

# Mitigating Illumination-, Leaf-, and View-Angle Dependencies in Hyperspectral Imaging using Polarimetry

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## Abstract

Automation of plant phenotyping using data from high-dimensional imaging sensors is on the forefront of agricultural research for its potential to improve seasonal yield by monitoring crop health. We developed a mast-mounted hyperspectral imaging polarimeter (HIP) that can image a corn field across multiple diurnal cycles throughout a growing season. Using the polarization data, we present preliminary results demonstrating the potential to use polarization to de-couple light reflected from the surface versus light scattered from the tissues, thus enabling time of day, solar incidence angle, and viewing angle to be reduced as confounding factors for the spectral measurement. We present two approaches for polarization correction of our image data. The first is by using ground truth Normalized Difference Vegetation Index (NDVI) with linear regression and convolutional neural networks to train a deep learning model capable of compensating for the leaf normal relative to the camera and sun angle. The second approach involves using a recently constructed instrument which fits a scattering model of corn leaves by measuring the Bidirectional Reflectance Distribution Function (BRDF). This function models the behavior of light reflected off a leaf relative to its spectrum, polarization, and angle of incidence. Incorporating this model with data collected by the HIP, we estimate that the system will be able to distinguish leaves with surface normals facing towards the camera from leaves facing away from the camera. Preliminary results demonstrate a promising solution to reduce confounding factors in high-throughput systems for applications in plant phenomics and remote sensing.



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**Mitigating Illumination-, Leaf-, and View-Angle Dependencies in Hyperspectral Imaging using Polarimetry**

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