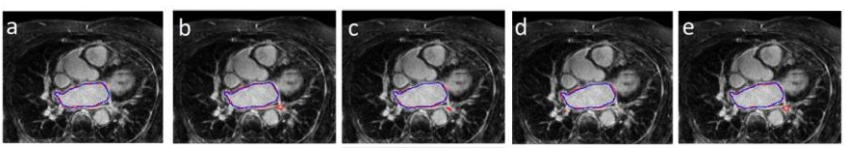
Performance Comparison of Deep Learning Approaches for Left Atrium Segmentation from LGE MRI Data

Davide Borra[1], Daniela Portas[1], Alice Andalò[1], Claudio Fabbri[1], Cristiana Corsi[1]
[1]DEI, Campus of Cesena, University of Bologna, Cesena, Italy

Quantification of viable left atrial (LA) tissue is a reliable information which should be used to support therapy selection in atrial fibrillation (AF) patients. Late gadolinium-enhanced magnetic resonance imaging (LGE-MRI) is employed for the non-invasive assessment of LA fibrotic tissue. Unfortunately, the analysis of LGE-MRI relies on manual tracing of LA boundaries. This task is time-consuming and prone to high inter-observer variability due to several reasons including the different degrees of observers' experience, LA wall thickness and data resolution. Therefore, an automatic approach for LA wall detection would be very helpful. Recently, several end-to-end approaches based on deep neural networks (DNNs) have been proposed in the biomedical image processing field to support data segmentation. In this study, we compared the performance of 5 different DNNs and 2 different cost functions to detect LA boundaries from LGE-MRI data.
U-Net, attention U-Net (AttnU-Net), AttnU-Net with deep supervision (DS), AttnU-Net with DS and multi-scale inputs (MS), and V-Net were trained, validated and tested with the data available from the Statistical Atlases and Computational Models of the Heart 2018 Atrial Segmentation Challenge (100 cardiac data) using the Dice loss (DL) and the Focal Tversky loss (FTL) functions. Five-fold cross-validation was used to obtain an estimate of the performance; a validation set (20% of the training set) was used to perform early stopping.
Among the solutions, U-Net resulted the best-performing approach, with higher Dice coefficient (DC) using both loss functions (mean DC: 0.901±0.03 (DL) and 0.894±0.04 (FTL)). However, the other DNNs showed similar results (DC range: 0.877±0.05÷0.894±0.03 (DL); 0.878±0.0÷0.893±0.03 (FTL)). No statistically significant differences were found between the compared loss functions for the 5 different architectures. Based on these results, the U-Net architecture provides the best performance; furthermore, AttnU-Net with DS and AttnU-Net with DS and MS, showed the most similar LA boundaries to U-net.



Example of the detected LA boundaries in one mid LA slice applying the five different DNN architectures (blue: reference contours; a: U-net; b: AttnU-Net; c: AttnU-Net with DS; d: AttnU-Net with DS and MS; e: V-Net).