# Electrophysiological Closed Loop Model of the Heart as Supporting Tool for Cardiac Pacing

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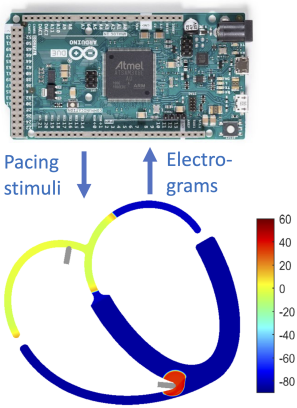
**Background**: In the last few years, pacemaker implantation has increased for the treatment of drug-resistant cardiac arrhythmias. Nevertheless, the rate of safety recall for cardiac devices is still high. Recently, it has been shown that both the design and the assessment of pacemakers can be enhanced by employing closed loop systems that include models of the heart electrical activity. In closed loop models, the heart activity is typically represented by finite automata. However, finite automata do not provide an accurate representation of the coupling between the heart tissue and the device.




Membrane potential (mV) during ventricular pacing

**Methods**: We developed a closed loop system consisting of a timed automaton pacemaker model and a 2D dynamical heart model. Our computational heart model is governed by the cardiac monodomain equations and includes different regions with heterogeneous electrophysiological properties. We emulated the pacemaker by programming an Arduino2 board using SIMULINK and the Stateflow toolbox of Matlab. The input to the Arduino2 were the instantaneous electrograms simulated by the heart model. The outputs of the Arduino2 were the pacing stimuli, which were given in input to the heart model. We developed a user interface (UI) to allow users to set the parameters of the pacemaker, electrodes position and modify the electrophysiological properties of the heart model. To demonstrate the functionalities of our framework, we analyse a pathological case of endless loop tachycardia, which insurges when the pacing stimuli and the intrinsic heart activity interfere.

**Results**: our closed loop system provided a promising environment for studying the interaction between the heart tissue and the stimulation device.

**Conclusion**: The closed loop framework combined with the UI may be an effective supporting tool to evaluate the safety and efficacy of the therapeutic effect of the pacemaker.