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DEVELOPMENT OF GROUND BASED MULTI-SOURCE INFORMATION COLLECTION SYSTEM BY CONVERTING PADDY TRANSPLANTER

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Abstract: Precision agriculture has created a technology revolution in production agriculture and it requires reliable technology to acquire accurate information on crop conditions. A ground-based integrated sensor and instrumentation system was developed to measure real-time crop conditions. The integration system included multispectral camera and N-sensor for real time Nitrogen application. The system was interfaced with a DGPS receiver to provide spatial coordinates for sensor readings. Before mounting of the sensors on modified paddy transplanter, different mountings and frames were attached with the paddy vehicle to mount the sensors, camera and power source. Battery mounting plate was required to fit imported 12 V & 80 A battery on vehicle. New bracket had fabricated to suit the new battery and it can be adjusted vertically 25~30 mm as per the requirement. For overturning balancing of rice transplanter extra weights of 100 kg were added at the rear of the rice transplanter. Trails were done in puddle rice field. By adding additional weight, there was no problem of over turning in the field in normal operations. The results showed that the integration sensor and instrumentation system supports multi-source information acquisition and management in the farming field except high clearance of tractor.

Key words: *ground based integration system, multi-spectral camera, N-sensor, paddy transplanter*

INTRODUCTION

Precision agriculture demands intensive field data acquisition. Frequent data acquisition and interpretation can be the key to understand variability in the field. Wireless

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sensor networks are a technology that can provide real time field data from sensors physically distributed in the field [1]. In developed countries, it is common to find combine harvesters with on-board data collection systems for mapping yield and moisture content of harvested crop. The agricultural equipment industry is moving towards controller area networks for agricultural equipment communication systems. These are basic factors that have led to increased opportunity for automation of agricultural guidance. With the advances of electronic and information technologies, various sensing systems have been developed for especially for crop production around the world. Accurate and reliable information technology is the basis of precision agriculture. Information on crop condition can be used to assess and monitor crop growth status, predict crop yield, or develop program for optimizing application of various inputs like nitrogen fertilizer, fungicide, and growth regulator for precision agriculture. Successful information acquisition relies on the ability of sensors and instrumentation to detect these crop canopy variables, which are indicative of crop growth [2].

[4] developed a guidance system by the sensor fusion integration with a machine vision, an RTK-GPS and a geometric direction sensor (GDS). The developed navigation planner involved a priority scheme of the control strategies using a knowledge-based approach. [5] developed an intelligent vision system for autonomous vehicle field operations. Field trials confirmed that the method developed was able to accurately classify crop and weeds through the entire growing period. After segmenting out the weed, an artificial neural network was used to estimate crop height and width. Finally, geographic information system (GIS) was used to create a crop growth map. [3] developed a multifunctional sensor node that can collect many kinds of data for agricultural applications. These sensor-intensive technologies include some benefits like sensing is non contact, large amount of information is collected quickly and the potential exists to be both cheap and powerful. But there are some difficulties also such as moving of ground vehicle within the submerged crop like rice, storing and processing the data, extracting usable information from images, dealing with natural objects and operating under natural lighting conditions.

Combinations of sensors provide data for crop management in addition to guidance functions. The combination of various sensors with Global Positioning System (GPS) provides opportunities for mapping crop responses as the vehicle performs field tasks. Rice crop being submerged, it is difficult to move a tractor or platform within the crop. Paddy transplanter available commercially can be used for mounting of different sensors and cameras. In relation to above view a ground-based integrated sensor and instrumentation system was developed to measure real-time conditions by converting paddy transplanter into a vehicle.

MATERIALS AND METHODS

Development of ground based integration system. The ground-based multi-source information system was developed to measure real time rice crop conditions through of N-sensor and Multi-spectral camera. The system is interfaced with a DGPS (Differential Global Positioning System) receiver to provide spatial coordinates for sensor data. N-sensor, multispectral camera and DGPS were mounted over the developed vehicle explained in following section. Individual sensor components has been calibrated and tested under laboratory and field conditions prior to system integration. The integrated system collected multi-sensor data and store the spatial information and crop property information in database. The different components and how they were unified are described in the following sections.

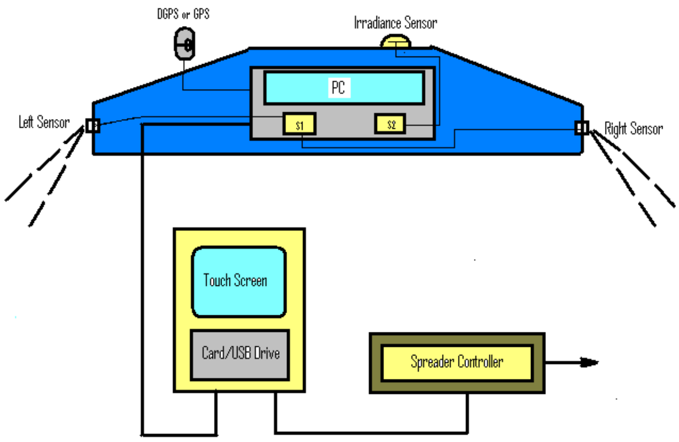


Figure1. System flow chart of N-sensor

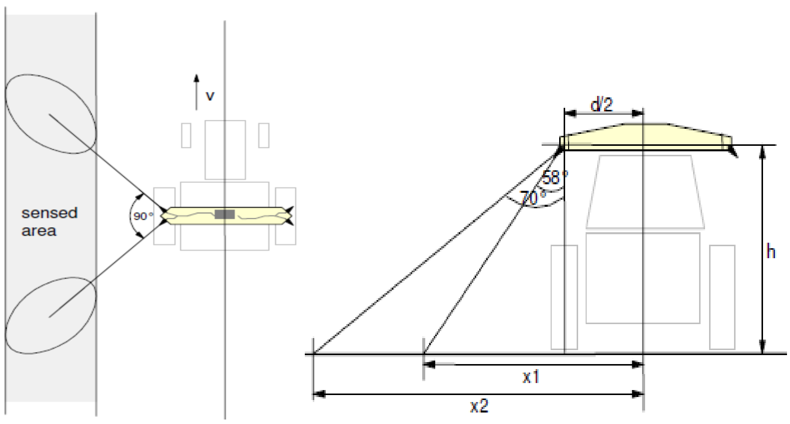


Figure 2. Geometry of N-sensor

N-sensor. A frame was developed to mount N-sensor with the vehicle (Fig.1 and Fig.2). The N sensor was installed on the vehicle at 2.74 m height (h) (Fig. 3) which made the scanning area 46.56 m2. N-sensor consists of two diode spectrometers, fiber optics and microprocessor in a hard shell, built on the roof of the vehicle. A spectrometer collects reflectivity of wavelengths from 620 to 1000 nm with four points, which are around the vehicle. A fifth sensor positioned skywards measures the intensity of light allowing the sensor system to compensate for different light conditions while operating. System flow chart and geometry of N sensor is shown in Fig. 1 and 2.

$$x1 = d/2 + h \tan 58° / \mathrm{sqrt}(2) = 0.5\ d + 1.13\ h$$

$$x2 = d/2 + h \tan 70° / \mathrm{sqrt}(2) = 0.5\ d + 1.94\ h$$

where:
d: width of the sensor rig
h: height of the sensor rig

Multi-spectral Camera. A frame to mount the Multi-spectral camera was developed and attached with the vehicle (Fig.1 and Fig. 2). The height of Multi-spectral camera was kept equal as the N-sensor. But its mounting height can increased or decreased by moving the frame upward or downward. The information available can be maximized by combining information found in multiple spectral bands. The photonic spectrum includes energy at wavelengths ranging from the ultraviolet through the visible, near infrared, far infrared, and finally, x-rays. The color image from a Charge Coupled Device (CCD) array is acquired by sensing the wavelengths corresponding to red, green, and blue light. CCD sensors are capable of detecting light beyond the visible wavelengths out to 1100 nm.

Differential Global Positioning System (DGPS). The N-Sensor and Multi-spectral camera system was connected to a Differential Global Positioning System (DGPS) signal to allow Location, sensor and application information to be plotted enabling the production real time crop information. The DGPS was mounted at the height of 2.5 m on the frame of Multi-spectral camera and its serial console was connected to the N-sensor display.

RESULTS AND DISCUSSION

Development of vehicle. Paddy transplanter used for the transplanting of mat type rice seedlings is available in the Japan, Korea and other Asian Countries. It can be used as a vehicle for other operations, if transplanting mechanism mounted at the rear of the transplanter is removed. It may become unstable after removing the transplanting mechanism but extra weight can be added to make it stable. Before mounting of the sensors, different mountings and frames were attached with the paddy vehicle to mount the sensors, camera and power source. Battery mounting plate was required to fit imported 12 V & 80 A battery on vehicle. New bracket had fabricated to fit the new battery and it can be adjusted vertically 25~30 mm as per the requirement. Battery positive cable had been replaced to suit the new battery. Separate MS sheet had been welded to support the foam of the operator seat. Hinges had been welded to the MS sheet. For balancing of rice transplanter extra 100 kg weights were added at the rear of the rice transplanter. By adding additional weight, there was no problem of over turning in the field in normal operations. It was observed that while entering into the field from main road (big bunds between field and road), rice transplanter has tendency to little lift from rear. A DC (12 V) to AC (230 V) converter was required for the frame grabber used to store the multi-spectral images acquired by the multi spectral camera.

Field operation of ground vehicle. The N sensor gives the data in the form of log file which can be converted into the CSV file format with the help of log converter software or with N sensor card writer software. This CSV file can be opened in excel format which contain the real time information of the crop. Vehilce was opeared in the Five wheat crop plot having inceasing nitrogen level rate (0, 40, 80, 120 and 150 kgN/ha) with N-sensor and Multi-spectral installed on it to measure real-time crop conditions. The data was taken after 60 days after sowing (DAS). The N-sensor Nitrogen recommendation map prepared after the operation of N-sensor (Fig.4). The recommendation map was also located on the Google Earth. The map showed that the minimum and maximum nitrogen recommendation rate were 16 and 105 kgN/ha.

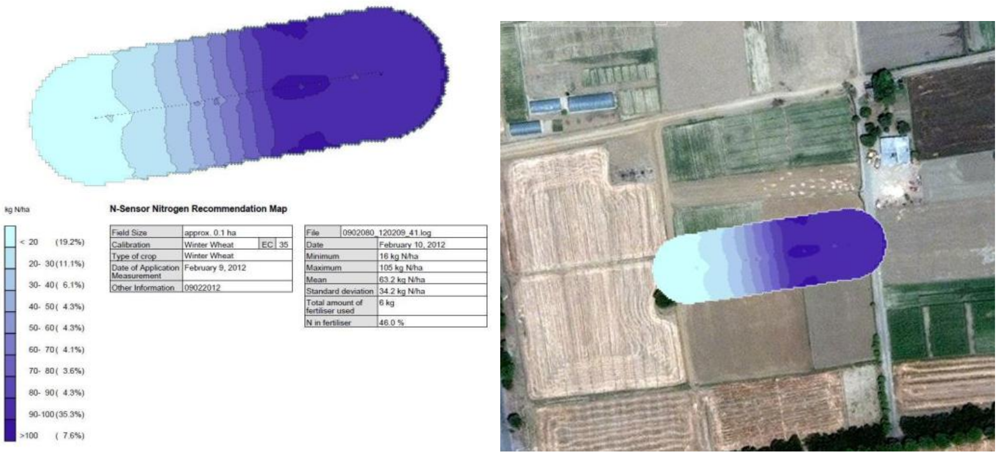
Multispectral camera was also operated during the operation. Images (Fig. 5) taken at 0 and 80 kgN/ha level plot showed that, there is textural difference between the images. Darker the red color of the canopy more is the nitrogen uptake. Brown color in the images depicts shadow of plant and white color showed reflectance of the bare soil. There is difference in terms of density of the canopy at different level of nitrogen.

Change in NDVI can be referred through change in scatter diagrams of NIR and R level. Multispectral images need to be first pre-processed by using various image enhancement techniques. Later, specific band information need to be extracted from the processed image and plotted in the form of graph.

Figure 1. Multispectral camera and N Sensor holding frame

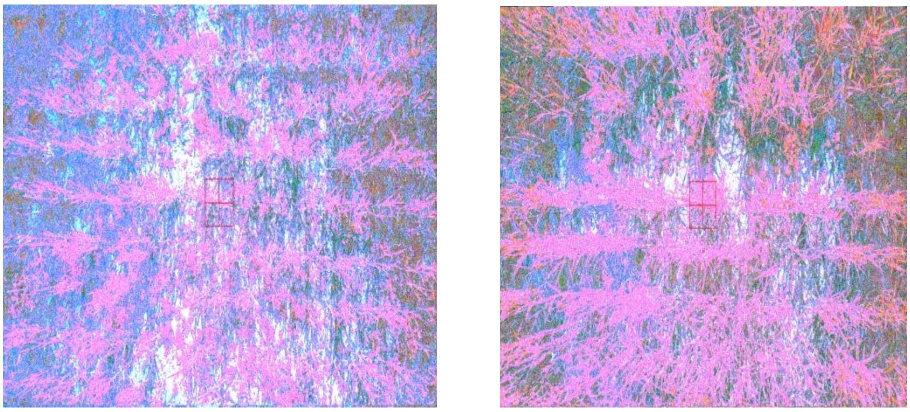
Figure 2. Different frames mounted to the developed vehicle

Figure 3. View of developed vehicle with installed sensor working in the field



(a) (b)

Figure 4. (a) N-sensor Nitrogen Recommendation Map and (b) its location on Google Earth



(a) (b)

Figure 5. Images of multispectral camera at (a) 0 and (b) 80 kgN/ha level plot

Nitrogen can be co-related with NDVI as written below:

NDVI= (NIR –R)/(NIR+R) ……..(1)

CONCLUSIONS

Experimental work to determine the best use of sensors in crop production is still in its infancy. Machine vision gives promising results, but is sensitive in field work still. The integration system included Multi-spectral camera and N-sensor for real time crop information. Before mounting of the sensors on modified paddy transplanter, different mountings and frames were attached with the paddy vehicle to mount the sensors, camera and power source. Battery mounting plate was required to fit imported 12 V & 80 A battery on vehicle. New bracket had fabricated to suit the new battery and it can be adjusted vertically 25~30 mm as per the requirement. For overturning balancing of rice transplanter extra weights of 100 kg were added at the rear of the rice transplanter. By adding additional weight, there was no problem of over turning in the field in normal operations. This preliminary study indicates that the potential of the integration sensor and instrument system to realize multi-source information acquisition and management in the field.

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RAZVOJ INFORMACIONOG SISTEMA ZA SAKUPLJANJE PODATAKA IZ VIŠE IZVORA

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Sažetak: Precizna poljoprivreda je dovela do tehnološke revolucije u poljoprivrednoj proizvodnji, koja zahteva pouzdanu tehnologiju za sakupljanje tačnih informacija o stanju useva. Zemaljski integrisani senzor i sistem instrumenata su razvijeni za određivanje stanja useva u realnom vremenu. Ovaj integrisani sistem je uključio multispektralnu kameru i N senzor za primenu azota u realnom vremenu. Sistem je povezan sa DGPS prijemnikom za određivanje prostornih koordinata očitavanja senzora. Pre postavljanja senzora na modifikovanu sadilicu postavljeni su razni sklopovi i ramovi koji nose senzore, kameru i izvor napajanja. Napajanje je obezbeđeno sa akumulatorske baterije na vozilu, 12V-80A. Za obezbeđenje vozila od prevrtanja postavljeni su dodatni tegovi od 100 kg na zadnju stranu.

Ključne reči: *integracioni sistem, multi-spektralna kamera, N-senzor, sadilica*

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