# Processing of ultrasound images by using convolutional neural networks for carotid artery detection and segmentation

**Abstract:**

In the era of personalized medicine, the cardiovascular diseases such as carotid atherosclerosis have to be analyzed by using advanced machine learning techniques in order to better estimate the patient's condition and visualize the carotid artery. The ultrasound (US) images were used in this study for the detection and segmentation of carotid artery lumen and wall, as the US technique is widespread in clinical practice.

The U-Net based Convolutional Neural Networks (CNNs) were applied on the US images, as this methodology is promising in processing of US data [1]. The used US dataset consisted of 108 patients who underwent the US examination (baseline time point), where each patient had captured carotid branches and bifurcation in transversal and longitudinal projections. The difference between the whole transversal carotid surface and lumen area represents the segmented patient-specific carotid wall. The US images had been preprocessed including resizing, classification (grayscale and color US images), as well as the annotation of US images by clinical experts. The obtained results for lumen showed high accuracy in region detection and segmentation (Precision 0.90, Recall 0.92, Dice coefficient 0.91). The segmentation of carotid wall included training and validation of two models, giving the U-Net results of high accuracy - first model (grayscale US images): Precision 0.9636, Recall 0.9634, Dice coefficient 0.9634; second model (color US images): Precision 0.9874, Recall 0.987, Dice coefficient 0.9872. The presented methodology based on automatic extraction of carotid lumen and wall gives the segmentation of individual patient-specific anatomy (Figure 1) and can be used for further analysis of the patient [2]. Development of these deep learning techniques, together with computer-based modelling can contribute to better risk stratification of patients with carotid atherosclerotic disease.
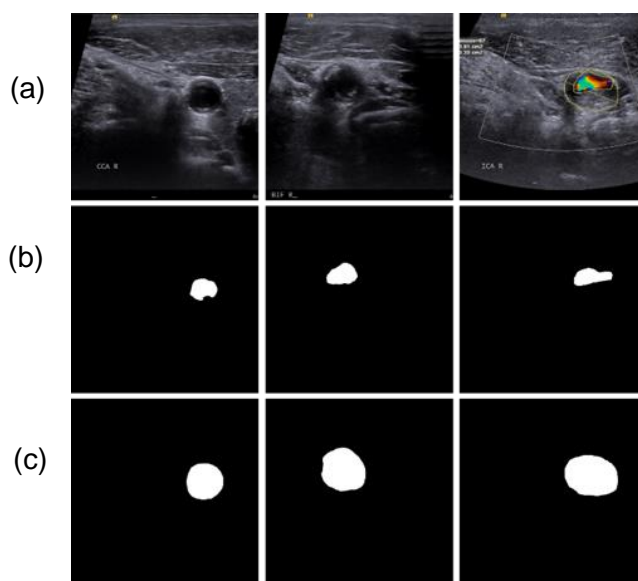
**Figure 1.** The carotid US images for one patient: original images (a), predicted lumen (b) and wall regions (c).

**References:**

[1] Hashimoto, H., Tagaya, M., Niki, H., Etani, H.: Computer-assisted analysis of heterogeneity on B-mode imaging predicts instability of asymptomatic carotid plaque, Cerebrovasc. Dis., (2009).

[2] Xie, M., Li, Y., Xue, Y. et al: Vessel lumen segmentation in internal carotid artery ultra-sounds with deep convolutional neural networks. IEEE International Conference on Bioinformatics and Biomedicine (BIBM), San Diego, CA, USA, 2019, pp. 2393-2398.