Improved Fingerprint Image Segmentation Approaches

Y. Suresh, S.V.N Sreenivasu, Ch. Anuradha

***Abstract*: The quality of fingerprint or fingerprint verification depends on the quality of the fingerprint image. Most of the fingerprint management algorithms depend on the features which are extracted based on the minutiae of the fingerprints. The quality of minutiae is depends on how good the fingerprint images. The background and foreground of the images are also effect the results of the fingerprint images. Fingerprint segmentation algorithms are used to extract the finger print image from background. In this paper we are presenting the two fingerprint segmentation algorithms which are the modifications of existing mean and variance based approach and gradient based approach.**

***Index Terms*: Bio-metric. Fingerprint, Image segmentation.**

I. INTRODUCTION

The use of biometrics has been increased drastically in the areas where the security is major concern. The biometric application is used to authenticate by their voice, fingerprint, face, etc. The fingerprint management system is the first choice among all the biometric methods. Face recognition is computationally expensive compared to other biometric methods. Compared to traditional identification systems like password or PIN finger print is a widely accepted one due to its advantage such as no two person's finger prints are same in the universe. Ridges and Valleys are the two important characteristics of the fingerprint which helps to differentiate two fingerprints. Ridges are the dark lines in fingerprint and the valleys are the bright lines in the fingerprint.

Most fingerprint automatic systems (AFIS) are uses ridge ending and ridge bifurcation (minutiae). All the fingerprint algorithms uses the feature extraction algorithms and the performance of the feature extraction algorithms depends on the quality of the fingerprint image and they perform poorly when applied to noisy background area. In the literature segmentation approaches are presented to remove the noisy area at the borders of the fingerprint images. It is required when the fingerprint minutiae are the basis for the fingerprint identification or verification methods.

In the literature two segmentation based approaches are presented one is the supervised algorithms and another one in unsupervised algorithms. Unsupervised approaches uses block wise features like histogram of ridge orientation [1], [2], gradient values in each block [3], Gabor features [4], [5] and any simple classifier can be used for the purpose of classification. In most of the algorithms to reduce effect of background mean and standard deviation are used in the approaches. But when there are pixels with extreme intensities then the mean of the methods adversely affect the methods. In this paper we are presenting two approaches, one is the modification to the existing mean and variance based approach [6], another one is modification for the existing gradient based method.

II. RELATED WORK

Minutiae based fingerprint algorithms are more popular approaches in fingerprint verification and fingerprint identification applications. Most of the approaches used the Delaunay triangulation based methods to identify or verify the given query fingerprint. Parzile, etc. al., in 2004 [7] each minutiae considered as an vertex in the triangle, and they measures the distance between minutiae pairs, angles between the minutiae pairs, etc. are used in their approach. By applying the three different filters they selected some subset of the triangles to compare with the triangles in the given query fingerprint. Liu et al. [8] proposed a similar approach for matching the fingerprints based on Delaunay triangulations. They used the concept of RMPs (reference minutiae pairs). They tried to find the similar edge pairs from the given query fingerprint and the template set of minutiae. In [9] Deng and Huo proposed another approach based on Delaunay triangulation, instead of considering the best minutiae pairs they tried to find the matching edge pairs.

Most of the fingerprint image works uses the 500 dpi images [10]. In the mean based approaches [11] [12], uses the approach of dividing the image into blocks, calculation of mean for each block and finding the standard deviation of the image, Finally the standard deviation is subtracted from the image and if any blocks difference is more than some specified threshold value and is treated as background. There are direction based approaches [12], [13] are also there in the literature, in these methods some specific masks are used for eliminating the local orientation. There are so many fingerprint verification algorithms exist in the literature based on the geometric properties, genetic algorithmic type approaches, etc. [14], [15], [16], [17], [18].

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III. FINGERPRINT IMAGE SEGMENTAION USING FREQUENT PIXEL

Fingerprint images are available in different resolutions and the resolution is varied from 300 dpi to 800 dpi, but most of the fingerprint images are available in 500 dpi. As discussed in the previous section there are many approaches are there for segmentation purpose. The identification or classification of fingerprint image processing depends on the quality of the fingerprint image. Most of the segmentation approaches are based on either mean and variance based approaches or direction based approaches. In this paper our proposed approach uses the frequent pixel based approach instead of using a mean. The steps for frequent pixel based approach for fingerprint image segmentation is as follows.

1. The given fingerprint image I (i, j) is partitioned into non-overlapping blocks B1, B2…Bq of each block size is w x w.
2. Compute the S (I) for each block B_i using the following approach.
   a. Construct a table T[w2][w2]with the following entries
      For each pixel (i, j) in B_i all the 8-connected pixel intensities are added to the table as a separate tuple.
   b. Compute the k-length frequent pixel in T by using algorithm [2], where k is the user defined threshold and another threshold s is used to declare some pixel as a frequent pixel. The mean value of these k-pixels is calculated and is denoted as S (I) for the block B_i.
   c. If there is more than one k-length frequent pixels, let us assume there are m k-length frequent pixels are there, and then find the mean of each k-length pixel. So we have m mean values. Again find the mean of the m values and is considered as S (I).
   d. If there is no such k-length frequent pixel, then try to find the k-1 length frequent pixel, and is repeated till k-k-1. Still there is no such pixel the median of all the pixels is selected.
3. Calculate the standard deviation from the following equation.

   std (I) = $\sqrt{\frac{1}{w^2}\sum_{-w/2}^{w/2}\sum_{-w/2}^{w/2}(I(i,j) - M(I))^2}$
4. Get a reasonable threshold value t from the expert.
5. For each block B_i, If the std (I) of the block is greater than t, then that block is considered as foreground, else it is treated as background.

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In the above procedure except the step 2 all other steps are same as in [10], [11]. Step 2 is the major contribution of our approach. Most of the algorithms follow to calculate the mean value as the block representative and it largely affected by the extreme values of the range. In our approach instead of using the mean value of the block we calculated the k-length frequent pixel in the block, to calculate such pixel we uses the concept of 8-connected. For each pixel we consider all the 8-connected pixels and will make a transaction table with 8*w entries. Where each transaction contains 8 entries, which are all 8-conned pixels for a specific pixel in the block. For the pixels in the edges, we consider only the edges connected to the pixels and it varies from 3 to 5. The intuition behind our idea is that our approach does not affect with the extreme values, or most repeated value (since we considering the k pixels). The most repeated set of pixels results in deciding the foreground or background. The value of w, s and k affect the quality of resulted fingerprint image. So need to take care in selecting the values of s, w and k.

Example – Consider the value of w is 3, k is 3, s is 5. Consider the following block.

12	**12**	**23**	**23**	**23**
12	**11**	**13**	**12**	**12**
12	**12**	**34**	**13**	**34**
13	**23**	**12**	**13**	**13**
24	**12**	**253**	**13**	**13**

Table – 1: Example block

If we consider the left most pixel with the intensity 11, the entries related to that pixel are {12, 12, 23, 13, 34, 12, 12, 12}. The corresponding table for this block is as follows:

1	**1**	**2**	**1**	**3**	**1**	**1**	**1**
1	**2**	**2**	**1**	**1**	**3**	**1**	**1**
2	**2**	**2**	**1**	**3**	**1**	**3**	**1**
1	**1**	**1**	**3**	**1**	**2**	**1**	**1**
1	**1**	**1**	**1**	**1**	**1**	**2**	**1**
1	**1**	**1**	**3**	**1**	**1**	**1**	**3**
1	**1**	**3**	**1**	**2**	**1**	**2**	**1**
1	**3**	**1**	**1**	**1**	**2**	**1**	**2**
3	**1**	**3**	**1**	**1**	**1**	**2**	**1**

Table- 2: Transaction table for the example table in table-1

One- length	**{12, 13, 23, 34}**
Two – length	**{{12,13}, {12, 23}, {12,34}}**
Three-length	**{{12, 13, 23}, {12, 13, 34}, {12, 23, 34}}**

Table – **33:**

Frequent pixels

From the table-3 it is evident that there are three 3-length pixels are there and the S (I) of this block is 20.

The following figure-1 and figure-2 shows the original and processed fingerprints.

Fig 1: Sample fingerprints from the FVC2004 databases

Fig 2: Fingerprint Image Segmentation using frequent pixel

IV. FINGERPRINT IMAGE SEGMENTATION USING MODIFIED GRADIENT BASED METHOD AND FREQUENT GRADIENT VALUE

In this section we present an approach which is a modified gradient based method for fingerprint segmentation. Here also we use the similar approach used in the previous section, and it results in detecting the sharp changes in grey level of background. The following presents the approach.

1. The given fingerprint image I (i, j) is partitioned into non-overlapping blocks B1, B2…Bq of each block size is w x w.
2. Enhance the contrast between foreground and background using the histogram equalization.
3. Use any 3 x 3 filter to decrease the noise in the background of fingerprint image.
4. Compute gradients $\partial x(i,j), \partial y(i,j)$ at every pixel (i, j) in the block center.
5. Find the Mx and My by using the following approach
   a. Construct a table Tx[w2][w2]with the following entries
      For each pixel (i, j) in Bi all the 8-connected gradients $\partial x(i,j)$ are added to the table as a separate tuple.
   b. Construct a table Ty[w2][w2]with the following entries
      For each pixel (i, j) in Bi all the 8-connected gradients $\partial y(i,j)$ are added to the table as a separate tuple.
   c. Compute the k-length frequent gradients in both Tx and Ty by using algorithm [20], where k is the user defined threshold and another threshold s is used to declare some gradient value as a frequent pixel. The mean value of these k-gradients are calculated and are named as Mx and My.
   d. If there is more than one k-length frequent gradient, let us assume there are m k-length frequent gradients are there, then find the mean of each k-length gradients. So we have m mean values. Again find the mean of the m values and is considered as Mx and My.
   e. If there is no such k-length frequent gradient, then try to find the k-1 length frequent gradient, if not, repeated till k-k-1. Still there is no such gradient the median of all the gradients is selected.
6. Calculate the standard deviation from the following equation.

$$\text{stdx} = \sqrt{\frac{1}{w^2}\sum_{-w/2}^{w/2}\sum_{-w/2}^{w/2}(\partial x(i,j) - Mx(I))^2}$$

$$\text{stdy} = \sqrt{\frac{1}{w^2}\sum_{-w/2}^{w/2}\sum_{-w/2}^{w/2}(\partial y(i,j) - My(I))^2}$$

7. Compute the gradient deviation using the following equation

   Gradientdev = stdx + stdy
8. Get a reasonable threshold value t from the expert.
9. For each block B_i, If the Gradientdev (I) of the block is greater than t, then that block is considered as foreground, else it is treated as background.

The following figure-3 and figure-4 shows the original and processed fingerprints.

Fig 3: Sample fingerprints from the FVC2004 databases

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Fig 4: Fingerprint Image Segmentation using modified gradient method

V. RESULTS & CONCLUSION

Our approaches are tested on FVC2004 dataset and the results are presented in the following table-4.

Table – 4: Performance of the proposed methods

	Accurately segmented	Poorly Segmented
Approach-1	196	124
Approach-2	234	86

In this paper we proposed two approaches for segmenting the fingerprint images and are working well under the circumstances where the extreme pixel intensities are there in the fingerprint images.

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