Extraction of PROSAIL-simulated Spectra from Multi-angular UAV Observations: Application for Leaf Angle Estimation

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Abstract

Crop leaf angle is a crucial feature of plant architecture which influences photosynthetic efficiency and yield. Therefore high-throughput mapping of leaf angle is of extreme interest for both precision agriculture and crop breeding operations. In this study, we propose a UAV-based hybrid approach by combining a radiative transfer model (PROSAIL) and deep neural networks to estimate leaf angle from multi-angular hyperspectral and LiDAR data. PROSAIL can simulate canopy hyperspectral reflectance from a given list of parameters, where Average Leaf Inclination Angle (ALIA) is one of the canopy parameters. The goal is to develop a deep learning-based inversion function that takes UAV hyperspectral reflectance and other PROSAIL parameters as input and estimate ALIA of Maize as output. The other PROSAIL parameters will be estimated using several machine learning pipelines from UAV hyperspectral and LiDAR information. We also propose a multi-angular reflectance scheme where each image pixel will generate multiple simulated and observed reflectance from the overlapping regions using different angles (i.e., solar zenith angle, viewing zenith angle, and relative azimuth angle between the sun and sensor) involved in the PROSAIL simulation. An automated Python-based tool was developed that can calculate all three PROSAIL angles for a given hyperspectral data cube and generate the simulated reflectance for every vegetation pixels per experimental plot. Since the proposed method incorporates both crop information (i.e., PROSAIL) and a data-driven approach (i.e., deep learning), the method can be easily transferable for other study areas and crops, and it can rely on less ground truth data.

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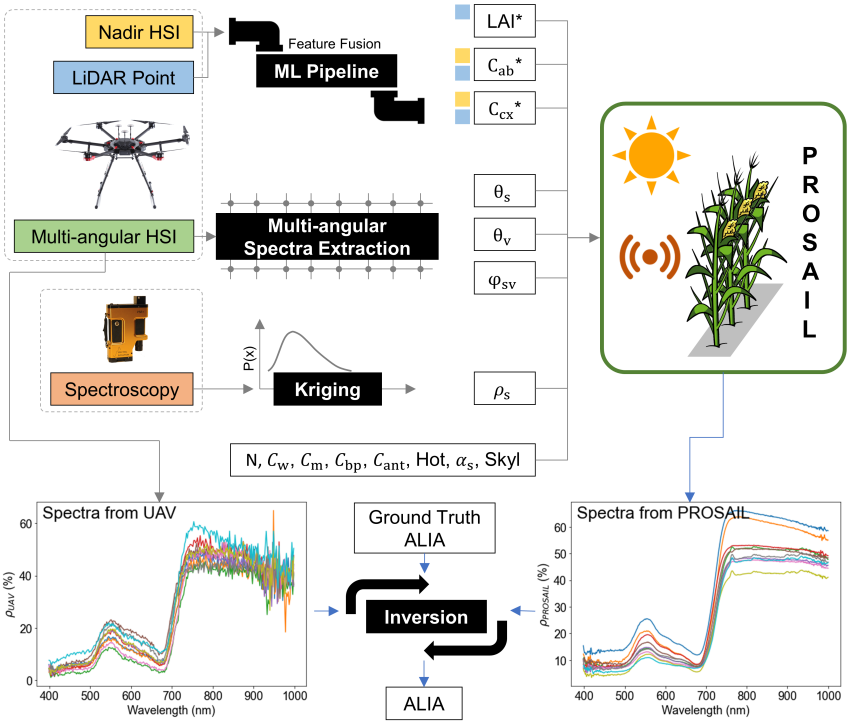

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