A Fully Automated Two-Stage Segmentation Approach for Late Gadolinium-Enhanced Cardiac Magnetic Resonance Images in Personalized Cardiac Modeling

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Background: The accurate and automatic segmentation of late gadolinium enhancement cardiac magnetic resonance (LGE-CMR) images is a crucial initial step for personalized cardiac modeling. The aim of this study is to validate our proposed segmentation method's precision for left ventricular (LV) and infarct tissue (IT), and evaluate the efficacy of the models reconstructed using our approach in predicting ventricular tachycardia (VT) occurrences.

Methods: In this study, a total of 180 patients' LGE-CMR images (100 from EMIDEC and 80 from Anzhen Hospital) were analyzed. We developed a two-stage method, which includes a deep learning (DL)-based solution for segmenting LV and a modified Gaussian mixture model (MGMM) solution for segmenting IT in LV, to perform fully automated cardiac segmentation. Subsequently, ventricular models were constructed using the segmented LGE-CMR images of 5 patients. Programmed electrical stimulation was employed to induce VT in each model. The simulation outcomes of models reconstructed using the automatic method and manual segmentation by experts were compared.

Results: Our proposed method attained a dice score (DS) of 81.21 for LV. For IT, the output predicted by the DL-based method was not ideal, with only a DS of 41.17. In contrast, the DS for the MGMM method was 79.58. Thus, the MGMM method was utilized for IT segmentation. Additionally, by analyzing the simulation results of the selected 5 patients, the reentry locations and morphologies induced in models using our method corresponded to those of the manual method, with an accuracy rate of 80%. It is worth noting that the 20% error might be attributed to poor image quality, which leads to unsatisfactory myocardium segmentation in the first stage.

Conclusion: The results demonstrate that our proposed fully automated two-stage approach can provide an efficient and satisfactory image processing pipeline for personalized cardiac modeling.