

Robust Identification and Measurement of the Intima Media Thickness to Find Severeness of Cardiac Diseases Using Thresholding Method

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ABSTRACT : Carotid artery is one of the parts that hard to identify by inexperience doctor or radiologist because the shape is almost same like the muscle layer. A common, non-invasive test used to check for carotid artery disease is a Doppler ultrasound. This variation of the conventional ultrasound assesses blood flow and pressure and possible narrowing of the blood vessel by bouncing high-frequency sound waves (ultrasound) off red blood cells. Ultrasound images of carotid artery are one of the parts that hard to identify by inexperience doctor or radiologist because the shape is almost same like the muscle layer. Hence, a carotid artery automatic detection method using threshold is proposed in this study. The results will help the doctors and radiologist for further diagnosis. Besides that, the patient can get the correct earlier treatment and the chance to recover is increased. Carotid artery is one of the parts that hard to identify by inexperience doctor or radiologist because the shape is almost same like the muscle layer. A common, non-invasive test used to check for carotid artery disease is a Doppler ultrasound. This variation of the conventional ultrasound assesses blood flow and pressure and possible narrowing of the blood vessel by bouncing high-frequency sound waves (ultrasound) off red blood cells. Ultrasound images of carotid artery are one of the parts that hard to identify by inexperience doctor or radiologist because the shape is almost same like the muscle layer. Hence, a carotid artery automatic detection method using threshold is proposed in this study. From 20 ultrasound images that have been tested in the proposed method, the percentage of accuracy of automatic detection is at least 90 percent. The results will help the doctors and radiologist for further diagnosis. Besides that, the patient can get the correct earlier treatment and the chance to recover is increased.

KEYWORDS: carotid, non-invasive, Doppler ultrasound.

I. INTRODUCTION

Common carotid arteries are two of the several arteries that supply blood to the head. The right common carotid artery branches from the artery and extends up the right side of the neck. The left common carotid arteries branches from the aorta and extends up the left side of the neck. Each carotid artery branches into internal and external vessels near to the top of thyroid. External carotid artery is the major artery of the head and neck. All the common carotid arteries differ in their length and the mode of origin. The right common arteries begin at the bifurcation of the innominate artery behind the sternoclavicular joint and are con-fined to the neck. On the other hand, the left common carotid arteries spring from the highest part of the arch of the aorta to the left of, and on a plane posterior to the innominate artery, and therefore consist of a thoracic and a cervical portion. The thoracic portion of the left common carotid artery ascends from the arch of the aorta through the superior mediastinum to the level of the left sternoclavicular joint, where it is continuous with the cervical portion.

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Stroke is the third leading cause of death in the United States, accounting for 600 000 cases each year, of which about 500 000 are first attacks. The causes of stroke are mainly due to the atherosclerosis of the aorta and its branches, especially the carotid artery. Atherosclerosis is a condition in which an artery wall thickens as the result of a build-up of fatty materials such as cholesterol.

A complete blockage leads to ischemia of the myocardial (heart) muscle and damage. This process is the myocardial infarction or "heart attack". Hence, it is important to have early detection about the blockage of carotid artery and have some treatment before the blockage become serious and cause stroke or dead. The extra thickness shows the occlusive plaque that might block the flow of the blood through the artery. The continuous the blockage of the arteries will cause stroke and heart attack. Thus early detection of blockage is important and can save lots of lives.

Carotid ultrasound may be difficult or impossible if a patient has a dressing covering a wound or surgical scar in the neck. An occasional patient is difficult to examine because of the size or contour of the neck. Calcium deposits in the wall of the carotid artery may make it difficult to evaluate the vessel. A small amount of soft plaque that produces low-level echoes may go undetected. Ultrasound cannot visualize the entire length of the vessel because the last portion of the carotid artery travels through the bone at the base of the skull.

Previous methods had been studied and the advantages and disadvantages are found out. A method for the measurement of the brachial artery diameter has been developed. They present a system for computing the brachial artery diameter in real-time by analyzing B-mode ultra-sound images. It is also based on a contour tracking technique applied to B-mode images of a longitudinal section of the vessel. The edge detector that they used is named "mass centre of the gray level variability." On the other hand, the contour tracking algorithm is based on the assumption that the segment of the vessel under investigation can be correctly approximated with a cylinder.

Another research proposed a new method to measure diameter of the wool fiber diameter. The proposed method is used in carotid artery detection and measurement. In this research, the image of the wool fibers were first undergo the grayscale image transformation, image contrast enhancement and smoothing and noise degradation. The Watershed algorithm is used for edge detection as well as extracting the object. Robust method in edge detection is good. However, the robust method does not show high contrast image for the output image.

II. PREVIOUS RELATED WORK

Bianchini et al (2007) introduced a method that local arterial stiffness of the superficial arteries can be evaluated by measuring the diameter change during the heart cycle from ultrasound data in conjunction with the local pulse pressure. In this work, such a system is introduced, and the obtained results on the common carotid artery are compared with those obtained by measuring the carotid to femoral pulse wave velocity (PWV) which can be considered to be the "gold standard" technique for the evaluation of arterial stiffness. 14 healthy subjects and 14 hypertensive patients were involved in the study. Results show that a direct evaluation of local carotid stiffness, obtained by an appropriate video processing system, can discriminate between healthy and hypertensive patients as does the Carotid-femoral PWV technique.

Destremes et al (2009) introduced a method to perform a segmentation of the intima media thickness (IMT) of carotid arteries in view of computing various dynamical properties of that tissue, such as the elasticity distribution. The echogenicity of a region of interest comprising the intima-media layers, the lumen, and the adventitia in an ultrasonic B-mode image is modeled by a mixture of three Nakagami distributions. It compute the maximum a posteriori estimator of the proposed model, using the expectation maximization (EM) algorithm and optimal segmentation based on the estimated distributions as well as a statistical prior for disease-free IMT using a variant of the exploration/selection (ES) algorithm. Convergence of the ES algorithm to the optimal solution is assured

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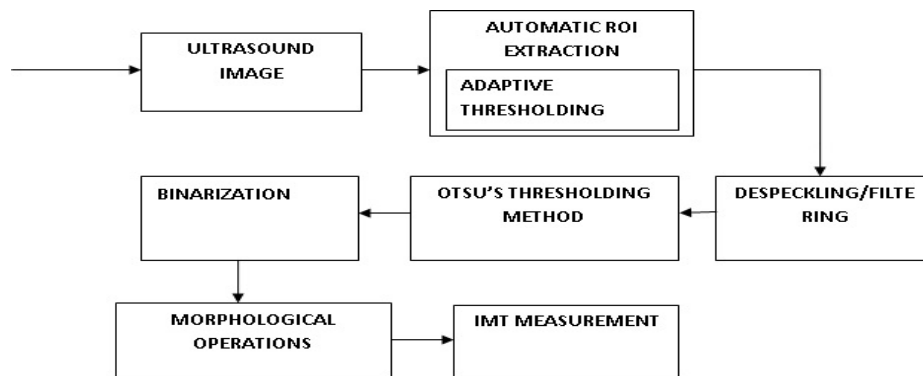
asymptotically and is independent of the initial solution. In particular, our method is well suited to a semi-automatic context that requires minimal manual initialization. Tests of the proposed method on 30 sequences of ultrasonic B-mode images of presumably disease-free control subjects are reported. They suggest that the semi-automatic segmentations obtained by the proposed method are within the variability of the manual segmentations of two experts.

Ilea et al (2009) introduced a method for common carotid intima-media thickness (IMT) is a reliable measure of early atherosclerosis - its can be used in the process of evaluating the presence and tracking the progression of disease. The aim is to introduce a novel unsupervised Computer Aided Detection (CAD) algorithm that is able to identify and measure the IMT in 2D ultrasound carotid images. The developed technique relies on a suite of image processing algorithms that embeds a statistical model to identify the two interfaces that form the IMT without any user intervention. The proposed image segmentation is based on a spatially continuous vascular model and consists of several steps including data preprocessing, edge filtering, model selection, edge reconstruction and data refinement. It manually segmented by clinical experts and performance metrics between the segmentation results obtained by the proposed method and the ground truth data were calculated.

III. METHODOLOGY

This study focuses on how to find the severeness of cardiac vascular diseases. It includes the process such as edge detection using adaptive thresholding, despeckling to remove speckle noises and finally thresholding is used to find severeness of cardiac diseases. The image acquisition process generates large ultrasound video sequences that are interpreted using either manual annotation procedures or histologically validated semi-automatic image-processing environments. The Ultrasound video sequences of longitudinal sections of the Common Carotid Artery (CCA) of some patients are captured as shown in **Fig 1**. The captured video is converted into frames using matlab codes as it act as a video to frame converter.

Automatic region of interest (ROI) detection is one of the steps used in segmenting the IMC in the first frame of the sequence which is completely unsupervised. The main principle behind the proposed approach is to identify the location of the far wall interface using a suite of image processing steps that combine the information contained in the intensity domain with knowledge relating to the anatomical structure of the carotid artery. From the input image, the required portion is cropped and that cropped image is used for further processing.



An adaptive thresholding algorithm that is applied to detect the borders between the two main image classes: the blood and the arterial tissues. This can be achieved by using common filters such Gaussian filter as shown in

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,average and sharpening filters in **Fig 2**. 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.

Thresholding is the simplest method of image segmentation. From a gray-scale image, thresholding can be used to create binary images. To determine the thresholding level, Otsu's thresholding method is used. Otsu's thresholding method involves iterating through all the possible threshold values and calculating a measure of spread for the pixel levels each side of the threshold, i.e. the pixels that either falls in foreground or background. The aim is to find the threshold value where the sum of foreground and background spreads is at its minimum

Binarization is a process where each pixel in an image is converted into one bit and you assign the value as '1' or '0' depending upon the mean value of all the pixel. If greater than mean value then its '1' otherwise its '0'. In the morphological processed image, remove the holes occurred between two lines.

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.[1]

The clear advantage is that CIMT allows investigators to monitor for changes in a study's endpoint with a therapy—progression or regression of CIMT—significantly earlier and with fewer participants than would be required with clinical endpoints such as myocardial infarction, reducing the time and expenses spent on the study. CIMT measurement has the advantages of being non-invasive, radiation-free, relatively easy to acquire regardless of patient anatomy, relatively inexpensive, and reliant on widely available equipment. Measurement of CIMT will be helpful in the prevention of CV (Cardio Vascular) diseases.

3.1.Filters

The common filters such as Gaussian,average,sharpening filters is used for adaptive thresholding and despeckling is achieved using filters such as lee,kaun,srad filters.[2] An adaptive thresholding algorithm that is applied to detect the borders between the two main image classes: the blood and the arterial tissues.despeckling is used to remove the speckle noise

3.1.1 gaussian filter:

Gaussian filter is a smoothing filter.The function of Gaussian filters the input signal using a Gaussian FIR filter.[3] The block expects the input signal to be upsampled, so that the Input samples per symbol parameter, N, is at least 2. The steps involved in gaussian filtering includes,Calculate 1D window weights G'_n ,filter every image line as 1D signal and filter every filtered image column as 1D signal.The zero-mean discrete function,

$$g[i,j]=e^{(-i^2-j^2)/(2\sigma^2)}$$

Larger values of σ produce a wider peak (greater blurring). Kernel size must increase with increasing σ to maintain the Gaussian nature of the filter.[4] Gaussian kernel coefficients depend on the value of σ . At the edge of the mask, coefficients must be close to 0

3.1.2.lee filter:

It is used for speckle noise reduction.It is based on the assumption that mean and variance of the pixel of interest is equal to the local mean and variance

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of all pixels.[5] The formula for lee filter,

$$R(t)1(i)W(t)_1(t)(1_w(1)) \text{ where } W(t)=1-C2 u/C2i(t)$$

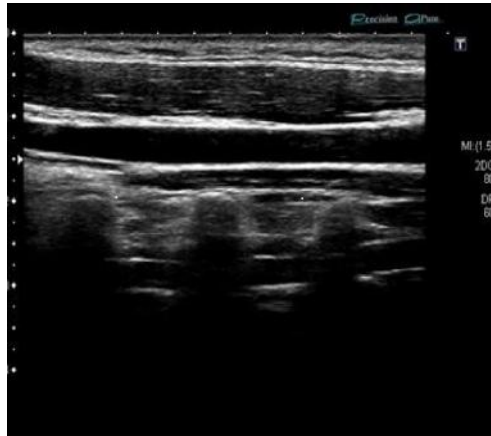


Fig 1.ultrasound image of carotid Artery

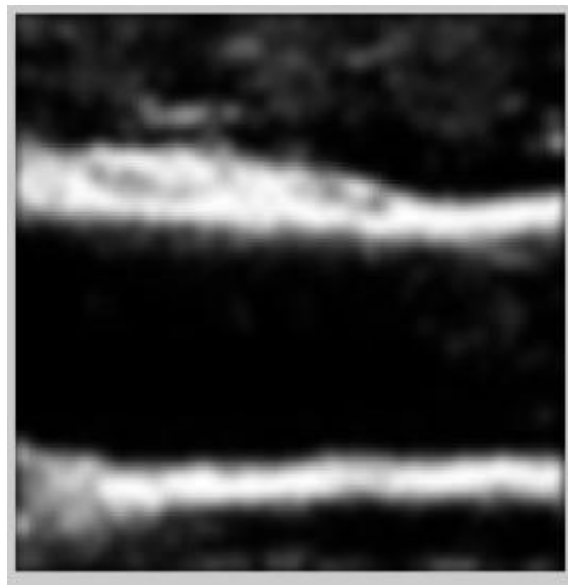


Fig 2.after applying gaussian filter

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3.1.3.kaun filter:

It is a multiplicative noise model is first transformed into a signal- dependent additive noise model. The resulting filter has the same form as the lee filter but the different weighting function which is given as, $W(t) = 1 - C2/C2(t)$

3.1.4.the srad filter:

SRAD filter is known as speckle reducing anisotropic diffusion. The SRAD can eliminate speckle without distorting useful image information and without destroying the important image edges. It provides superior performance in comparison to the conventional techniques in terms of smoothing and preserving the edges and features.[6]

3.2.Thresholding

Thresholding is the simplest method of image segmentation. From a grayscale image, thresholding can be used to create binary images. During the thresholding process, individual pixels in an image are marked as "object" pixels if their value is greater than some threshold value (assuming an object to be brighter than the background) and as "background" pixels otherwise.[7] This convention is known as threshold above. Variants include threshold below, which is opposite of threshold above; threshold inside, where a pixel is labeled "object" if its value is between two thresholds; and threshold outside, which is the opposite of threshold inside. Typically, an object pixel is given a value of "1" while a background pixel is given a value of "0". Finally, a binary image is created by coloring each pixel white or black, depending on a pixel's labels.[8]

To determine the thresholding level, Otsu's thresholding method is used.[9] Otsu's thresholding method involves iterating through all the possible threshold values and calculating a measure of spread for the pixel levels each side of the threshold, i.e. the pixels that either falls in foreground or background. The aim is to find the threshold value where the sum of foreground and background spreads is at its minimum.[10]

IV. ANALYSIS & DISCUSSIONS

The Ultrasound video sequences of longitudinal sections of the Common Carotid Artery (CCA) of some patients are given as the input and we get the output as number of frames (i.e., images) by using video to frame converter. The ultrasound image or the first frame of the sequence is given as the input and the segmented carotid artery region is get at the output. The segmented Carotid artery region is given as the input and then the enhanced image or filtered image is received at the output due to de-speckling process.[11] The enhanced or filtered image is given as the input and we get the binarized and morphological processed image as the output. The morphological processed binarized image is given as the input and the measurement of intima media thickness is processed at the output stage.[12]

V. CONCLUSION

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 help inexperienced doctor to identify which is carotid artery and finally the measurement of intima media thickness is processed and various performance parameters are evaluated

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