AN AUTOMATIC 2D CAD ALGORITHM FOR THE SEGMENTATION OF THE IMT IN ULTRASOUND CAROTID ARTERTY IMAGES

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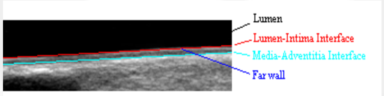
INTRODUCTION

Common Carotid Intima Media Thickness (IMT) is the 1st indicator of atherosclerotic vascular diseases and a well-established independent predictor of cardiovascular events.

Consequences of arterial degeneration include: aherothrombotic events, myocardial infarction, stroke and are responsible for 35% of total mortality in the western world and the leading cause of morbidity burden worldwide.

Aim - Introduce a novel unsupervised Computer Aided Detection (CAD) algorithm for the segmentation and measurement of the IMT in 2D ultrasound carotid images.



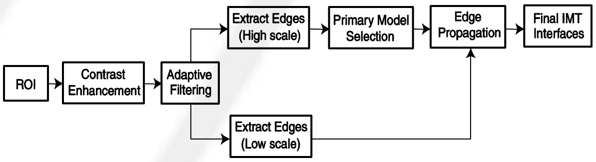
ULTRASOUND IMAGE ACQUISITION

49 longitudinal views of the Common Carotid Artery (CCA) acquired from a cohort of women with and without history related hypertension by our clinical partners from Beaumont Hospital, Dublin.
Scanners: Philips IU22, HDI5000
Transducers in use: VL13-5, L17-5 and L9-3

PROPOSED IMT SEGMENTATION ALGORITHM

The developed technique relies on a suite of image processing algorithms that embeds a statistical spatially continuous vascular model to identify the two IMT interfaces without any user intervention.

- Automatic ROI detection
- Data pre-processing
- Edge filtering
- Model selection
- Edge reconstruction
- Data refinement

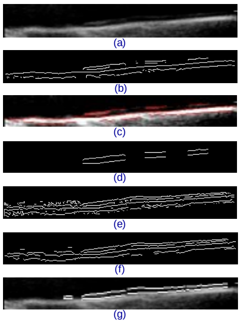


➢ ROI Adaptive Pre-Filtering to attenuate the speckle noise.

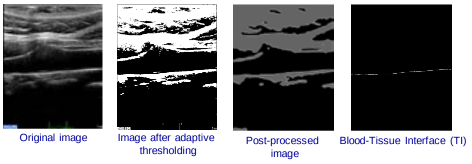
➢The proposed algorithm adopts a COARSE TO FINE strategy for the IMT detection:

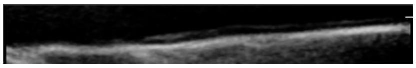
➢ Initial Edge Structure Extraction – is obtained by applying Canny edge detector, non-maxima suppression and thresholding with hysteresis. The initial (coarse) edge detection – the scale is set to a high value to detect strong IMT edge features.

➢ Primary Model Selection – The initial coarse edge information is extracted with respect to a spatially continuous vascular model based on pairs of quasi-parallel lines using statistical solutions.



Intermediate steps of the proposed segmentation algorithm. (a) Detected ROI data. (b) Initial edge structure. (c) The filtered edges that are quasi-parallel to the TI are superimposed on the contrast-enhanced image. (d) The primary IMT model. (e) The lower scale edges. (f) Lower scale edges filtered using least square fitting. (g) The final pair of lines of the IMT complex resulting after the edge data reconstruction (the maximum IMT value calculated by our algorithm is 0.70 mm).





Automatic ROI detection

➢ Edge Data Reconstruction – The edges that define the primary model will be further propagated using the lower scale edge information that is spatially contiguous and consistent with the geometrical characteristics of the primary IMT model.

EXPERIMENTAL RESULTS

TABLE I: The overall point to curve errors between the proposed segmentation algorithm and the ground truth data when calculated for the Lumen-Intima interface

	$\mu_{Lumen\text{-}Intima}$	σ_{Lumen_Intima}	RMS_{Lumen_Intima}
Errors (mm)	0.079	0.058	0.100
Errors (pixels)	0.989	0.725	1.248

TABLE II: The overall point to curve errors between the proposed segmentation algorithm and the ground truth data when calculated for the Media-Adventitia interface

	$\mu_{Media\_Adventitia}$	$\sigma_{Media\_Adventitia}$	$RMS_{Media\_Adventitia}$
Errors (mm)	0.082	0.060	0.103
Errors (pixels)	1.045	0.750	1.304

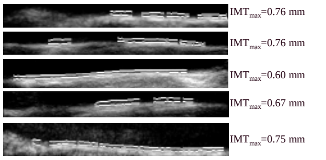
TABLE III: The overall average errors calculated for maximum and minimum displacements between the ground truth annotated IMT and the IMT estimated by the proposed method

	Max_IMT	Min_IMT
Average Errors (mm)	0.085	0.065
Average Errors (pixels)	1.061	0.795

➢ **The images in our database have been manually annotated by clinical experts from Beaumont Hospital.**

➢ **The quantitative evaluation was performed by computing the minimum Euclidian distance between the pixels situated on the border of the lumen-intima interface and media-adventitia interface in the ground truth image and the pixels from the lumen-intima interface and media adventitia interface identified by the proposed algorithm. To evaluate the border displacement between the ground truth annotated data and the segmented IMT, the mean, standard deviation and Root Mean Square errors were calculated.**

➢ **The evaluation was performed separately for both interfaces that form the IMT.**



Additional segmentation results and the maximum IMT values calculated by our algorithm

CONCLUSIONS

➢ The major aim of this work was to introduce a novel algorithm for the segmentation of the IMT in longitudinal carotid ultrasound images. The main novelty of this approach resides in the development of an unsupervised algorithm that embeds a statistical IMT model in a coarse to fine fashion.

➢ The proposed algorithm proved to produce accurate segmentation results when applied to various carotid ultrasound images that are characterized by low-resolution and high level of image noise.

➢ This research is on-going and we plan to extend the capabilities of the proposed CAD system to automatically measure the IMT in multi-dimensional ultrasound carotid data in order to allow the calculation of dynamical properties of the carotid artery.

ACKNOWLEDGEMENTS

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