NEW TECHNOLOGIES FOR MANAGING COTTON MODULES J.D. Wanjura

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<u>Abstract</u>

New cotton harvesters with the ability to form seed cotton modules have changed the way that cotton is stored and handled before ginning. Cylindrical or "round" modules formed by John Deere cotton pickers and strippers are wrapped in three layers of plastic material to protect the cotton and maintain the cylindrical module shape during storage. The wrap material on each cylindrical module contains several radio frequency identification (RFID) tags that contain a module identification number unique to that module. The module serial number can be read from the RFID tag using electronic scanning tools and used to help growers and ginning processes. However, to date, no commercial systems have been developed to facilitate the collection of module ID or position information using RFID technology. Therefore, the objective of this work is to develop a mobile application for use in collecting cotton module location and identification information using RFID and/or 1D/2D barcode technology. This system provides basic functionality to help ginners and producers identify ways to glean additional value from the new ability to manage modules using RFID technology.

Introduction

New cotton harvesters recently released by John Deere (CS 690 and CP 690) form round cotton modules onboard as the machines harvest cotton in the field. The round modules are wrapped in three-layers of engineered plastic film which restrain the cotton in cylindrical form and protect it from wind and moisture damage prior to ginning. The round modules offer other unique benefits relative to conventional cotton modules in regard to the extended maximum storage period prior to ginning and the ability to haul cotton on semi-tractor-trailer vehicles which cheapens the cost of transporting modules over long distances.

Each portion of plastic module wrap contains four passive RFID transponders (tags) and two human readable identification tags that display a serial number unique to each round module. The human readable tags also contain a 2D data matrix which can be scanned by a barcode reader. Harvest ID – Cotton is a system offered by John Deere which associates the module identification number with other harvest related data (table 1) wirelessly transmitted from the harvester to the MyJohnDeere.com website. Part of the Harvest ID-Cotton system is an RFID reader on the harvester that scans the modules as they are ejected from the module formation chamber. Other system components associate the module ID with other harvest data collected on the machine.

Table 1. Data available for each found module serial number on MyjohinDeere.com.						
Module ID	Client	Gin ID				
Module Serial Number	Farm	Producer ID				
Latitude	Field	Local Time				
Longitude	Variety	Field Area				
GMT Date/Time	Machine PIN	Season Total Modules				
Tag Count	Operator	Diameter				
Module Weight*	Moisture Content*					

Table 1. Data available for each round module serial number on MyJohnDeere.com.

*Available in John Deere - HID Cotton-Pro released in 2017.

The use of RFID technology to identify cotton modules has enabled new methods for tracking and managing seed cotton from the field to the gin. This new technology creates new possibilities for logistical management, asset

tracking, product traceability, and precision agriculture regarding fiber quality mapping. While some in the cotton ginning industry have used pieces of the system to create module inventory lists or pickup reports, no system exists that compiles all of the module ID and harvest data along with other additional RFID tag scan location data into one management system. The overall goal of this research is to develop a module management system for use by gins which utilizes RFID module ID technology and other associated systems to provide useful information (e.g. current module location, processing status, and load weight) to ginners and producers. The specific objective of the work described in this manuscript is to develop a mobile application for use in collecting cotton module location and identification information using RFID and/or 1D/2D barcode technology. The system described herein is one of several tools used in the electronic module management system. Our goal is for this system to demonstrate the utility of this new module tracking technology and help producers and ginners identify new sources of value through the enhanced use of module location and harvest information.

Materials and Methods

Application Development

An application was designed to facilitate the collection of module identification, position, ownership, and other management data utilizing two scanning tools. The first scanning tool, known as the "Load Scan Tool," allows the user to scan a group of module ID tags (RFID or 1D/2D barcodes) and associate the module serial numbers with a load number. In concept, the load scan tool would be used to scan and locate a group or "load" of modules after they have been staged together at the edge of the field for transport. The load scan tool provides specific loading location information for module trucks. Gins commonly associate the cotton loaded onto a transport vehicle with a particular load number in order to track seed cotton, lint, and seed weights through the ginning process. The ability for the mobile application to provide this functionality reduces the need for an office worker to manually assign load numbers after transport. The user is not restricted by the application in regard to the number of modules that can be associated with a particular load number. The second scanning tool, known as the "Field Scan Tool" allows the user to scan module ID tags and generate a continuous list of module serial numbers. The field scan tool is useful in scenarios when the user needs to generate an inventory list of modules (e.g. a list of all modules harvested from one field, a gin yard inventory, etc.). When a module ID tag is scanned using either scanning tool, the module serial number, cotton ownership information (Client, Farm, and Field), GPS position coordinates, time/date, tablet ID, and other scan specific information is recorded by the device. The data collected using either scanning tool is transmitted to the gin office as a comma separated value file (.csv file) attached to an email using the device email client.

The application design criteria were laid out in flow charts and presented to a custom software developer for code development (Bohn Technology Solutions LLC., Lubbock, TX). The program code was written in C# in the Xamarin development environment. The application was deployed to operate under the Android operating system but can be easily recompiled in Xamarin to work under iOS or Windows platforms. Beta testing was conducted on 10.1 and 8 in Samsung Tab A tablet devices and on a 5.5 in LG smart phone. A GPS receiver onboard each device provides position data to the application. Additionally, each device utilizes a Bluetooth wireless connection to communicate with the hand held RFID/1D/2D barcode reader (TSL 1128 UHF RFID, Technology Solutions LTD, UK). The software written for this application was developed under an open-source license (MIT License Agreement) for free integration into other software packages.

Application Operation

The user opens the application titled "RFID Module Scan" by tapping the app icon and is presented with the home screen (figure 1) which allows the user to select one of six buttons:

- Continue Scan
- New Scan
- Scan Modules in Field
- Settings
- Transmit All
- Clear Data



Figure 1. Home screen for RFID Module Scan.

Tapping the settings button brings the user to the "Settings Page" (figure 2) where they can set the Tablet ID, default serial numbers per load, and Bluetooth connection settings for the hand held RFID/Barcode scanner. The app was written to work with the TSL 1128 scanner which communicates with the tablet via Bluetooth.



Figure 2. Settings page used to input tablet id, default serial numbers per load, and configure Bluetooth connection settings.

Tapping the "Save" button on the "Settings" page brings the user back to the home screen where they can select either the Continue Scan or New Scan button to begin a new load scan. Selecting the Continue Scan button brings the user to the All Scans page (figure 3). At first use, the All Scans page will not display any previous scan data but the user can tap the plus button at the top right corner to begin a new scan. This action opens the Field Settings page (figure 4) which is the same action that occurs when the user selects the New Scan button on the Home page. When beginning a new scan, the user must enter a Grower, Farm, and Field name. The user has the option to accept the default first load number or enter a different first load number which can be based on a pre-assigned load number sequence assigned by the gin. The auto load assign function, when turned on, will cause the app to begin a new load when the Max SNs/Load value is reached. The Max SNs/Load is initially set to the default number entered in the Settings page > Serial Numbers per load but can be modified for the current scan on the Field Settings page. If the Auto Load Assign toggle is off, the app displays a green colored button "Start New Load" to allow the user to generate a new load once the user has scanned the desired number of SNs for the load. Once all the data is entered, the user selects "Save" and the Scan page opens (figure 5).

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¢	All Scans			+	٠
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Farm:	vardeman	Modules:	36		
Field:	project 068	Last scan:	11/23/2016 10:36 AM		
SENT:	11/28/2016 08:59 AM				
Grower	: Mike Henson	Loads:	7		
Farm:	Drip	Modules:	28		
Field:	Deere Test Project 077	Last scan:	12/14/2016 05:53 PM		
SENT:	12/16/2016 12:12 PM				
Grower	: Vardeman	Loads:	9		
Farm:	Drip	Modules:	36		
Field:	Project 068	Last scan:	11/17/2016 03:52 PM		
SENT:	12/16/2016 01:42 PM				
Grower	: Joe Farmer	Loads:	13		
Farm:	Parker	Modules:	52		
Field:	South Pivot	Last scan:	10/24/2016 06:27 PM		
SENT:	12/21/2016 02:22 PM				
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Figure 3. All Scans page that displays all fields for which load scan data exists.

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Grower:	Enter grower		
	required		
Farm:	Enter farm		
	required		
Field:	Enter field		
	required		
Start Load#:	1		
Auto load assign	ON		
Max SNs/Load	4		
-	Save	Cancel	
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Figure 4. Field Settings page that appears when beginning a new load scan and where the user enters grower, farm, and field information along with starting load number and max serial numbers per load.

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Field Settings		
Delete S/Ns	Move	Review
Delete Al	Renumber	
Modules: 52		Loads: 13
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Load 2016007		Modules: 4
Load 2016008		Modules: 4
Load 2016009		Modules: 4
Load 2016010		Modules: 4
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Load 2016009		Modules: 4
Load 2016010		Modules: 4
Load 2016011		Modules: 4
Load 2016012		Modules: 4
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Tan here to add notes		

Figure 5. Top image -load scanning page showing load bars and number of modules in each load. Bottom image – load scan page showing green button used to advance load number when auto-load assign switch is off in field settings page.

With the Scan page open, the user can begin scanning module RFID tags or barcodes. As each tag is read, the app associates the timestamp and GPS coordinates for the location of each scan. The Scan screen updates the serial numbers associated with a particular load number as the modules are scanned. When a RFID or Barcode tag is scanned and the GPS system is functioning, the serial number is displayed in black text. If the GPS coordinates are not associated correctly, the app displays the serial number in red text with a note indicating "no GPS." The user can simply rescan the tag for which GPS data was not available once the GPS system is functioning to replace the red serial number scan. Each gray colored "load bar" displays the load number and total modules (serial numbers) associated with the load. A carrot located on the far left side can be tapped to hide or display the serial numbers in the load as well as the note field associated with that load. Each serial number within a load has a check box located to the left of the number that when checked allows the user to delete or move the selected SNs. The Delete S/Ns button deletes only selected serial numbers. The Move button opens a screen that allows the user to assign the selected serial numbers to a different load within the same scan or assign the selected numbers to a new load. The Delete All button will delete all loads and SNs within the open scan after the user confirms the action. The Renumber button allows the user to modify the beginning load number and renumber the loads in the sequence that they were scanned. The Renumber function will only modify load numbers if the user taps the Field Settings bar at the top left corner of the Scan page and changes the Start Load# field and taps save. The Review button opens the "Review" page (figure 6) allowing the user to see each load included in the current scan as well as the SNs assigned to each load. The Grower, Farm, Field, total modules (Modules), total loads (Loads), total modules without GPS coordinates, and hand scanner (Reader) ID for the current scan are displayed at the top of the Review page.

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Modules: 52 Loads: 13			Modules without GPS: 0 Reader: 003627-US-1128
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Load 2016001			Modules: 4
Load 2016002			Modules: 4
Load 2016003			Modules: 4
Load 2016004			Modules: 4
Load 2016005			Modules: 4
Load 2016006			Modules: 4
Load 2016007			Modules: 4
Load 2016008			Modules: 4
Load 2016009			Modules: 4
Load 2016010			Modules: 4
▼ Load 2016011			Modules: 4
15403712866 15403712858	15403712857	154037128	854
Load 2016012			Modules: 4
15403712869 15403712860	15403712859	154037128	861
Load 2016013			Modules: 4
15403712856 15403712855	15403712852	154037128	853

Figure 6. Review page.

When the Transmit button is tapped, the app generates a flat file (.csv file) with the information associated with the current scan (Table 2), opens the default email client on the device, and attaches the file to an email message with "Load List" in the subject line and "Grower, Farm, Field" in the body (figure 7). The user must enter a valid recipient email address before sending the message with attached data file. The Find button on the Review page brings up a tool that can be used to determine if a tag has been previously read and included in the current scan. To use the Find function, the user may scan a tag or manually type in a serial number. If the SN is located, the Load Number, SN, GPS, and Scan Time is displayed.

(💮 Review	←	ATTACH	SEND	MORE	¢
Joe Farmer	To john.wanjura@ars.usda.gov			\sim	
South Pivot	Load List				
Modules: 52 Loads: 13	GROWER: Joe Farmer FARM: Parker FIELD: South Pivot				ales without GPS: 0 ur: 003627-US-1128
Load 20	Please see attached load list.				Modules: 4
Load 201	Sent from my Galaxy Tab® A				Modules: 4
Load 20'					Modules: 4
Load 20	1 item (7 KB/24.7 MB)				Modules: 4
Load 20	Transmission-12282016_02_02_25_PM.csv 7 KB			∍	Modules: 4
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Figure 7. Email used to transmit the comma separated value file generated from the current load scan when the "transmit" button is tapped on the "Review" page.

Table 2. Example of the data parameters and format of the comma separated value file generated.

Grower	Farm	Field	SerialNumber	Load	ScanLocation	ScanType	Timestamp	Latitude	Longitude	TabletID	Notes
USDA	CPPRU	Liberty Block 1	15401664050	2016001	Staging	John Deere RFID	10/13/2016 14:17	33.69389073	-101.8201356	tablet-1	
USDA	CPPRU	Liberty Block 1	15405657820	2016001	Staging	John Deere RFID	10/13/2016 14:17	33.69389073	-101.8201356	tablet-1	
USDA	CPPRU	Liberty Block 1	15405657822	2016001	Staging	John Deere RFID	10/13/2016 14:17	33.69389073	-101.8201356	tablet-1	
USDA	CPPRU	Liberty Block 1	15401664053	2016002	Staging	John Deere RFID	10/13/2016 14:17	33.69389073	-101.8201356	tablet-1	
USDA	CPPRU	Liberty Block 1	15408699862	2016002	Staging	John Deere RFID	10/13/2016 14:18	33.69389073	-101.8201356	tablet-1	
USDA	CPPRU	Liberty Block 1	15408699863	2016002	Staging	John Deere RFID	10/13/2016 14:18	33.69389073	-101.8201356	tablet-1	

From the Home page, tapping the Scan Modules in Field button opens the Scan in Field "Field Settings" page where the user is required to enter Grower, Farm, Field, and Scan Location names (figure 8). Once the user enters the required data and taps save, the application opens the Scan in Field page and allows the user to continuously scan ID tags and generate a list of SNs with associated GPS and scan time data (figure 9). Notes can be entered at the top of the page and will be appended to the data lines for the SNs that are scanned after entering the note. The "Scan Modules in Field" tool is useful for scanning modules in the field prior to staging or as they sit on the gin yard as an inventory tool. Load numbers are not assigned in this tool and are set to a default value of 1 in the .csv file. The app generates a .csv file and transmits the data via the default email client on the device when the Transmit button is tapped. The email message will have "Module List" as the default subject line.

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Grower:	Mike Henson		
Farm:	Drip		
Field:	Deere test project 077	7	
Location:	in field		
	Save	Cancel	
			-

Figure 8. Scan in Field "Field Settings" page.

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Field Settings		
Delete S/Ns	Transmit	Delete all
Modules: 28 GPS: Reader: Not connected.		
Tap here to enter notes		
16405947891 16405947890 1640	5947889 16405947888 16405947887	16405947886 16405947885
16405947884 16405947883 1640	5947882 🗌 16405947881 🗌 16405947880	16405947879 16405947878
16405947877 16405947876 1640	5947875 🗌 16405947874 🗌 16405947873	16407087804 16407087803
16407087802 16407087801 1640	7087800 🗌 16407088799 🗌 16407088798	16407088797 16407088796
Figure 9. Scan in field page.		

The "Transmit All" button on the Home page allows the user to transmit all of the data collected using the load building scanning tool or the Scan Modules in Field tool via a .csv file. The app attaches the .csv file to an email similar to the other transmit functions. This Transmit All tool was included as a quick method for backing up all of the scan data on the device. The "Clear Data" button on the Home page will clear all scan data from the device once the user confirms the operation.

Results and Discussion

The RFID Module Scan application was demonstrated at several field locations in 2016. No problems were noted in the process of scanning the module tags or generating the loads. The application functioned as designed with no problems noted in regard to software bugs or failures. The data transmission function worked without issue.

Scan data on 28 modules from one field location using both scanning tools is shown in figure 10. The data in .csv format from both scanning tools was easily imported into Google Earth for display. The modules were initially scanned using the Scan in Field tool as they were dropped by the harvester (yellow symbols) and then again after they were staged into groups of four at the edge of the field using the Load Scan tool (purple symbols). The GPS system onboard the tablets worked adequately for the Scan in Field tool. However, the update rate and resolution of the position data were not adequate to discern individual modules in a group of 4 staged modules using the Load Scan tool. This issue is related to hardware selection and can be resolved by utilizing GPS systems with improved position accuracy.



Figure 10. Google Earth map with module locations recorded by the Scan in Field tool (yellow symbols) and the Load Scan tool (purple symbols).

Additional modifications to the RFID Module Scan app are planned based on user feedback. Additional code development is underway to allow module ID information to be extracted from 1D/2D barcodes using the camera onboard the device. This change will allow users to forgo the use of the hand held scanner but will require that they be close enough to the tags to capture a usable image. Additional work is underway to adapt this application for use on a tractor used to stage the modules for transport allowing for the automated collection of staging location information. Future work is planned to expand the use of this software for use on module transport vehicles in an effort to automate the scanning and data collection process when modules are loaded or unloaded in the field or at the gin.

<u>Summary</u>

The introduction of RFID technology to identify cotton modules has opened up new possibilities in regard to the management of cotton modules prior to ginning. RFID technology has found extended use in other industries for inventory management but is completely new to the post-harvest processing industry for cotton. Thus, few tools are available to help producers and ginners glean value from the ability to identify cotton modules using RFID technology. This work was conducted to develop an open-source tool to gather basic identification and position information for cotton modules and transmit this data to a cotton gin for use in managing module trucks and module yard inventories. The mobile application achieves this objective through the use of two scanning tools: the Load Scanning Tool and the Scan in Field tool. The Load Scan tool automates the process of associating module serial numbers to a gin load number for record keeping purposes. The Scan in Field tool allows for the quick generation of inventory lists of modules from a particular field or as they sit on a module yard. Additional development of this application is planned to expand its use for automated collection of staging location information on the tractor used to stage modules for transport, and also on module transport vehicles in the process of loading and unloading modules in the field and at the gin.

Disclaimer

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