Integrated Software Toolkit for Solving Bioelectric Field Problems

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The lack of robust, comprehensive, and integrated software remains a major impediment to the effective use of numerical simulation techniques in both basic cardiology and clinical practice. To be effective, simulations must provide an end-to-end solution, must require minimal tuning of parameters by the user, and must generate subject (patient) specific solutions in an acceptable time frame on realistically available computational resources. We have developed such a system for use in the simulation of bioelectric field problems in electrocardiology. This system consists of a set of software tools that are well coupled and well matched to both the sources of input data and the needs of biomedical scientists, engineers, and physicians. The input to the system is a set of medical images (MRI, CT), which are then segmented using a combination of automated tools and manual intervention. The segmentation then becomes the input for a polynomial mesh generation system, which creates either surface or volume geometric models suitable for computation. In this presentation, we will focus on recent progress specifically in the simulation toolkit that uses the geometric model and applied boundary conditions (measured electric potentials and tissue conductivities) to solve electrocardiographic forward and inverse problems. Within our problem solving environment, SCIRun, we have developed a complete set of open source tools for both boundary element and finite element approaches to both potential and activation-time based electrocardiographic source formulations. With this system, our biomedical and clinical collaborators are able, for example, to predict defibrillation fields from given device and electrode locations, to simulate epicardial and body surface potentials during acute myocardial ischemia from prescribed regions of poor perfusion, and to solve cardiac inverse problems in the setting of ventricular arrhythmias and reentrant tachycardias.