Abstract of Doctoral Dissertation

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Development of novel method to make empirical Hemispherical Direction Reflection Factor (HDRF) model dedicated to vegetation measurement

（植生計測における経験的半球方向反射係数（HDRF）モデル作成法の開発）

The Empirical Hemispherical-Directional reflectance Factor (HDRF) is an understudied aspect in the field of remote sensing, overshadowed by the more widely adopted simulation-based Vegetation Canopy Radiative Transfer models (such as PROSAIL). These simulation-based models predominantly produce synthetic data. Establishing reliable empirical models is crucial to complementing and enhancing these simulation models for further advancements. This process requires accurate HDRF measurements, but the current measurement methods lack angular precision due to a limited number of measurement viewing angles.

Accurately measuring the HDRF of the vegetation is essential for advancing our ability to retrieve the properties of the vegetation's internal physiological state. The one major challenge is the number of measurement viewing angles is constrained by changes in solar angle changes or the sky condition, which restricts the positional movement of traditional measurement methods, reducing the angular sampling in previous studies.

To address the limitation in the number of viewing, this study introduces a novel methodology for HDRF measurement. This new strategy follows: the custom-developed device, placed at an elevated point in the vegetation field, uses a spectral optical sensor to scan the surrounding vegetation with high angular precision. Because the scanning pattern is solely on angular movement rather than physical positional movements, the device achieves high-precision angular sampling.

The novelty of this method lies in how the data is reconstructed as HDRF measurement. With the assumption that the surrounding vegetation is homogenous, data collected from the different parts of the field can be interpreted as if they were measurements of a single, representative vegetation element. Since the measurements are taken from numerous viewing angles, it's effectively equivalent to representative vegetation elements measured from numerous viewing angles. Thus making the collected data HDRF, capturing the complex angular and spectral patterns in the vegetation canopy.

In the study, we analyzed rice, tea, and wheat fields. The method introduced in this study is practical such that it easily works on any other crops/vegetation, offering possible future advancements in the current vegetation radiative transfer models. Additionally, this research investigates reconstructing HDRF from a limited number of viewing angles for these fields, which could substantially enhance future satellite or UAV-based remote sensing efforts by enabling effective HDRF reconstruction despite their limited angular observations.