Enhancing Landslide Detection Using Feature Fusion of Spectral and Topographic Information: A Time Series Approach

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The act of mapping historical landslides facilitates the modeling various causal factors, leading to the identification of areas susceptible to landslides. Earth resources satellite images are commonly used for large-scale landslide mapping due to their wide coverage and high resolution. However, most studies rely on the interpretation of single or two images, and the choice of images directly influences the detection results. By utilizing Google Earth Engine (GEE), time series data can be conveniently acquired, reducing potential omissions caused by image selection. In this study, we employed GEE to acquire Landsat-8 multispectral time series data. Furthermore, we developed a landslide detection framework that integrates spectral and elevation features. The process commences with the implementation of multiresolution image segmentation on a well-defined, cloud-free mosaic image. Additionally, slope units derived from catchment delineation are integrated as supplementary information during the segmentation process. Subsequently, we treated the multispectral time series data and the principal component transformed topographic features as two sequences and utilized them to train and predict using a bivariate LSTM model. In the mountainous region of central and southern Taiwan, the experimental area demonstrated remarkable performance in the test data, achieving an accuracy and precision of 92%. The Kappa value was approximately 0.85, and both the omission error (OE) and commission error (CE) rates were below 8%. In a real scenario involving segment-wise classification with areas larger than 1 hectare, the OE rate using only spectral information was 11.2%, and the CE rate was 35.2%. However, with the inclusion of topographic information, the OE rate decreased to 5.8%, and the CE rate reduced to 17.0%. In summary, this study demonstrates that a time-series-based landslide detection approach can effectively identify landslide areas, and the fusion of spectral and topographic information can significantly improve overall accuracy.

Keywords: Landslide Detection, Time Series, Landsat-8, Feature Fusion, LSTM