An Automated Algorithm for Generating of AHA Model Based on 3D Heart Geometry

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In recent years, computer technology has become increasingly prevalent in medicine, especially in the field of medical imaging, particularly heart segmentation. This segmentation has allowed for various heart measurements and the use of cardiac computer models for early therapy planning. However, automated processing and calculation tools are necessary for these purposes. This study presents an automated algorithm that constructs a heart mesh with a scalar field of the cardiac fibers, universal ventricular coordinates (UVC), and a 17-segment bull's-eye model, with additional segments for the right ventricle.

As initial data, our algorithm starts with the surface mesh of the left and right ventricles, which can be constructed from the segmentation of computer tomography, magnetic resonance imaging, or echocardiography data. The first step is to identify the endocardial and epicardial surfaces of the heart. Subsequently, a tetrahedral mesh is constructed, and the UVC is determined. Using these coordinates, each point of the heart is assigned to one of the 17 segments of the LV bull's-eye model and an additional 9 segments for the RV, ensuring roughly equal segment sizes. The number of segments can be adjusted as needed. Furthermore, cardiac fibers are calculated into the heart model at each point using a rule-based approach. The output of this process is a heart geometry with UVC, cardiac segments, and fibers, which can be utilized to perform further calculations using mathematical models.

Our automated algorithm was tested on 400 triangle surfaces with the LV and RV, which were obtained from semi-automatic CT segmentation. The mean time of model building is 87 seconds. As a result, our algorithm worked successfully in 95% of cases. Moreover, we validated the results on a manually prepared dataset with a 17-segment bull's-eye model at two ventricular heart geometries. For basal segments, middle, and apex segments, we obtained a Dice coefficient of 0.86, 0.76, and 0.56, respectively.