LandslideNet-SL: A PROPOSED HIERARCHICAL CROSS-MODAL ATTENTION FUSION FRAMEWORK FOR MULTI-SOURCE SATELLITE-BASED LANDSLIDE DETECTION IN SRI LANKA

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Abstract

Communities and infrastructure in the wet zone and the Central Highlands of Sri Lanka are at risk from landslides, so there is a need for reliable satellite based detection methods. In this study, we propose LandslideNet-SL, a deep learning framework for pixel-wise landslide segmentation from multi-temporal Sentinel-1 SAR, Sentinel-2 optical images, and Digital Elevation Model (DEM) data, called Hierarchical Cross-Modal Attention Fusion (HCMAF). The goal is to explore the efficacy of cross-modal interactions on multiple levels and adaptive weighting of modality at the pixel level in order to enhance the integration of various satellite data sources. A Design Science Research (DSR) methodology was followed in implementing the framework, that included three modality specific encoders, Cross-Modal Attention Gates, multi-scale feature interactions, and a U-Net style decoder. HCMAF allows the exchange of information at various levels of features, integrating detailed surface features with information from the broader terrain, unlike the simple early- and late-fusion approaches. Baseline models, ablative-modality procedures, and comparisons of fusion-strategies are included in the implementation. Useful reference results from published works- multi-input U-Net using SAR, optical and terrain data has an F1-score of 0.6618 and D2FLS-Net has a mean Intersection over Union of 0.7286 on Landslide4Sense2022. The Sen12Landslides benchmark also achieved an F1 score of up to 0.82 with the combination of SAR and optical data. These results represent the potential of multimodal fusion, but due to different sets of data and evaluation methods, performance comparisons are not directly possible. The implemented HCMAF framework was verified through preliminary computational testing which was used to prove the possibility of its ability to perform the training, segmentation output generation and calculation of adaptive modality weights. The proposed framework will serve as a basis to explore hierarchical multimodal fusion and future application to landslide detection in Sri Lanka.

Keywords: Landslide Segmentation, Hierarchical Cross-Modal Attention, Multimodal Data Fusion, Deep Learning, Remote Sensing