Paper ID: 57835
student

18th IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Operations in Space Debris Environment, Situational Awareness (7)

Author: Ms. Emma Stevenson
Universidad Politécnica de Madrid, Spain, emma.stevenson@upm.es

Dr. Victor Rodriguez-Fernandez
Universidad Politécnica de Madrid, Spain, victor.rfernandez@upm.es
Dr. Edmondo Minisci
University of Strathclyde, United Kingdom, edmondo.minisci@strath.ac.uk
Prof. David Camacho
Universidad Politécnica de Madrid, Spain, david.camacho@upm.es

A DEEP LEARNING APPROACH TO SPACE WEATHER PROXY FORECASTING FOR ORBITAL PREDICTION

Abstract

The effect of atmospheric drag on spacecraft dynamics is considered the most dominant source of uncertainty in low earth orbit. These effects are characterised in part by the atmospheric density, a quantity highly correlated to space weather. Current thermosphere models account for this through the use of proxies for the solar Ultraviolet flux, and geomagnetic activity. However, owing to their aleatory nature, and the absence of a generally accepted physical solar model, prediction of these quantities is a limiting factor in the accurate estimation of future drag conditions. This has fundamental implications both in the short term, in the day-to-day management of operational spacecraft, and in the mid-to-long term, in determining satellite orbital lifetime.

In recent years, the application of machine learning techniques to the forecasting of space weather proxies has become a topic of extensive research [1]. Although promising, there is still some contention with traditional statistical methods, and there exist several open challenges, not limited to interpretability, uncertainty quantification, and geomagnetic storm prediction.

In this work, a novel deep learning architecture is employed for the forecasting of space weather proxies relevant to orbital prediction. This state-of-the-art framework uses an untailored, purely machine learning approach, which has been shown to outperform well-established statistical models in the field of time series forecasting [2], and shows promising preliminary results.

The extension of this architecture to include complementary proxies during the forecasting process will also be studied. The use of multiple correlated proxies to enhance the predictive power of each other has particular relevance, as different thermosphere models consider different indices to be most representative of the space weather conditions [3]. Finally, the issue of uncertainty treatment will be addressed, and a comparison of the results with currently used operational forecasts, as well as other recent deep learning based methods, will be presented.

References:

[1] Camporeale, E. (2019). The Challenge of Machine Learning in Space Weather: Nowcasting and Forecasting. Space Weather, 17(8), 1166–1207.

[2] Oreshkin B.N., Carpov D., Chapados N., Bengio Y. (2020). N-BEATS: Neural basis expansion analysis for interpretable time series forecasting. arXiv:190510437

[3] Virgili, B. B., Lemmens, S., Stevenson, E., Reihs, B. (2017). Statistical comparison of ISO recommended thermosphere models and space weather proxy forecasting on re-entry predictions. Proceedings of the International Astronautical Congress, IAC.