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EVALUATING THE ACCURACY AND ROBUSTNESS OF INITIAL ORBIT DETERMINATION METHODS FOR SSA IN LOW EARTH ORBIT USING REAL OBSERVATION DATA

Abstract

Space Situational Awareness (SSA) has become the focal point of space borne missions with ever-increasing activity in near earth orbit. Nations and private corporations rapidly started to invest in their SSA programmes to track, identify and catalogue overflying objects. Maintaining an accurate catalogue is crucial not only to take precautions to avoid potential collusions of space assets, but also it is important to classify domestic and foreign space activity. To be able effectively track and identify space objects, orbital parameters or the state vectors of the object should be determined. This study will be carried out with the real observation data gathered from ground station located in Ankara, Turkey. Using ground-based telescopes, high fidelity images of low-earth orbit (LEO) satellite tracks will be obtained and using an open-source image processing library stvid by Cees Bassa, equatorial right ascension (RA, α) and declination (DEC, δ) angles of the satellite will be extracted. One can then obtain Keplerian parameters by applying various Initial Orbit Determination (IOD) methods such as Laplace, Gauss, Gooding etc. Since the question here becomes an accuracy issue rather than how to implement IOD methods, the efficiency, accuracy, and robustness of these different methods as a function of the observation arc and the temporal separation between individual observations will be addressed within this study. Comparison of already available IOD algorithm and potential improved algorithms will be thoroughly discussed. Additionally, a circular orbit assumption will be applied to aforementioned IOD methods that require three set of angle measurements so that this necessity will be reduced into only two observations. Upon thorough examination of different IOD methods, it is found that when the number of observations is limited, it is necessary to increase the time between observations in order to improve the accuracy of the solution. For the objects orbiting in LEO, the time separation between individual observations should be maximized within the constraints of available resources. As a general statement, it is observed that methods for IOD tend to produce very elliptical or even hyperbolic orbits for very short arcs. When determining the orbit of an object, it is usually a good idea to start by assuming that the orbit is circular and to consider the degree of deviation from circularity (eccentricity) only when there are enough observations over a long period of time. This approach is considered to be a safe and reliable way to proceed.