Weakly-Supervised Deep Learning for Left Ventricle Fibrosis Segmentation in Late Gadolinium Enhanced Cardiac MRI using Image Level Labels

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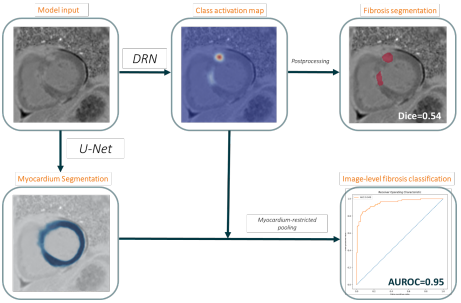
Background Automated segmentation and quantification of myocardial fibrosis in LGE cardiac MRI (CMR) has the potential to improve efficiency and precision of diagnosis and treatment of cardiomyopathies. However, state-of-the-art Deep Learning approaches require manual pixel-level annotations, which are cumbersome to obtain, and ambiguity in interpretation results in high interobserver variability. We hypothesize that a weakly-supervised fibrosis segmentation method may be a better alternative for detection of fibrosis, allowing for expedited and scalable dataset curation and potentially greater generalizability. **Methods** Short-axis CMRs with late gadolinium enhancement (LGE) were retrospectively obtained from 470 patients with ischemic and non-ischemic cardiomyopathies. Each LGE CMR had on average 10 image slices. For image-level detection of fibrosis a dilated residual network (DRN) was trained on 430 CMRIs with image-level fibrosis annotations, validated and tested using 20 CMRs each with pixel-precise delineation of fibrotic lesions. Lesion delineations were obtained from the network using Class Activation Maps (CAMs). To guide fibrosis predictions, a U-Net was tasked with delineation of the LV myocardium using 75 CMRs with 70/10/20 training/validation/test-split (Dice score 0.821). Subsequently, the CAMs are restricted to the U-net myocardium predictions. The model is evaluated for image-level classification and pixel-level fibrosis segmentation. **Results** Automatic image-level fibrosis classification resulted in an Area Under the Receiver Operator Curve of 0.95 and an accuracy of 0.86. Our method, trained with only image-level labels, reached a reliable pixel-level segmentation performance with a Dice score of 0.54. **Conclusion** Our Deep Learning models show promising results for both image-level fibrosis classification and fibrosis segmentation in LGE CMR, despite only being trained for image-level predictions. Both can provide invaluable features for subsequent automated diagnosis and risk prediction.



Classification and segmentation pipeline.