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FAST CONJUNCTION ANALYSIS PIPELINE FOR SPACE SITUATIONAL AWARENESS

Abstract

The advent of mega-constellations has given rise to an unprecedented exponential growth in the numbers of objects in orbit. As the number of objects sharing similar orbital trajectories increases, as do the probabilities of close encounters and subsequent collisions. Collisions produce more objects further increasing the probability of later collisions until the Earth orbit environment is rendered unusable. Accurate prediction of these encounters is key to enabling satellite operators to perform collision avoidance manoeuvrers. This prediction is typically performed by a chain of: Orbital Propagators, to determine an objects state vector at a given time; Encounter Analysers, to determine which objects are sufficiently close to warrant further examination; and Statistical Models, to determine the probability that a conjunction will result in a collision. There is a need to rapidly compute data for a timelier response to threats as new observation is received. The generation of both historical augmented-future observation data can improve existing statistical models or as training data for machine learning systems. A key issue is how to ingest, propagate and provide statistics on historical observation data from JSpoC – estimated to take ¿20 years on a typical CPU only pipeline. By approaching the problem from a more data-oriented perspective, we propose a new prediction and analysis pipeline that 1/ enables historical analysis and trends for instrument development to government policy making, and 2/ is also practical for current and future operators decision making for early warning of encounters can be converged upon much more quickly than traditional methods. Our alternative perspective focuses on exploiting the underlying Nvidia-CUDA GPU architecture for the software tools. We also reconsider how the data is represented in memory, choosing appropriate detail at each analysis stage, and how this can be leveraged to improve computation performance. Using our method, we can compute a full historical dataset containing every 5 km conjunction since the first spaceflights of 1957 in approximately 11 days. Using the modest 2xGTX1060 available a traditional solution would have taken 6 months. New data can be appended as it becomes available each day, and executes in under 5 minutes per day for new updates. The historical dataset is 430 GB, can be used in statistical modelling and future opportunities in machine learning training data to determine trends.