DIVAID: Automatic Division of Bi-Atrial Geometries Into Clinically Important Regions

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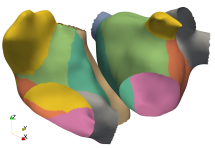
Introduction: Cardiovascular diseases are the leading cause of death globally. Recent technological advances in cardiac imaging, e.g. cardiac computed tomography, magnetic resonance imaging and electroanatomical mapping allow detailed analyses of cardiac morphology and function. However, to perform regional quantitative intra- and inter-individual, as well as cross-modality comparisons, a standard nomenclature for the regionalization of the heart is required. While a standardized regionalization of the left ventricle (AHA 17-segment model) has been established, there is currently no consensus regarding the regionalization of the atria.

Methods: In a multi-disciplinary task force within the PersonalizeAF consortium, we developed a 15-region bi-atrial model based on anatomical, electrophysiological and clinical considerations. The regional boundaries are defined by the shortest geodesic paths connecting two points located on anatomical landmarks that are precisely defined by standardized anatomical orientations. Moreover, we developed an atrial division pipeline (DIVAID, https://gitlab.kit.edu/kit/ibt-public/divaid) to automatically divide any bi-atrial geometry according to our proposed definitions. The automatic division results were compared to manual expert regionalizations in 20 bi-atrial geometries from multiple acquisition modalities.

Results: The mean regional overlap (Dice score) between both division results across all geometries for both atria combined was 0.92. In the LA, the Dice score was 0.95, whereas in the RA, it was 0.88. The mean Euclidean distance between regional boundaries derived from either manual or automatic division in both atria was 1.70 mm. In the LA, the mean Euclidean distance between regional boundaries was 1.16 mm, while in the RA it was 2.25 mm. Given a mesh element edge length of 1 mm, this implies a mean deviation between manual and automatic division of less than 2 mesh elements.



Conclusion: This algorithm enables standardized, consistent, reproducible and operator-independent regional quantitative comparisons of the atria between multiple modalities, patients and centers which may facilitate cardiac research towards personalized treatment approaches.