

Prediction of latitude/longitude distribution of sunspot and tilt angle using machine learning

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In space weather forecasting, it is important to estimate the solar activity in near future. Recent studies have shown that there is a correlation between the value of the polar magnetic field during the solar minimum and the next solar activity level. This means that the value of the polar magnetic field is one of the most important indicators for predicting the activity level. For this reason, many studies have tried to predict the polar magnetic field. The value of the polar field can be calculated using the surface flux transport model (SFT model). The SFT model consists of advection term due to differential rotation and meridional circulation, magnetic diffusion term, and flux emergence term. The advection and the diffusion coefficients are estimated by modern observations. On the other hand, estimation of future flux emergence is still very difficult without reliable information about these coefficients. Therefore, it is crucial problem about the solar cycle prediction to estimate when and where the sunspots will emerge.

In this study, we predict the latitude distribution (butterfly diagram) using 2D-CNN (two-dimensional Convolutional Neural Network), which is one of the machine learning technique. As a result, we can reproduce the transition and the periodicity of the appearance of the sunspot from the middle latitude to the low latitude. Furthermore, as a result of predicting cycle 25 using this model, the maximum sunspot number is slightly larger than cycle 24, and the structure of the butterfly diagram is similar to cycle 16. We present the prediction results on latitude distribution, longitude distribution, and tilt angle using 3D-CNN (three-dimensional Convolutional Neural Network) and LGB (Light Gradient Boosting) method.

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