Accepted Manuscript

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PII: S0273-1177(18)30203-5
DOI: https://doi.org/10.1016/j.asr.2018.03.001
Reference: JASR 13659

To appear in: *Advances in Space Research*

Received Date: 21 February 2017
Revised Date: 14 December 2017
Accepted Date: 2 March 2018

Please cite this article as: Peng, H., Bai, X., Improving Orbit Prediction Accuracy through Supervised Machine Learning, *Advances in Space Research* (2018), doi: https://doi.org/10.1016/j.asr.2018.03.001

Improving Orbit Prediction Accuracy through Supervised Machine Learning

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Abstract

Due to the lack of information such as the space environment condition and resident space objects' (RSOs') body characteristics, current orbit predictions that are solely grounded on physics-based models may fail to achieve required accuracy for collision avoidance and have led to satellite collisions already. This paper presents a methodology to predict RSOs' trajectories with higher accuracy than that of the current methods. Inspired by the machine learning (ML) theory through which the models are learned based on large amounts of observed data and the prediction is conducted without explicitly modeling space objects and space environment, the proposed ML approach integrates physics-based orbit prediction algorithms with a learning-based process that focuses on reducing the prediction errors. Using a simulation-based space catalog environment as the test bed, the paper demonstrates three types of generalization capability for the proposed ML approach: 1) the ML model can be used to improve the same RSO's orbit information that is not available during the learning process but shares the same time interval as the training data; 2) the ML model can be used to improve predictions of the same RSO at future epochs; and 3) the ML model based on a RSO can be applied to other RSOs that share some common features.

Keywords: Orbit Prediction; Resident Space Object; Supervised Machine Learning; Support Vector Machine.

1. Introduction

The amount of resident space objects (RSOs) and the quantity of conflicts between RSOs are rapidly escalating. The number of space objects larger than 10 cm is presently approaching 21,000, the estimated population of objects between 1 and 10cm is about 500, 000, and for objects smaller than 1cm the number exceeds 100 million (NASA). At the heart of the challenges for Space Situational Awareness (SSA) is to predict each object's orbit efficiently

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