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STATION-KEEPING FOR QUASI-PERIODIC ORBITS

Abstract

The shallow gravity gradient in the libration point regions enables manoeuvring low Δv expenses, but implicates a sensitivity to small perturbations. A variety of bounded orbits can be determined at each point and station-keeping is required to maintain them. In this paper, the station-keeping procedure and their associated costs are studied for so-called quasi-periodic solutions in particular. The method described here, utilises a bisection method to estimate the lifetime of an orbit and introduces manoeuvres that maintain the orbit within a defined box. The station-keeping can be applied at arbitrary discrete time intervals depending on the dynamical environment, e.g. the gravitational effect of other planets have a large impact on the solution. The manoeuvre direction is finally optimised with a differential evolution algorithm providing the maximal lifetime of the orbit. The quality of the station-keeping manoeuvre is determined by the time the orbit remains within the defined bounding box. The study shows that the manoeuvre direction is directly correlated to stability information that is provided by the theory of invariant tori. The direction can be pre-calculated and if the location of the manoeuvre is the same every time it is even constant. A similar methodology is already applied in the past to periodic orbits, where the manoeuvre direction is determined by the eigenvector if the monodromy matrix. The novelty of the method presented here is the applicability to quasi-periodic orbits and the suitable choice of the global optimisation method. The magnitude of the manoeuvre remains as unknown and is evaluated by the lifetime analysis of the orbit after manoeuvre execution. The results are compared with a simple target point scheme and the Floquet mode approach using knowledge from dynamical system theory to cancel some modal components. Finally, numerical calculation were carried out for a trajectory around the far-side libration point in the Earth-Moon system to show the robustness and effectiveness of the station-keeping approach in a dynamical system fed with planetary ephemeris data.