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Author: Mr. Chen Gao
German Aerospace Center (DLR), Simulation and Software Technology, Germany

Mr. Philipp Martin Fischer
German Aerospace Center (DLR), Simulation and Software Technology, Germany
Dr. Andreas Gerndt
German Aerospace Center (DLR), Simulation and Software Technology, Germany
Prof. Zhen Yang
CSSAR/CAS, China

A STUDY OF UNCERTAINTY ANALYSIS FOR FORMATION SATELLITE DETECTION SYSTEM
IN SPACE SCIENCE MISSION

Abstract

A space science mission is a detection system. Formation satellite mission plays a more and more important role in space science. It has unique advantage in detecting high dimensional physical phenomenon like the magnetic connection in Geo magnetosphere while single satellite mission is hard to distinguish spatial and temporal variations. In the space engineering, error of the detection needs to be discussed. Accuracy of positioning, timing and attitude adjusting, the error of the payload itself are inevitable uncertain parameters which will have effect on the detection. In the designing phase of a space mission, a method which can make a quantitative analysis on how these uncertainties affecting the detection will have benefits in evaluating and optimizing the mission.

In the formation satellite missions, spatial and temporal parameters are highly coupled during the detection. Differential analysis which is widely used in single satellite mission is hard to meet the requirement for uncertain analysis in formation satellite mission. Monte Carlo method based simulation is a general approach to solve this kind of problem. I n this simulation, uncertainties of parameters are expressed in a distribution such as Gauss distribution. And a set of parameters is randomly generated by these distributions. By analyzing the results from massive numbers of repeated simulations, it can be figured out how the detection system is affected by these input uncertainties. But, the re-sampling process of Monte Carlo method is complex and time consuming. In the early design phase of a space mission, the details of a precise statistic result from Monte Carlo simulation are seldom used. The statistic characters such as the mean value, variance and interval of probability are more meaningful. In this paper, the Most Probable Failure Point (MPP) method which is used in reliability analysis is introduced to this study. In MPP method, the detection system function is approximately replaced by a linear or second order function using Taylor's theorem in a proper point. This point is called the most probable failure point. With this approximate function, the effect of uncertainties in parameters can be calculated directly. Compared to Monte Carlo method, this method is roughly but less complexity. In this paper, both Monte Carlo and MPP method are implemented for a formation satellite mission. By comparing the result, the availability and accuracy of MPP method is evaluated.