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A FAST, MODULAR APPROACH TO OBJECT PROPAGATION AND COLLISION ANALYSIS

Abstract

Recent long-term simulations of the space debris environment predict that collision fragments will become the major source of orbital debris on low Earth orbits in the future. To accurately assess potential hazards to spacecraft it becomes even more important to calculate collision risks in such simulations. For this purpose, various models exist that estimate collision probabilities of certain objects within a given population. These populations often include millions of objects which have to be propagated over time spans of several decades for long-term simulations. The high computation times required for these calculations are even further increased by large numbers of Monte Carlo runs that are required to account for randomly triggered events. Since all object positions of a population can be calculated independently from each other, propagation algorithms can be accelerated by implementing them on massively parallel hardware architectures such as graphics processing units (GPUs). This has been shown in previous research. For fast collision detection among large object numbers, various methods exist which pre-sort possible collision partners using tree-based data structures. To efficiently combine GPU-based object propagation and post-processing algorithms such as collision detection, a software architecture is required that allows both components to directly interface with each other and keeps time-expensive data transfers between CPU and GPU at a minimum. In this paper, a fast algorithm for collision analysis is introduced that works on large object populations. It is embedded into a plugin-based software architecture that has been specifically designed for space debris object propagation and analysis. Its modular structure allows for tight coupling of orbital propagation and post-processing algorithms both on the CPU and the GPU. The propagator itself is designed in a fashion that models of perturbation forces can be interchanged depending on speed and accuracy requirements as well as available hardware platforms.