ROUND MODULES: HANDLING LOGISTICS AND COVER DAMAGE

Tianyi Wang
Robert G. Hardin IV
Texas A&M University
College Station, TX
Jason K. Ward
North Carolina State University
Raleigh, NC
John D. Wanjura
USDA ARS
Lubbock, TX

Abstract

Round modules are becoming the predominant method of seed cotton storage and transport, with different methods of field staging, transport, and handling at the gin used. A single board computer-based system was developed and installed on module trucks or handlers to record module tag numbers, equipment location, and images of the modules. Throughput rates of different handling systems were calculated, and costs per module were estimated. Module images were analyzed to determine the frequency and source of cover damage. A case study was conducted at El Campo, TX.

Introduction

The conventional cotton harvesting and storage system requires significant labor (Hardin & Searcy, 2011). As a result, the onboard module system costs around $64.25/ha ($26/acre) less than a basket picker (Salassi et al., 2015), which has led to the increasing adoption of round module technology. However, the round module technology also requires additional handling such as staging modules on the edge of fields, loading modules on a flatbed trailer, and unloading trailers in the gin yard, which incurs extra costs. In order to record and study the costs of this handling, new technolgies such as radio-frequency identification (RFID) and global navigation satellite systems (GNSS) can be used.

RFID uses electromagnetic fields to read and identify tags that are attached to objects. The TAMA wrap for round modules has four embedded RFID tags with unique ID numbers, and John Deere harvesters are equipped with RFID readers. However, RFID could have more potential uses in module management (Robb, 2017; 2018).

Plastic contamination is another challenge for the US cotton industry. This contamination, including plastic wrap film or bags, impacts the quality of cotton fiber. Module wrap is the primary cause of plastic contamination, with over 90% of extraneous matter calls for plastic due to module wrap, and observations by gin operators indicate that modules with damaged wrap are more likely to cause contamination. As a result, recording and tracking wrap damage is necessary to identify the specific causes of contamination.

Materials and Methods

Experimental Equipment

A smart cotton module tracking system was designed and built for tracking cotton modules and recording damage on the wrap. The system contains four main parts, which are the central processing unit (CPU), RFID module, GNSS module, and cameras (Figure 1). The CPU, a Raspberry Pi 3b+, logs all collected data every three seconds. Three cameras are used to collect images of each module on loaders and tractors, while four are needed on a module truck to capture images of most of the module. The images were collected from the cameras beginning when the loader slowed down to load and unload the cotton modules.

(a) (b)

(c) (d)

Figure 1. The smart cotton module tracking system contains (a) data logging CPU, (b) RFID module, (c) GNSS module, and (d) cameras.

The system was installed on a Caterpillar 938M equipped with a round cotton module spear (Figure 2). An enclosure containing the CPU, RFID module, and GNSS module was installed in the cabin of the loader. An RFID antenna is installed on each side of the loader mast. One camera was installed on each side of the mast and one camera was installed under the chassis to collect images of the bottom of the module. The system was powered from the Caterpillar 938M battery with 12 V.

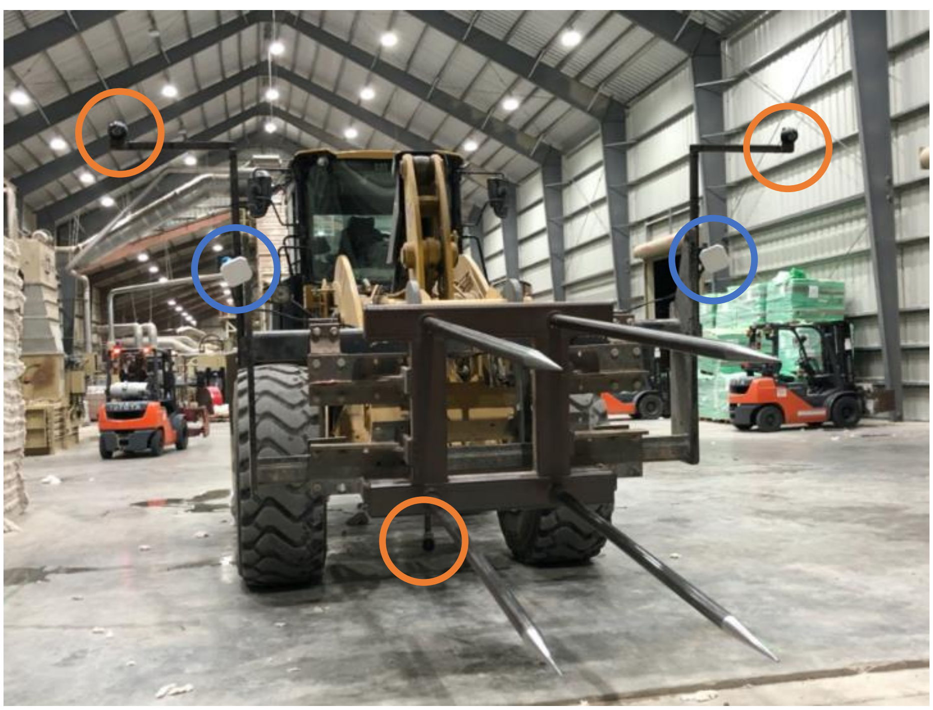
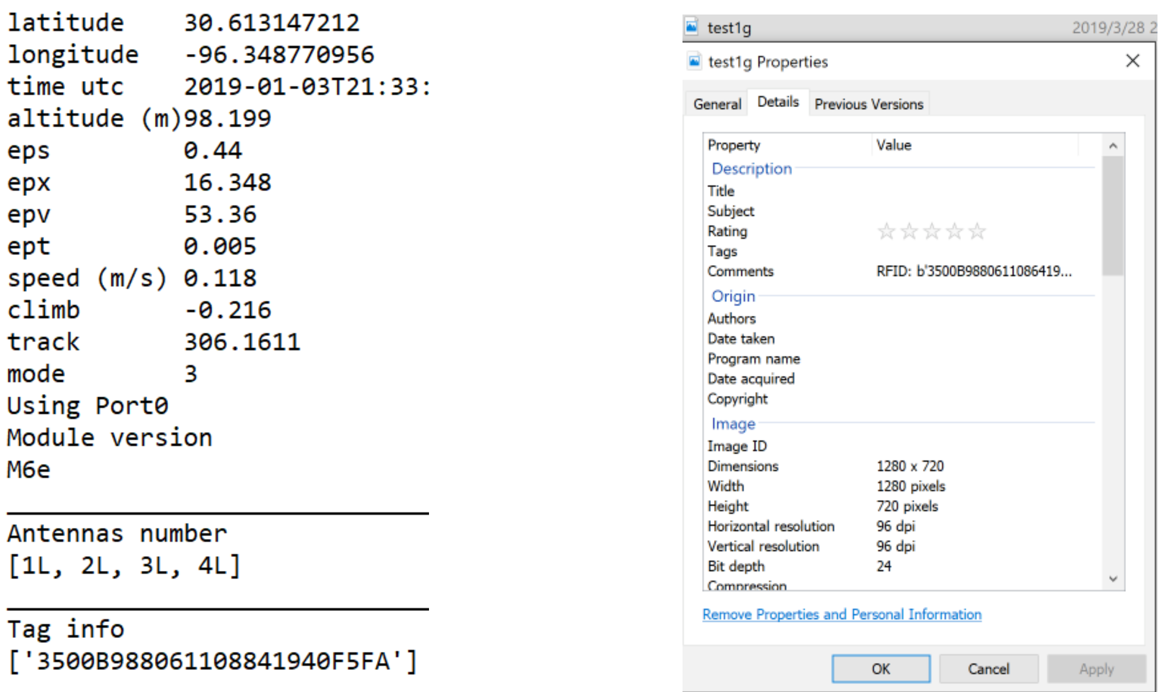


Figure 2. The Caterpillar 938M equipped with round cotton module handler had the system installed. The cameras are highlighted with orange circles and the RFID antennas with blue ones.

Data Collection
The time and motion study was conducted on a gin yard in 2019. From Sept. 21 to Sept. 27, a total of 5603 images were collected in eight separate periods.

Data Processing
Comma-separated values (CSV) files containing RFID and GNSS information were generated (Figure 3a). Using the CSV file, ArcGIS software was used to map the machinery route. RFID and GNSS information collected at the same time an image taken was added to the image metadata (Figure 3b).

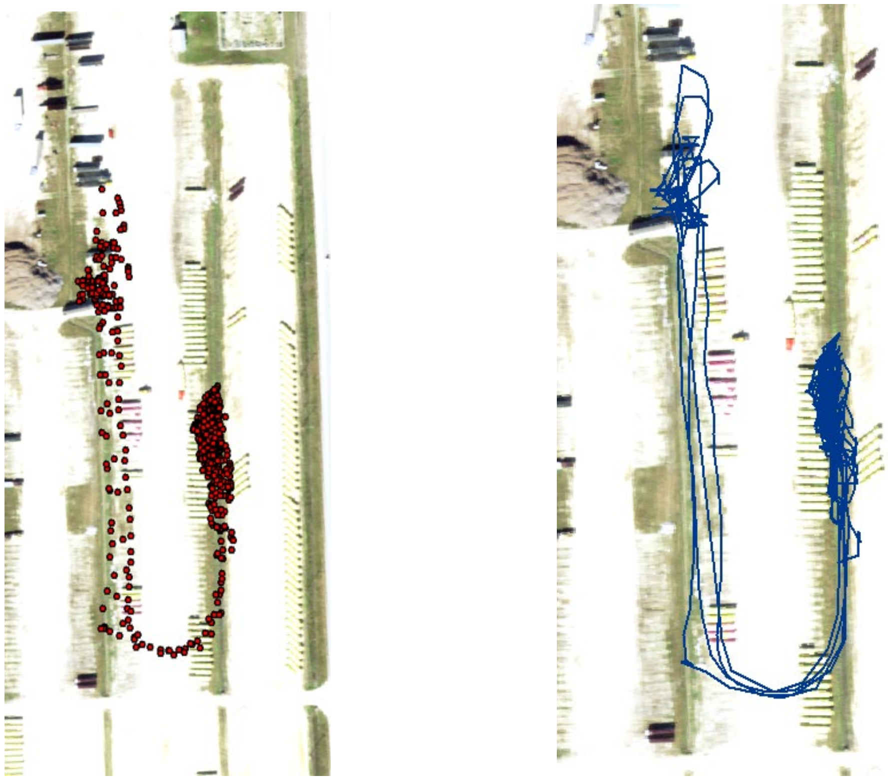


(a) (b)

Figure 3. The RFID and GNSS information collected (a) and appended to the image metadata (b).

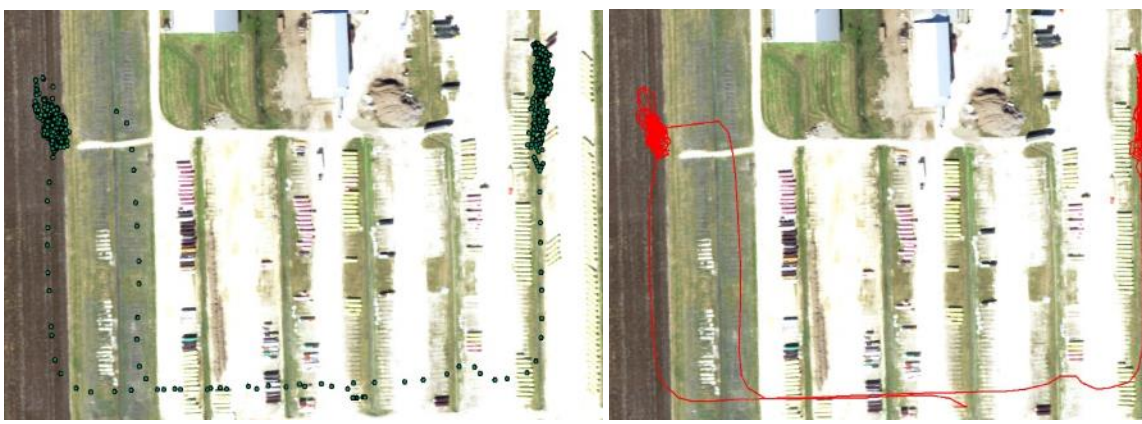
Results and Discussion

An 80-min. working period on Sept. 26, 2019 was used as an example. The loader was in the gin yard to unload the cotton modules from a flatbed trailer on the gin yard. A total of 619 images with GPS coordinates were collected during this period. Each GNSS point was sequentially linked to form a polyline to indicate the moving route of the forklift (Figure 4). The results indicated that the forklift was driven a total of 4.856 km during unloading. In as second sample period on Sept. 27, there were 374 images captured in 55 minutes. The forklift was driven a total of 5.375 km (Figure 5). Additional time and motion data will be analyzed to determine cycle times for unloading modules.



(a) (b)

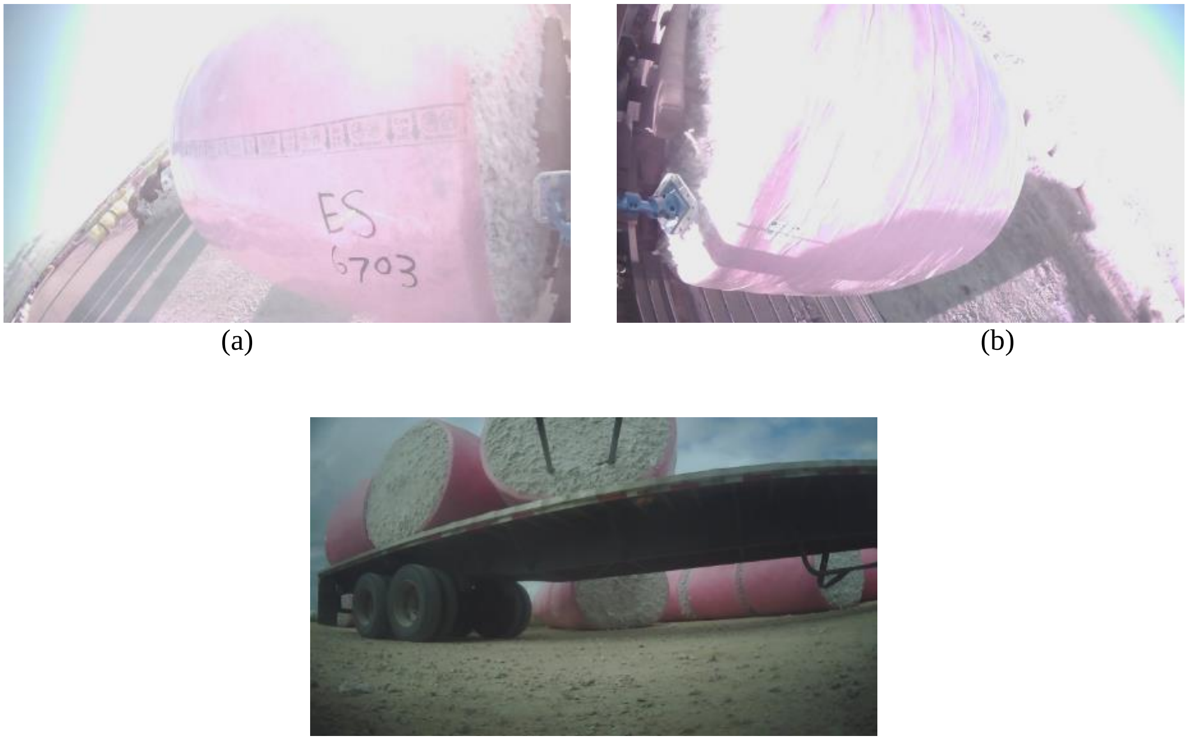
Figure 4. GNSS points (a) and the polyline (b) indicating the loader route on Sept. 26.



(a) (b)

Figure 5. GNSS points (a) and the polyline (b) indicating the loader route on Sept. 27.

Images were captured from the three cameras (figure 6). The two cameras mounted on the mast were often in bright sunlight and had many overexposed images.



(a) (b) (c)

Figure 6. The images of one round cotton module captured from (a) the top left, (b) the top right, and (c) the bottom cameras.

Summary

A low-cost smart cotton module tracking system was designed and tested for tracking the movement of round cotton modules and capturing images of the module wrap. The system was able to provide necessary information to evaluate machine efficiency and wrap damage during handling. Preliminary analysis of time and motion data during several periods of operation has been completed. Additional analysis will be done on the collected data. Further refinements will be made to the system for use in 2020, including upgrading the CPU and installing shrouds around the upper cameras to obtain high-quality images. Additional sensors will be installed to collect module moisture content and weight.

Acknowledgements

Thanks to Cotton Incorporated for funding this work under Agreement No. 18-496 and the cooperating producers and ginners for their assistance on this project.

References

Hardin, IV, R.G., & Searcy, S.W. (2011). Autonomous cotton module forming system. *Appl. Eng. in Agric.*, *27*(4), 559-568.

Robb, B. (2017). RFID technology ushers in new era in module management. *Delta Farm Press*, December 1, 2017.

Robb, B. (2018). Tailoring RFID technology for managing cotton modules. *Delta Farm Press*, June 11, 2018.

Salassi, M. E., Deliberto, M. A., Falconer, L. L. (2015). Comparative costs of onboard module building cotton harvest systems in the mid-south. *Journal of the ASFMRA 2015*, 1-14.