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Enhanced Contour based Segmentation for Fingerprint Extraction

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Abstract—***In Automatic Fingerprint Recognition System, the segmentation is one of the significant and key step. It is a means that separates the fingerprint image into two regions which are the foreground and background regions. The foreground region will have the fingerprint region containing features for recognition and the background region is the unwanted region which can be excluded from process. In this paper some of the regularly available methods are analysed. Later we have combined the methods in a sequential manner and proposed an enhanced segmentation method. We have analysed these algorithms in terms of performance and execution speed and have carried out comparative study between new and the existing algorithms. Our Experimental results have proved that the efficiency of the proposed method is higher than those of the available methods.***

Keywords— Automatic, segmentation, histogram, resolution, counter.

I. INTRODUCTION

Segmentation of fingerprint image plays a key role in an Automatic Fingerprint Identification System (AFIS) which is one of the primary and necessary pre-processing event as shown in Figure.1. Fingerprint segmentation is a process of extracting the foreground region from the background region. In fingerprint images a clear fingerprint ridge area constitutes the foreground and rest of the image such as blank regions but the dirt and oil regions and noisy regions would create devoid of clear fingerprint ridges [3]. The additional steps can be intended only on the foreground for recognition like enhancement, ridge skeleton, noise cleaning, minutiae extraction, and the background region can be removed from additional analysis thus saving time and cost. Thus, segmentation plays a major role in the accuracy of a fingerprint recognition scheme.

Figure 1. (a) Fingerprint Image (b) Foreground Region

A fingerprint image segmentation algorithm receives fingerprint image as an input, applies a set of intermediate steps on the input image, and lastly outputs the fingerprint foreground region where the ridge structure is coherent. In this the segmentation result should satisfy the following conditions:-

i. It should not be receptive to the contrast in the image.
ii. It should detect soiled and noisy regions.
iii. The result of segmentation should be independent of input image i.e. enhanced image or a raw image.
iv. It should give consistent result for a variety of images expected by the application.

A. Classification of fingerprint segmentation algorithms

There are two types of fingerprint segmentation algorithms namely unsupervised and supervised. Unsupervised algorithms take out block wise features such as local histogram of ridge orientation, Gray-level variance and magnitude of the gradient in each image block Gabor feature [1]. The Supervised method typically first pull out several features like coherence, average gray level, variance and Gabor response then a simple linear classifier is chosen for classification. Though this method provides exact results but its computational complexity is higher than most unsupervised methods. A strong segmentation method is required to deal with low quality images and also to save time and costs though these existing methods have shown good results in terms of efficiency and robustness with high resolution fingerprints [2] [11]. A good segmentation will lead to an accurate fingerprint recognition system. In this paper we have analysed some of the existing segmentation methods and have combined the merits of these methods to generate a new segmentation method.

II.EXISTING METHODS FOR IMAGE SEGMENTATION

In this section we describe some of the existing methods that are frequently used to segment images.

A. Region Growing Algorithm

The other name for this method is pixel based segmentation algorithm. The fundamental idea of this algorithm is to find a special block in the fingerprint region called seed block. The seed block region is called seed region. On scanning a seed block's 8 neighbours, if they meet the growing conditions, they are added to the seed blocks' set. The algorithm stops until non-block matches the conditions [10]. This process is continued till the end of image spread [5]. This method is very excellent as it is simple and stable to noise but it is very much time consuming.

B. Active Contour Algorithm

In the last few years implicit active contours, also known as level set techniques, have been the subject of active research. The implicit active contour, or level set, approach was introduced by Osher and Sethian and later it has been improved by several authors [4]. The idea behind active contours, or deformable models, for image segmentation is quite simple. The user specifies an initial guess for the contour, which is then moved by image driven and forces to the boundaries of the desired objects. In such models, two types of forces are considered – the internal forces, defined within the curve that are designed to keep the model smooth during the deformation process, while the external forces, which are computed from the underlying image data, are defined to move the model towards an object boundary or other desired features within the image. The method is accurate but the disadvantage lies in initial selection of seeds [6] [7].

C.Wavelet Based Algorithm

The wavelets use a hierarchical framework and each level passes through a low pass and high pass filter to capture the approximation and details of the image. One of the most important features of wavelet transforms is their multi-resolution representation where in the image is transformed into a local spatial/frequency representation by convolving the image with a bank of filters with some tuned parameters. Much research has developed in Multi resolution analysis models such as wavelet Transform and gabor wavelet transform which are the most popular multi resolution methods. When compared to the wavelet transform, the Gabor transform needs to select the filter parameters according to different texture. There is a compromise between redundancy and completeness in the design of the Gabor filters because of non-orthogonality. The effect of the Gabor transform is also limited to its filtering area. The Dual Tree Complex Wavelet Transform (DTXWT) is an over complete wavelet that provides both good shift invariance and directional selectivity over the discrete wavelet transform(DWT) and is computationally faster than the Gabor transform .

III. PROPOSED METHOD

The main consideration in the proposed method is to take up the merit from the above existing methods and to unite the methods to propose a new mechanism. The proposed method initially applies wavelets to a set of images in different resolutions. Region growing algorithm is used as a preliminary segmentation process to obtain initial seeds for active contour algorithm. These results are then used by the active contour model to segment the fingerprint image from its background. Active contours can produce more reasonable segmentation results than traditional segmentation methods, and therefore it offers better final results of image analysis as active contours always give continuous boundaries of sub-regions. The block diagram of the proposed method is shown in figure 2.

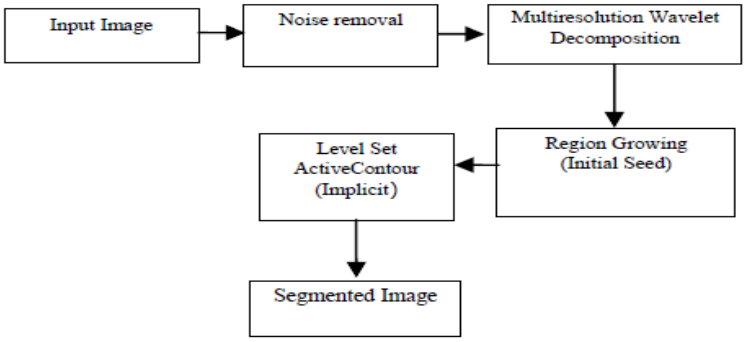

Figure 2. Block diagram of proposed method

A. Multi resolution Wavelet Transformation

Hierarchical framework is adopted by the wavelets and every level passes through a low pass and high pass filter to confine the approximation and details of the fingerprint image. Once filtering is done, the image is sub sampled by two, therefore reducing the resolution by half. This decomposition step can be repeated using low-pass filtered subsamples as a best approximate representation of the original image at multiple resolutions. The pyramid structure obtained is shown in Figure 3. This image reveals that the bottom image is at the original resolution and gets smaller while moving towards the top as a result of successive decompositions. The outcome of wavelet transformation is a set of images at dissimilar resolutions.

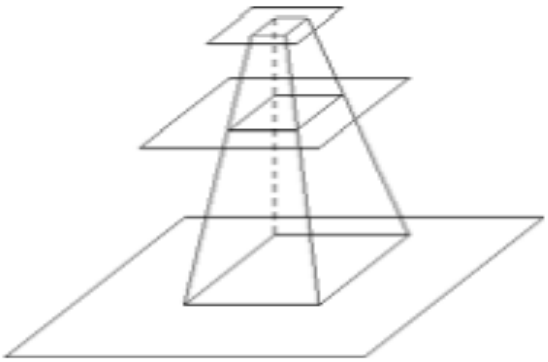

Figure 3. Representation of the original image at multiple resolutions

B. Region Growing Procedure

The region growing procedure is carried out by four steps which are as follows:-

1. Convert the RGB color space to HIS color space.
2. For each resolution image, decide the maximum and minimum intensity. Component) and compute its mean value. Also compute the standard deviation and let this be represented as $f\acute{Y}$ and $f\tilde{a}$ respectively.
3. Compute the threshold T as $f\tilde{a} + 0.2f\acute{Y}$. The value 0.2 was obtained after performing a number of experiments and select it as the optimum result.
4. The regions which are having less than T value spot them as background and the rest as foreground regions. So that the initial seed points for active contour algorithm is obtained.

C. Level set Active Contour Algorithm (Implicit)

The algorithm execution starts with a closed curve in two dimension counter and allows the curve to move perpendicular to itself at a specified speed. In two ways a curve can be described. An explicit parametric form and the implicit active contour approach. In case of splitting or merging of a curve is required the explicit parametric form may cause difficulties, during their evolution to the preferred shape [9]. To defeat this complexity the implicit active contour approach is used. In the implicit active contour approach it takes the original interface and embeds it in higher dimensional scalar function, defined over the entire image instead of explicitly following the moving interface itself. The interface is now represented implicitly as the zero'th level set of this scalar function. The initial seed points obtained from region growing procedure is given as input to the active contour algorithm [8].

The active contour algorithm consists of the following steps:-

Step 1: Set the first contour.
Step 2: Set the contour shape as circle and obtain the preliminary assumed distance.
Step 3:At the beginning of each iteration compute external energy with respect to x and y Level set algorithm for all N iterations do.
Step 4: Find shortest traveling time from point x to boundary.
Step 5: Estimate energy, compute partial differential equation and decide distance, curvature terms, gradient, and speed.
Step 6: Update level set function and reinitialize seeds.
Step 7: Compute change and record in contour.
Step 8: Display segmented image.

IV. EXPERIMENTAL RESULTS

A number of experiments were conducted to analyze the performance of the proposed segmentation algorithm. A data set containing 100 fingerprint images was considered for conducting the experiment. We have used MATLAB to develop the segmentation model. The proposed algorithm was evaluated using four test images shown in Fig.4 which were selected randomly.

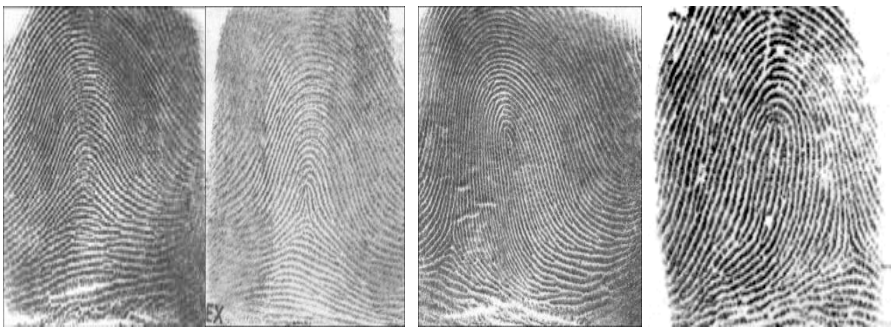

Figure 4. Test Images

The result of the segmentation is shown in Figure 5. From the results that the proposed algorithm with the combination of region growing and active contour is efficient in segmenting the fingerprint from its background.

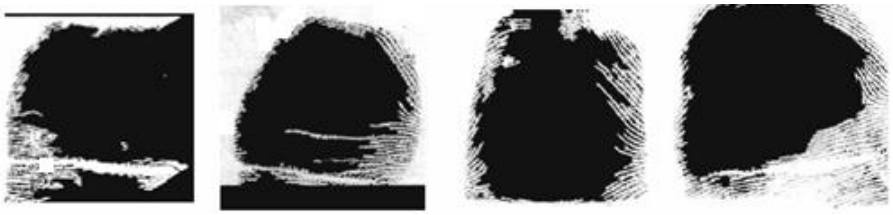

Figure 5. Region growing method

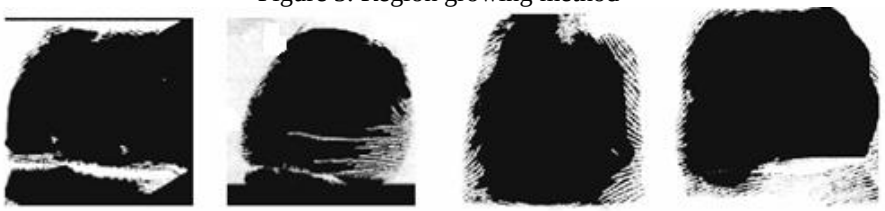

Figure 6. Active Counter Method

Figure 7. Proposed Segmentation Method.

Table 1 shows the speed of segmentation. From the table (from a set of sample images) , it can be seen that the proposed algorithm is the fastest when compared with the other segmentation algorithms.

Table I. Speed of the segmentation algorithms

Sample Images Chosen	Image Region	Contour	Proposed Method
Image 1	8.86	7.10	3.19
Image 2	11.22	8.61	4.21
Image 3	11.27	7.61	4.86
Image 4	9.86	6.10	5.12
Image 5	10.22	8.61	6.11
Image 6	13.27	9.61	7.45

Thus, from the set of results it is found that the proposed technique of segmentation is proficient in extracting the fingerprint from its background.

V. CONCLUSION

In this paper, we have discussed how to segment an image from its background using hybrid segmentation method. In the proposed algorithm we have used wavelet decomposition, region growing algorithm and active contour model in a sequential manner to extract the fingerprint. When compared with the existing algorithms performance evaluation of the proposed algorithm witnessed more on efficiency front and was faster than existing methods.

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