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Study of the Impact of Particle Resolution on the Computational Efficiency of a CPU-GPGPU Hybrid Running of a Single Plant Cell Model

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Modelling of plant has been an ever challenge to the numerical modelling community and so far, researchers have developed different types of numerical models to simulate such cell and tissues for the predication of different physical mechanisms. However, the main limitation of most of such models is the higher computational cost when mainly relying on Central Processing Unit (CPU) based running. As an alternative, literature suggest the possibility of using the General Purpose Graphical Processing Units (GPGPUs). Therefore, this research focused to develop a Smoothed Particle Hydrodynamics (SPH) based numerical model for running in CPU-GPGPU hybrid mode with the aid of CUDA (Compute Unified Device Architecture) programming language. The research aimed to investigate the relative computational advantages and sensitivity of the computational performance of the model to particle resolution of cellular models. Accordingly, a single cell model was developed using different particle resolutions such that wall particle number is changed to 24, 48, 96, 120, 150, 180 and 210, respectively. The simulations were run on a High-Performance Computer (HPC) having Intel® Core™ i7-6700, 3.4 GHz processor having 32 GB RAM and NVIDIA® QUADRO K1200 GPU with 4 GB RAM (512 CUDA cores), in Ubuntu 14.04 platform. The CPU-GPGPU hybrid running of the model was compared with the original CPU running of the model and found that the CPU-GPGPU hybrid running on above resolutions reduced the computational time by 38%, 40%, 56%, 57%, 57%, 56% and 56%, respectively. So, it is overserved that with higher number of particles in the model, the CPU-GPGPU hybrid running can lead to more computational savings, which can be significant in modelling large tissues with many cells. Accordingly, future works of this research will focus on modelling large tissues with the developed CPU-GPGPU hybrid running mode and such computationally efficient models will contribute largely for the advance analysis of morphological changes of plant tissues in different physical conditions.

Keywords: Computational efficiency, CUDA (Compute unified device architecture), General purpose graphical processing unit (GPGPU), Parallel processing, Smoothed particle hydrodynamics (SPH)