Deep Learning for End-to-End Atrial Fibrillation Recurrence Estimation

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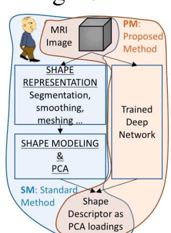
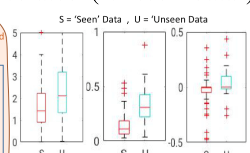
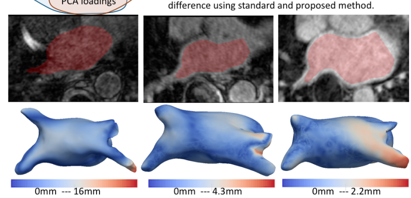
Motivation: Left atrium shape has been shown to be an independent predictor of recurrence after atrial fibrillation (AF) ablation. Nonetheless, Population-level shape representations in form of image segmentation and correspondence models (*standard method - SM*) derived from cardiac MRI require significant human resources with sufficient anatomy-specific expertise. In this study, we propose a machine learning approach to study AF recurrence by predicting shape descriptors from raw MRI images (*proposed method - PM*), with NO image pre-processing involved. **Methods:** We train a deep network to estimate a low-dimensional shape representation, in the form of PCA loadings, directly from 3D images. With a representative set of 100 AF patients collected retrospectively, 10 PCA loadings were found to capture 90% shape variability. We used a multi-layer perceptron (MLP) to regress AF recurrence. **Results:** For deep network training, we augment the data by sampling from the PCA space of 75 MRI scans ('seen data'). Remaining 25 are isolated ('unseen data'). PCA loading from the SM and the ones estimated from images were found as statistically same by Hotelling T^2 statistic of 6.01 with 82% confidence (99% confidence on seen and 63% confidence on unseen). The recurrence probability prediction by MLP (trained using SM PCA loadings) using PCA loadings from SM and PM, are statistically same by T-Test with 79.6% confidence. **Conclusion:** PM performs similar to SM and produce statistically similar outcomes on AF recurrence, eliminating the need for heavy pre-processing and associated manpower. Occasional errors of the method can be attributed to the huge variability in image intensities arising from different scanners and acquisition protocols (Figure), the performance can be improved with smart data selection while training.





Left : The boxplot of the particle wise difference between standard method and the proposed method. *Middle*: Boxplot of L2-normalized PCA loading difference between the standard and proposed method. *Right*: Boxplot for AF recurrence probability difference using standard and proposed method.



Top row represent representative samples with vastly different image intensity profiles in our database, going from worst to best (left to right). Bottom row represent shape derived from corresponding image above using the proposed method, with a distance map overlay which shows the deviation from the standard particle based shape model.