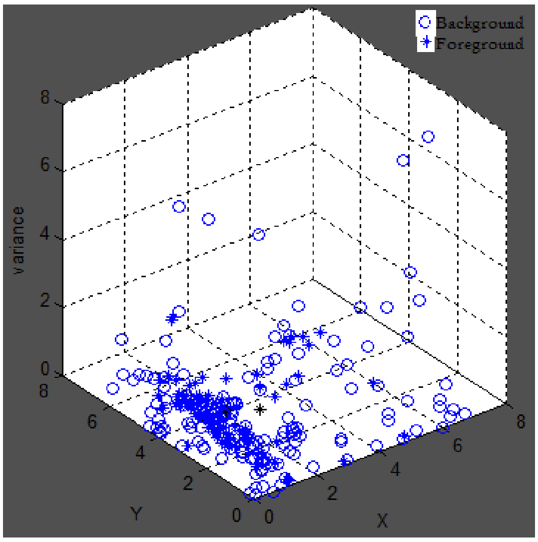


Figure 3.3 Distribution of variance in image

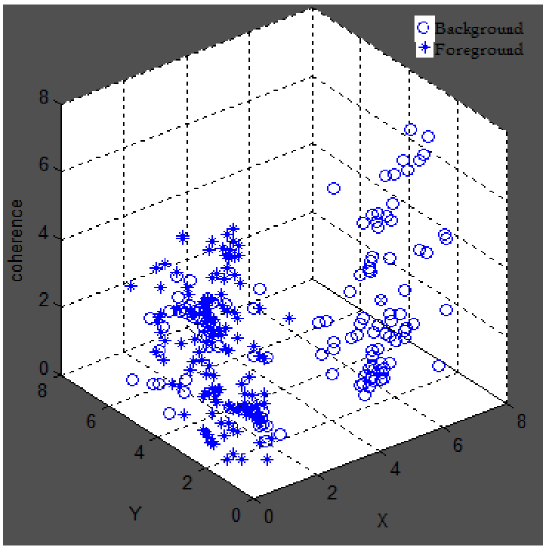


Figure 3.4 Distribution of coherence in image

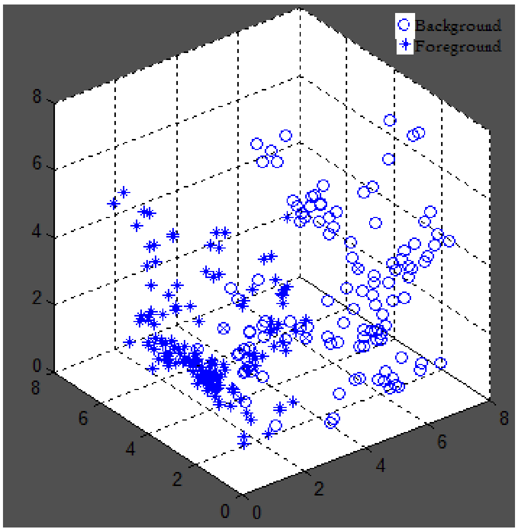


Figure 3.5 Distribution of mean, variance, coherence in image

IV. PROPOSED ALGORITHM

The proposed algorithm is implemented in three stages; pre-processing, segmentation, and post-processing. Gaussian filter and histogram equalization are applied in the pre-processing stage. Segmentation is applied using the local features. Finally, fill the gaps algorithm and linear svm classifier is invoked in the post-processing stage.

Step I PRE PROCESSING

The aim of pre processing is to enhance the visual appearance of images and improve the manipulation of datasets that suppresses unwanted distortions or enhances some images features which is important for further processing.
Techniques used in this paper for preprocessing are Gaussian Filter, and Histogram Equalization .

B.Gaussian Filter:

Gaussian filters are class of linear smoothing filters which is used to blur images and removes noise.

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{\frac{x^2-y^2}{2\sigma^2}} \qquad (4)$$

where σ is the standard deviation of the distribution .The distribution is assumed to have a mean of zero .We use Gaussian filter because convolution of Gaussian with itself is another Gaussian so we can first smooth an image with Gaussian then we convolve that smoothed image with another small Gaussian result is equivalent to smoother the original image with larger Gaussian.

B.Histogram Equalization:

Histogram equalization is a technique for adjusting image intensities to enhance contrast, basically Histogram equalization give us transform image where the intensity value having uniform distribution and because of this process image we get appear to be high contrast Histogram Equalization defines a mapping of gray level *p* into gray level *q* such that the distribution of gray level *q* is uniform. This mapping stretches the contrast of gray level near the maxima in the histogram [10]. The probability density function of a pixel intensity level r_k is yield by formula:

$$P_r(r_k) = \frac{n_k}{n} \qquad (5)$$

Where r_k is between 0 and 1,k=0,1…..255, n_k is the number of pixels at intensity level r_k and n is the total number of pixels. The new intensity value S_k for level k is derived by formula:

$$S_k = \sum_{j=0}^{k} \frac{n_k}{n} = \sum_{j=0}^{k} P_r(r_j) \qquad (6)$$

Result of histogram equalization is shown in the figure 4.1.

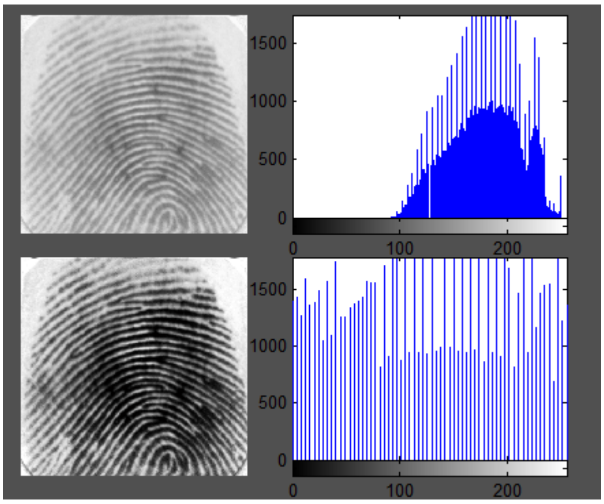
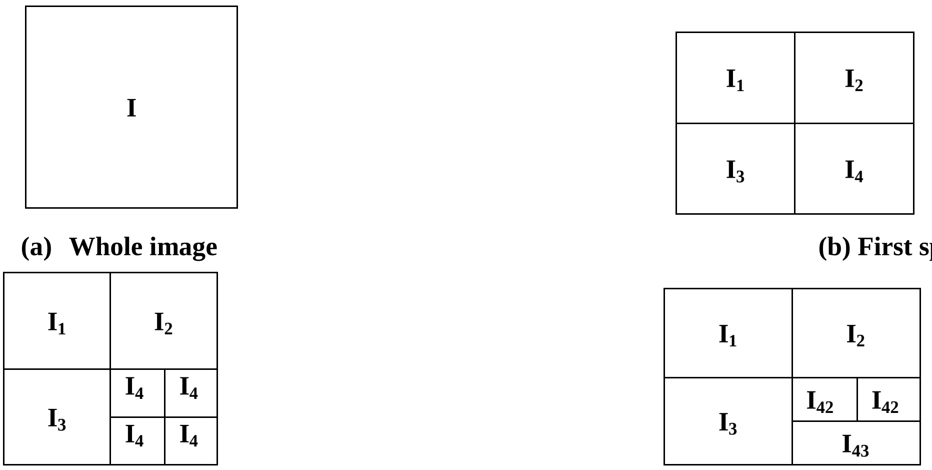


Figure 4.1 Histogram equalization of an image

Step II SEGMENTATION

Segmentation improves the fingerprint images so that features can be extracted from these images and used for high level image understanding operation .The aim for fingerprint segmentation is to separate the foreground from background for this purpose split and merge procedure of image can be performed by recursively splitting the whole image or by merging together a large number of minute region until a specified condition is satisfied which is based on quad tree structure. Let I represent the entre image region and decide a predicate V.The purpose is that P(V)=FALSE, we divided the image I into quadrants,I_1,I_2,I_3,I_4. If V is FALSE for any quadrant we sub divide that quadrant into sub quadrants and so on till for any region V(I_i)TRUE. After the process of splitting merging process is to merge small region that is I_i and I_k if P(I_i) ∪ P(I_k) =TRUE . Split and merge algorithm is shown in figure 4.2.First whole image is split into four descends and each nodes is corresponds to subdivisions .subdivisions is based on some characteristics like mean variance which is consider as predicates for this region segmentation. As splitting contains adjacent region with same properties so merging is done to combine adjacent regions having identical properties.



(a) Whole image **(b) First split**

(C) Second split **(d) Merge**

Figure 4.2 Split and Merge Algorithim

Local mean , local variance and local coherence are compiled for each images as show in figure 3.2,3.3,3.4,3.5 and combination of value of used to generate the parameter value α ,used to build a rule based system to segment foreground and background .these rules are used to decide whether a certain block is belong to foreground and background of images.

Step III Post-processing

In Post-processing, Fill the gap in image and Linear SVM is applied in post processing step**.** Output of segmentation The may contain isolated background blocks which are surrounded by foreground blocks .In order to eliminate the presence of these isolated blocks simple fill the gap algorithm[3] is apply

For all blocks in the image, if a background block (i,j) is found

- Check the N4 neighbor blocks which are located at (i, j-1), (i, j+1), (i-1, j) and (i+1, j) for the presence of foreground.
- If two or more of these neighbors are foregrounds, change all of the pixel in the block (i,j) back to their original value before any segmentation

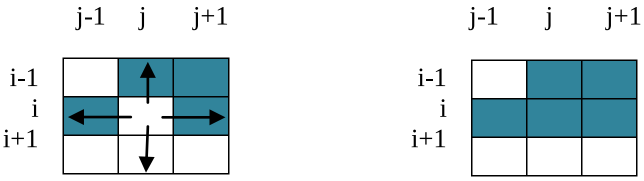


Figure 4.3. Filling gaps in a block image

After filling the gap Linear SVM classify used with aim of discriminating for classification of valuer from low to high SVM is designed to separate set of training images X_n ,Y_n such that $X_n \in R^n$;$Y_n \in (-1,1)$ where X_n is input and Y_n is target lies in between (-1,1) having feature mapping $Ø:X \rightarrow R^q$ where q basic function representing input training instant X_n, value of training is given by $Z(X_n)=W^T Ø\ (X_n)\ +b$;$W \in R^q$: $b \in R$,W is vector and perpendicular to plane Class A:$Z(X) \geq 1$ and Class B:$Z(X) \leq -1$, Decision Boundary :$Z(X)=0$. Result of SVM show in figure 4.5.

Figure 4.4Finger Print image

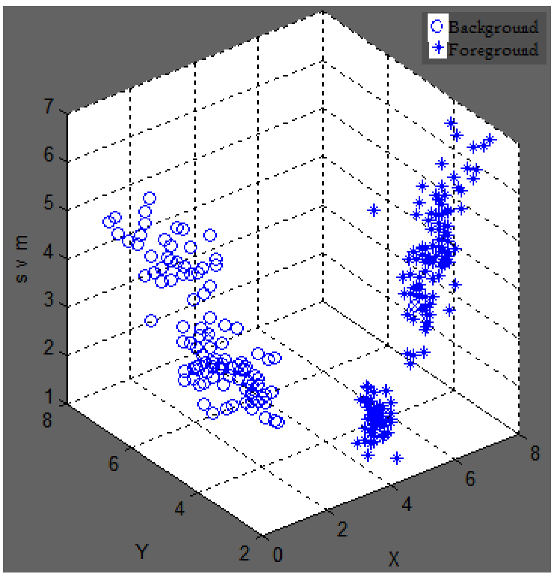


Figure-4.5. showing output of SVM classifier

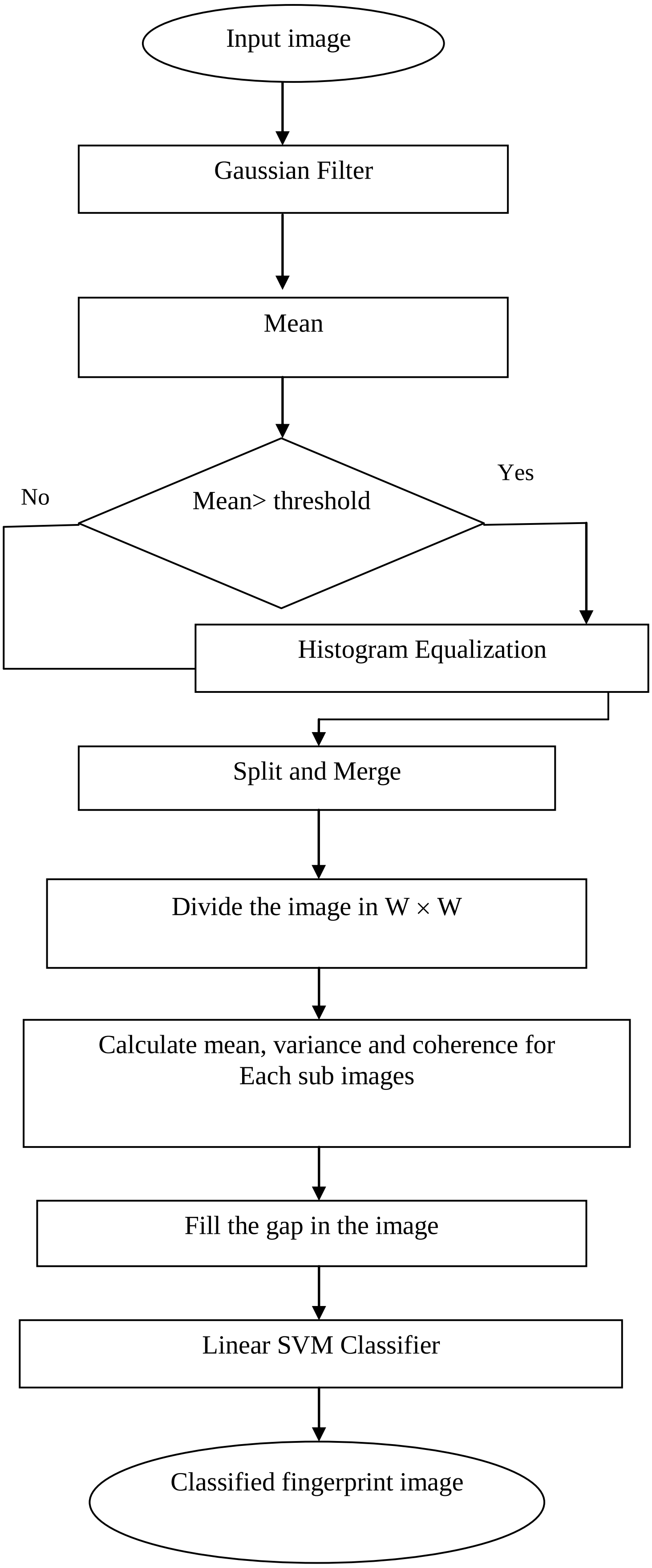


Figure 10.Flow Chart of Proposed algorithm

V. EXPERIMENTAL RESULT:

In this paper In order to evaluate the performance of the proposed fingerprint image segmentation method, 100 fingerprint images from database DB fingerprint is selected without any reputation. Result is shown in figure 5.1.

Figure 5.1.Correctly segmented images from FVC2002 fingerprint database

In order to evaluate the performance of our algorithm we compare our algorithm with traditional algorithm naming segmentation based on Modified Otsu Method result is shown in table 1 result is based on following scheme [6]:

- Good, when more than 90% of the background blocks are segmented correctly.
- Almost Good, when 75% - 89% of the background blocks are segmented correctly.
- Almost bad, when 60% - 74% of the background blocks are segmented correctly.
- Bad, when less than 60% of the background blocks are segmented correctly

RESULT	Percentage based on Modified Otsu' Method	Percentage based on SVM Classifier
Good	66%	81%
Almost Good	16%	10%
Almost Bad	4%	3%
Bad	14%	6%

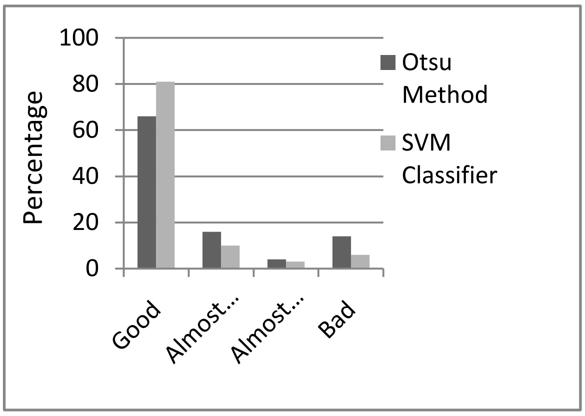


Table 1.show comparison between **Graph show comparison between Modified Otsu and SVM**

Modified Otsu and SVM Classifier

In order to evaluate Qualitative Comparison, we compare SVM classifier with results obtained from gray level-based method [14] which is based on is how to select a optimal threshold in the histogram to segment the foreground from background and direction-based method[9] which is based on the coherence of Direction in which we calculated threshold, if the coherence is bigger than a threshold, the block is considered as foreground, otherwise, it belongs to background. Testify that our segmentation scheme is effective, our method can obtain good performance on deciding which part is belong to foreground and which belong to background. Result is shown in figure 5.2.

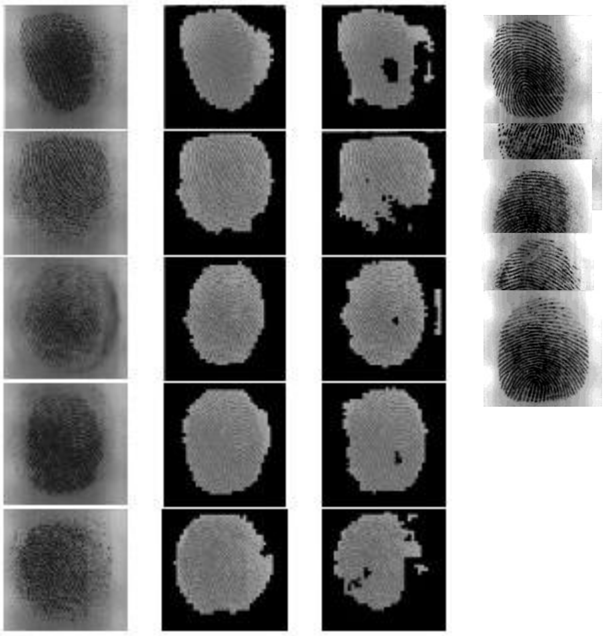


Figure 5.2 The results compare our algorithm with traditional algorithms. The second and third columns are based on gray level and coherence and the last column is based SVM Classifier

VI. CONCLUSION

In this paper, a new algorithm for segmentation of low quality fingerprint images is proposed. The algorithm is implemented in three steps preprocessing, segmentation, post processing. Techniques used in preprocessing are Gaussian Filter and Histogram Equalization Segmentation is done by using method split and merge and finding global mean, local mean, local variance and coherence. In post processing we used fill the gap in image algorithm finally linear svm classifier is used for fingerprint image classification. testing. Experiments of testing this algorithm show that it is able to segment 90% of images used for testing. Further analysis to this result can reveal that modification is possible these modification can be either the use of fuzzification techniques .

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