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Leverage data fusion from s1-s2 to enable fast and accurate land cover classification

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Abstract
Urban areas face unique challenges in monitoring and managing land cover changes, particularly due to cloud cover that a9ects optical imagery. This study presents an innovative approach to urban land cover classification by fusing `Sentinel-1` Synthetic Aperture Radar (SAR) data with `Sentinel-2` optical data. We aim to develop an automated algorithm capable of providing monthly monitoring of urban land cover changes, enhancing classification accuracy and o9ering critical insights into urban growth and environmental resilience.
Utilizing a combination of 4 images from `Sentinel-1` (VV, VH, VV/VH) and 5 key spectral indices derived from `Sentinel-2` (NDVI, SAVI, BAI, NDWI, and alternative BAI), we created a comprehensive merged dataset of 20 bands. This dataset serves as the foundation for our classification models, including Support Vector Machines (SVM), K-Nearest Neighbors (KNN), Random Forest (RF), and Neural Networks (NN), which are evaluated for their performance in accurately classifying various urban features.
Additionally, we explore Convolutional Neural Networks (CNN) and the `SAM2` model for advanced classification techniques. Our results demonstrate the potential of SAR and optical data fusion to overcome the limitations of cloud cover, providing a robust framework for automated urban land cover monitoring. This research contributes to a better understanding of urban dynamics and supports e9ective environmental management strategies. Einstein (1905)

Key words: data fusion – machine learning – geospatial

1 Introduction

In recent years, approximately 90% of the world's mapping data has been generated, underscoring the critical importance of leveraging state-of-the-art technologies to create accurate maps that reflect the real challenges facing our planet today. The rapid pace of urbanization has transformed cities, leading to an urgent need for precise tools that can monitor land cover evolution. By comprehensively understanding these changes, we can identify detrimental impacts on the environment while also highlighting effective remediation efforts, ultimately contributing to the development of greener, more sustainable urban landscapes.

However, the utility of optical imagery, particularly from satellites like Sentinel-2, is often compromised by cloud coverage, especially in tropical and coastal regions. This phenomenon results in significant data gaps, which can severely limit the effectiveness of urban monitoring tools. For instance, in Rouen, France, persistent cloud cover restricts the availability of usable optical images to only ten per year, presenting a substantial challenge for consistent urban analysis.

To address these limitations, this study focuses on the exploitation of classification models on fused Sentinel-1 Synthetic Aperture Radar (SAR) and Sentinel-2 optical data. By employing data fusion techniques to mitigate the impacts of cloud coverage, we aim to enable more reliable monthly monitoring of urban land cover changes. The primary objective of this research is to evaluate and compare various machine learning and deep learning models— including Random Forest, Support Vector Machines (SVM), and Convolutional Neural Networks (CNNs)—to identify the most effective methodologies for achieving accurate and robust land cover classification in urban environments.

1.1 Why Rouen?

Rouen, a historic city in northern France, presents a diverse urban landscape with a mixture of commercial, residential, and industrial zones, as well as surrounding vegetation and water bodies (the Seine River). Its coastal proximity also makes it a relevant choice for studying urban resilience and environmental dynamics, as it faces potential impacts from coastal erosion and urban expansion.

1.2 Urban Dynamics and Environmental Challenges

- Population: Approximately $111,000$ inhabitants in the city center, with a wider metropolitan area exceeding $500,000$ residents.
- Urban Challenges: Urban growth, environmental remediation e9orts, and flood management due to its proximity to the river and low-lying coastal areas.
- Environmental Focus: Monitoring urban development, green

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spaces, and remediation strategies aimed at reducing the environmental footprint of urban sprawl.

References

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