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Machine Learning Approaches for Evaluating Forest Fire Impacts on Sentinel-2 Satellite Imagery across Ukraine

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Introduction
This study explores the utilization of machine learning techniques to detect the impacts of forest fires through the analysis of satellite imagery. The objective is to address the pressing need for improved forest fire monitoring systems by harnessing the capabilities of advanced machine learning models. The study specifically aims to assess the accuracy of convolutional neural networks (CNNs) in identifying fire-affected areas from Sentinel-2 satellite images of Ukrainian forests.

Data and Method
The research encompasses Ukrainian forest territories affected by wildfires. The dataset employed consists of Sentinel-2 satellite images, utilizing the true colour composite (Bands 2, 3, and 4), selected for their spectral characteristics in differentiating between burned and unburned forest areas. These images, 100 in total, each with a resolution of 128x128 pixels, were annotated by experts to create a reference for training a CNN model. The machine learning approach involved the CNN learning from these labelled image patches, adjusting its internal parameters through iterative training to minimize classification errors and improve its predictive accuracy.

Results
The trained CNN model achieved an impressive 97% accuracy rate in correctly classifying pixels corresponding to undamaged forest areas. However, the model identified burned areas with a moderate accuracy of 55% only. These quantitative results demonstrate the model's robust capability in general forest fire detection while also highlighting the need for improvements in accurately detecting areas affected by fires.

Conclusion
The research shows the potential of machine learning, and CNNs in particular, as an effective instrument for the remote assessment of forest fire damage via satellite imagery. The study confirms that neural networks are adept at processing spatial data, providing critical insights for environmental surveillance and aiding in the management of forest resources. To further enhance the model's detection accuracy, future research should investigate other architectures and loss functions, expand the dataset, and incorporate additional relevant spectral bands to better distinguish between burned and unburned areas.

Keywords
Forest Fire Detection, Machine Learning, Convolutional Neural Networks, Spectral Bands, Ukraine Forests