UNIVALOR

Bridging Knowledge and the Economy

Method for semi-automatic segmentation of the intima-media layers of carotid arteries in ultrasonic B-mode images

Reference: VAL-550-CHUM

Keywords: Image processing, segmentation of carotid arteries, segmentation of anatomical structures, statistical modeling of ultrasonic images of biological tissues, stochastic optimization, external echography, medical utrasound imaging

Background

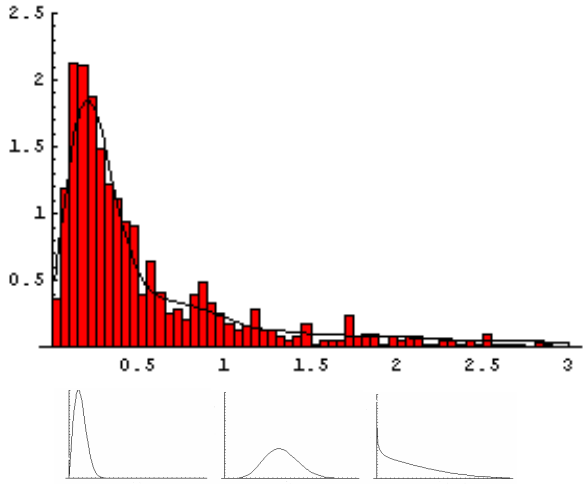
To monitor the arterial disease atherosclerosis, a precise segmentation of ultrasonic B-mode images of intima-media layers is performed to assess various biomechanical and anatomical properties of the arterial walls. Algorithms that can replace time consuming manual procedures and perform segmentations with minimal user interaction (and intra and interobserver variability) are essential in both clinical and research contexts.

Technology

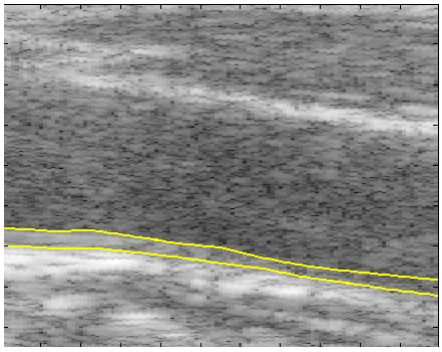
The segmentation method developed by Dr Guy Cloutier at the *Centre Hospitalier de l'Université de Montréal*, uses a Bayesian model to interpret B-mode ultrasonic images of the carotid artery's intima-media layers. Likelihood is based on Nakagami distributions, which are used to describe the statistical properties of intensity in the image. These distributions are automatically estimated with the Expectation-Maximization (EM) algorithm combined with the Exploration-Selection-Estimation (ESE) method. Also incorporated into the algorithm are anatomical, geometrical and physiological priors, which can help assess thickness, action (or energy) of a curve, and temporal movement between two consecutive images of the video sequence. The segmentation problem is then formulated as the computation of the Maximum A Posteriori (MAP) of the Bayesian model, which is performed in turn with an original variant of the Exploration-Selection (ES) stochastic optimization algorithm. All computations are automatically performed following the manual introduction of a few points on the first B-mode image of the intima-media layers to be segmented.

Results

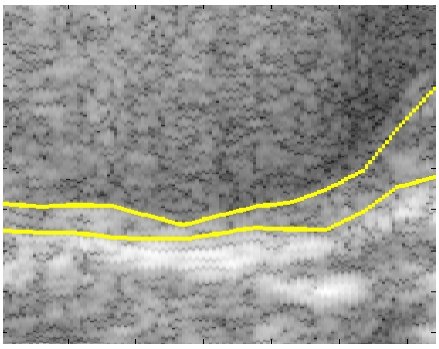
The following figure shows the normalized histogram of the grey levels on an ultrasound image of a carotid artery, as well as the corresponding Nakagami statistical distributions of the vessel lumen, the intima-media layers, and the adventitia (outer layer of an artery) that are detected by the proposed method.



The next two figures show an ultrasound image of the carotid artery as well as the contours (in yellow) of the intima-media layers detected by the proposed method.



common distal carotid



internal proximal carotid

Applications

The product of this research could lead to the marketing of software for segmenting ultrasonic images. The software could also be coupled with a commercial echograph for the analysis of other anatomical structures than arteries. Segmentation of the vascular wall could very well turn out to be an important pre-processing step to any ultrasonic elastography algorithm, which enables the study of deformations of a tissue under mechanical constraints. In fact, the invention is complementary to the technology entitled *Non-intrusive vascular elastography* also from Dr Cloutier's group (see VAL-358-359-CHUM). The pre-segmentation of vascular images could help the registration of the various sequences in order to minimize artefacts due to motion and could also help reduce computation time of elastograms by reducing the region of interest to the segmented region.

Competitive Advantages

This method is the first model for segmenting ultrasonic images that uses a mix of Nakagami statistical distributions. It is more general than previously popular combinations of Rayleigh distributions, which correspond to a high density of random ultrasonic scatterers (small tissue structures scattering echoes) without the presence of coherent components. Nakagami distributions have the advantage of taking into account a low density of scatterers, as well as the possibility of coherent components such as a calcified nodule in the vascular wall.

Moreover, this is the first use of the Exploration Selection stochastic optimization algorithm in the context of ultrasonic image segmentation. This algorithm is particularly easy to implement and is guaranteed to converge to an optimal solution, a major advantage over simulated annealing methods and genetic algorithms which are guaranteed to converge only to a (possibly sub-optimal) local solution of the model.

Patent Status

A provisional patent application was filed in March 2007.

Business Opportunity

Univalor is seeking an exclusive licensing agreement or contracts with a commercial partner.

Contact

Anne-Marie Larose, PhD, MBA
Manager, Business Development
Life Sciences
Gestion Univalor, Limited Partnership
+1 (514) 340-3243, ext. 4239
anne-marie.larose@univalor.ca

Guy Cloutier, PEng, PhD
Director LBUM – Professor
Centre hospitalier de l'Université de Montréal /
Université de Montréal
+1 (514) 890-800, ext. 24703
guy.cloutier@umontreal.ca