AUTOMATIC SEGMENTATION OF THE CAROTID ARTERY IN ULTRASOUND B-MODE IMAGES

André M.F. Santos[2,3(*)], João Manuel R.S. Tavares[1,2(#)], Elsa Azevedo[3], Luísa Sousa[1,2]
[1] Department of Mechanical Engineering
[2] Faculty of Engineering, University of Porto
[3] Faculty of Medicine, University of Porto
[(*)] *Email:* andremfs52@fe.up.pt
[(#)] *Email:* tavares@fe.up.pt, www.fe.up.pt/~tavares

ABSTRACT

B-mode ultrasound imaging is well-known and used in the medical imaging field; however, it presents various difficulties, specifically in tasks of image segmentation and surface reconstruction, due to intrinsic adverse characteristics, such like low contrast and noise [1,2]. Despite this, B-mode ultrasound imaging has been used in the diagnosis of several cardiac diseases, particularly, carotid artery diseases like atherosclerosis, known as the "hardening of the artery", after the accumulation of fatty substances, i.e. lipoproteins, in the artery walls, known as "plaques". In this work, an anisotropic diffusion filter is used for speckle removal, and morphological operators are employed in the detection of the artery. The obtained information is used in the definition of two initial contours, one for the lumen and another for the bifurcation boundaries, used to initiate a Chan-Vese-based segmentation method.

Keywords: Medical imaging; common carotid artery; internal and external carotid arteries; ultrasound imaging; image segmentation; Chan-Vese model.

INTRODUCTION

Ultrasound imaging has been widely used in the medical diagnosis of arterial diseases, like atherosclerosis, due to its lower cost and smaller risk to the patient, when compared with other imaging modalities, such as X-ray angiography, positron emission tomography (PET) and Magnetic Resonance Imaging (MRI) [3,4]. However, the automatic segmentation of ultrasound images is extremely challenging due to the large amount of artifacts, speckle and attenuations, that are characteristic in this type of images [4]. Here is described an approach for the automatic segmentation and consequent identification of the lumen region of the carotid artery (CA) in longitudinal B-mode images.

The method developed searches for hipoechogenic structures in the image to be segmented, and the lumen region of the CA is identified based on mean and standard deviation calculus concerning the input image intensity. Afterwards, the lumen and bifurcation boundaries of the carotid artery are identified through the application of a geometrical model based on the Chan-Vese level set method [5].

The method was tested on 11 B-mode real images, with 4 of them corresponding to arteries with plaques, confirming that is robust to speckle noise, does not require human interaction and can adjust suitability the segmentation contours to the lumen boundaries represented in the input images.

RESULTS AND CONCLUSIONS

Four examples of the contours obtained for the lumen and bifurcation boundaries are represented in Figure 1. From a visual based analysis of the results, one can conclude that the segmentation results are very good. The results of a quantitative comparative evaluation between the 11 automatic and manual segmentations are presented in Table 1.

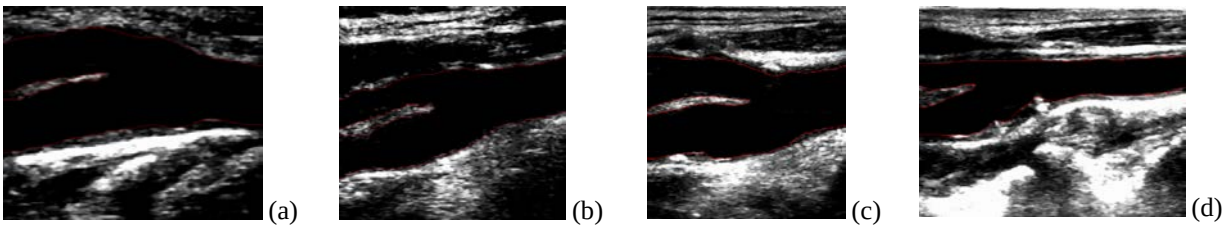

Figure 1: Examples of lumen and bifurcation boundaries of carotid arteries segmented by our method

Table 1: Comparison between the results of the automatic and manual segmentations in 11 B-mode ultrasound images.

Images	Size (pixels)	Number of pixels manually defined	Number of coincident pixels	Number of non-coincident pixels	Maximum error (pixels)	Mean error (pixels)	Area Overlapped (%)
#1 (Fig. 1a)	409x504	46	35	11	1	0.24	98.89
#2	490x533	73	42	21	1.41	0.29	97.13
#3 (Fig. 1b)	417x482	66	44	22	8	0.66	95.92
#4	490x522	45	34	11	1	0.24	96.88
#5	486x525	56	34	22	8.25	0.98	95.42
#6	493x351	39	29	10	8	0.83	96.67
#7	499x457	38	24	14	9.84	0.47	94.64
#8 (Fig. 1c)	496x457	44	33	11	7.62	0.64	97.73
#9 (Fig. 1d)	499x631	43	33	10	5.38	1.42	97.76
#10	473x505	57	45	12	3.22	0.33	98.03
#11	490x457	60	50	10	2.71	0.27	97.91

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