Landslide Extraction with Convolutional Neural Networks Using Sentinel-2 Images

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Abstract: In recent years, large-scale landslide disasters caused by heavy rains and earthquakes frequently occur. Rapid detection of the damage situation and extent using earth observation satellite images is expected. Many landslides induced by the 2018 Hokkaido Eastern Iburi Earthquake occurred on September 6, 2018, causing great damage. The authors used the Normalized Difference Vegetation Index (NDVI) of pre- and post-event Sentinel-2/MSI images to extract landslide areas, but it was difficult to extract them accurately using the traditional methods, which are thresholding or pixel-based classification. Therefore, we tried to extract landslide areas using Convolutional Neural Networks (CNNs), which are being used for computer vision and semantic segmentation. Sentinel-2/MSI images were used by downloading Level-1C products via the Copernicus Open Access Hub. This product is radiometrically and geometrically corrected data. An NDVI image with a pixel size of 10 m was created using band 4 and band 8 of Sentinel-2/MSI. In addition, since slope failures occur on slopes, slope angle calculated from a Digital Elevation Model (DEM) of 10-m mesh was used. Landslide extraction was based on U-Net architecture, which enables accurate segmentation from a small amount of training data. The U-Net consists of contracting paths and expansive paths. The contractive path adopts the typical CNNs. The expansive path combines the feature and spatial information based on up-sampling and concatenations with high-resolution features. The U-Net was trained for 100 epochs with a mini-batch size of 8 using 256 × 256-pixel images. 1,600 datasets were prepared, of which 80% (1,280) were used as training data. The test data was 20% (320) not used for learning. Three datasets, that is, pre- and post-event NDVI and slope angle, pre- and post-event NDVI, and post-event NDVI and slope angle were compared. As a result, the dice coefficients of pre- and post-event NDVI and slope angle dataset showed the highest value in the datasets. On the other hand, the dice coefficient of pre- and post-event NDVI dataset showed a similar result as including slope angle data. In this study, the U-Net architecture was effective for landslide extraction using Sentinel-2/MSI images. Moreover, pre- and post-event NDVI data were suitable as input data.

Keywords: U-Net, deep learning, NDVI, disaster monitoring, slope angle