Based on Vector Parameters from SDO/HMI

Daye Lim[1], Yong-Jae Moon[1,2], Jongyeob Park[3], Kangjin Lee[1,4], and Jin-Yi Lee[2]
[1]School of Space Research, Kyung Hee University, [2]Department of Astronomy & Space Science, Kyung Hee University, [3]Korea Astronomy and Space Science Institute, [4]Electronics and Telecommunications Research Institute

We present the relationship between vector magnetic field parameters and solar major flare occurrence rate. Based on this, we are developing a forecast model of major flare (M and X-class) occurrence rate within a day using hourly vector magnetic field data of Space-weather HMI Active Region Patch (SHARP) from May 2010 to April 2017. In order to reduce the projection effect, we use SHARP data whose longitudes are within ±60 degrees. We consider six SHARP magnetic parameters (the total unsigned current helicity, the total photospheric magnetic free energy density, the total unsigned vertical

current, the absolute value of the net current helicity, the sum of the net current emanating from each polarity, and the total unsigned magnetic flux) with high F-scores as useful predictors of flaring activity from Bobra and Couvidat (2015). We have considered two cases. In case 1, we have divided the data into two sets separated in chronological order. 75% of the data before a given day are used for setting up a flare model and 25% of the data after that day are used for test. In case 2, the data are divided into two sets every year in order to reduce the solar cycle (SC) phase effect. All magnetic parameters are divided into 100 groups to estimate the corresponding flare occurrence rates. The flare identification is determined by using LMSAL flare locations, giving more numbers of flares than the NGDC flare list. Major results are as follows. First, major flare occurrence rates are well correlated with six magnetic parameters. Second, the occurrence rate ranges from 0.001 to 1 for M and X-class flares. Third, the logarithmic values of flaring rates are well approximated by two linear equations with different slopes: steeper one at lower values and lower one at higher values. Fourth, the sum of the net current emanating from each polarity gives the minimum RMS error between observed flare rates and predicted ones. Fifth, the RMS error for case 2, which is taken to reduce SC phase effect, are smaller than those for case 1.

[구 SS-03] Application of Convolution Neural Network to Flare Forecasting using solar full disk images

Kangwoo Yi, Yong-Jae Moon, Eunsu Park and Seulki Shin
School of Space Research, Kyung Hee University

In this study we apply Convolution Neural Network(CNN) to solar flare occurrence prediction with various parameter options using the 00:00 UT MDI images from 1996 to 2010 (total 4962 images). We assume that only X, M and C class flares correspond to “flare occurrence” and the others to “non-flare”. We have attempted to look for the best options for the models with two CNN pre-trained models (AlexNet and GoogLeNet), by modifying training images and changing hyper parameters. Our major results from this study are as follows. First, the flare occurrence predictions are relatively good with about 80 % accuracies. Second, both flare prediction models based on AlexNet and GoogLeNet have similar results but AlexNet is faster than GoogLeNet. Third, modifying the training images to reduce the projection effect is not effective. Fourth, skill scores of our flare occurrence model are mostly better than those of the previous models.

[구 SS-04] Application of Deep Learning to the Forecast of Flare Classification and Occurrence using SOHO MDI data

Eunsu Park[1], Yong-Jae Moon[1], Taeyoung Kim[1,2]
[1]School of Space Research, Kyung Hee University
[2]Department of Research and Development, InSpace Co., Ltd.

A Convolutional Neural Network(CNN) is one of the well-known deep-learning methods in image processing and computer vision area. In this study, we apply CNN to two kinds of flare forecasting models: flare classification and occurrence. For this, we consider several pre-trained models (e.g., AlexNet, GoogLeNet, and ResNet) and customize them by changing several options such as the number of layers, activation function, and optimizer. Our inputs are the same number of SOHO)/MDI images for each flare class (None, C, M and X) at 00:00 UT from Jan 1996 to Dec 2010 (total 1600 images). Outputs are the results of daily flare forecasting for flare class and occurrence. We build, train, and test the models on TensorFlow, which is well-known machine learning software library developed by Google. Our major results from this study are as follows. First, most

of the models have accuracies more than 0.7. Second, ResNet developed by Microsoft has the best accuracies : 0.77 for flare classification and 0.83 for flare occurrence. Third, the accuracies of these models vary greatly with changing parameters. We discuss several possibilities to improve the models.

[구 SS-05] A comparison of deep-learning models to the forecast of the daily solar flare occurrence using various solar images

Seulki Shin[1], Yong-Jae Moon[1,2], Hyoungseok Chu[3]
[1]School of Space Research, Kyung Hee University, [2]Department of Astronomy & Space Science, Kyung Hee University, [3]Software Policy & Research Institute

As the application of deep-learning methods has been succeeded in various fields, they have a high potential to be applied to space weather forecasting. Convolutional neural network, one of deep learning methods, is specialized in image recognition. In this study, we apply the AlexNet architecture, which is a winner of Imagenet Large Scale Virtual Recognition Challenge (ILSVRC) 2012, to the forecast of daily solar flare occurrence using the MatConvNet software of MATLAB. Our input images are SOHO/MDI, EIT 195Å, and 304Å from January 1996 to December 2010, and output ones are yes or no of flare occurrence. We consider other input images which consist of last two images and their difference image. We select training dataset from Jan 1996 to Dec 2000 and from Jan 2003 to Dec 2008. Testing dataset is chosen from Jan 2001 to Dec 2002 and from Jan 2009 to Dec 2010 in order to consider the solar cycle effect. In training dataset, we randomly select one fifth of training data for validation dataset to avoid the over-fitting problem. Our model successfully forecasts the flare occurrence with about 0.90 probability of detection (POD) for common flares (C-, M-, and X-class). While POD of major flares (M- and X-class) forecasting is 0.96, false alarm rate (FAR) also scores relatively high(0.60). We also present several statistical parameters such as critical success index (CSI) and true skill statistics (TSS). All statistical parameters do not strongly depend on the number of input data sets. Our model can immediately be applied to automatic forecasting service when image data are available.

[구 SS-06] FISS and SDO Observation of a Brightening Event Near a Pore

Juhyeong Kang, Jongchul Chae
Astronomy Program, Department of Physics and Astronomy, Seoul National University, Seoul 151-747, Korea

We report a fine scale transient brightening event near a pore boundary with the Fast Imaging Solar Spectrograph (FISS) of the 1.6m Goode Solar Telescope (GST), the Atmospheric Imaging Assembly (AIA) aboard the Solar Dynamics Observatory (SDO), and Helioseismic and Magnetic Imager (HMI) aboard SDO. The event appears in all AIA extreme ultraviolet bands, also in the two FISS lines, Hα and Ca II 8542 Å, and lasted for a minute. The brightening occurred at a footpoint of a loop. The conjugate brightening occurred at the other foot point outside the FISS field of view. The brightening near the pore exhibit a redshift of 4.3 km s-1 in the Hα and about 2.3 km s-1 in Ca II line. Differential emission measure derived from 6 AIA EUV passbands and cloud model fitting of the two FISS lines indicate the temperature increase of between 10,000 and 20 MK at the main event. After the brightening, the upward mass motion appears in the AIA images. We discuss the physical implication of this brightening in the context of magnetic reconnection and coronal heating.

[구 SS-07] Analysis of Ellerman Bomb Spectra Observed by FISS

Minju Seo, Jongchul Chae, and Jeongwoo Lee
Seoul National University

We have studied the high-resolution Hα and Ca II 8542Å line profiles of Ellerman Bombs (EBs) obtained with the Fast Imaging Solar Spectrograph (FISS) installed on the 1.6m Goode Solar Telescope (GST) in Big Bear Solar Observatory (BBSO). The FISS spectra of EBs are compared with synthetic profiles computed using RH non-LTE radiative transfer code and a set of 1D atmospheric models with local transient heating, the latter of which is modeled by varying local temperature enhancement in magnitude and height. We could reproduce each of the observed Hα and Ca II line profiles separately with different atmospheric models, but not with a single atmospheric model. To fit the observed Hα lines we often need much higher temperature enhancements than those needed for fitting Ca II lines. Possible causes for this temperature mismatch are briefly discussed.

[구 SS-08] Statistical study on the kinematic distribustion of coronal mass ejections from