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A Scalable Data-driven Framework for Predicting Crop Yield in Smart Agriculture

Timely crop yield estimation is a key component of Smart Agriculture, enabling proactive decision-making and optimized resource allocation under the constraints of climate variability and sustainability goals. Traditional approaches based on manual sampling and empirical models are constrained by labour intensity, limited spatial coverage, and sensitivity to within-block (-site) heterogeneity. Smart Agriculture leverages digital technologies, geospatial data, temporal data and predictive models to monitor and manage crops in a site-specific and data-driven manner. In this context, image analysis and CNN architectures are powerful tools for yield prediction with high-resolution imagery which, however, requires expensive acquisitions and often lacks in historical databases. This study proposes a scalable, data-driven framework for yield prediction based on Time Series Extrinsic Regression (TSER) algorithms. The modelling approach exploits multi-temporal medium-resolution imagery from Sentinel-2 satellite to extract, across the growing season, block-specific temporal statistics of vegetation indices (e.g., NDVI). The adopted approach is acknowledged to be robust to sensor noise, intra-block variability and geolocation inaccuracies which are common challenges in medium-resolution satellite data. The predictive framework is further enriched with site-specific crop management data, allowing the model to account for structural (e.g., plants density) and phenological variability (e.g., cultivar-dependent ripening time). The proposed strategy leverages freely accessible and temporally consistent Sentinel-2 archives, enabling retrospective modelling over multiple seasons. Results from a comparative evaluation conducted across multiple state-of-the-art TSER algorithms show that the best-performing TSER models achieve predictive performance comparable to image-based predictive strategies, while offering substantial advantages in terms of computational efficiency, and operational scalability.

Special/ Invited session

Classification

Both methodology and application

Keywords

Smart Agriculture, Crop Yield Prediction, Time Series Extrinsic Regression

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Track Classification: Machine Learning