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Operation of Solar Flare Prediction by Deep Flare Net

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The mechanism of solar flares is a long-standing puzzle in solar physics. Solar flares are the largest explosive events in the Heliosphere. They affect the earth by X-ray and UV emissions, high energy particles, and magnetic storms, causing troubles of satellites and blackout in a large area. Therefore, the precise prediction of solar flares is important to avoid these problems in space weather, as well as to reveal fundamental mechanism of solar flares. The energy of solar flares are carried up by the emerging magnetic flux in the photosphere, and it is released by a trigger mechanism. Several researchers have tried to predict flares occurring in the following 24 hr, by human forecasting, observational techniques and numerical simulations, but it is still difficult to predict flares in the daily forecast. Currently, the amount of solar space observation data, which is available in the near real time, has remarkably increased. The data is too huge for human to deal with in the daily forecast operations, so we tried to apply some machine-learning techniques for solar flare predictions.

We developed a solar flare prediction model using a deep neural network (DNN), named Deep Flare Net (DeFN), and we started to run it in the daily forecast operations in our laboratory of NICT. The model can predict probabilities of the maximum class of flares occurring in the following 24 hr. From 3x10^5 images during 2010-2015 taken by SDO, we detected active regions and calculated 79 features for each region, to which flare occurrence labels (X, M, C) were attached. We used features in our previous work (Nishizuka et al. 2017) and added novel features for operational prediction: coronal hot brightening at 131 A (T=10^7 K) and the histories of X-ray and 131 A emissions 1 and 2 hr before an image. We divided the database into two with a chronological split: the dataset in 2010-2014 for training and the one in 2015 for testing. Then, we applied DeFN model to give the output of probabilities for >=M-class flares and >=C-class flares. The model consists of deep multilayer neural network, formed by adapting skip connections and batch normalizations. It was trained to optimize the skill score, i.e. the true skill statistic (TSS), and we succeeded in predicting flares with TSS=0.80 for >=M-class flares and TSS=0.63 for >=C-class flares in an operational setting.

In this talk, we would like to introduce our DeFN model and our activity to use it in a real-time forecasting operation. We would like to discuss how to optimize and evaluate our models in the daily forecast operations. We will also discuss the flare triggering mechanisms by the comparison of the extracted solar features, because in our model, the features are manually selected and it is possible to analyze which features are effective for prediction.