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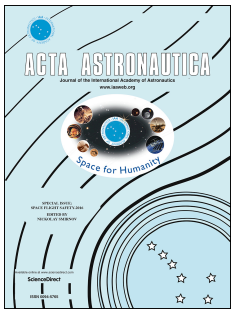

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Recovering Area-to-Mass Ratio of Resident Space Objects through Data Mining

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Abstract

The area-to-mass ratio (AMR) of a resident space object (RSO) is an important parameter for improved space situation awareness capability due to its effect on the non-conservative forces including the atmosphere drag force and the solar radiation pressure force. However, information about AMR is often not provided in most space catalogs. The present paper investigates recovering the AMR information from the consistency error, which refers to the difference between the orbit predicted from an earlier estimate and the orbit estimated at the current epoch. A data mining technique, particularly the random forest (RF) method, is used to discover the relationship between the consistency error and the AMR. Using a simulation-based space catalog environment as the testbed, this paper demonstrates that the classification RF model can determine the RSO's category AMR and the regression RF model can generate continuous AMR values, both with good accuracies. Furthermore, the paper reveals that by recording additional information besides the consistency error, the RF model can estimate the AMR with even higher accuracy.

Keywords: Area-to-Mass Ratio; Resident Space Object; Data Mining; Decision Tree; Random Forest; Consistency error.

1. Introduction

There has been increasing need for new methods and techniques that can improve the space situation awareness (SSA) on the resident space objects (RSOs), including both space debris and operational satellites. As of April 6, 2016, more than 17,385 large objects are circling around the Earth in space, and the total number of space debris larger than 1 cm is estimated to be in the order of 1 million [1]. Moreover, the collision between Iridium 33 and Cosmos 2251 in 2009 has created thousands of fragments larger than 4–5 cm, which seems to confirm that the chain reaction of the collisions between space debris has already been triggered [2].

Fundamentally, orbits of RSOs are governed by physical forces. Among these, conservative forces including the Earth gravity force and third body perturbations are now well understood and can be computed

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