Automatic Segmentation and Tracking of Intima Media Thickness in the Diagnosis of Common Carotid Artery Diseases

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Abstract

The identification and measurement of the Intima Media Thickness (IMT) have a high clinical relevance in accordance with cardiovascular disease. Fully automatic algorithm is developed for the analysis of arterial wall thickening and for automatic measurement, tracking and segmentation of the Intima Media Complex (IMC) in B-mode ultrasound video sequences. The Adaptive Normalized Correlation (ANC) algorithm requires a two-stage image analysis process that initially labels the segmentation of the IMC in the first frame of the ultrasound video sequence using a model-based approach.

Keywords: Intima Media Thickness (IMT), Cardiovasular disease, Adaptive Normalized Correlation (ANC)

I. INTRODUCTION

Atherosclerosis is a potentially serious condition where arteries become blocked by fatty substances known as plaques or atheroma. Atherosclerosis is a disease in which plaque builds up inside the arteries (i.e.) blood vessels that carry blood from the heart to the various organs of the body. Healthy arteries have smooth linings, allowing blood to flow smoothly which is called a normal artery. Damage to the lining of the arteries makes them rough, fatty substances, such as cholesterol which stick to the rough lining in the arteries as a result, plaque forms on the inner walls of the arteries. Plaque is made up of fatty substance like, cholesterol, calcium, and other substances found in blood. The plaque hardens and narrows your arteries. When plaque causes artery walls to narrow, it is called atherosclerosis. Atherosclerosis limits the flow of blood to the organs and other parts of the body. This can lead to serious problems or even death. Another way atherosclerosis affects blood flow is by causing blood to clot inside the artery. This is known as a thrombus. A thrombus can limit blood flow to important organs or detach itself from the plaque site, flow upstream in the artery and plug smaller arteries. Thrombus detaches itself it is called an embolism.

Plaque can build up in the major arteries that supply oxygen-rich blood to the legs, arms, and pelvis. This disease is called peripheral arterial disease. Fig 1 (a) shows the formation of plaque in human body. Fig 1 (b) shows the healthy artery and Fig 1 (c) shows the plaque buildup artery. If these major arteries undergoes any change in their shapes or blocked, it leads to numbness, pain, and dangerous infections. Atherosclerosis can be caused by many factors. Atherosclerosis may start when the inner layers of the arteries become damaged. Arteries may become damaged through, Smoking, High amounts of certain fats and cholesterol in the blood, High BP. When the arteries are damaged, plaque begins to build up in that region. An area of plaque can rupture, or break open.When this happens, vegetative cell fragments referred to as platelets stick with the positioning of the injury. They will clump along to create blood clots. Clots slim the arteries even additional, limiting the flow of oxygen-rich blood to your body.

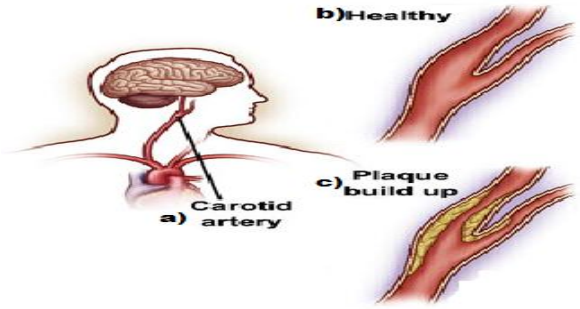

Fig. 1: (a) shows carotid artery present in human body. (b) Shows the clear view of healthy artery. (c) Shows the formation of plague build up in the artery

II. OUTLINE OF PROPOSED WORK

The complete outline of the work is shown in Fig 2 where the flow of module is illustrated. The algorithm developed is to find Intima Media Thickness (IMT) have the simple computational step. Adaptive Normalized Correlation (ANC) has following steps: automatic extraction, filtering, binarisation and morphological operation, these are detail explained in following section. The special feature of this algorithm is, it has two main principles, in first step the segmentation part will be done effectively and in second part tracking is done.

The advantages of Adaptive Normalized Correlation (ANC) are as follows,

- In ROI detection, the complexity to estimate the LI & MA interface is reduced.
- In IMT measurement, the need of assisting physicians is negligible and the measure of Stenosis can identified in early stage.

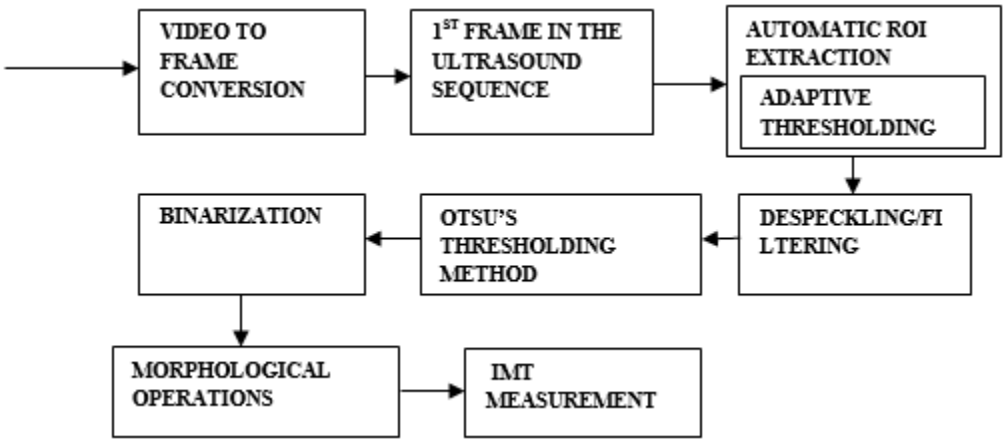

Fig. 2: shows the outline of proposed algorithm

A. Video to Frame Conversion in B-Mode Ultrasound Video Sequence:

The ultrasound video sequence of some patients is captured and using the command 'frame2im' the video is converted to frames in MATLAB software where the video is converted into sequence of images.

B. Automatic ROI Extraction:

Medical images hold decisive property and are very crucial and important part of information. Such part of the cropped medical image is called as Region of Interest (ROI). The ROI is helpful in providing further diagnosis by the physician. A small bit of distortion in ROI may lead to undesirable treatment for patient. Segmentation plays an important role in medical image processing. In medical image analysis segmentation is the first step to be followed, to avoid distortion of ROI. Image segmentation deals with the process of partitioning an image into different regions by grouping together neighborhood pixels based on some predefined similarity criterion. This similarity criterion can be defined by specific properties of pixels in the image. Segmentation in medical imaging in image processing is used for extracting the particular features, image display and for the measurement of image. The goal of segmentation is to divide entire medical image into sub regions i.e. (white and gray matter). In addition, this helps in classifying the medical image pixels into anatomical regions.

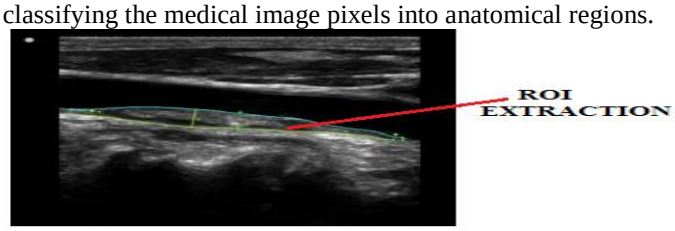

Fig. 3: shows the ROI of common carotid artery

C. IMC Segmentation in the Selected Frame of the Video Sequence:

Segmenting biological structures, e.g. artery or tissues structures, blood vessels, etc., from various types of medical images is very important for detecting abnormalities and that is used for studying and tracking progress of diseases, and surgery planning. Medical image segmentation is a difficult problem due to the fact that medical images commonly have poor contrasts, different types of noise, and missing or diffuse boundaries. There are number of algorithms developed in the literature targeting on either

general segmentation problems or the segmentation of special biological structures. Here, we propose a novel segmentation model called watershed segmentation that is the area with overlapping blood supply.

D. De-Speckling/ Filtering:

The segmented carotid artery region consists of multiple noises. Among them speckle noise content will be high. So in order to remove the noise we can use filters like lee, kuan, wavelet denoising and SRAD. The process of removing the noise content in the image by using filters is called De-speckling.Speckle, is a form of multiple and locally correlated noise, in certain images that has speckle, a goal is to remove the speckle without destroying important image features such as plague images. In certain applications, however, the removal of speckle may be difficult task. Examples in which speckle preservation is important which includes feature extraction, tracking in ultrasonic imaging [6] and detection of features that is of the same scale as the speckle patterns. In cases where speckle removal is needed (e.g., region-based detection, segmentation, and classification), the speckle reducing filters have originated mainly in the synthetic aperture radar community. The most widely cited and applied filters in these categories like Lee, Kuan. The Lee and Kuan filters have the same formation as above, although the signal model assumptions and the derivations are slightly different. Essentially, these filters form an output image by computing a linear combination of the center pixel intensity.

Based on parameters, the best filter was chosen and that image is given as input for next image. The parameters are PSNR, Mean Square Estimation, Normalized Cross Correlation and Normalized Absolute Error. Table 1 shows the value of parameter, it depends on the frame which we choose.

E. Morphological Operations:

After converting the image into binarized image, remove all the pixels smaller than 600 by using morphological operations. In the morphological processed image, remove the holes occurred between two lines. *Morphology* is a broad set of image processing operations that process images based on shapes. Morphological operations apply a structuring element to an input image, creating an output image of the same size. In a morphological operation, the value of each pixel in the output image is based on a comparison of the corresponding pixel in the input image with its neighbours. By choosing the size and shape of the neighbourhood, you can construct a morphological operation that is sensitive to specific shapes in the input image.
The most basic morphological operations are dilation and erosion. Dilation adds pixels to the boundaries of objects in an image, while erosion removes pixels on object boundaries. The number of pixels added or removed from the objects in an image depends on the size and shape of the *structuring element* used to process the image. In the morphological dilation and erosion operations, the state of any given pixel in the output image is determined by applying a rule to the corresponding pixel and its neighbors in the input image.

F. Measurement of Intima Media Thickness (IMT):

Intima-media thickness (IMT), also called intimal medial thickness, is a measurement of the thickness of tunica intima and tunica media the innermost two layers of the arterial wall. The measurement is usually made by external ultrasound, occasionally by internal, invasive ultrasound catheters, see IVUS, and measurements of the thickness of the wall of blood vessels can also be using other imaging modalities. Here, while measuring the intima media thickness the area cropped will give the result (i.e.) the thickness of the plaque. If the cropped region is affected by plaque then the result shows the value of IMT, else it returns null value.

III. SIMULATION RESULTS

To illustrate the performance of the proposed algorithm in a graphical mode, Fig. 5 and Table 1 shows the parameter comparison of proposed work, by comparing PSNR rate which is computed with other parameters the best filter is chosen as the output and this output will be the input of rest of the process.

Table - 1
The parameters and the corresponding filter values

Parameter	*LEE*	*KUAN*	*WAVELET*	*SRAD*
PSNR	*40.3677*	*37.5028*	*11.4928*	*47.486*
MSE	*5.9747*	*11.5558*	*4.611*	*1.1601*
NCC	*0.9943*	*0.9874*	*0.701*	*0.2309*
NAE	*0.0249*	*0.0376*	*0.9994*	*0.7885*

While comparing the parameters, the best filter is chosen as the final image and that image is given as the input for further process.

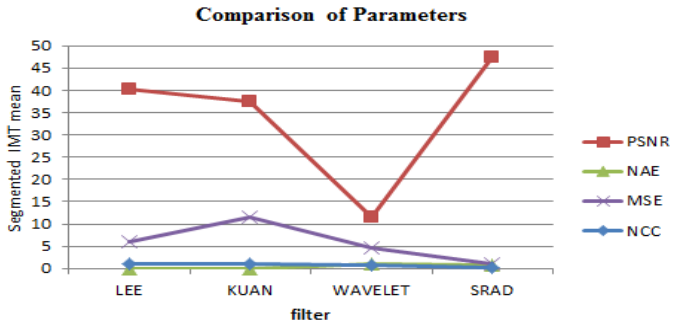

Fig. 4: shows the comparison of parameters

Fig 4 depicts the comparison graph of the parameters, where in the selected frame SRAD filter shows the mark able performance. The proposed algorithm entitles two stage of operations, in the first stage automatic segmentation is done and later the in the second part the plaque region was automatically tracked and the existing thickness will be displayed in the display screen. In Fig 5 the measurement of intima media thickness is shown.

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SRAD FILTER

ans =

PSNR is 47.358671 dB


ans =

EXISTING UPPER INTIMA MEDIA THICKNESS is 1.137707 mm
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Fig. 5: Intima Media Thickness

IV. CONCLUSION

A distinct characteristic of the majority of the published works that addressed the IMC segmentation is the substantial level of supervision that is required to compensate for the errors that are generated by the challenging imaging conditions that are present in the CCA video ultrasound data. The major objective of this paper was to introduce a new automatic methodology for the segmentation of IMC in longitudinal carotid B-mode video ultrasound sequences that is able to identify in an unsupervised manner the IMT changes. Thus an approach had successfully developed using MATLAB to automatically detect the carotid artery from ultrasound image.This software can aid inexperience doctor to identify which is carotid artery and finally the measurement of intima media thickness is processed and various performance parameters are evaluated.

REFERENCES

[1] Dana E. Ilea, Caoimhe Duffy, Liam Kavanagh, Alice Stanton, And Paul F. Whelan, "Fully Automated Segmentation And Tracking Of The Intima Media Thickness In Ultrasound Video Sequences Of The Common Carotid Artery, "IEEE Trans, On Ultrasound Ferroelectrics And Frequency Control Vol, 60 No 1, Jan 2013

[2] Francesco Faita, Vincenzo Gemignani,Elisabetta Bianchini, Chiara Giannarelli,Lorenzo Ghiadoni,Marcello Demi, "Real-time Measurement System for Evaluation of the Carotid Intima-Media Thickness With a Robust Edge Operator," Institute of Clinical Physiology, National Research Council, Pisa, Italy. Mar 2008.

[3] Dana E. Ilea, Paul F. Whelan, Catherine Brown, and Alice Stanton, "An Automatic 2D CAD Algorithm for the Segmentation of the IMT in d Artery Images," 31st Annual International Conference of the IEEE EMBS Minneapolis, Minnesota, USA, September 2-6, 2009.

[4] S. Golemati, S. Lehareas, N. N. Tsiaparas, A. Chatziioannou, K. S. Nikita, D. N. Perrea, "Multiresolution features of carotid artery wall and plaque toward identifying vulnerable asymptomatic cases from B-mode ultrasound "IEEE Joint UFFC, EFTF and PFM Symposium 2012.

[5] Filippo Molinari, Member, IEEE, Ganapathy Krishnamurthi, U. Rajendra Acharya, S. Vinitha Sree, Guang Zeng, Luca Saba, Andrew Nicolaides, And Jasjit S. Suri," Hypothesis Validation Of Far-wall Brightness In Carotid-artery Ultrasound For Feature-based IMT Measurement Using A Combination Of Level-set Segmentation And Registration "IEEE Transactions On Instrumentation And Measurement, Vol. 61, No. 4, April 2012

[6] D. E. Ilea, P. F. Whelan, C. Brown, and A. Stanton, "Automatic detection and measurement of the IMT in longitudinal sections of ultrasound images of the CCA," in European Congress of Radiology (ECR), 2010, art. No. SS 1205, B-522

[7] MA Gutierrez, PE Pilon, SG Lage, L Kopel, RT Carvalho, SS Furuie, "Automatic Measurement of Carotid Diameter and Wall Thickness in Ultrasound Images" IEEE Computers in Cardiology 2002.