Fast LAI Retrieval with Smart fLAIr

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ABSTRACT

The exploration and monitoring of bio-physical crop parameters enabled by modern sensor technology in the context of smart farming is crucial for a sustainable agriculture. The leaf area index (LAI) is one of the most important parameters which serves as an indicator for the vital condition of plants. This proposal presents *Smart fLAIr*, a smartphone application developed for a reliable in-situ LAI estimation. It leverages a non-destructive, radiation-based approach using the smartphone's Ambient Light Sensor (ALS) and offers a cost-efficient alternative to commercial plant canopy analyzers. Without special hard- and software requirements and due to a focus on simplicity and ease of use, a wide scientific user group, that is interested in a feasible LAI acquisition, is reached by the application.

1. MOTIVATION

The LAI is an essential parameter describing the amount of solar radiation intercepted by the canopy which is used in scientific models of a wide range of disciplines such as climatology, meteorology, ecology, and agronomy, particularly in the context of *smart farming*. LAI is an integrative quantity defined as the ratio of one-sided leaf area per total ground area, which can be accurately measured directly by planimeters. However, this method is destructive since leaves have to be harvested. Moreover, it is very time- and labor-consuming and, thus, infeasible for a large-scale monitoring of agricultural fields. That has been recognized decades ago and more and more non-destructive approaches appeared, along with commercial instruments, which estimated LAI indirectly by measuring certain quantities closely related to this parameter, cf. [3]. The LAI-2200 (LI-COR, USA), for instance, is a representative and widespread instrument which derives LAI estimates from solar radiation measured from above and below the canopy. Although such instruments perform very well and are frequently used by scientists, they are expensive and have limited portability. The enormous technological progress in the area of mobile phones has produced ubiquitous computing and sensing devices which have recently been shown to be an economical alternative for in-situ LAI estimation [2, 4, 5].

2. METHODOLOGY

Smart fLAIr (fast LAI retrieval) is a novel and unique smartphone app for a cost-efficient and convenient in-situ LAI assessment which was recently developed for Android and has been partially presented in [2]. To the best of our knowledge, there are only two similar apps in this domain, namely PocketLAI [4] and VitiCanopy [5]. Both implement a digital hemispherical photography (DHP) approach using image processing algorithms on photographs acquired below the canopy using an upward oriented camera. Inspired by the LAI-2200, we adopt a complementary, radiation-based approach that senses the transmittance of canopies in order to derive LAI. It is realized by a direct luminance sensing, exploiting the smartphone's internal ALS. Therefore, two consecutive measurements are required, one above (A) the canopy gathering non-intercepted luminance and the other one below (B). In order to cope with small-scale variances induced by user movements or weather effects, we actually take the mean of multiple sensor readings per measurement position. According to the *Monsi-Seaki* model, the app estimates the LAI as follows:

$$LAI = -\omega \cdot ln\left(\frac{\overline{B}}{\overline{A}}\right), \quad (1)$$

with a species- and also site-specific correction factor ω. Smart fLAIr has been successfully evaluated in various maize field campaigns and shown to achieve promising results in comparison with the above mentioned LAI-2200 instrument. For further details, please refer to [1, 2].

3. FEATURES AND USABILITY

Ergonomic aspects and a typical Android user experience are realized by the application. Its basic functionalities are demonstrated in the short video trailer[1] attached to this proposal. After launching the app, the user can create new measurement campaigns or select existing ones. Then, new (or additional) LAI records can be assessed. In the record activity, sensor readings are continuously visualized. According to our method (cf. Eq. 1), the user has to perform two ALS measurements in order to gather an LAI estimation. Therefore, the upward oriented ALS of the smartphone must be placed above and below the canopy (or vise versa). Each measurement can be started with button on the display or by using the shutter button of a common selfie stick. The sensor orientation is supervised during the measurement and vibration feedbacks are used to inform the user about an incorrect orientation. Moreover, a summary activity offers a detailed overview of all acquired LAI entries and their metadata, comprising timestamps, GPS positions, as well as statistical data which is highlighted in case of unusual variances. Furthermore, all data sets can be exported as CSV files via bluetooth or Android sharing.

4. SPECIAL FEATURES

As optional sensor accessory, we additionally propose a low-cost diffuser cap which consists of a hemispherical diffuser and a blue band-pass filter that increases the contrast between sky and vegetation and, thus, improves Smart fLAIr's quality. Another unique feature is that wireless sensor network nodes (as presented in [1]) can be connected via USB or Bluetooth and contribute to the data gathering process as additional in-field sensors.

5. REFERENCES

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