Paper ID: 96389
oral
student

IAF ASTRODYNAMICS SYMPOSIUM (C1)
Interactive Presentations - IAF ASTRODYNAMICS SYMPOSIUM (IP)

Author: Mr. Edgar Kirchner
Technische Universität München, Germany

Mr. Max Kisch
Germany
Mr. Antonius Adler
Germany
Prof.Dr. Thomas Mannchen
Duale Hochschule Baden-Württemberg, Germany

DIMENSIONALITY REDUCTION IN ANGLES-ONLY OPTIMAL ORBIT DETERMINATION

Abstract

The modern, globally connected civilisation relies on space-based services such as communication, navigation and Earth observation. However, due to the growing number of objects in orbit, space systems are increasingly exposed to the risk of collisions with other spacecraft or debris, requiring increased situational awareness for operations in space. Mission-critical decisions rely on space surveillance and tracking capabilities, while orbit determination is crucial for subsequent orbit propagation and collision avoidance. Furthermore, a number of high-profile, unpredicted asteroid impacts on Earth in the past emphasize gaps in the knowledge of the orbital interplanetary environment.

Optimal orbit determination is the process of estimating the most accurate Keplerian parameters of an orbital object by minimising the error between observed and predicted positions in an inertial reference frame. This paper presents the concept of utilizing an analytic relationship between orbital parameters to reduce the number of degrees of freedom of the optimization. By using this approach, the reliability of convergence is improved and the computation time is reduced by up to 90%.

The analytic relationship that is introduced relates the *semi-major axis* to the *eccentricity* and *true anomaly*, thereby eliminating one degree of freedom. This is achieved by constraining the problem domain to solutions that match the time-interval between observations of the object in orbit. However, an additional parameter is introduced by the analytic relationship. An advanced approach is demonstrated by which the introduced parameter can be obtained from the boundary conditions given by the observations of the object. Therefore, only five degrees of freedom remain in the optimization instead of six.

This approach is successfully demonstrated on the example of an angles-only initial orbit determination algorithm, specifically developed to treat interplanetary objects, such as asteroids. As inputs, artificial observation geometries as well as actual observation datasets are used. These where collected by the authors on the asteroid *(25330) 1999 KV4* over a period of six months.