An Enhanced Active contour based Segmentation for Fingerprint Extraction

S.Uma maheswari
Research Scholar
Department of Computer Science,Karpagam University
Coimbatore, India

Dr.E.Chandra
Dean, School of Computer Studies
Dr.SNS Rajalakshmi College of Arts and Science
Coimbatore,India

***Abstract*— Fingerprint Segmentation is one of the critical and important steps in Automatic Fingerprint Recognition System (AFIS). It is a process that separates the fingerprint image into two regions, the foreground and background. 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 further process. In this paper some of the frequently used existing methods are analyzed and implemented. Then all these methods are combined in a sequential manner to propose an enhanced segmentation method. Finally the proposed method is evaluated and compared with the existing algorithm. Experimental results proved that the efficiency of the proposed method is higher than those of the previously described methods**.

Keywords- Segmentation, AFIS, Multiresolution Wavelet, Region Growing, Active contour.

I. INTRODUCTION

Segmentation of fingerprint image plays a major role in an Automatic Fingerprint Identification System (AFIS) which is one of the first and essential preprocessing step. Fingerprint segmentation is a process of extracting the foreground region from the background region as shown in Fig.1. In the fingerprint images a clear fingerprint ridge area constitutes the foreground and rest of the image such as blank regions, the dirt and oil regions, and other such noisy regions devoid of clear fingerprint ridges, constitute the background. The further steps for recognition like enhancement, ridge skeleton, noise cleaning, minutiae extraction and so on, can be concentrated only on the foreground and the background region can be removed from further analysis thus saving time and costs. Therefore segmentation plays a major role in the accuracy of a fingerprint recognition system.

(a) (b)

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

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

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

Several approaches to fingerprint segmentation are given in the literature [1].There are two types of fingerprint segmentation algorithms: unsupervised and supervised. Unsupervised algorithms extract blockwise

features such as local histogram of ridge orientation [2] [3]. Gray-level variance, magnitude of the gradient in each image block [4], Gabor feature [5], [6]. Practically, the presence of noise, low contrast area, and consistent contact of a fingertip with the sensor may result in loss of minutiae or more spurious minutiae

Supervised method usually first extracts several features like coherence, average gray level, variance and Gabor response [6],[7],[8] then a simple linear classifier is chosen for classification This method provides accurate results, but its computational complexity is higher than most unsupervised methods. In the method proposed in [9] a variance and mean based threshold method has been used for segmentation. All these methods showed good results in terms of efficiency and robustness with high resolution fingerprints. But still a robust segmentation method is required to deal with low quality images and also to save time and costs. A good segmentation will lead to an accurate fingerprint recognition system.

In this paper we have analyzed some of the existing segmentation methods and implemented. Then by combining the advantages of the methods a new segmentation method has been proposed. This paper is organized as follows. In the following sections, first, some of the most important segmentation methods are introduced. In section 3, the proposed method is implemented and experimental results are shown. Finally a brief conclusion section will summarize the paper.

II. EXISTING METHODS FOR IMAGE SEGMENTATION

This section presents some of the existing methods that are frequently used to segment images

A. Wavelet Based Model

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 the image is transformed into a local spatial/frequency representation by convolving the image with a bank of filters with some tuned parameters. Many Research is developing multiresolution analysis models such as wavelet Transform(10-14) and gabor Wavelet ransform(15-19) which are the most popular multi resolution methods[20]. 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 nonorthogonality. The effect of the Gabor transform is also limited to its filtering area. The Dual Tree Complex Wavelet Transform (DTXWT) [21] 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.

B. Region Growing Algorithm

This method is also known as pixel based segmentation image segmentation. The basic idea of this algorithm is: finding a special block in the fingerprint region, called seed block, the seed blocks region is called seed region. On scanning a seed block's 8 neighbors, if they meet the growing conditions, they are added to the seed blocks' set. The algorithm stops until non-block matches the conditions. This process is iterated on. Though the method is simple and stable to noise it is very much time consuming.

C. Active Contour Model

Implicit active contours, also known as level set techniques, have been the subject of active research in the last few years. The implicit active contour, or level set, approach was introduced by Osher and Sethian[22] and has since been enhanced by several authors.[23-26] An easy-to-understand high-level description of the level set method is given in.[27] .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 forces to the boundaries of the desired objects. In such models, two types of forces are considered - the internal forces, defined within the curve, 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 toward an object boundary or other desired features within the image. The method is accurate but the disadvantage lies in initial selection of seeds**.**

III. PROPOSED METHOD

The main idea of the proposed method is to take up the advantages of the above existing methods and to combine all the three methods to propose a new method. The proposed method first 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. As active contours always provide continuous boundaries of sub-regions, they can produce more reasonable segmentation results than traditional segmentation methods, and consequently improve the final results of image analysis. The block diagram of the proposed method is shown in Fig. 2.

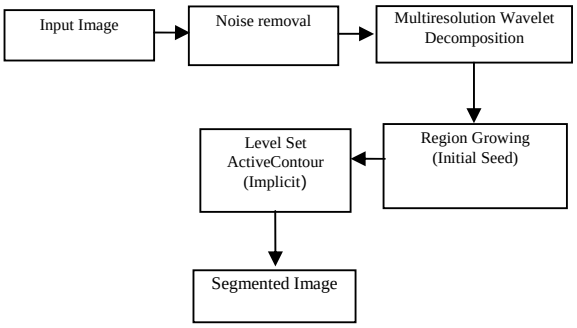

Figure 2.Block diagram of the proposed method.

A. Multrresolution Wavelet Transformation

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 fingerprint image. After filtering, the image is subsampled by two, thus reducing the resolution by half. This decomposition step can be repeated using low-pass filtered subsamples as best approximate representation of the original image at multiple resolutions. The pyramid structure obtained is shown in Fig.3, the bottom image is at the original resolution and gets small while moving towards the top as a result of successive decompositions. The result of wavelet transformation is a set of images at different resolutions.

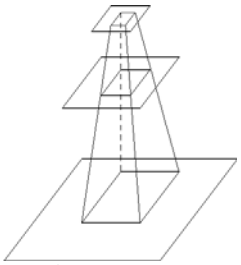

Figure 3.Representation of the original image at multiple resolutions

B. Region Growing Procedure

The steps followed in region growing procedure are:

1. Convert the RGB colour space to HIS colour space.
2. For each resolution image, determine the maximum and minimum intensity (I Component) and calculate its mean value. Also calculate the standard deviation. Let this be denoted as μ and σ respectively.
3. Calculate the threshold T as $\sigma + 0.2\mu$. The value 0.2 was obtained after performing several experiments and selecting the one which gave optimum result.
4. Mark regions less than T as background and the rest as foreground regions.

Therefore the initial seed points for active contour algorithm is obtained.

C. Level set Active Contour Algorithm(Implicit)

Initially the algorithm starts with a closed curve in two dimensions and allow the curve to move perpendicular to itself at a prescribed speed .There are two ways in describing the curve, an explicit parametric form(approach used in snakes) and the implicit active contour approach. The explicit parametric form may cause difficulties when the curves have to undergo splitting or merging, during their evolution to the desired shape. To overcome this difficulty the implicit active contour approach is used, where 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 (or contour) of this scalar function. The initial seed points obtained from region growing procedure is fed as input to the active contour algorithm. The steps followed in active contour algorithm are

1. Set the initial contour.
2. Set the contour shape as circle and obtain the initial assumed distance.
3. At the beginning of each iteration calculate external energy with respect to x and y separately.

4. Level set algorithm
5. for all N iterations do
6. Find shortest traveling time from point x to boundary
7. Estimate Energy and calculate Partial Differential Equation
8. Determine distance, curvature terms, gradient, speed
9. Update level set function
10. if Iterations ≤ N then
11. Reinitialize seeds
12. Calculate change and record in Contour
13. end
14. end
15. Displays segmented image

IV. EXPERIMENTAL RESULTS

Several experiments were conducted to analyze the performance of the proposed segmentation algorithm. The experiments were conducted on a dataset containing 1000 fingerprint images. The segmentation model was developed in MATLAB 2009a and was tested on a Pentium IV machine with 4 GB RAM. The proposed algorithm was evaluated using four test images shown in Fig.4 that were selected randomly.

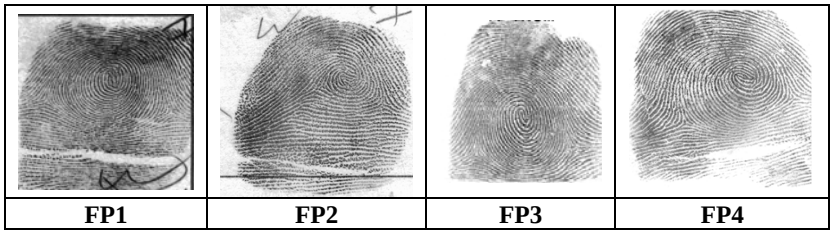

Figure 4. Test Images

The segmentation result is shown in Fig.5. It can be seen from the results that the proposed algorithm combining region growing with active contour is efficient in segmenting the fingerprint from its background

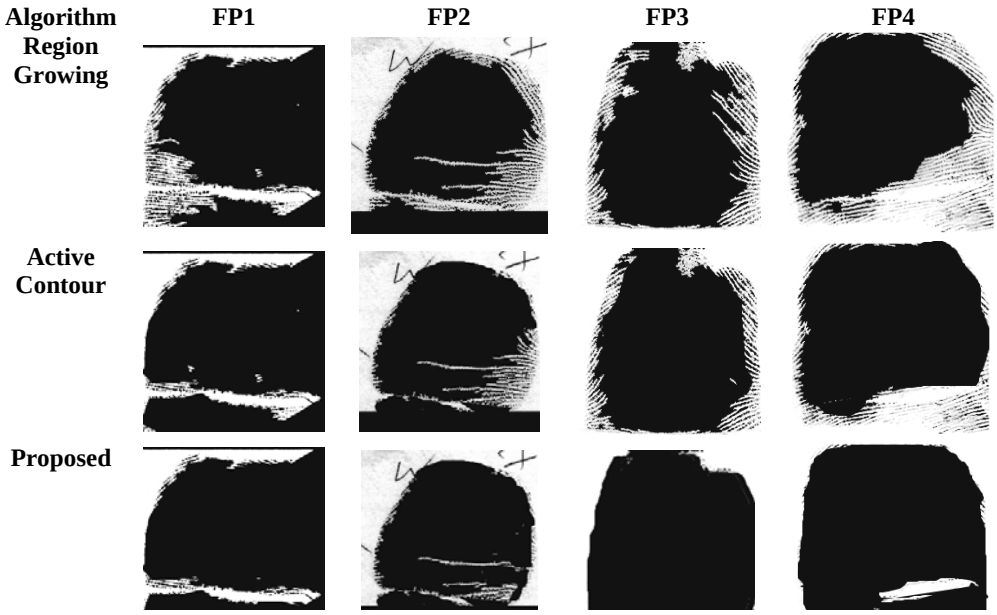

Figure 5.Segmented Images

Table 1 shows the speed of segmentation. From the table, it can be seen that the proposed algorithm is the fastest when compared with the other segmentation algorithms.

TABLE 1 SPEED OF THE SEGMENTATION ALGORITHMS

Image	Region	Contour	Proposed
Image 1	9.86	8.02	3.19
Image 2	11.41	9.41	4.13
Image 3	10.97	8.81	3.76

Thus, from various results it can be seen that the proposed method of segmentation is efficient in extracting the fingerprint from its background in a fast manner.

V CONCLUSION

In this paper, we introduced a hybrid segmentation method to segment fingerprint image from its background. The proposed algorithm used wavelet decomposition, region growing algorithm and active contour model in a sequential manner to extract the fingerprint. Performance evaluation of the proposed algorithm showed that the method is efficient and fast when compared with the existing algorithms. In future, this algorithm will be combined with a fingerprint recognition system.

REFERENCES

[1] Lumini, A., L. Nanni and D. Maltoni, 2008.Learning in Fingerprints book chapter, In Boulgouris, N.V., K.N. Plataniotis and E. Micheli Tzanakou, Biometrics: theory, methods and applications, IEEE/Wiley Press.

[2] M. Mehtre, et al., 1987,Segmentation of Fingerprint Images Using the Directional Image, Pattern Recognition, (20) 4,429-435.

[3] B.M.Mehtre and B.Chatterjee, 1989,Segmentation of Fingerprint Images-A Composite Method, Pattern Recognition, (22) 4,381-385.

[4] Bazen A.M., Sabih H.G, 2001,Segmentation of fingerprint images, Proc. ProRISC .

[5] Alonso-Fernandez, F., Fierrez-Aguilar, J., Ortega- Garcia, J.,2005,An enhanced gabor filter-based segmentation algorithm for fingerprint recognition systems, Proceedings of the 4th International Symposium on Image and Signal Processing and Analysis, 239–244.

[6] Bazen, A., Gerez, S., 2001, Segmentation of fingerprint images,Workshop on Circuits Systems and Signal Processing,. 276–280.

[7] Pais Barreto Marques, A.C., Gay Thome, A.C., 2005, A neural network fingerprint segmentation method, Fifth International Conference on Hybrid Intelligent Systems.

[8] Zhu, E., Yin, J., Hu, C., Zhang, G., 2006, A systematic method for fingerprint ridge orientation estimation and image segmentation. Pattern Recognition 39(8), 1452–1472.

[9] M. S. Helfroush, Dec. 2006, *Non-minutiae Based fingerprint verification*, Ph.D. Thesis, Tarbiat Modares University, Tehran, Iran.

[10] M.Unser 1995., "Texture classification and segmentation using wavelet frames," IEEE Trans. Image Process., vol. 4, no. 11, pp. 1549–1560.

[11] T. Chang and C.-C. J. Kuo 1992,, "A wavelet transform approach to texture analysis," in Proc. IEEE ICASSP, vol. 4, no. 23–26, pp.661–664.

[12] T. Chang and C.-C. J. Kuo 1992., "Tree-structured wavelet transform for textured image segmentation," Proc. SPIE, vol. 1770, pp. 394–405.

[13] T. Chang and C.-C. J. Kuo 1993., "Texture analysis and classification with tree-structured wavelet transform," IEEE Trans. Image Process., vol. 2, no. 4, pp. 429–441.

[14] W. Y. Ma and B. S. Manjunath 1995, "A comparison of wavelet transform features for texture image annotation," Proc. IEEE Int. Conf. Image Processing, vol. 2, no. 23–26, pp. 256–259.

[15] W. Y. Ma and B. S. Manjunath 1996., "Texture features and learning similarity," Proc. IEEE CVPR, no. 18–20, 425–430.

[16] B. S. Manjunath and W. Y. Ma ,1996., "Texture feature for browsing and retrieval of image data," IEEE Trans.Pattern Anal. Mach. Intell., vol. 18, no. 8, pp. 837–842.

[17] A. K. Jain and F. Farrokhnia 1991, "Unsupervised texture segmentation using Gabor filters," Pattern Recognition vol. 24, no. 12, pp. 1167-1186.

[18] W. E. Higgins, T. P. Weldon, and D. F. Dunn 1996. "Gabor filter design for multiple texture segmentation," Opt. Eng., vol. 35, no. 10, pp. 2852–2863.

[19] [19] N.W. Campbell and B. T. Thomas 1997,, "Automatic selection of Gabor filters for pixel classification," in Proc. 6th Int. Conf. Image Processing and its Applications, pp. 761–765.

[20] Roshni V.S, Raju G,2011," Image Segmentation using Multiresolution Texture Gradient and Watershed Algorithm", *International Journal of Computer Applications (0975 – 8887),Volume 22– No.6.*

[21] N. Kingsbury 2000,"The dual-tree complex wavelet transform with improved orthogonality and symmetry properties," in Proceedings IEEE Conference on Image Processing, Vancouver

[22] S. Osher and J. A. Sethian, 1988, "Fronts propagating with curvature dependent speed: Algorithms based on Hamilton-Jacobi formulations," Journal of Computational Physics 79, pp. 12-49.

[23] J. Sethian, 2003,Level Set Methods and Fast Marching Methods: Evolving Interfaces in Computational Geometry, Fluid Mechanics, Computer Vision, and Materials Science, Cambridge University Press.

[24] R. Malladi, Geometric methods in Bio-Medical Image Processing, Springer, 2002.

[25] S. Osher and N. Paragios, 2003, Geometric Level Set Methods in Imaging, Vision, and Graphics, Springer-Verlag.

[26] S. Osher and R. Fedkiw, 2003 ,Level Set Methods and Dynamic Implict Surfaces, Springer-Verlag.

[27] J. A. Sethian, 1997, "Tracking interfaces with level sets," American Scientist 85(3).

AUTHORS PROFILE

S.Uma maheswari received the M.Sc degree from Bharathiar University, India and she is currently pursuing the Ph.D., degree in Karpagam University, India. Her research interests include image processing and their applications in Biometrics.

Dr.E.Chandra received her B.Sc., from Bharathiar University, Coimbatore in 1992 and received M.Sc., from Avinashilingam University ,Coimbatore in 1994. She obtained her M.Phil., in the area of Neural Networks from Bharathiar University, in 1999. She obtained her PhD degree in the area of Speech recognition system from Alagappa University Karikudi in 2007. She has totally 16 yrs of experience in teaching including 6 months in the industry. At present she is working as Director, School of Computer Studies in Dr.SNS Rajalakshmi College of Arts & Science, Coimbatore. She has published more than 30 research papers in National, International journals and conferences in India and abroad. She has guided more than 20 M.Phil., Research Scholars. At present 3 M.Phil Scholars and 8 Ph.D Scholars are working under her guidance. She has delivered lectures to various Colleges in Tamil Nadu & Kerala. She is a Board of studies member at various colleges. Her research interest lies in the area of Neural networks, speech recognition systems, fuzzy logic and Machine Learning Techniques. She is a Life member of CSI, Society of Statistics and Computer Applications. Currently Management Committee member of CSI Coimbatore Chapter