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| **A Spatiotemporal Data Fusion Strategy for Forest Mapping and Monitoring in Semi-Arid Environments** |
| Given their integral part in ecosystem function through the preservation of biodiversity and wildlife habitat, climate regulation, and carbon sequestration as well as their importance to local communities and the economy, robust and efficient methods for monitoring forests are of critical importance. In semi-arid regions such as sub-Saharan West Africa, this is especially true considering forests' role in conserving water resources, maintaining healthy and productive soils, and preventing desertification. In Senegal, where a majority of its inhabitants live in rural areas and earn their living from smallholder farming or pastoralism, trees are used for much more than their timber. They are heavily relied upon for shade during cultivation and for grazing animals, as well as for medicinal purposes and charcoal, an important source of fuel. In addition to deforestation, excessive use of these activities such as charcoal harvesting and overgrazing threaten the health of forests by contributing to degradation, making the monitoring of such changes important for enabling sustainable resource management.  However, forests in these dryland agriculture regions are often sparse and fragmented, characterized by a mix of dry deciduous forest patches and savannah woodland tree stands, as well as individual trees within agricultural fields. These distinct landscapes can make it difficult to adequately map and monitor forests with standard remote sensing methods and moderate to coarse resolution satellite data. Conversely, Very High Resolution (VHR) data such as Maxar’s WorldView (WV) presents its own challenges in the context of land cover/land use change analyses due to their sporadic coverage throughout space and time, and lack of radiometric consistency between observations.  To address these challenges, we developed an object-based deep learning approach for mapping and monitoring changes in land use. We identify the conversion of forestry to agroforestry, agriculture, urban area, and degraded forests using a data-driven 1D Convolutional Neural Network (CNN) model, fuelled by a combination of VHR Multi-spectral data from WV and SAR time-series from Sentinel-1. A domain-agnostic data fusion strategy is used to combine these datasets at a variety of spatial and temporal scales for time series monitoring. Additional data-driven and morphological methods are used to individually characterize agroforestry objects. Independent validation on the initial model results, substantiated by in-situ observations collected on a recent field campaign to Senegal, reveals an overall classification accuracy greater than 75%. The science output from this model includes a georeferenced temporal land use database that can be used for change detection in forests and subsequent resource management and conservation efforts. |