AI-Based Left Atrial Scar Segmentation from LGE MRI With Integrated Uncertainty Evaluation

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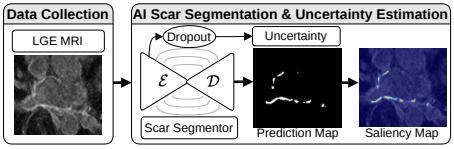
Background. Cardiac MRI late gadolinium enhancement (LGE) enables non-invasive identification of left atrial (LA) scar, whose spatial distribution is strongly associated with atrial fibrillation severity and recurrence. However, current LA scar segmentation remains challenging due to low contrast, low image resolution as compared to LA wall thickness, annotation variability, and the lack of anatomical constraints, often leading to non-reliable predictions. Accordingly, our aim was to design an artificial intelligence (AI) driven strategy to segment LA scar from LGE images, while incorporating uncertainty analysis. **Methods.** After training the model on LA cavity, we introduced an anatomy-aware spatially weighted loss that incorporates prior clinical knowledge by constraining scar predictions to anatomically plausible LA wall regions while mitigating annotation bias. Monte-Carlo dropout was applied on the model to calculate predictions uncertainty and post-hoc interpretability method was used to generate saliency maps. In addition, to prevent thin and small scar features from vanishing during training, a residual encoder-decoder network with skip connections between downsampling and upsampling layers was implemented. Physio-pathological and physics-inspired 3D data augmentation was employed to increase data diversity given the limited number of annotated LGE MRI scans. **Results.** Our preliminary results were obtained on LGE data from the public LASCARQS dataset (60 cases) after 5-fold cross validation. The proposed method for scar segmentation achieved Dice score (DSC)=0.52, Hausdorff Distance (HD)=10.30mm, Average Surface Distance (ASD)=1.48mm. Entropy (H) and Variance (V) of scar are 0.12 and 9.32e-3, while the model performance without LA prior and residual connection decreased: DSC=0.49, HD=15.30mm, ASD=2.13mm, H=0.25 and V=3.88e-2. **Conclusion.** By explicitly embedding clinical anatomical priors into AI model, the pro-posed approach improved the accuracy and reliability of LA scar segmenta-tion. The uncertainty analysis quantitatively provides an estimate of the model's prediction confidence. By providing visibility into how a model reaches its decisions, post-hoc interpretability increases transparency and bolsters clinical confidence.



AI-based LA scar segmentation model.