MISSISSIPPI SOYBEAN PROMOTION BOARD
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TITLE: Low Altitude Plant Sensing on Unmanned Aerial Vehicle with a Hyperspectral Imager for Detection of Glyphosate-Resistant Weeds in Soybean Fields

PRINCIPAL INVESTIGATOR: Yanbo Huang, Ph.D. yanbo.huang@ars.usda.gov

BACKGROUND

Repetitive and intensive use of glyphosate has exerted a high selection pressure on weed populations, resulting in the evolution of 32 glyphosate-resistant (GR) weed species in the world. Nine of them have appeared in Mississippi. Of the 9, a number of them are troublesome in soybean fields. Hyperspectral plant sensing techniques have been developed to effectively detect GR and glyphosate-susceptible (GS) weeds in soybean fields. However, in-field hyperspectral plant sensing is still time-consuming and laborious because the current sensors are either operated on a slow-moving tractor for imaging certain areas in the field, or handheld by a technician to measure canopy spectra at certain points in the field. This tedious manner of hyperspectral data acquisition is an obstacle for us to extend the research results to practical uses. A more advanced hyperspectral method for rapidly measuring the entire soybean field is needed to accurately determine the distribution of GR and GS weeds.

Unmanned aerial vehicles (UAV) are a unique platform for obtaining field-level vegetation data. UAV-based remote sensing techniques have great potential for precision crop management with ultra-high spatial resolution (a few centimeters to millimeters per pixel) imagery through the flight at ultra-low altitudes (tens of meters to a few meters). Therefore, a portable hyperspectral sensor mounted on a small UAV has the potential to overfly a soybean field and quickly determine the distribution of weeds, including GR and GS weeds. This information can be provided in a timely manner for Mississippi soybean producers and consultants to improve their site-specific weed management.

The purpose of this project is to develop UAV-based hyperspectral remote sensing techniques for rapid, consistent, and accurate differentiation between naturally grown GR and GS weeds in soybean fields. This year is basically to study the feasibility of the technology and prepare to improve the research in the second year. The research results so far provide strong, positive proofs for it.

OBJECTIVES

1. To determine the optimal flight altitude to best characterize the hyperspectral reflectance properties of GR and GS weeds in soybean fields.
2. To classify GR and GS weeds from the hyperspectral data acquired from soybean fields.
3. To map the distribution of GR and GS weeds in soybean fields based on the results of classification.
4. To evaluate technical and economic feasibilities of UAV-imaging systems for detection of GR and GS weeds in practical soybean production.

PROGRESS

In the summer of 2017, an 11-acre soybean field with naturally grown weeds was imaged by a digital color camera, a multispectral camera, a pair of digital and near-infrared cameras, and a hyperspectral camera on two UAVs, respectively. In the field, an 800-ft long, 16-row-wide stripe was focused on to acquire images to differentiate GR and GS weeds. In order to achieve millimeter resolution, a10m altitude, which is the minimal altitude to allow UAV autopilot control, was adopted for imaging. Through the flights and evaluation of the images, it was found that:

1. UAV flying in such low altitude is very sensitive to altitude fluctuation caused by wind if the wind speed is higher than 10 mph, which caused inconsistency of imaging operation.
2. Image mosaicking in near-infrared band is difficult because unique features in consecutive image sequence were hard to be identified to match up.

Also, the hyperspectral imaging system we used was not reliable, so it was difficult to acquire a full set of hyperspectral images.

Based on what we found, we chopped off the plants in the strip and replanted soybean to start the second round of experiments. In this experiment we:

1. Flew at 15m and 20m altitudes instead of 10m
2. Configured to use a new multispectral camera in addition to the hyperspectral camera.

To overcome the problems from the early flights, we continued to fly over the 11-acre soybean field with upgraded technologies by a digital color camera, two narrow-band multispectral cameras, and a hyperspectral camera on three UAVs, respectively, to evaluate the weed density over the field. At the same time, we conducted the second-round experiment in the 800-ft-long, 16-row-wide stripe with replanted Liberty Link soybean instead of Roundup Ready as in the last quarter.

To overcome the problems we met earlier, we flew at 20m altitude instead of 10m and used a new narrow-band multispectral camera in addition to the hyperspectral camera. The data we acquired indicated more reliable flight and better data quality, but the ground spatial resolution may not be as fine as we expected while the later study provides us the hint that the flight altitude of 15m could be optimal, which is the answer of the key research question (goal) of the project.

In order to have more reliable hyperspectral imaging in the second year of the project, we purchased a BaySpec OCIB150 true push-broom hyperspectral imager. This imager (~300g with computer) is lighter than the HeadWall one (~500g) we used and easier to operate. We hope to use it to have more reliable imaging operation and to achieve better quality images than what we had with the HeadWall hyperspectral imager in the summer of 2017.

Dr. Yanbo Huang had the OCI hyperspectral camera ready-to-fly system on-site training in the UAS Operation, Precision Ag and UAS Research Center, College of Business and Social Sciences, University of Louisiana at Monroe with George Shu, OCI Engineer, and Jeff MacCubbin, OCI Applications Specialist, of BaySpec Inc. Since then we installed and tested the new hyperspectral imaging system. The mount was built to allow the DJI S1000+ UAV to carry the hyperspectral imaging system to be fully operated in the summer of 2018 for continuation of the project.

This research has drawn the attention of the media, such as USDA-ARS AgResearch Magazine and Australian Cotton Grower Magazine. The report from these popular magazines allows farmers to be aware of this technology with the potential to use it in their farm management.