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A U-P IMPLEMENTATION FOR DYNAMIC SIMULATION OF SATURATED SOIL IN A CUDA-BASED MPM FRAMEWORK

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Abstract. In recent years, the Material Point Method (MPM) has emerged as a promising computational technique for simulating complex material behaviors, including the behavior of saturated soils. The saturated soil modelling, with huge deformations, requires handling large amounts of data and complex computations, making it a computationally intensive task. To address this challenge, in the present work an accelerated implementation of a modern MPM formulation for saturated soil analysis using the CUDA framework. The CUDA framework enables efficient parallel computing on Graphics Processing Units (GPUs), which can significantly accelerate the computational performance of MPM simulations. By exploiting the parallel processing capabilities of GPUs, the proposed implementation achieves remarkable speedup compared to traditional CPU-based implementations. The implementation begins by partitioning the computational domain into a regular grid of cells. The CUDA implementation leverages optimized memory access patterns and data structures to minimize memory latency and maximize memory bandwidth utilization. This reduces the communication overhead between the CPU and GPU, further enhancing the overall performance. Also, a modern numerical improvements in the classical MPM methodology was introduced, such as the Affine Particle-in-Cell (APIC) and Moving Least Squares Material Point Method (MLS-MPM), which source from graphics literature, reviewed and rephrased here for engineering applications In conclusion, the CUDA-based MPM implementation presented in this work provides a powerful computational tool for analyzing saturated soils. By harnessing the computational power of Multi-GPUs, it enables efficient and accurate simulations, facilitating advancements in the understanding and design of saturated soil systems.