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Development of a closed-feedback loop device between graphics card simulations and cardiac tissue

Cardiovascular disease is number one cause of death worldwide. Tachycardias, which are potentially deadly rapid rhythms, are often associated with reentry. Reentry is either anatomical, where a wave rotates around an unexcitable obstacle, or functional, where the wave has a spiral or scroll morphology in the tissue. Methods for studying and generating strategies for abolishing reentrant waves are limited due to difficulties in dynamically responding to the wave in real-time. A hybrid computer tissue interface that controls cardiac tissue in real-time therefore has the potential to revolutionize approaches for treating arrhythmias. However, until recently the development of computational simulations that predict cardiac electrophysiological wave propagation required the use of dedicated workstations that typically took many minutes to simulate seconds of activity. With the aid of a newly developed computational library (Abubu.js) that harnesses the power of the graphics card, it is now possible to develop large-scale simulations that predict wave dynamics in real-time. Using these GPU based simulations, we built a closed feedback loop device that connects a cultured cardiac monolayer with 2D simulations in real-time. This device can control cardiac tissue through the use of optogenetic tools that sensitize the tissue to light. Motion detection cameras with the aid of appropriate algorithms read the monolayer activations and provide information to the simulation, which in turn stimulates the tissue using microcontrollers and LEDs. We plan to use our closed-feedback loop to investigate anatomical re-entrant waves and also aim to study the effect of neuronal input on anatomical waves.