"Processing Solar Images to forecast Coronal Mass Ejections using Artificial Intelligence"

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Abstract

In this project, we develop a new processing tool that provides the input, which is used by Artificial Intelligence algorithms to create a new type of forecasting model for Coronal Mass Ejections. The reason A.I. models are used is because compared to atmospheric weather forecasting that we can rely on a large network of weather stations. In space, there are not enough satellites and a physics based modeling of interplanetary Space is limited.

The processing tool is a module, built in python, that downloads process and organize images from SDO in order to be fully utilized as inputs in the A.I. model that is being built. The idea behind the processing tool is to create an automatic procedure that uses Sun's differential rotation and images from SDO to derive "History Maps". These maps show how the intensity of a specific area of the Sun developed during a specific time period. The tool takes the intensity of multiple longitudes at a given date, and then tracks their position back in time ([x] hours), creating one history image per longitude. A 3D representation of the line's intensity ([longitude vs latitude vs time]) keeps a recollection of the evolution of fast evolving features in the atmosphere of the Sun, like CMEs. Multiple wavelengths can be used to also take into account the feature evolution in altitude.

The goal of the project is to forecast possible development of Coronal Mass Ejections (CMEs) from different part of the Sun along with their characteristic. CMEs are one of the energetic events that can lead to disturbances in the magnetic field of Earth and therefore are directly connected to Space Weather Applications. For the prediction model, Convolution Neural Networks (CNN) are used to obtain information from the CME catalog of CACTus and LASCO, using images from SDO. The input of our model is, therefore, a pre-processed time-series of 2D images from the Sun, whereas, the final output is the forecasting of a CME and its characteristics. Feature selection of our model is carefully done from a wide range of observations, that include different wavelengths, magnetometers etc. until the perfect combination of data is found. For the training of the CNN and for the image processing, we will be implementing HPC techniques using the Flemish Supercomputer Centre (VSC).

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