Development of a small tracking device for Cattle using IoT Technology

Adam Blocker[a], Elaina Stuckey[a], Joe Mari Maja[a*], Scott Sell[a], Gillian Tuttle[a], John Mueller[a] and John Andrae[b]

[a]Edisto Research and Education Center, Clemson University, 64 Research Road, Blackville, SC 29817, USA

[b]Simpson Research and Education Center, 101 Ag Service Center Old Cherry Road Box 340385 Clemson, SC 29634, USA

A paper from the Proceedings of the
14th International Conference on Precision Agriculture
June 24 – June 27, 2018
Montreal, Quebec, Canada

Abstract. *The US is the largest producer of beef in the world. Last year alone, it produces nearly 19% of the world's beef. This translate to about almost $90 billion in economic impact in the country. Aside from being a producer, the US also consumed more than 26 billion pounds of beef which have a retail value of the entire beef industry to more than $74B. For this level of production and consumption, each rancher in the US must produce a herd size of at least 100 or more to sustain the current demand. Ranchers often employ different techniques to minimized cattle losses by regularly monitoring their cattle' health and well-being. With the recent advances in Global Positioning System (GPS) and the miniaturization of GPS module and internet of things (IoT) provide the medium of developing small tracking device for cattle.*

This paper describes the development of cattle tracking device using GPS and IoT technology. The wireless tracking module may provide a framework that may be used for a large scale tracking system to help in monitoring cattle location and health. A prototype system for cattle tracking was developed. The system consists of a GPS Receiver module, Wifi, and sensors such as temperature and accelerometer+magnetometer. The GPS receiver module was tested to determine the minimum time to get a fixed signal. The shortest warm-up/cold start was determined to be around 32-35 sec. which was consistent with the datasheet of the receiver module. The tracking device was tested in a 3 sec. lag time and used ubidots cloud (cloud-based iot platform) for real-time data tracking. Three ubidots widgets were used, GPS data which was overlayed with a local Google map, data points, and graph style display for temperature data. The test under the latest prototype (version 6) produced real-time tracking.

Keywords. *iot, tracking device, GPS, wifi, cattle tracking*

Introduction

The US is the largest producer of beef in the world and also consumed more than 26 Billion pounds of beef in 2010 which has a retail value of the entire beef industry to more than $74 Billion (USDA, 2012). To address the demand for consumption alone, each rancher must at least maintain an average of herd size to at least 100 or more cattle.

Global Positioning System (GPS) has previously been used to observed wildlife and domestic animal movement (Davis et al., 2011; Moen et al., 1996; Rutter et al., 1997; Turner et al., 2000; Schlecht et al., 2004; Agouridis et al., 2005). These different studies utilized GPS information to observed the animal's behavior or simply tracking the cattle intensively to determine if the cattle are grazing, traveling or resting (Ungar et al., 2005).

The concern of earlier work (Moen et al., 1996) on tracking animals was based on the accuracy of the GPS and the number of GPS points. Depending on what the objective of tracking the animal, each of these concerns may be important. For instance, if one wants to track on the precise movement of the animal (e.g., how long the animal stays in one location), then more data points are needed even if it is not accurate. Both issues are not relevant nowadays as GPS chips have been miniaturized with a high level of accuracy. The limiting factor for tracking system is the power source. We can shrink most of the electronics parts by using Surface Mount Device (SMD), but a smaller battery with high capacity is still unavailable.

Based on the average requirement of addressing the demands of consumers in the US, monitoring at least 100 cattle becomes cost prohibitive. GPS collars that are currently on the market are expensive not to mention all the required hardware and software to keep the system working.

The main objective of this study was to develop a simple tracking device which is low-cost and used an internet of things technology.

Materials and Methods

With the advancement of GPS technologies which addresses the previous issue in the 90’s, e.g., satellite clock errors, position errors, receiver errors, etc. (Turner et al., 2000). The current technology also encapsulates the whole GPS module into a small footprint and can track more than 50 satellites with a fast update. The main goal of this work was to develop a low-cost and used the iot technology. Thus, RTK-GPS module was not used but instead a small compact GPS module with a 3 meters accuracy was used. Though there is quite a few low-cost RTK GPS module available in the market the cost is still prohibitive (Emlid REACH, TERSUS-GNSS, swiftnav and etc.).

Our design utilized the small-sized GPS Module (FGPMMOPA6H, GlobalTop Technology Inc., Taiwan) which utilizes the MediaTec new generation chipset MT3339 which has the higher industry level of sensitivity (-165 dBm). External antenna was used to provide long distance connectivity to the research center WiFi. The FGPMMOPA6H used NMEA protocol to transmit data over its serial pins. The module can also be programmed to transmit multiple NMEA sentences or only specific sentences. World Geodetic Datum (WGS) 1984 was used to calculate the location. The default baud rate of the GPS module was used which was 9600 bps.

Data Storage

Since our tracking system utilized an iot technology, there was no data storage cards or disk that was available on the system. There was an Erasable Read-only memory (EEPROM) on the microcontroller but was used only for configuration purposes. All data were transmitted in real time to ubidots which host our data. Aside from the GPS location, data such as the temperature of the cattle, triple-axis accelerometer+magnetometer, current battery voltage, and cattle ID were also available (Fig. 2). Though the accelerometer+magnetometer data was not currently used.

Figure 1.A cattle fitted with our tracking module. The metal parts in the middle is the GPS receiver module.

Microcontroller

The tracking device used a microcontroller (STM32F205, ST, Geneva, Switzerland) due to its high-performance 32-bit Flash based on ARM Cortex-M processor. It comes with a 1Mb flash and 128 Kb of Random Access Memory (RAM). It also has multiple serial ports and General Purpose I/O pins that could be configured for digital and analog. It has built-in eight analog channels with 10-bit resolutions. The microcontroller code was developed to enable the microcontroller to read the GPS NMEA data from the GPS module as well as data from the temperature sensor at pre-determined intervals

The Tracking system used an ARM Cortex M3 microcontroller with a Broadcom Wi-Fi chip. The board layout measures about 1.5-inch x 1.7 inches with a 2.4 GHz ceramic internal RF antenna. For this work, an external antenna was used to increase the coverage of the Wi-Fi reception. The control of the tracking system was implemented using C Language. A 3-second delay for new events was used for our test. The Bull tracking system transmits the following messages; GPS (GRMC), Bull Identification, Battery Level, and three ADC sensor values.

Antenna and power

Two dipole antennas with two different gains (5 and 10 dB) and a flat omnidirectional were used and tested. Though there are different battery types available in the market, the tracking device used a Lithium Polymer-Oxide battery due to its power density and size. The battery was a Bovon Portable 5V and 10000 mAh. The battery dimension is 100 mm x 20 mm x 10 mm (4 inches x 0.8 inch x 0.4 inch) and weighed 120 grams (0.3 lbs). The solar panel was also considered in this work but was not used due to the size and the limited amperage.

Enclosures and Harness

We tested different methods of securing the device on the cattle; collar, shoulder, and special glue. Enclosures were also created in a 3D printed and carbon fiber enclosure (Fig. 3). The battery was enclosed on special clothing which was glue directly to the cattle. The tracking device with enclosure only measures 50.8 mm x 50.8 mm (2 inches x 2 inches). The first enclosure was a 3D printed part as shown in Fig. 1. It has a slot on both ends to securely attach to a strap. The antenna used for the first prototype is a ceramic antenna which was soldered directly to the printed circuit board. The device was position on the back of the cattle's neck. The total weighed of the device was around 300 grams.

Field Test

The Edisto Forage Bull Test was located at the Edisto Research and Education Center at Blackville, South Carolina (lat. 33.360781 N, long. 81.334604 W). There were other locations available at the center, but the current location was selected due to the area's WiFi availability.

Three Angus bulls [Bos taurus L.; initial body weight 646 ± 31 kg (1425 ± 70 lb)] were fitted with the tracking device unit. The device was set to transmit data at 3 seconds intervals for two days during August 2016.

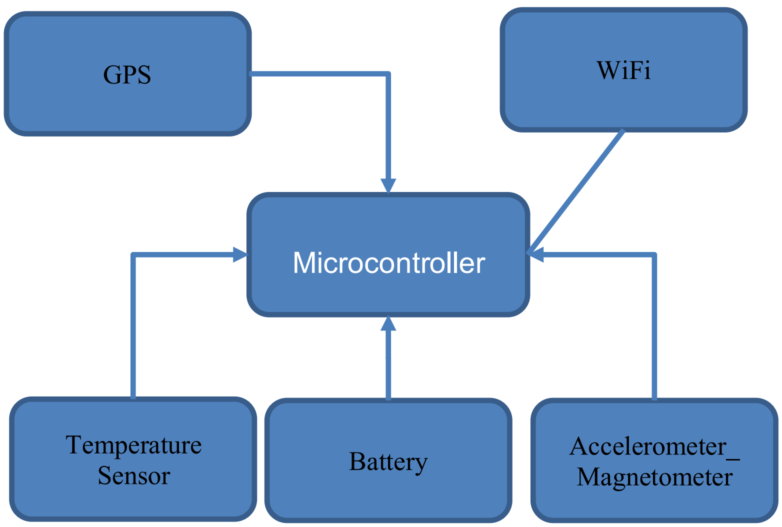
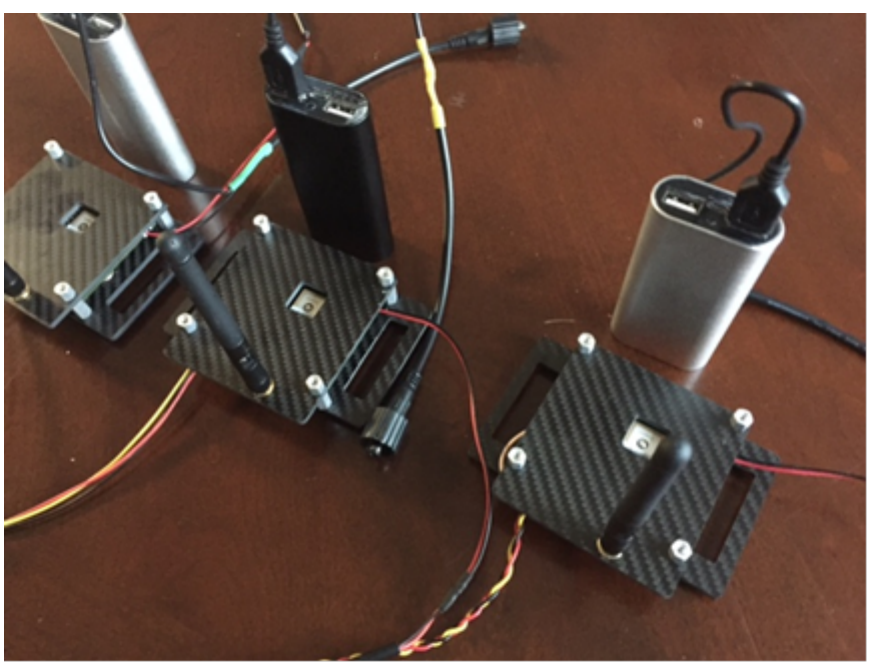


Figure 2. The Hardware Design Schematic of the tracking device.

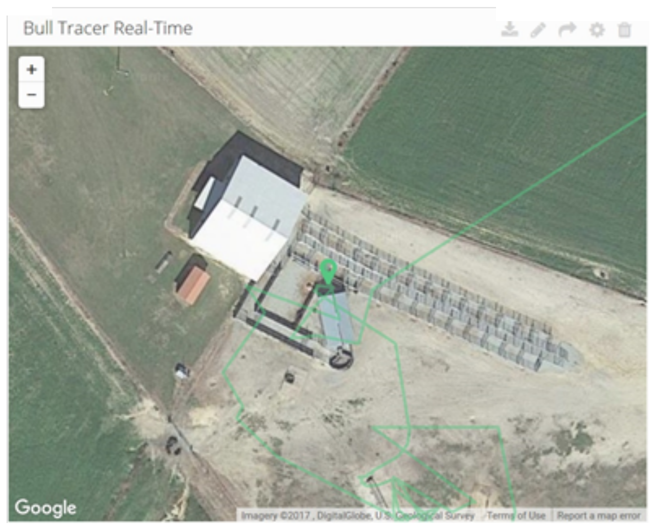


Results and Discussion

The GPS data were viewed at ubidots dashboard (http://www.ubidots.com) as shown in Figure 4.

Bull #1

Bull #2



Bull #3

Figure 4. GPS data from the tracking devices attached to the cattle.

Note that Bull #3 in Fig. 4, the tracker was not turn off after it was brought to the cattle from the Sensor and Automation Laboratory which was located at the center. The cattle location was overlaid upon the map images from Google Earth. Data collected for each cattle at 3 sec. Intervals were directly uploaded to the ubidots website where it can also be downloaded into a comma delimited file.

Conclusions

A prototype system for cattle tracking was developed. The system consists of a GPS Receiver module, Wifi, and sensors such as temperature and accelerometer+magnetometer. The GPS receiver module was tested to determine the minimum time to get a fixed signal. The shortest warm-up/cold start was determined to be around 32-35 sec. Which was consistent with the datasheet of the receiver module.

The tracking device was tested in a 3 sec. lag time and used ubidots cloud for real-time data tracking. Three ubidots widgets were used; GPS data which was overlayed with a local Google map, data points, and graph style display for temperature data. The test under the latest prototype (v6) did produce promising results. Dipole antennas with two different gains (5 and 10 dB) and a flat omnidirectional were used. The omnidirectional antenna provided 56 seconds faster connection time to the Wi-Fi network and maintained the connection longer than the two dipole antennas.

As with all portable wireless systems, the power source was the limiting factor. The battery can only last five days of continuous used, if not yet broken by the cattle. Future work includes battery replacement and additional test with 10 or more cows.

Acknowledgments

The authors would like to express sincere gratitude to Mr. Harry McAlhany and Webb Lewis for their effort during the field test. Also, this material is based upon work supported by NIFA/USDA, under Project number SC-1700540. Mention of specific products is for information only and not to the exclusion of others that may be suitable.

References

Agouridis, C.T., Edwards, D.R., Workman, S.R., Bicudo, J.R., Koostra, B.K., Vanzant, E.S., and Taraba, J.L. 2005. Streambank erosion associated with grazing practices in the humid region. Trans. ASABE 48(1): 181-190.

Davis, J.D., Darr, M.J., Xin, H., Harmon, J.D., and Russel, J.R. 2011. Development of a GPS Herd Activity and Well Being kit (GPS Hawk) to monitor Cattle Behavior and the effect of sample interval on travel distance. Applied Engineering in Agriculture Vol. 27(1): 143-150.

Moen, R., Pastor, J., Cohen, Y., and Schwartz, C.C. 1996. Effects of moose movement and habitat use on GPS collar performance. J. Wildl. Manage. 60(3): 659-668.

Rutter, S. M., Beresford, N.A., and Roberts, G. 1997. Use of GPS to identify the grazing areas of hill sheep. Computers and Electronics in Agric. 17: 177-188.

Schlecht, E., Hulsebusch, C., Mahler, F., and Becker, K. 2004. The use of differentially corrected global positioning system to monitor activities of cattle at pasture. J. Applied Animal Behaviour Sci. 85: 185-202.

Turner, L. W., Udal, M.C., Larson, B.T., and Shearer, S.A. 2000. Monitoring cattle behavior and pasture use with GPS and GIS. Can. J. Anim. Sci. 80(3): 405-413.

Ungar, E. D., Henkin, Z., Gutman, M., Dolev, A., Genizi, A., and Ganskopp, D. 2005. Inference of animal activity from GPS collar data on free-ranging cattle. J. Rangeland Ecol. Manage. 58(3): 256-266.

USDA, 2012. U.S. Beef and Cattle Industry: Background statistics and Information. http://www.ers.usda.gov/news/BSECoverage.htm