

Toward the virtual heart: graphics processor accelerated interactive simulations of cardiac function

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Heart disease is the leading cause of death in the developed world. Despite this, our understanding of the mechanisms of cardiac dysfunction, particularly acute disorders related to the electrical system of the heart is limited. Our goal is to create a realistic virtual model of the heart to develop insight into this clinically important problem.

Using the multiscale modelling approach, we began at the molecular level with mathematical descriptions of the ion channels, pumps and buffers present in every heart cell. Integration of these subcellular components reproduces the cardiac action potential waveform the basic unit of cardiac electricity at the single cell level. From this building block we can extend our simulations to simple strings (1D), sheets (2D) and wedges (3D) of cells and even include descriptions of the overall architecture, anatomical detail and tissue heterogeneity necessary to simulate realistic hearts. At each level of complexity we have endeavored to gather appropriate experimental data to validate the model.

The computational complexity of the virtual heart has been prohibitive until very recently. However, the continued development of massive parallelisation using graphics processor technology has allowed us to compute the electrical activity of over several thousand cells concurrently. This has made the virtual heart a much more realistic and achievable goal.