Paper ID: 13904
student

SYMPOSIUM ON COMMERCIAL SPACEFLIGHT SAFETY ISSUES (D6)
Commercial Space Flight Safety and Emerging Issues (1)

Author: Mr. JeongJae Seo
Korea Advanced Institute of Science and Technology (KAIST), Korea, Republic of, sjj164@kaist.ac.kr

Prof. Jaemyung Ahn
Korea Advanced Institute of Science and Technology (KAIST), Korea, Republic of,
jaemyung.ahn@kaist.ac.kr

A RESPONSE SURFACE MODEL FOR THE EFFECTS OF THE ATMOSPHERIC DRAG ON THE INSTANTANEOUS IMPACT POINT (IIP) OF A ROCKET

Abstract

The instantaneous impact point (IIP), which is defined as the touch-down point of a rocket in a thrust-free trajectory with current point and velocity, is critical information for launch operations that can be used to determine whether the flight of the rocket is normal or not. An accurate prediction of the IIP of the rocket under a constraint that it should be calculated in real-time with limited computational resources is one of key requirements that a successful range safety system should satisfy.

There have been many studies on the methodologies to accurately predict the IIP of a rocket without using the numerical integration, which consumes lots of computational resources and hence does not well fit for real-time implementation. This paper proposes a methodology that calculates the effects of the atmospheric drag on the IIP of a rocket in an efficient way and can improve the accuracy of the Keplerian IIP, which is an analytic and exact solution of the impact point for the vacuum flight in the inverse-square gravitational field. The response surface method (RSM) is used to model the flight angle error and the flight time error due to the drag with planar position and velocity of a rocket in flight as inputs. A weighted least-square approach, with the inverse of the impact range as the weight, has been used to determine the parameters of the model.

Simulation results for two-dimensional thrust-free flight under gravity and atmospheric drag with various initial velocities and positions have been used as the experiment data for fitting. A statistical analysis has been carried out to determine the optimal structure of the response surfaces for the model. Initial analysis results for the response surface model using the vertical and horizontal velocity components with coefficients varying dependent on the altitude indicates very high goodness of fit with R-square value larger than 0.99.

The proposed model has been verified against the numerical simulation results for three-dimensional rocket flights. Some discussions to improve the model to capture the effect of the J2 spherical harmonics term are also provided.