Computers and Electronics in Agriculture 141 (2017) 286–291

Contents lists available at ScienceDirect

Computers and Electronics in Agriculture

journal homepage: www.elsevier.com/locate/compag

Application note

A ground based platform for high throughput phenotyping

Juan Enciso [a,*], Murilo Maeda [b], Juan Landivar [b], Jinha Jung [c], Anjin Chang [c]

[a] Texas A&M AgriLife Research and Extension Center, 2415 E. US Hwy 83, Weslaco, TX 78596, United States
[b] Texas A&M AgriLife Research, 10345 State Hwy 44, Corpus Christi, TX 78406, United States
[c] Texas A&M University Corpus Christi, 6300 Ocean Dr., Corpus Christi, TX 78412, United States

ARTICLE INFO

Article history:
Received 12 December 2016
Received in revised form 8 July 2017
Accepted 6 August 2017

Keywords:
Phenotyping
Remote sensors
Agricultural management

ABSTRACT

The objective of this effort was to evaluate current commercially-available sensor technology (three sonic ranging and two NDVI sensors) for use in a ground-based platform for plant phenotyping and crop management decisions. The Global Positioning System (GPS) receiver from Trimble provided a high level of accuracy during our tests. Normalized Difference Vegetation Index (NDVI) data collected using the GreenSeeker sensors were more consistent and presented less variability when compared to the Decagon SRS sensor. The consistency could be due to the GreenSeeker system averaging readings of more rows. The tests also indicated that although sonic ranging sensor technology may be employed to obtain average plant height estimates, the technology is still a limiting factor for high-accuracy measurements at the plant level.

© 2017 Published by Elsevier B.V.

1. Introduction

Growers require innovative agricultural management tools to improve quality, productivity, and reduce production costs while remaining profitable. Precision agriculture is a management practice that involves better management of farm inputs such as fertilizers, herbicides, seed, and fuel by implementing best management practices at the right place and time (Mulla, 2013). Precision agriculture offers the opportunity to improve crop productivity and farm profitability through improved management of agricultural inputs (Mulla, 2013). Proximal remote sensing involves mounting sensors on a tractor, spreaders, sprayers or irrigation booms to assess crop growth and stress. Mobile platforms mounted with various remote sensors may facilitate management decisions in vegetable, fruit, and row crops and may be useful to accelerate crop breeding/cultivar development by phenotyping large segregating populations and identifying desirable traits related to earliness, disease, and insect resistance. These platforms may also assist breeders in finding varieties with specific traits that confer tolerance to key environmental stresses such as heat and drought. Several vehicle-based platforms have been proposed for crop phenotyping and to determine spatial and temporal plant characteristics (Sharma and Ritchie, 2015; Adrade-Sanchez Pedro et al., 2014; Sui and Thomasson, 2006; Montes et al., 2011). These vehicle platforms have been mounted with several combinations of sensors. The advantage of these sensors is that data can be collected extensively at low cost, without conducting a high number of destructive measurements. For example, Sui and Thomasson (2006) used sonic ranging sensors to determine plant height and optical sensors to determine spectral reflectance to correlate with leaf nitrogen concentration of cotton plants. Colaizzi et al. (2003) used a remote sensing system mounted aboard a linear moving irrigation system to monitor water status, nitrogen status, and canopy density by measuring four reflectance bands and soil temperature. Hunsaker et al. (2005) used remote sensing observations of NDVI obtained with a mobile platform to estimate crop coefficients and crop evapotranspiration. O'Shaughnessy et al. (2012) mounted infrared thermometers in a center pivot for irrigation scheduling. Imagery remote sensing technologies are mainly based on particular leaves and canopies' wavelength reflectance in the visible range of the spectrum RGB (red, green and blue), non-visible as (Infra-red) IR, and the emission of far-IR (thermal). Indices based on leaf/canopy reflectance can be used as an indicator of plant function because green vegetation absorbs a greater portion of the light reflected and depend directly on a leaf's pigment composition (e.g. chlorophylls and xanthophyll), which can be correlated with the plants' physiological status (Jones and Vaughan, 2010). The most employed index is the normalized difference vegetation index (NDVI) = (IR−R)/(IR + R); where IR (infrared) is the reflectance in the near-infrared band (800 nm) and (R) in the red band (680 nm). This index has commonly been used to detect plants and "greenness", due to the high IR reflectance of chlorophylls (Zarco-Tejada et al., 2012).

* Corresponding author.
E-mail address: Juan.Enciso@ag.tamu.edu (J. Enciso).

http://dx.doi.org/10.1016/j.compag.2017.08.006
0168-1699/© 2017 Published by Elsevier B.V.

Link et al. (2002) and Reusch et al. (2002) developed a tractor based passive sensor to determine crop N status based on NDVI. This sensor was formerly known as the Hydro-N sensor and later became known as the Yara-N sensor (Yara, Olso, Norway). Holland et al. (2004) developed an active crop sensor known as Crop Circle that was initially used to determine reflectance in the green and NIR bands to estimate crop N deficiencies. The rationale behind using green rather than red reflectance with Crop Circle was that the green NDVI is more sensitive to changes in chlorophyll concentration and potential crop yield than NDVI (Gitelson et al., 1996; Shanahan et al., 2008; Sripada et al., 2008). Some other low-cost NDVI sensors have been developed to study environmental and physiological constraints on photosynthesis (Gamon et al., 2015). Mobile platforms offer the opportunity to determine spatial and temporal characteristics of the plant when equipped with the right sensors. The objective of this paper was to evaluate current commercially-available sensor (three sonic ranging and two NDVI sensors) for use in a ground-based platform for plant phenotyping and crop management decisions.

2. Material and methods

2.1. Plant health sensing system

A mobile phenotyping platform was built on a Lee Agra 3218-GM open rider sprayer (Lee Spider, Lubbock, TX, US). A boom was attached to the front end of the platform frame to provide mechanical support for the sensors. Battery, solar panel, datalogger, and Global Positioning System (GPS) antennas were installed behind and above the platform's cabin. The boom was supported by three arms to reduce lateral movement. A hydraulic system allowed the vertical movement of the boom from approximately 1 to 3 m above ground and provided enough versatility to adjust to different crop types such as cotton, peppers, cantaloupes, etc.

The platform contained two independent data collection systems running simultaneously (Fig. 1). The first system consisted of a datalogger CR1000 (Campbell Scientific, Logan, UT, US) connected to a power supply with a charging regulator and rechargeable battery. The battery was recharged from an external 10-W photovoltaic solar panel (Cambell Scientific, Logan, UT, US). The datalogger and battery were enclosed in a box. The sensors were installed on the boom and connected to the datalogger. A GPS receiver (GPS16X-HVS, Garmin International Inc., Olathe, KS) was connected to the datalogger to geo-tag the location of the measurements. A spectral reflectance sensor (SRS) was used to monitor NDVI of the plant canopy (Decagon Devices, Inc, Pullman, WA, US). The SRS consists of two-band radiometers, where one radiometer measures incident radiation while the other measures reflected radiation with a field of view of 36° to measure canopy-reflected radiation. The data collected in each operation was downloaded from the datalogger to a computer. The data collected with the spectral reflectance sensor was plotted with the 3D Filed Pro 4.2 program. The first system also had two infrared radiometers (SI-111, Campbell Scientific, Inc., Logan, UT), two sonic ranging sensors (SR50A, Campbell Scientific, Inc., Logan, UT), and a temperature and relative humidity probe (HC2S3, Campbell Scientific, Inc., Logan, UT).

The second independent system consisted of a GPS receiver (AgGPS 162, Trimble Navigation Limited, Sunnyvale, CA) and two multi-spectral GreenSeeker RT 200 sensors (Trimble Navigation Limited, Sunnyvale, CA) which were connected to the Trimble Nomad 900 datalogger (Trimble Navigation Limited, Sunnyvale, CA). The system was configured to average the measurements from both sensors. The two NDVI systems were evaluated and compared by matching the time of the two GPS systems in a cotton field containing 35 entries. Each plot consisted of six rows spaced at 1.02 m with a row length of 12.2 m. The NDVI data collected was also plotted with the 3D Field Pro 4.2 program.

2.2. Evaluation of sonic ranging sensors

Three sonic ranging sensors were evaluated and compared to determine their accuracy in a static and dynamic setting (Table 1). In the static setting, cotton plant heights were measured by stopping the platform in the middle of a cotton plot. In the dynamic setting, the sensors were evaluated while the platform was in

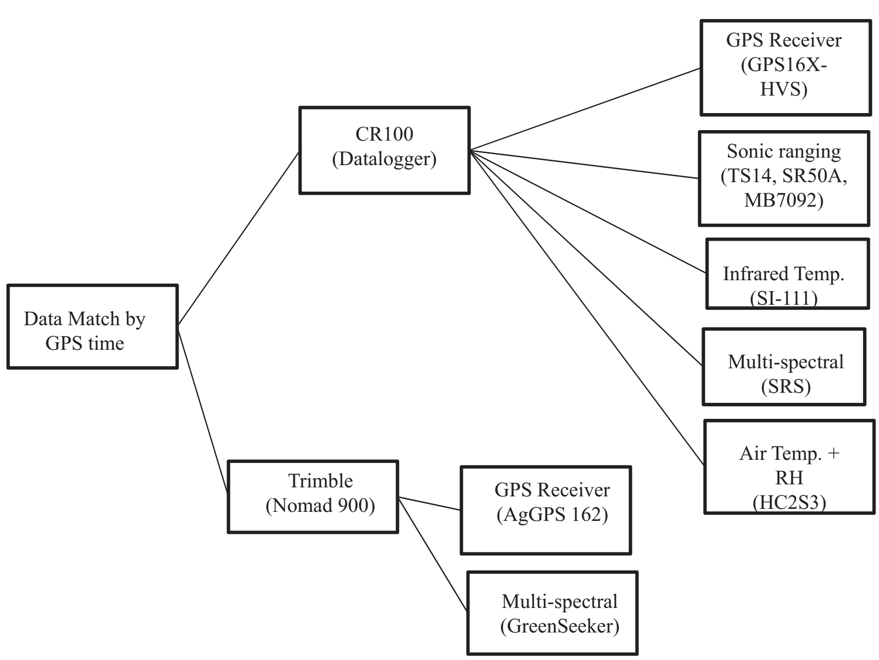

Fig. 1. Data were collected by two independent systems running simultaneously. Data were matched using Global Positioning System time for post-collection processing and analysis.

Download English Version:

https://daneshyari.com/en/article/4759096

Download Persian Version:

https://daneshyari.com/article/4759096

Daneshyari.com