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Predicting the Transit Time and Geo-effectiveness of Coronal Mass Ejections using Neural Networks

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Predicting the arrival time of Coronal Mass Ejections (CME) and the strength of their geomagnetic storms at Earth is crucial in space operations and essential to avoid losing our space instruments and not to risk our astronauts' lives in space. Besides, protecting the power grids and pipelines on the ground from the side effects of geomagnetic storms. We contribute to this matter by implementing Neural Network (NN) models to predict the CME transit time and the minimum value of the Disturbed storm time (Dst) index of the associated geomagnetic storm.

For the first time, we employed the planets' ephemeris as input features. Taking the CME properties (angular width, linear speed, speed at 20 solar radii, measurement position angle, latitude, and longitude), the solar wind and plasma parameters (the differential speed between the CME and the solar wind, the average interplanetary magnetic field with its 3D components, proton density and plasma temperature, speed in 3D components, dynamic pressure, electric field, plasma beta parameter, Mach number, and magnetosonic Mach number), and the planets' ephemeris in the solar system (distance from the Sun, latitude, and longitude) as inputs, we performed a grid of NNs to predict not only the CME transit time but also the minimum disturbed storm time (Dst) index of the associated geomagnetic storm.

We proposed the new Best-of-the-Best (BOB) approach to optimize the NN hyperparameters using the *GridSearch* method in Python. We assembled our dataset from (Gopalswamy et al., 2010), (Micha lek et al., 2004), and (Richardson and Cane, 2010) with a total of 230 events between 1997 and 2020. This is the largest dataset of CME-ICME pairs along with solar wind indices and planets locations in the solar system so far.

Remarkably, for the given dataset, the best set of input features for predicting the CME transit time was the CME features and the planets' ephemeris, while for predicting the Dst index were the top correlated features, with a Mean Absolute Error (MAE) of 13.54 hr and 35.57 nT, respectively. More details are described in the manuscript.