A Network-based Cardiac Electrophysiology Simulator with Realistic Signal Generation and Response to Pacing Maneuvers

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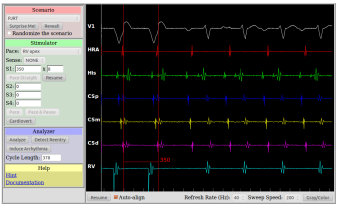
Background: Diagnosis and localization of cardiac arrhythmias, especially supraventricular tachycardia (SVT), by inspecting intracardiac signals and performing pacing maneuvers is the core of electrophysiology studies. Acquiring and maintaining complex skill sets can be facilitated by using simulators, allowing the operator to practice in a safe and controlled setting. An electrophysiology simulator should not only display arrhythmias; it has to respond to the user's arbitrary inputs. While, in principle, it is possible to model the heart using a detailed anatomical and cellular model, such a system would be unduly complex and computationally intensive.

Methods and Results: In this paper, we describe a freely available web-based electrophysiology simulator (http://svtsim.com). Its two main modules are a visualization/interface unit and a heart model based on a dynamical network, where nodes represent the points of interest, such as the sinus and the atrioventricular nodes, and links model the conduction system and pathways. The dynamics are encoded explicitly in the state machines attached to the nodes and links. Simulated intracardiac signals and surface ECGs are generated from the internal state of the heart model. The user interacts with the system by modifying the state of the state machines. Reentrant tachycardias, especially various forms of SVT, can emerge in this system in response to the user's actions. Additionally, the resulting arrhythmias respond realistically to various inputs, such as overdrive pacing and delivery of extra stimuli, cardioversion, ablation, and infusion of medications.

Conclusions: For nearly a decade, svtsim.com has been used successfully to train electrophysiology practitioners in many institutions. We will present our experience regarding best practices in designing and using electrophysiology simulators for training and testing. We will also discuss the current trends in cardiac electrophysiology and the next generation of electrophysiology simulators.



A screenshot of the svtsim showing the pacing interface (right panel), simulated ECG (the top channel), and simulated intracardiac signals.