A Fully Automatic Scheme for Medical Image Segmentation with Wavelet Based Image Fusion

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Abstract **-** *Medical image segmentation has become an essential technique in clinical and research- oriented applications. Because manual segmentation methods are tedious, and semi automatic segmentation lacks the flexibility, fully-automatic methods have become the preferred type of medical image segmentation. This work proposes a robust fully automatic segmentation scheme based on the modified contouring technique. The entire scheme consists of three stages. In the first stage, the wavelet transform of image is computed. This is followed by the fusion of LH, HL and HH coefficients (Method-II) or fusion of two different source images (Method-I). For that fused image local threshold is computed. This is followed by the second stage in which the initial points are determined by computation of global threshold. Finally, in the third stage, searching procedure is started from each initial point to obtain closed-loop contours. The whole process is fully automatic. This avoids the disadvantages of semi-automatic schemes such as manually selecting the initial contours and points.*

Keywords: A discrete wavelet transforms, image fusion, global threshold, local threshold.

1 Introduction

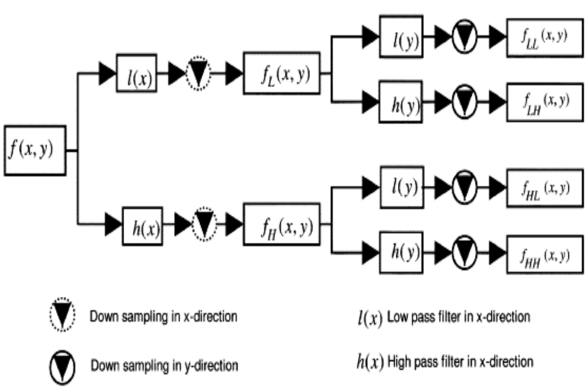
In recent years, medical image segmentation is the primary research subject of image processing applications. This performing various types of volumetric and shape comparisons among different structures. Since the introduction of medical image segmentation, many methods have been implemented for segmentation. These methods can be categorized into manual, semi-automatic, and fully automatic methods. Manual segmentation is tedious, requires training and much attention to detail, and the results are not reproducible. The semi-automatic method is second method become the preferred type of some of medical image segmentation [1]. The drawbacks of Semi-automatic Segmentation requires selecting different initial points for different images, as well as setting different thresholds before deriving the desired contour of an object. However an object With many sharp corners needs user selected points, thereby increasing operation time. The fully automatic segmentation may be applied to a specific type of image or general type of Images. In this paper the method is applied for specific type of images. The segmented objects exhibit some similarity. Accordingly, some criteria may be predetermined to simplify the segmentation procedure. In the case of medical images, fully automatic segmentation is applied on body part images to obtain their contours. With such a method, information on characteristics such as the area, lengths, and angles of an organ could be obtained to provide assistance to a doctor's diagnosis. Fully automatic segmentation is known to be exceedingly fast and completely free of human interaction. In practice, these attributes would provide fast, correct and objective data to assist with diagnosis, which is a critical aspect related to medical image processing.

This new method used the wavelet domain association rules for efficient segmentation. The performed computer simulation results showed that the proposed wavelet domain association rules were quite efficient. The results are better than the intensity domain association rules results.

The organization of this paper is as follows, the Section 2 gives the theory for 2-D discrete wavelet transform. In Section 3 the methodology and the implementation of the proposed process is explained. In Section 4 experimental study is introduced and the segmented image results are shown.

2 2-D Discrete Wavelet Transform Based Image fusion

Wavelets are finite duration oscillatory functions with zero average value. The irregularity and good localization properties make them better basis for analysis of signals with discontinuities. Wavelet decomposition is widely used in time series and image analysis. Its salient advantage over other analysis methods, especially Fourier transform, is that it can give not only frequency information of a signal, but can also localize that information in the temporal (spatial) domain. Because of their suitability for analysing non-stationary signals, they have become a powerful alternative to Fourier methods in many medical applications, where such signals abound. The main advantages of wavelets is that they have a varying window size, being wide for slow frequencies and narrow for the fast ones, thus leading to an optimal time-frequency resolution in all the frequency ranges. Furthermore, because windows are adapted to the transients of each scale, wavelets lack the requirement of stationary.



(a)

LL	LH
HL	HH

(b)

Fig. 1. (a) Schematic of one-level 2-D Discrete Wavelet decomposition. (b) Representation of 2-D Discrete Wavelet Transform of an image.

A schematic for a one-level decomposition of a 2-D image is shown in Fig. 1(a). A high-pass and a low-pass filter are applied to the image in the direction (across the row of the matrix), and the results are down-sampled by deleting every other column. This results in two images of approximately half size of the original, one containing high frequency components of the rows and the other containing low frequency components. These two images are then each filtered down the columns using high-pass and low-pass filters and down-sampling the results along the rows (deleting every other row). The resulting four images are approximately one-fourth the size of the original image. The sub images fLL, fLH, fHL and fHH represent the smoothed approximation, the horizontal detail, the vertical detail, and the diagonal detail sub images, respectively Fig. 1(b). The process can be iterated on the smoothed approximation sub image to obtain the decomposition in the next level.

2.1 Image Fusion

The importance of information offered by the medical images for diagnosis support can be increased by combining images from different compatible medical devices. The fusion process allows combination of salient feature of these images. Fusion process should conserve all important analysis information in the image and should not introduce any artifacts or inconsistencies while suppressing the undesirable characteristics like noise and other irrelevant details. The input images to be fused are decomposed by forward wavelet transformation. Each image is decomposed into the same levels using a discrete wavelet transform. The wavelet transform decomposes each image into low- and high-frequency sub-band images. The principle of image fusion using wavelets is to merge the wavelet decompositions of the original images using fusion methods to approximations coefficients and details coefficients. In this paper the preferred fusing method for approximation and details of medical images are maximum mode.

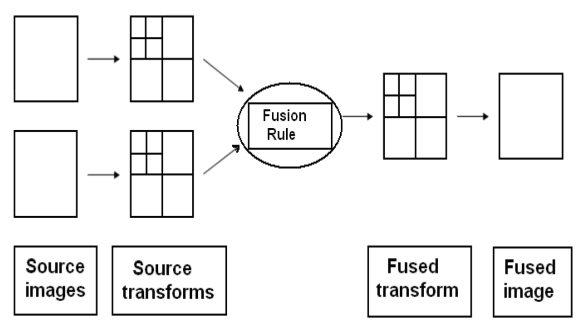


Fig 2: General Fusion Transform

The main idea of our algorithm is that:

(1) The two images to be processed are re sampled to the one with the same size.

(2)They are respectively decomposed into the sub images using forward wavelet transform, which have the same resolution at same levels and different resolution among different levels.

(3) Information fusion is performed based on the high frequency sub images of decomposed images and finally the result image is obtained inverse wavelet transform.

3 Proposed Scheme

The entire procedure consists of three stages. The final output is automatic segmented image. Fig 3 illustrates the flowchart of the system. The fully automatic segmentation process steps are as follows:

Step1: Read the two different source medical images to be fused (MRI/CT Scan images-Method-I). Otherwise fuse 3-sub bands of DWT coefficients of input image (except LL –Method-II).

Step2: Perform image fusion on two different images with one level transformation with maximum mode for approximation and details coefficients.

Step3: Determine the local threshold

The fused image is partitioned into B X B blocks. The maximum of the difference between the right and left neighboring points in direction of d are defined as $C_{m,n}(x,y)$ in eq.(1).

$$C_{m,n}(x, y) = \mathrm{Max}\left(\left| I\left(r^{d}_{m,n}(x,y)\right) - I\left(l^{d}_{m,n}(x,y)\right)\right|\right) \quad (1)$$

where d=0 to 3.

The right and left neighboring points of (x, y) in direction of d are shown below

$$r^{d}(x,y) = \left(x + \left(Cos\left(d \times \frac{\Pi}{4} \right)\right), Y - \left(Sin\left(d \times \frac{\Pi}{4} \right)\right)\right) \quad (2)$$

$$l^{d}(x,y) = \left(x + \left(Cos\left(\left((d+4) \bmod 8 \right) \times \frac{\Pi}{4} \right)\right), Y - \left(Sin\left(\left((d+4) \bmod 8 \right) \times \frac{\Pi}{4} \right)\right)\right) \quad (3)$$

$$T_{G\,m,n} = \max\left(C_{m,n}(x, y)\right) \quad (4)$$

$$T = \left(\min\left(T_{g\,m,n}\right) + \max\left(T_{g\,m,n}\right)\right)/2 \quad (5)$$

The coordinates of each block in an image frame are (m, n) both m and n range from 0 to B-1. The coordinates in each block are (x, y), where x ranges from 0 to (M/B)-1 and y ranges from 0 to (N/B)-1. M and N represent the width and the height of the image, respectively.

Step 4: Finding the global threshold

After T is computed, the global threshold is computed as follows:

$$C(x, y) = \mathrm{Max}\left(\left| I\left(r^{d}(x,y)\right) - I\left(l^{d}(x,y)\right)\right|\right) \quad (6)$$

Here the x ranges from 0 to M-1 and y ranges from 0 to N-1 this indicates the whole image to compute the relation between all possible neighboring directions is considered.

Step 5: obtain the closed loop contours

If C(x, y) is greater than T, then the pixel value is set at 1 otherwise 0. This gives segmented output.

After computing all the steps the obtained binary image is automatic segmented image of input image.

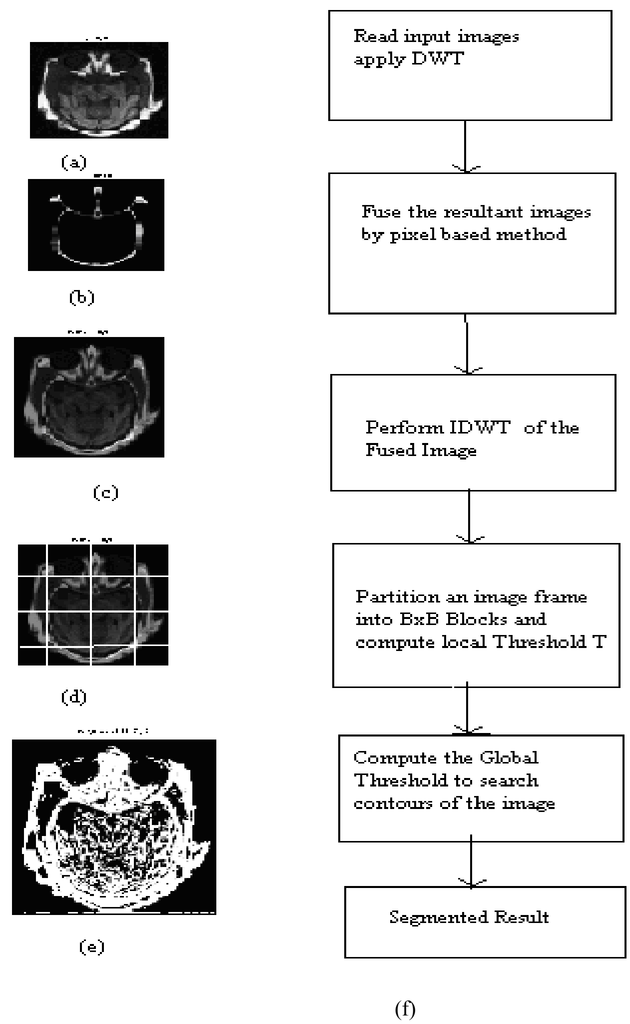
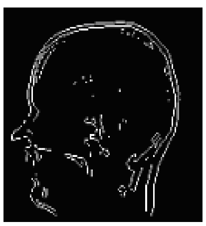


Fig 3: (a) – (b) CT Scan &MRI Scan image (c) IDWT of Fused Image (d) the entire image is partitioned into BxB blocks (e) Closed loop Contours (f) Flow chart of the proposed Scheme.

4 Experimental Results and Discussion

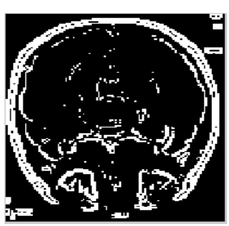
The most essential task of the segmentation process is the discrimination of each spot's foreground from its background. The experiments are performed on 20 different images which are having the size of divisible by selected mask size. The experiment is performed on different MRI & CT scan images of body. The same experiment also performed on individual medical images with sub band coefficient fusion method. The all segmented results give almost closed contours and gives detailed analysis. The various segmented results are shown below with both the methods:

1(a)

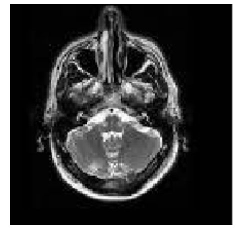


1(b) 1(c)

2(a)



2(b) 2(c)



3(a)

3(b) 3(c)

4(a)

4(b) 4(c)

Fig 4: 1(a)-4(a) the input images 1(b)-4(b) the output of conventional edge method 1(c)-4(c) the closed contours obtained by proposed method. (This process is through method –II i.e., fusion of sub band co efficient.)

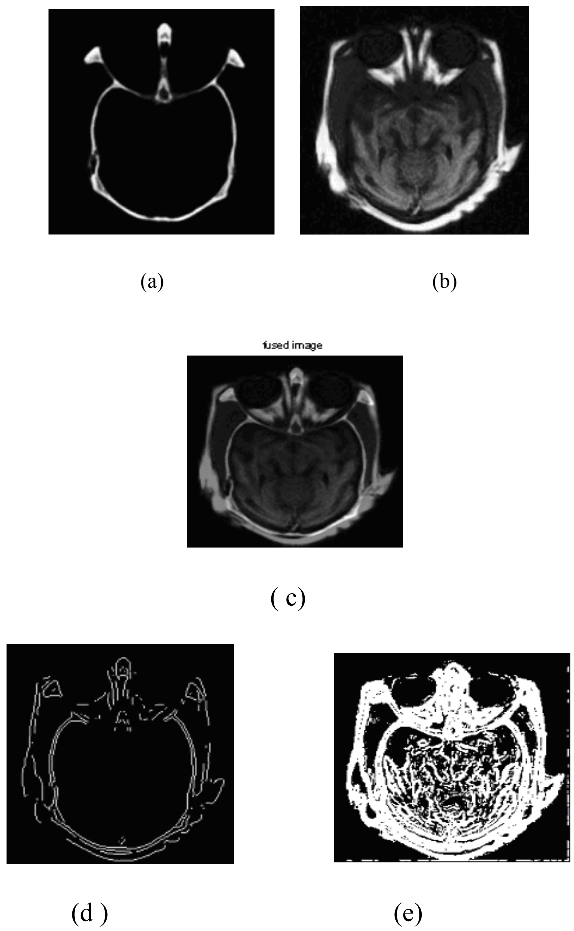


Fig 5: (a)-(b) are input images of MRI & CT scan (c) Fused image for further processing (d) output image of conventional edge method (e) output image with closed contours obtained by proposed method. (Method-I).

By comparing the proposed scheme results with watershed scheme results, the contour is nicely segmented without broken sections, and the regions are more successfully segmented.

5 Conclusions and Future Scope

In this paper, we proposed a new fully automatic segmented method without any manual interaction. This method integrates multi scale image segmentation and a statistical fusion scheme. With this proposed method computing and analyzing the characteristics of the left and right neighboring points of the next estimated contour points has the ability to overcome noise interference. One of the main importances of proposed scheme does not need human input to select initial points and threshold values. This method can easily be extended to locate the closed loop contours of general images with small change on setting the threshold value. This fully automatic segmentation scheme as proposed herein can accurately and repeatedly segment multiple objects for various image and video applications.

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7 References

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