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MASSIVE GPU PARALLELISATION FOR CISLUNAR DEBRIS MITIGATION ANALYSES

Abstract

Nowadays, the issue of space debris is becoming central to any operation in space. Future lunar exploration missions won't be exempted from this issue, with the aggravating factor of operating in a gravitational multi-body chaotic environment. Debris-related analyses often involve propagating numerous trajectories independent from each other. These allow, for example, estimating probabilities of further interaction of space debris with the Earth and other protected regions of space; additionally, initial uncertainties on the object's state or the magnitude and direction of manoeuvres can be introduced in the analyses. This can translate into massive grid searches or Monte-Carlo runs, to map the totality of the solution space. Operators and mission designers can then use this cartography to support the design of normal mission and disposal phases. A similar approach can also help identify the areas most susceptible to chaotic behaviours, or the risk posed by a spacecraft fragmentation in such locations. All these efforts are often paired with the necessity to propagate for very long times with high precision, which increases the load on the computational infrastructure.

This paper discusses the application of Graphics Processing Units (GPUs) to implement massive parallelisation of the propagation of motion in the Sun-Earth-Moon gravitational environment. GPUs, when compared to CPUs, are capable of performing simpler independent tasks in parallel in a much faster fashion. CUDAjectory, a CUDA-based software developed by the European Space Operations Centre, has been employed: parallel computations are used to obtain, in reasonable amounts of computational time, dynamical maps starting from hundreds of thousands of starting states. Some example cases are discussed, in an effort to show the type of analyses that can be performed, showing the logic followed in the samples creation, propagation and post-processing. The inner workings of the propagating tools are also introduced, showing how the advantage with respect to CPU parallelisation is achieved. The results of this work are the creation of a set of pictorial maps to visualise cislunar dynamical behaviours and patterns. The paper focuses on some example starting locations, considered as of interest for future exploration, such as Near Rectilinear Halo Orbits, or Distant Retrograde Orbits. These maps can, for example, link initial states and manoeuvres magnitudes to possible future disposal locations, such as lunar impacts or escapes in solar orbit.