Design and Implementation of Automated Logging and Tracking System for Livestock at Oakley Farm

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Abstract

This project is an interdisciplinary effort between the School of Agriculture, Departments of Manufacturing and Engineering Technology, Department of Computer Science, and the Manufacturing Research Center. The main objective of this project is to develop a system that collects data on livestock and determine the means to manufacture the system. There is a dire need to be able to track the location of animals for a variety of reasons such as theft concerns, medical care, and collecting useful data to be used for future animal research in animal science. The self-sustaining integrated mineral feeder, our team is building, acts as a relay to collect data on the cattle and log the information into a cattle management system produced by team of students from the Computer Science Department. Similar technologies are not feasible because the systems currently available in the market cost $300 per head of cattle, while the average annual profit per head of cattle is $125. The projects' goal is to reduce this cost to $20 with an estimated saving of about $280 per head of cattle. Therefore, the approach our team is taking is to create a mesh network throughout the Oakley Farm's ranch, and connect a Rasberry Pi to relay vital information such as mineral consumption to the management system. This data network provides necessary information to allow for quick responses to abnormal behavior signaling potential for highly infectious and contagious diseases that require containment. Additionally, the system can provide alerts for potential theft of cattle to protect ranch assets. Our projections for this product is that it will become a necessity at every livestock facility across Tennessee. Furthermore, this project provides a foundation for future developments to collect additional information on livestock for years to come.

Developments

Initial plans focus on the design of solar powered RFID tag reader housing made wood that has a mineral feeding trough for the cattle. On the underside is a waterproofed box that houses a battery bank and the Raspberry Pi that runs the cattle management system. Cattle generally go to the mineral feeder twice a week unless sick or pregnant. Using an RFID ear tag we can log and monitor each cow notifying the ranch owner if the cow is not visiting the mineral feeder like it should be. Additionally, the solar power system must be robust enough to store power to power the equipment for up to 5 days with minimal sunlight to recharge the battery bank.

Completed Project

Statement of the Problem

1. Last year, 28 head of livestock were stolen from the Oakley Center over a several month period. The thief is now in prison. However, only 6 head of livestock were recovered, and while the thief was ordered to pay restitution, it is highly unlikely that he will pay. This project seeks to develop a constantly updated inventory of the cattle with additional information to better manage the cattle assets.

2. About 20 years ago, USDA contemplated ordering all cattle to have "GPS-like" cattle tracking devices attached to them, likely in the form of a cattle ear tag, similar to the one seen below. However, at issue is costs. The typical beef producer may make a profit of $100 per head annually on a beef calf; a GPS-like device would cost $300 and upwards, making it impossible economically. Acme Cattle Company surveyed the marketplace, and found prices would need to be held in the $20 per head range to as a price-point. USDA backed off their plans to mandate cattle tracking.

3. Acme Cattle Company is the largest seller of cattle ear tags in the world, with a RFID ear tag and reader already commercially available. However, it can only "read" to a distance of about 40 inches.

4. Emerging technology exists to "read" an active tag to 3 miles, where direct line-of-sight is possible, or using a tower, or a drone.

5. Currently in the US, there are about 350 million head of animals that someone would like to keep track of, if tracking could be more than within 40 inches of the reader. With tracking up to 3 miles away, it is highly likely USDA will revisit their position on mandating cattle tracking, particularly with certain diseases, such as "Hoof and Mouth Disease," and "Mad Cow Disease."

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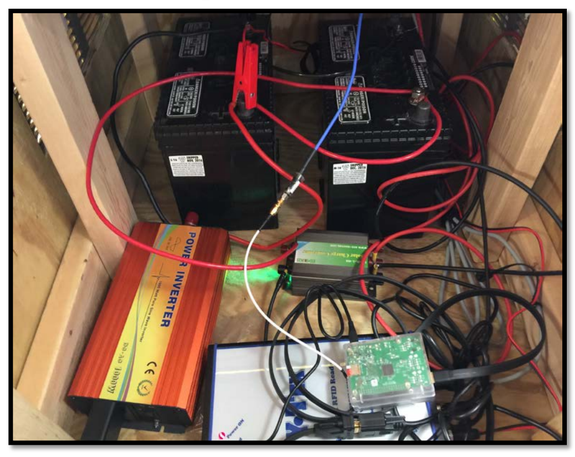
Power Consumption

- One of the primary features of this self-sustaining cattle management system is that based on power calculations, battery bank capacity and solar panel output, this system can run for up 5 days with minimal sunlight.
- The solar charging system consist of two 100W output solar panels, and two 12V 105Amp hour batteries wired in parallel.
- Power consumption of the components and future work components are as follows:

Component	Power Rating
Rasberry Pi 3	250mA 1.25W
RFID System	1.5A 18W
Networking Device(Future Works)	15-25W (depending on range needs and broadcast strength)



Cost Estimations

- The goal was to maintain cost at around $20 per head of cattle, with our primary customer market being larger livestock facilities where keeping inventory is difficult, expensive, and often unreliable.
- With cost to manufacturing under $2000 we believe we are consistent with our goal with obvious room for improvements.

Material	Quantity	Cost per unit	Total Cost	Supplier
Treated lumber 4"x4"x6'	4	6.97	27.88	Lowes
Treated Plywood 1/2"x4'x8'	2	31.57	63.14	Lowes
1lb 3" screws 10yr exterior	2	9.12	18.24	Lowes
Untreated Lumber 2"x4"x8'	9	3.14	28.26	Lowes
Untreated Lumber 2"x6"x8'	4	4.88	19.52	Lowes
200W solar kit w/charge controller	1	549.99	549.99	Amazon
Raspberry Pi 3 Kit	1	78.99	78.99	Ebay
RFID	1	?	0	Provided
Battery 12V 100Ah	2	174.99	349.98	Walmart
Power Inverter	1	154.17	154.17	Amazon
Hot rolled mild steel angle A36 - 5'	3	10.92	32.76	onlinemetals.com
1/4" Hex bolt	15	0.5	7.5	Lowes
Network Extender	1	99.99	99.99	UBNT
		Total	1430.42	

Results

The data logging system is fully operational and works. The computer science team can successfully log the tag reads and formed a database that can be accessed remotely by the livestock manager. This is done by the Rasberry Pi unit mounted in the mineral feeder which is connected to an existing network. Through our design project many of the problems were overcome by the designs of our team.

Conclusion

This project became a major success for all the departments involved in its creation. The mineral feeder works as intended, with it being completely solar powered, with all the data logging equipment mounted safely. It can read the ear tags of cattle with no issues. Combining all these successes from each team has delivered a well rounded and working prototype. This prototype with more development could become a stepping stone to a new era of livestock management systems. With the ability to change the market of livestock management forever, this project is a huge success for the University and for all departments that are involved. For future development of this system many options are available to collect more data to be further analyzed by the School of Agriculture, examples of which are as follows:

- Scale to log the weight of the cattle
- Camera to monitor the livestock remotely
- Sprayer system to administer insect repellants and vaccines as needed
- Voltage meters to monitor power consumption for increased efficiency in later developments
- Modular design to meet variable price points for the varying cattle markets

Partners on the Project and Outlook

This project would not have been possible without the funding, support, and advisement from the Agriculture Department, Manufacturing Research Center, Computer Science Department, and Manufacturing and Engineering Technology Department. Computer Science students developed the software program allowing the Oakley Farms to maintain an inventory of the cows and how often each cow comes into the mineral feeder. By involving students across campus, we have developed a foundational process to track cattle behaviors to be utilized by the agricultural school. Students are at the core of what could become a major tracking project in the US for years to come, partnering with a technology company, and a major sales company, with Tennessee Technological University students providing the technical development.