Accelerating Action Potential Generation using GPU Implementation of a Resonant Model of a Cell

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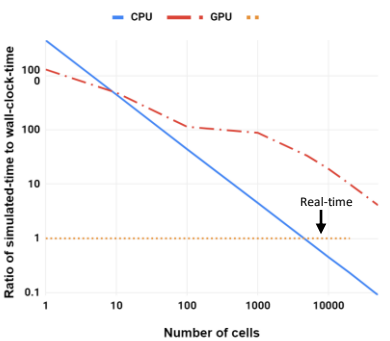
Aims: Computational modelling of the bioelectric phenomena of the cardiac tissue has made major contributions to our understanding of the bioelectric activity of the human heart. However, spanning these simulations over large temporal and spatial ranges is an inherently computational expensive task. Fueled by the establishment of the advantages of GPU over CPU in many areas of science, we have developed a new Resonant Model (RM) amenable to parallel computing. In this study, we have investigated the potential performance benefits of the implementation of the RM on a GPU.

Methods: The performance of the RM was evaluated on a PC with an Intel Xeon E7-8867 2.4 GHz dual-core CPU, 1160 GB RAM, and an NVIDIA Tesla V100 GPU. All the simulations were executed in double precision both on the CPU and GPU. In addition, all the simulations were run for 500,000 steps with a time step of 0.1ms. The RM CUDA C code was derived from the code written in C for CPU simulations.

Results: For more than ten cells, simulations of the RM cells were faster on the GPU in comparison to the simulations on the CPU. For 5000 and more RM cells, the GPU implementation executed ~45 times faster than the CPU. Simulating 50,000 cells on GPU were four times faster than the real-time. In contrast, RM execution for less than ten cells on the GPU was slower than the CPU. On the CPU only less than 5000 RM cells were simulated in real-time.

Conclusion: The significant performance gains obtained from the GPU implementation of the cardiac cell RM may result in the real-time performance of heart simulations minimizing the need for dedicated supercomputers. This facilitates the adoption of modelling-based precision health in the near future.



Comparison between CPU and GPU implementations