Paper ID: 58911
oral
student

53rd IAA SYMPOSIUM ON SAFETY, QUALITY AND KNOWLEDGE MANAGEMENT IN SPACE ACTIVITIES (D5)
Space Environment and Effects on Space Missions (3)

Author: Mr. Vincenzo Chiaramida
Politecnico di Torino, Italy, vincenzo.chiaramida@studenti.polito.it

Mr. Aitor Estarlich
Politecnico di Torino, Spain, aitor.estarlich@gmail.com
Mr. Aswin Manohar
Politecnico di Torino, Italy, s278896@studenti.polito.it
Mr. Lippin Pauly
Politecnico di Torino, Italy, lipzpauly@gmail.com
Ms. Theodora Varelidi Strati
Politecnico di Torino, Italy, theo.varstr96@gmail.com

A CONVOLUTIONAL AND RECURRENT NEURAL NETWORK BASED APPROACH FOR SOLAR WEATHER PREDICTION

Abstract

The harming effects originating from solar activity on ground and space-based assets have been repeatedly demonstrated over the years. Induced electric fields and X-ray bursts coming from the Sun can damage power transmission lines, wired and wireless communications as well as produce additional drag that can affect spacecrafts in orbit. Several studies have been carried out for the development of solar weather models, able to predict phenomena like solar flares and Solar Particle Events, driven by the analysis and the observation of the photosphere and the solar magnetic field. This work introduces a machine learning approach with the objectives of first detecting and classifying sunspots, and secondly predicting their correlation with the outbreak of solar flares and SPE. The dataset exploits a combination of publicly available resources, in particular from the National Oceanic and Atmospheric Administration (NOAA), the National Solar Observatory (NSO) as well as pictures of the photosphere taken from the Solar and Heliospheric Observatory (SOHO) mission archive. The network applies a set of preprocessing operations to increase the level of uniformity among the raw data coming from different sources. Sunspots detection is achieved through semantic segmentation that exploits the capabilities of Convolutional Neural Networks (CNN) that well fit the nature of the problem. Additional complexity is added by the need of the distinction between single and grouped sunspots, a feature that requires the correct processing of the umbra and penumbra zones. The prediction task relies instead on the power of Long Short-Term Memory (LSTM) cells, a kind of gated Recurrent Neural Network (RNN) that proved to be very effective in modelling time-series predictive problems. The main feature that this approach aims to exploit is the dependency between consecutive time inputs, as the same sunspot can span over adjacent portions of the photosphere during its lifecycle. Exploiting future and higher resolutions data coming from NSO Inouye Solar Telescope (DKIST), as well as NASA Parker Solar Probe and ESA Solar Orbiter, the model could represent a base reference for further advances in the analysis and predictions of solar activities.