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資源・エネルギー

Cloud detection from ground based all-sky images by deep learning

TECHNOLOGY SHOWCASE

SATテクノロジー・ショーケース2025

■ はじめに

The role of solar energy is expected to rise in the coming years because it is a green technology that does not cause harm to the environment. Also, thanks to technological advancement, it has become easier and cheaper than before to install photovoltaics (PV). However, there remains a major problem for successfully integrating large-scale solar systems into the electric grid, which is its unstable characteristic. Most of the instability is caused by the clouds. Therefore, it is of great interest to investigate cloud properties.

1. All-sky images

Local sky conditions can be analyzed with a fisheye lens installed at the surface level facing upwards. Its wide angle of view allows monitoring the sky horizon continuously. The captured images are called all-sky images (ASI) and the first step of analyzing them is to detect cloud pixels. However, simple methods such as the red-to-blue color channel ratio fail to detect clouds near the circumsolar area where it becomes difficult to distinguish between cloud and sky. On that account, other high-performance methods, such as neural networks, should be explored for this task.

2. U-Net

Convolutional neural networks (CNN) are well known for their superior performance in processing image data. U-Net [1] is one of the renowned, fully convolutional architectures and was initially designed for medical image segmentation. It is called U-Net because it looks like the letter "U" with the encoding and decoding paths that retrieve high-level abstract features from images. Nowadays, this network is being applied in other fields to efficiently utilize image data.

■ 活動内容

1. Data collection

For effective supervised learning, it is required to have enough labeled data. That way, the deep network adjusts its weights to map input features to the output target.

●Train

WSISEG database [2] provides 400 annotated ASI under various sky conditions for training cloud segmentation models. The pixels are masked as clouds, sky, and others such as the sun and buildings.

●Test

Unlabeled ASI was taken by Mobotix Q26 hemispheric camera in May 2024. The camera is installed on the rooftop of the National University of Mongolia. 31 images are selected daily to evaluate the trained model.

2. Implementation

U-Net model is trained on the WSISEG database for the cloud segmentation task. When applied to the test data, as shown in Fig. 1, its performance was almost the same as the conventional red-to-blue color channel ratio method. Thus, further improvement should be introduced by training on big data covering various atmospheric conditions.

■ 関連情報等

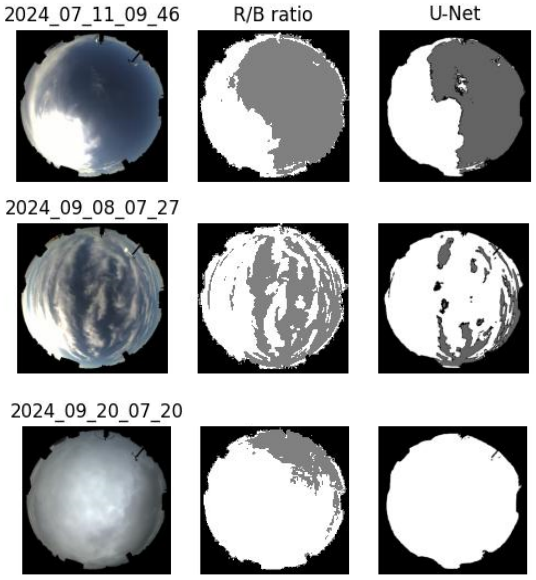

Fig. 1. Cloud segmentation results on clear, cloudy and overcast sky conditions.

[1] Olaf Ronneberger et al. (2015)
https://arxiv.org/abs/1505.04597
[2] Wanyi Xie et al. (2020) Atmospheric Measurement Techniques
https://amt.copernicus.org/articles/13/1953/2020/

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■キーワード: (1) cloud detection
(2) all-sky imager
(3) clear sky library
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