Collision Risk Assessment for Perturbed Orbits via Validated Global Optimization

Alessandro Morselli
Politecnico di Milano, Italy

A method intended to assess the occurrence of impacts between satellite and space debris is presented. The method is based on the computation of the Minimal Orbit Intersection Distance (MOID) between two perturbed orbits. The MOID is obtained by means of a global optimization, using a global optimizer based on Taylor Models. The position of the orbiting objects is described through analytical solutions that take into account zonal harmonics and atmospheric drag. The global optimizer searches the local minimum of the square distance between the two orbits, that is a function of the two true anomalies and time. The optimization is capable of providing tight enclosures of the global minimum. The method is applied to the case of a Sun-synchronous orbit and an equatorial elliptic orbit. Due to the effect of the Earth zonal harmonics, the orbital plane of the Sun-synchronous orbit performs a complete rotation around Earth's North Pole direction. The relative geometry of the two orbits is such that four intersections occur within one year window. A second test-case demonstrates the ability to predict the effect of drag perturbations. Two LEO orbits are considered, one of which is strongly influenced by atmospheric drag. The decrease of semi-major axis leads to an intersection between the two orbits in the considered time span. The method is capable to recognize correctly the intersections between two orbits. It can thus identify the conditions in which close approaches between satellites and debris occur. The method is intended to perform a fast screening of all possible combinations of orbiting object, since the use of analytical theory cuts down simulation time.