



Multi-Temporal Road Surface Classification from Sentinel-2 and OpenStreetMap Data Using Deep Learning

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During natural hazards and other rapidly evolving crisis situations, the accessibility of evacuation routes and the delivery of emergency supplies strongly depends on road surface type. However, in many regions affected by environmental changes, conflicts, or population displacement, reliable information on road surface conditions is incomplete, outdated, or entirely unavailable, which limits effective disaster response and environmental monitoring. This study presents a satellite-based framework that classifies roads as either paved or unpaved using multispectral Sentinel-2 imagery and volunteered geographic information (VGI) from OpenStreetMap (OSM).

OSM road geometries are used to extract spectral samples from Sentinel-2 surface reflectance data, which is used to train a convolutional neural network (CNN) for road surface classification across diverse environmental settings. To improve spatial consistency and practical usability, classification results are aggregated at the road-segment level to produce coherent surface classifications aligned with real-world road infrastructure. The framework is designed to be transferable and applicable across regions with varying climates, land-cover characteristics, and degrees of urbanisation.

The approach has been evaluated across multiple target regions and demonstrates consistent performance beyond the training domain, which highlights its potential for cross-regional application. Due to the regular revisit time of Sentinel-2, the framework further supports multi-temporal analysis. This makes it possible to assess changes to the road surface before and after dynamic events, such as flood-induced degradation, sediment coverage or long-term urbanization. By combining freely available satellite data and open VGI, the proposed method provides a scalable tool for infrastructure monitoring, disaster response, and environmental assessment in data-scarce and rapidly changing regions.