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LeafSpec: An accurate and portable hyperspectral corn leaf imager

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Highlights

- Hyperspectral imaging suffered from ambient light, imaging distance and angle.
- A hyperspectral imaging handheld device was developed for corn leaf.
- Field test showed significant differences between genotypes and treatments.
- The device showed high performance to predict N content and RWC.
- Each hyperspectral image was geo-referenced based on a smartphone.

Abstract

Hyperspectral imaging (HSI) technology has been widely applied in industry and academia for plant phenotyping. However, most HSI systems are large and expensive, making it challenging to benefit more people. The overall goal of this study was to develop a portable and low-cost hyperspectral imaging handheld device (named LeafSpec) with even improved measurement quality compared with traditional HSI systems for crop leaves imaging. The hardware of LeafSpec device was comprised of a push-broom hyperspectral camera (HSC), leaf scanner with an encoder system for leaf position information, a lightbox as an intensive and uniform beam lighting source, and an ARM-based microcontroller. In each scanning, a smooth and clear hyperspectral image of the entire leaf was obtained by quickly sliding LeafSpec across the leaf from the beginning to tip. Each measurement was geo-referenced by sending processed data to a smartphone and combining it with the GPS location and time information before uploading to a Geography Information System (GIS) with Digital Ag Map Services and internet connection. After calibration, the HSC's imaging results were highly consistent with a commercialized hyperspectral camera. In the field test in the summer of 2018, LeafSpec was able to detect the difference between two nitrogen treatments of corn plants in each genotype, as well as the differences between three genotypes in high nitrogen treatment, and the difference between two genotypes in low nitrogen treatment before it was visible to human eyes. In the greenhouse test in the spring of 2019, LeafSpec predicted nitrogen content and relative water content with R^2 of 0.880 and 0.771, RMSE of 0.265 and 0.049, respectively. Generally, LeafSpec is an easy-to-use and low-cost crop phenotyping sensor with improved measurement accuracy, which could benefit more people in plant science research and agriculture production.

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LeafSpec

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