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Poster

We consider the development of machine learning models to forecast the occurrence of solar flares a few tens of minutes in advance. Such results can be used to support projects such as the NASA Solar Flare Sounding Rocket Campaign in Spring 2024, during which three rocket-borne instruments will be launched near-simultaneously to observe the evolution of a flare. Accurate advance prediction of the flare will enhance the chances of observing the flare in its impulsive/rise phase. We have trained Convolutional Neural Networks (CNNs) on images of active regions recorded by the Atmospheric Imaging Assembly on board the Solar Dynamics Observatory (SDO/AIA) in seven EUV wavelengths at several consecutive timesteps, forming four-dimensional $(x,y,?,t)$ “datacubes”. These datacubes contain information on both morphological and thermodynamic changes within the active regions, both of which are likely precursors of flaring activity, and hence have an enhanced predictive capability compared to the magnetograms that are usually employed. We show preliminary results obtained by training CNNs on a dataset of active region datacubes recorded between 2010 and 2018. We also discuss Fourier-based data compression techniques that can be used to significantly reduce the size of the dataset while retaining its essential morphological and thermodynamic information. We also describe the training of CNNs on Differential Emission Measure (DEM) datacubes that are constructed from the original $(x,y,?,t)$ datacubes by means of a novel Regularized Maximum Likelihood inversion algorithm.

Solar flare forecasting using multi-wavelength SDO/AIA data
Paolo Massa

Introduction
of this project is to develop machine learning methods for forecasting times of solar flares ~10 min in advance. Such results can be used to support projects such as the NASA Solar Flare Sounding Rocket Campaign in Spring 2024, during which three rocket-borne instruments will be launched near-simultaneously to observe the evolution of a flare. We have trained Convolutional Neural Networks (CNNs) on images of active regions recorded by the Atmospheric Imaging Assembly on board the Solar Dynamics Observatory (SDO/AIA) in seven EUV wavelengths at several consecutive timesteps, forming four-dimensional $(x,y,?,t)$ “datacubes”. These datacubes contain information on both morphological and thermodynamic changes within the active regions, both of which are likely precursors of flaring activity, and hence have an enhanced predictive capability compared to the magnetograms that are usually employed. We show preliminary results obtained by training CNNs on a dataset of active region datacubes recorded between 2010 and 2018. We also discuss Fourier-based data compression techniques that can be used to significantly reduce the size of the dataset while retaining its essential morphological and thermodynamic information. We also describe the training of CNNs on Differential Emission Measure (DEM) datacubes that are constructed from the original $(x,y,?,t)$ datacubes by means of a novel Regularized Maximum Likelihood inversion algorithm.

Machine learning approach
We trained and tested a LongShort-Term Memory (LSTM) network developed in [1].

Conclusions and future developments
The LSTM network obtained a rather low forecast accuracy. To improve model performance, we are planning to train a CNN on DEM datacubes using a Regularized Maximum Likelihood (ML) method. Thermodynamic changes in DEM datacubes should be more revealing in flare forecasting. We are also planning to train a CNN on DEM datacubes using a Regularized ML method. Thermodynamic changes in DEM datacubes should be more revealing in flare forecasting.

Results on the test set
We selected the seven events with largest flare SDO/AIA (193, 195) on the validation set and we defined an ensemble method as follows. We evaluated the selected seven models on each example of the test set, and we associated each example with the error frequency prediction. The results are reported in the table below.

Event	ML	ML+ML	ML+ML+ML	ML+ML+ML+ML
2011-03-01	0.0	0.0	0.0	0.0
2011-03-02	0.0	0.0	0.0	0.0
2011-03-03	0.0	0.0	0.0	0.0
2011-03-04	0.0	0.0	0.0	0.0
2011-03-05	0.0	0.0	0.0	0.0
2011-03-06	0.0	0.0	0.0	0.0
2011-03-07	0.0	0.0	0.0	0.0

References
[1] S. Guastavino, et al., “Machine Learning Methods for Solar Flare Forecasting”, *Space Weather*, vol. 19, no. 1, pp. 1-12, 2021.
[2] S. Guastavino, et al., “Machine Learning Methods for Solar Flare Forecasting”, *Space Weather*, vol. 19, no. 1, pp. 1-12, 2021.
[3] S. Guastavino, et al., “Machine Learning Methods for Solar Flare Forecasting”, *Space Weather*, vol. 19, no. 1, pp. 1-12, 2021.

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