IMT Measurement Of Common Carotid Artery Usingmodifiedsnake Contour Segmentation

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Abstract: A new method of segmentation of ultrasound Carotid Artery (CA) has been proposed. Atherosclerosis is the thickening and narrowing of the arteries due to formation of plaque on the walls of the artery. It is one of the major causes of stroke.Intima-media thickness (IMT) is now being considered as an indicator of atherosclerosis. CA segmentation is based on the improvised snake's initialization method after the speckle reduction and normalization. All the images obtained here are b-mode longitudinal US images. This computerized method shows closer results as that obtained from manual measurements.

Initial terms: atherosclerosis, IMT measurement, speckle reduction, IMT initialization,snake based segmentation.

1. INTRODUCTION

A lumen in biology is the inside space of a contour structure, such as an artery [1, 2]. The figure 1 shows the different layers of the far wall of CA. The zones Z1 & Z6 correspond to the adventia layer while zones Z2 & Z5 correspond to the media layer and zones Z3 & Z4 correspond to the intima layers. Mainly our focus is on the Intima – Media thickness.

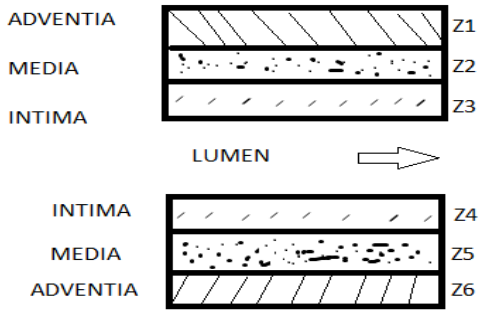

FIGURE 1: LAYERS OF CA WALL

The objective of work is to estimate IMT, which is supposed to be the indicator of atherosclerosis that leads to vascular diseases and stroke [3, 4].IMT is measured from the boundaries of lumen intima and media adventia. — Normal: IMT < 1.0 mm; Thickening: 1.0 mm < IMT < 1.3 mm Plaque: IMT > 1.3 mm. Initially the measurement of the thickness IMT was done manually using the steps in the algorithm but these methods suffer from many variations [5].

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The amount of human error encountered can also lead to chaos. These techniques are time consuming [6, 7].Hence to overcome all these automated systems was introduced. There is also softwaredeveloped to make this process automated. Even though automation has brought about some benefits there are a few problems associated with them [8,9].

2. PROBLEMS IN AUTOMATED SYSTEMS

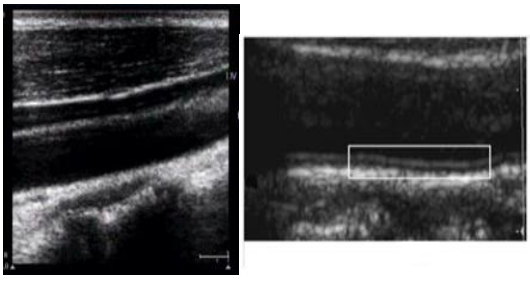
Presence of speckle noise-due to which the adventia layer may not have uniform intensity-incomplete boundaries. Dependence of entire procedure on the manually traced initial seed points.

3. PROPOSED ALGORITHM

The algorithm that is developed uses the snake based segmentation technique. It is a very simpler and efficient method. It aims in segmentation following the speckle noise reduction and image normalization [10]. This includes the image acquisition followed by the preprocessing which involves the normalization and removal of noise. This step is then followed by initialization of the snake contour [11] and applying it to the image and performing segmentation. The images must be obtained in sufficient number so that the exact analysis can be obtained. All the images obtained should be B-mode longitudinal ultrasound images. In includes the following steps.

3.1. Acquisition of the digital images

1. Resize the images using bicubic method to a standard pixel density of 16.66/mm.
2. Logarithmically compress the image and convert to 256 grey levels with a resolution of 768 X 576.



(a) (b)

FIGURE 2: A. ORIGINAL IMAGE, **B.** ROI

3.2. Image normalization

1. Algebraic linear scaling performed to obtain a median grey level value of 0-5 for blood and 180-190 for adventia.
2. The brightness of all the pixels in the image is adjusted according to this linear scale by selecting the two reference region.

3.3. speckle reduction

1. A linear scaling filter (lsmv) utilizing the mean and variance of a pixel of neighborhood is applied iteratively for 5 times on the image [12, 13].
2. The filter is applied 5 times continuously on each image and stored.

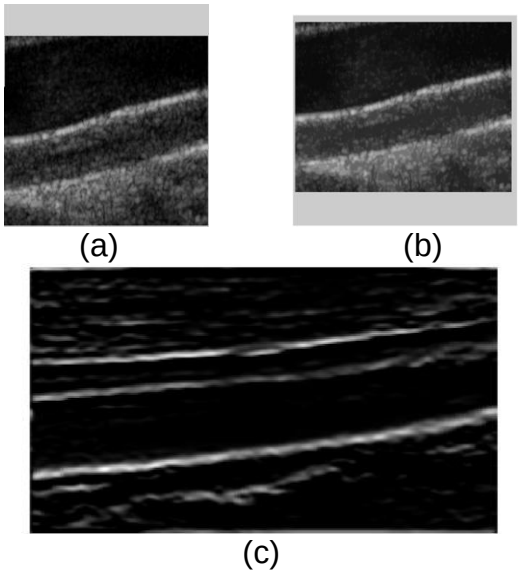


FIGURE 3: A. CROPPED IMAGE **B.** DILATED IMAGE **C.** NORMALIZED IMAGE

3.4. IMT initialization

It is done to ensure that the initial snake contour is closer to the area of interest.

1. Acquire the image and pick the area of interest for IMT to be detected.
2. Crop the selected area.
3. Despeckle the area by using lsmv filter.
4. convert the area into binary by image thresholding so that the edges can be easily found.
5. Dilate the image by using a 3X3 pixel element consisting of all ones which is multiplied with binary image.
6. Remove erroneous edges by connecting components in image using 8 pixels in the neighborhood.
7. Extract the contour matrix of above by locating the points and their coordinates on adventia and constructing a interpolating b-spline [13, 14].
8. Sample the interpolating b-spline in equi distant points to define the points on snakes contour.
9. Map the contour obtained to the initial image. Displace the initial contour upto 17 pixels to form initial snake contour based on the fact that IMT varies between 0.6 to 1.4 mm.
10. Thus the initialization using snakes is accomplished.

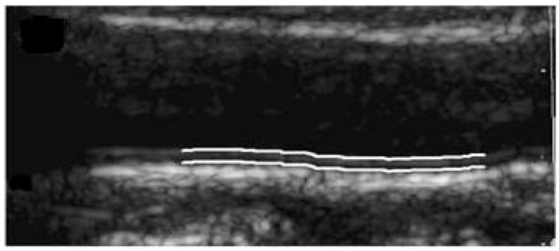


FIGURE 4. INITIAL SNAKES CONTOUR OF CA

3.5. IMT Segmentation

1. The snake segmentation based on Williams and shah snake using an energy function is discussed [15].
2. An additional image energy due to negative gradient of the current contour point gi,jis

$$E_{image}(v) = -\nabla_{i,j}^{2}$$

3. The irregular spacing between the contour points were considered to find the snake parameters $\alpha(s)$ and $\beta(s)$ where their initial values were taken asαi(s)=0.6,

   βi(s)=0.4 and γi(s)=2.

4. The final contour thus obtained shows the boundaries of intima and adventia. Difference between them is computed at all points. Average of them is computed as IMT_{mean}. Typically 0.65 for snake segmentation. $IMT_{min}$and IMT_{max} are also computed.

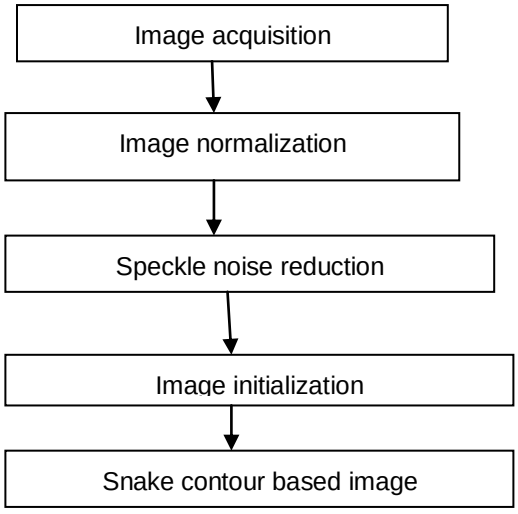


FIGURE 5: FLOWCHART OF THE PROCESS

4. RESULTS AND DISCUSSIONS:

The simulation is done using MATLAB. The results of the various steps involved in snake based IMT measurement are reported.

Step1: Initially the image is read and resized to the expected resolution.

Step 2: Linear scaling is done to obtain the 256 level grayscale image.

Step 3: Linear filtering is done to remove speckle noise in the adventia layer.

Step 4: Dilated binary image is obtained

Step 5: Edges are detected to obtain IMT using B Spline segmentation.

Step 6: Snake based contour is extracted fom the energy function.

The comparison results of different methods are tabulated-table 1.

Segmentation method	Accuracy of IMT(%)	Level of difficulty
Dynamic programming	93	Moderate
Edge detection	78	Moderate
Snakes	95	Moderate
Contour based segmentation	65	High
Model based	60	High

TABLE 1: COMPARISON OF VARIOUS METHODS

5. CONCLUSION:

The presented technique of snake based IMTmeasurement technique shows better performance due to the inclusion of efficient speckle noise reduction and image initialization. Initialization helps in maximizing the probability of the obtained snake contour to be closer or more or less equal to the actual area contour. The main advantage of the method is that it showssimilar results as that obtained by manual measurements.

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