INTEGRATED CROP CANOPY SENSING SYSTEM FOR SPATIAL ANALYSIS OF IN-SEASON CROP PERFORMANCE

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ABSTRACT

Over the past decade, the relationships between leaf color, chlorophyll content, nitrogen supply, biomass and grain yield of agronomic crops have been studied widely. In many parts of the world, nitrogen fertilization and artificial water supply are major inputs required to achieve relatively high yields. However, as a result of the increasing costs of energy and a decline in available water, researchers are looking for ways to increase fertilizer and water use efficiency. Site-specific management of these inputs is a promising approach that involved the use of real-time crop canopy sensors. Since the effect of nitrogen and water stress can produce similar changes in optical sensor measurements, the goal of this work was to integrate conceptually different sensing elements to evaluate crop canopy performance during the growing season. Thus, active optical crop canopy sensors have been augmented with ultrasonic proximity and infrared thermal sensors to simultaneously assess crop canopy chlorophyll content, height and biomass, as well as temperature. Integrated sensors have been used to study the interactions between water stress and nitrogen stress in corn.

SUMMARY

The integrated crop canopy sensing system shown in Figure 1 was developed to simultaneously detect crop optical reflectance, height and temperature along with geographic coordinates in real time. The optical sensors were two active light reflectance sensors that emit and measure light in the near-infrared and visible parts of the spectrum. CropCircle 470[1] as well as CropCircle 210 (Holland Scientific, Lincoln, Nebraska) were used. While model 210 was recording and measuring light reflectance at 880 and 590 nm, model 470 was making measurements at 760, 670, and 720 nm. These spectral bands were used to calculate different vegetation indices.

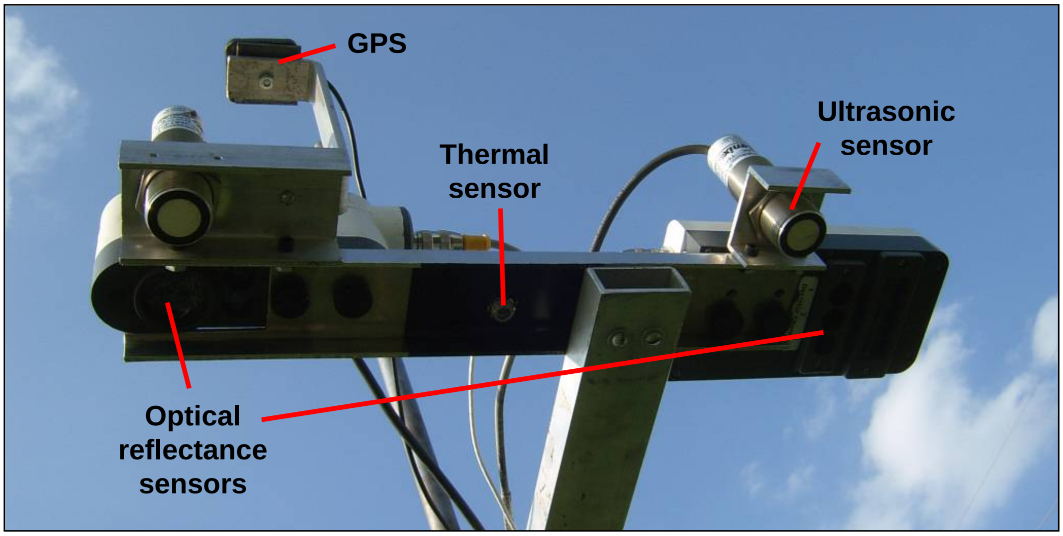

Figure 1. An integrated crop canopy sensing platform.

For plant height measurements two ultrasonic distance sensors TSPC-30S1 (Senix, Bristol, Vermont) were used. They had a maximum range of measurement of 4.3 m and an optimum range from 0.1 to 3.0 m, with a field of view of less than 5 cm at a height of 1 m from the target. These sensors were waterproof and temperature-compensated. Output data were calibrated in the laboratory and converted to distance. Plant height was determined by the difference of the sensor height and the distance from the top of the canopy to the sensor.

Canopy temperature was measured using a non-contact infrared temperature sensor, PSC SSS-LT02H (Process Sensors Corp., Milford, Massachusetts), with a lower limit temperature of 0 ºC and an upper limit of 500 ºC, with a 2:1 field of view, and accuracy of 0.5 ºC at object temperatures > 20ºC for the target temperature. The sensor was oriented in nadir position and maintained at about 1 m above the crop canopy. The sensor was calibrated at the factory.

The system was also equipped with a differentially corrected global positioning system receiver (Trimble GeoXT, Trimble Navigation Ltd., Sunnyvale, California) to record geographic coordinates. A CropDAQ interface (Figure 2) was developed using LabView software (National Instruments Corporation, Austin, Texas). The software was capable of configuring six serial ports and recording the data using a box-car averaging method (except for the ultrasonic sensor measurements) while synchronizing the measurements in time.

[1] Mention of a trade name, proprietary product, or company name is for presentation clarity and does not imply endorsement by the authors, the University of Nebraska-Lincoln, McGill University, Embrapa, or Virginia Tech University, nor does it imply exclusion of other products that may also be suitable.

A special upper crop canopy boundary detection algorithm was implemented to utilize ultrasonic measurements for crop height measurement.

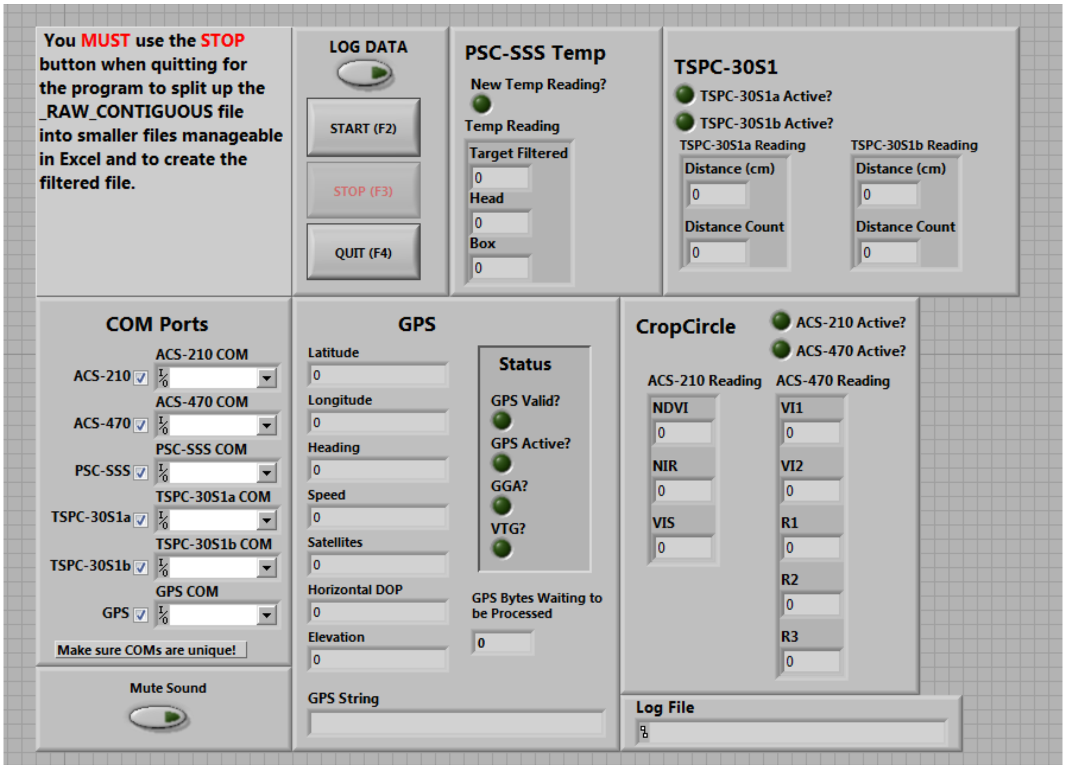

Figure 2. CropDAQ software interface.

This system has been used during three growing seasons in Nebraska when generating crop canopy status datasets in small plot experiments as well as in production agricultural fields. While initial measurements were conducted using a bicycle-mounted platform, newer versions have been placed on high-clearance sprayers. Initial data processing and analyses suggest a number of advantages and drawbacks of each sensor component and these will be discussed in future publications.