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Author: Mr. Ang Zhang
Beihang University, China

Dr. Ming Xu
Beihang University, China
Dr. Shengli Liu
DFH Satellite Co., Ltd., China

PROBABILISTIC ASSESSMENT AND OPTIMIZATION FOR FRACTIONATED SPACECRAFT ARCHITECTURE FROM THE ECONOMIC COST POINT OF VIEW

Abstract

Fractionated spacecrafts are of particular interest for pointing-intensive, remote sensing missions because of their abilities to physically decouple subsystems and payloads. Compared with the classical monolithic architecture, the fractionated spacecraft has **intuitively** less development and operation cost, and more robustness and reliability. However, the **quantitatively** evaluations between such fractionated and other candidate architectures are required by the aerospace institutes to invest some innovative missions benefited from the fractionated spacecraft architecture. Therefore, it is necessary to present a systematic cost-assessing methodology during the mission lifecycle with a thorough consideration of all the uncertainties.

Considering the probabilistic uncertainties during the mission lifecycle, the cost assessment or architecture optimization is essentially a stochastic problem. This paper seeks to quantitatively assess and probabilistic optimization for a pointing-intensive, remote sensing mission. The lifecycle is divided into three phases, i.e., module development, launch vehicle design and on-orbit control, which is modeled by some physics-based parameters, as mass, power, propellant usage, and so on. And then an economic concept, the net present value (abbr. NPV) is introduced to count up financially all the costs on the operations.

It is well known that the Monte-Carlo method is good at creating all the stochastic situations to handle with the nonlinear uncertainties during the mission lifecycle; however, the classical Monte-Carlo simulation is weak in involving in lots of computations. Therefore, another contribution in this paper is to introduce the unscented transformation (abbr. UT) to reduce similar stochastic situations, which was proposed firstly to improve the deficiencies of linearization for the extended Kalman filter. Thus, the improved Monte-Carlo algorithm is efficiently working for the evaluation procedure.

Furthermore, due to the parallelization of the Monte-Carlo technique, the GPU accelerating genetic algorithm based on the CUDA architecture is employed to optimize the fractionated spacecraft architecture from the viewpoint of probability. Both the mean and variance of NPV can be selected as the optimization goals; however, the former will yield the most economic spacecraft, but the latter will obtain the most robust fractionated cluster. The first round optimization indicates that four modules flying on a sun-synchronous orbit of the altitude of 573km and the RAAN of 10:30AM are preferred to achieve the maximum NPV.