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Orbit Determination and Propagation (9)

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ON THE PERFORMANCE ANALYSIS OF INITIAL ORBIT DETERMINATION ALGORITHMS

Abstract

Space Situational Awareness (SSA) refers to the ability to view, understand and predict the physical location of natural and manmade objects in orbit around the Earth. While the ability to view is made possible thanks to ground and space based sensors (e.g. Radars, Telescopes or Lasers) the ability to understand and predict the physical location of objects needs the determination of their orbital state vectors, which uniquely determine the trajectory of the object in space.

For the determination of the orbital state of an object, mainly two different situations have to be considered. Either the object is already known (i.e. it is regularly observed by sensors and an a priori state vector exists) or the object has been newly discovered by a so-called surveillance sensor. In the first case, the problem is already well known and the a-priori orbital state of the object can be updated thanks to the new gathered observations and a batch (Least-Squares) or a sequential (Extended Kalman Filter) filtering approach. In the second case, an a priori orbital state has to be computed from the gathered observations, in order to predict the position of the newly detected object at short term and to improve the orbit thanks to the acquisition on new observations from surveillance and/or tracking sensors.

On this paper we interest ourselves to the second problem, and in particular to the efficiency and accuracy of existing Initial Orbit Determination (IOD) as a function of available measurements (e.g. angles only), the accuracy of such measurements, and of the orbital region of the observed object. In addition of the previous variables, the response of studied IOD algorithms (Gauss [1], Gooding [2], Karimi and Mortari [3]), to the temporal separation of measurements and to the length of the observed arc has also been studied.

The results presented on this paper may be used by sensor operators to decide which IOD algorithm to use as a function of the characteristic of their measurements and of the orbital region observed.

[1] D.A. Vallado. Fundamentals of Astrodynamics and Applications, 3rd edition. Space Technology Library (2007)

[2] R. H. Gooding. A new procedure for the solution of the classical problem of minimal orbit determination from three lines of sight. Celest Mech Dyn Astr (1997) 66 : 387-423

[3] R.R. Karimi and D. Mortari. Initial orbit determination using multiple observations. Celest Mech Dyn Astr (2011) 109:167-180