Measuring Cloud Coverage for Estimating Solar Irradiance

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Performance of solar renewable power generators can be predicted by estimating cloud coverage over time. Additionally, cloud coverage estimation based on ground-based sky images is one of the most critical factors for analyzing current weather conditions. It is challenging to estimate cloud coverage because boundaries of clouds are unclear, and their shape changes due to local climate conditions. We propose a method to predict solar irradiance based on using images to estimate cloud coverage. In this research, individual sky and cloud pixel segmentations were performed using machine learning methods; a color-based cloud segmentation using partial least-squares regression and three semantic segmentation deep neural networks: Fully Convolutional Network (FCN), U-Net, and Deep Convolutional Network (DeepLabv3). The individual cloud pixel segmentation results were ensembled using AdaBoost regression to further improve accuracy of cloud pixel segmentation. As a preliminary experiment, we collected and labeled ground-based sky images from a webcam that is deployed at Argonne National Laboratory. The machine learning models were trained with a dataset which was mixture of the labeled images and Singapore whole sky imaging segmentation (SWIMSEG) dataset to reinforce the labeled dataset. The cloud segmentation results represent ratio of cloud pixels in sky images. We then estimate solar irradiance using the ratio of cloud pixels along with historic solar irradiance that was recorded from 2007 to 2018. By improving the method using a long-short term memory (LSTM) neural network, we forecast local cloud cover and solar irradiance. In addition to local condition forecasting, we are expecting to predict the direction of motion of clouds by analyzing sequences of sky images in order to forecast cloud coverage and solar irradiance in neighboring areas.