Machine learning based prediction of solar power generation by utilizing all-sky camera

*Masataka Imai[1], Toru Kouyama[1], Hideaki Ohtake[1], Takashi Oozeki[1], Mitsuteru Sato[2]

1. National Institute of Advanced Industrial Science and Technology, 2. Hokkaido University

In recent years, the installed capacity of the global solar photovoltaic (PV) represents exceeds 500 GW and that meets 2.6% of world electricity demand at the end of 2018 (the new 2019 Edition of the IEA PVPS report: 2019 Snapshot of Global PV Markets). Because of the awareness of climate change rises, increasing the renewable energy sources must be crucial and solar PV is regarded as the largest component of the renewable energy source. The cost of solar panels continues to decline, and the growth of PV is expected to continue as their strongest increase in five years.

The long-term average power output of solar PV is well characterized by diurnal and seasonal changes in solar insolation. However, short-term (minutes and hours) PV output is much harder to predict due to meteorological volatility, especially cloud coverage. At the current stage, the electric demands still depend on the other sources (e.g. fossil fuels). Therefore, it is desired to control the production and distribution of electricity more efficiently (smart grid), and the precise prediction of solar PV power generation is one of the important tasks to minimize the waste of other resources and to establish the efficient energy system as well as increasing the total capacity of solar PV. The state-of-the-art short-term predictions of PV output are poor, with a root mean square error (RMSE) of order 200–400 W m^{-2} for ~10 minute level predictions in partly cloudy conditions. Recently, the machine learning technique becomes popular prediction methods for the solar PV power generation. Several studies utilized all-sky images to predict the power generation assessing images correlate with contemporaneous PV output. One of the issues to develop such kind of machine-based prediction model is preparing the dataset. Ideally, the all-sky camera should be installed at the close place of PV panels located, and the data was collected for several years considering the seasonal weather change.

In this study, we used over 5 years of all-sky images obtained at Nayoro Observatory, Faculty of Science, Hokkaido University. Solar irradiance and other meteorological measurements (e.g. temperature, humidity, wind speed and direction, and precipitation) are recorded every 1 minute at the same time of image acquisition. We developed a multi-layered 3D convolutional network model with fully connected layers, where we input five sequent images with reduced size of 100 x 100 pixels and tested to predict solar irradiance at the next time step (1 minute later). Our model can predict the solar irradiance within the RMSE of 10% when the weather is fine. As for the partially cloudy condition, our model results showed spiky variations of the irradiance Although the absolute precision is worse in such sky condition, large variability in the solar irradiance (PV power generation) could be predicted by our model. In order to increase the total performance of our model we now developing other RNN (Recurrent Neural Network) based model to enable to learn the temporal feature in the sequent sky condition change. Additionally, we are preparing additional input information of other weather information. In this presentation, we will demonstrate our latest results for predicting the solar power generation by utilizing the all-sky images obtained at an astronomical observatory.

Keywords: Solar power , Deep learning, All-sky camera