Computer simulation of the carotid artery

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Background: Disturbed flow conditions at the bifurcation of common carotid artery and proximal internal carotid artery plays an important role in the development of local atherosclerotic plaques, which are important causes of stroke. Being able to build 3D models based on ultrasound imaging can improve diagnostic assessment and support interventions like endarterectomy or carotid stenting. Our aim was to describe a carotid segmentation algorithm to build these 3D models.

Methods: We developed an automatic segmentation algorithm for the lumen of the carotid artery in B-mode images. Hough transform (HT) was used in order to extract straight lines automatically and consequently perform the initial contour definition, for the application of a level set active model detection in the lumen sections of the carotid artery. Our algorithm comprises: definition of a region of interest (ROI) in the original image; morphological closing and edge detection, using the Sobel operator, resulting in a binary image with 1s at edge location after a global thresholding based on the first 15% of the histogram width; application of the HT for all edge pixels and identification of the HT parallel to each other and with the maximum width, that will allow defining the artery borders; definition of a rectangular contour for the carotid, which is improved by using the active level set model.

Results: The automatic segmentation was applied to carotid common carotid bifurcation ultrasound images, with a satisfactory reconstruction of the arteries. The main advantage of our segmentation method relied on the HT initialization, overcoming the limitations of traditional methods.

Conclusion: We were able to successfully apply a carotid segmentation technique based on cervical ultrasonography, allowing us, in the future, to perform 3D modelling. These computational models will be important for testing hypotheses and address practical clinical vascular problems related to carotid disease.