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Urban Flood Mapping Using SPH Method and Precipitation Data Based on LiDAR Data

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Abstract

Urban floods are among the most dangerous and devastating natural hazards with extreme and undeniable consequences. With the recent creation of freely accessible, high-accuracy Light Detection and Ranging (LiDAR) data at 1-meter resolution, one approach to mitigate flood risk involves pinpointing inundated areas through detailed flood mapping. Incorporating the precipitation data can improve the realism and accuracy of flood simulation due to its ability to provide invaluable insights regarding the quantity and spatial distribution of rainfall. Urban flooding's intricate flow patterns, influenced by structures and obstacles, challenge traditional Eulerian models. Smoothed Particle Hydrodynamics (SPH), a meshfree approach, offers a possible solution as it mitigates grid generation and mesh distortion issues.

This study aims to identify inundated areas by producing flood mapping using the SPH method and LiDAR data. DualSPHysics, an open-source code developed based on the SPH method, is used to map the urban flood. However, SPH models are generally more computationally demanding than grid-based approaches. Therefore, this code is accelerated by high performance computing and modern graphic processing units (GPUs), and its Lagrangian nature facilitates the tracking of flood particles in the simulation.

For this research, 1 km^2 of LiDAR data from Montpellier City in France, which is highly prone to flooding, is selected. The city geometry serves as a fixed solid boundary condition, and the dynamic boundary treatment is used to simulate fluid particles. In the SPH method, dynamic particles are fixed on the boundaries. As a fluid particle approaches the solid boundary, the density and pressure of the dynamic particles escalate, leading to an augmentation in the magnitude of the repulsive force acting on the fluid particle. Therefore, the fluid particles are maintained within the domain. The interparticle distance in the SPH simulation is also considered 0.5 meters. By comparing the results, specifically the inundation extent and velocity, with another numerical simulation, the application of the SPH method demonstrates success in simulating floods. This comparison affirms the effectiveness of the SPH method in capturing water flow dynamics. Identifying the flooded areas using the available LiDAR data provides decision-makers with essential information to develop plans addressing urban flood challenges and minimizing their impact.