4-20-2018

Monitoring Activity and Climate Impact in Market Hogs with Activity Ball

Brad Aronson
Iowa State University, baronson@iastate.edu

Eli Sents
Iowa State University, esents@iastate.edu

Kyle Wenck
Iowa State University, kwenck@iastate.edu

Derek Yegge
Iowa State University, djyegge@iastate.edu

Joseph R. Vanstrom
Iowa State University, vanstrom@iastate.edu

See next page for additional authors

Monitoring Activity and Climate Impact in Market Hogs with Activity Ball

Problem Statement

Prairie Systems is a web-based data management provider, primarily servicing the swine industry. Their products include the Feed Allocation System, which helps producers manage feed inputs, Smart Order, which helps feed manufacturers and distributors manage feed order fulfillment, and LeeO, which tracks individual animals through RFID technologies. Prairie Systems' line of products is implementing precision agriculture practices into the livestock industry.

To help producers better manage their operations, Prairie Systems is seeking to gain a better understanding of the daily activity of market hogs. To do this, we were tasked with designing and fabricating a container to collect activity data using an existing sensor package. Ideally, the container must maximize stability of the system while testing in the field and minimize the amount of interference when collecting data. The system will automatically report the data as an Internet of Things (IoT) device. The data can then be analyzed for significance in daily animal activity and feed consumption. Unlike some current systems on the market, this device will not utilize cameras to track activity which lack portability and require consistent cleaning.

Disciplines

Bioresource and Agricultural Engineering | Industrial Technology

Authors

Brad Aronson, Eli Sents, Kyle Wenck, Derek Yegge, Joseph R. Vanstrom, Jacek A. Koziel, Steven Hoff, and Brett Ramirez

IOWA STATE UNIVERSITY

Department of Agricultural and Biosystems Engineering (ABE)

TSM 416 Technology Capstone Project

Monitoring Activity and Climate Impact in Market Hogs with Activity Ball

Brad Aronson[a], Eli Sents[b], Kyle Wenck[c], Derek Yegge[d]
Joseph R. Vanstrom[e*], Jacek A. Koziel[f*], Steven Hoff[g*], Brett Ramirez[h*]

[a] Agricultural Systems Technology, ABE, ISU, baronson@iastate.edu
[b] Agricultural Systems Technology, ABE, ISU, esents@iastate.edu
[c] Agricultural Systems Technology, ABE, ISU, kwenck@iastate.edu
[d] Agricultural Systems Technology, ABE, ISU, djyegge@iastate.edu
[e] Dept. of Agricultural and Biosystems Engineering, ISU, 2321 Elings Hall, Ames, IA 50011, vanstrom@iastate.edu, 515-294-9955
[f] Dept. of Agricultural and Biosystems Engineering, ISU, 4350 Elings Hall, Ames, IA 50011, koziel@iastate.edu, 515-294-4206
[g] Dept. of Agricultural and Biosystems Engineering, ISU, 4331 Elings Hall, Ames, IA 50011, hoffer@iastate.edu , 515-294-6180
[h] Dept. of Agricultural and Biosystems Engineering, ISU, 4332B Elings Hall, Ames, IA 50011, bramirez@iastate.edu , 815-353-8299

*course instructors and corresponding authors.

Client:

Prairie Systems, 1803 Hwy Blvd, Spencer, IA 51301, www.prairiesystems.com

- **Brad Guyer**, Senior Product Manager, **E:** bguyer@prairiesystems.net
- **Joel Stave**, Managing Director, **E:** jstave@prairiesystems.net

1 PROBLEM STATEMENT

Problem Statement

Prairie Systems is a web-based data management provider, primarily servicing the swine industry. Their products include the Feed Allocation System, which helps producers manage feed inputs, Smart Order, which helps feed manufacturers and distributors manage feed order fulfillment, and LeeO, which tracks individual animals through RFID technologies. Prairie Systems' line of products is implementing precision agriculture practices into the livestock industry.

To help producers better manage their operations, Prairie Systems is seeking to gain a better understanding of the daily activity of market hogs. To do this, we were tasked with designing and fabricating a container to collect activity data using an existing sensor package. Ideally, the container must maximize stability of the system while testing in the field and minimize the amount of interference when collecting data. The system will automatically report the data as an Internet of Things (IoT) device. The data can then be analyzed for significance in daily animal activity and feed consumption. Unlike some current systems on the market, this device will not utilize cameras to track activity which lack portability and require consistent cleaning.

Business Case Statement

The swine industry has entered the era of big data and precision agriculture. Producers are continually challenged with improving the efficiencies of their operation to remain competitive in the tight market. The greatest input for swine production today is feed, making it an area of great significance for improvement. Another significant duty of producers is maintaining animal health. Access to detailed data may help producers identify earlier stages of health-related issues. Producers and researchers need tools to easily collect and analyze large sets of data to identify areas for improvement in what and how they are feeding as well as how they care for their stock.

The Activity Ball focuses on creating a tool for collecting data related to animal activity throughout the day as well as varying conditions in the animal's environment. The strategic approach to the activity ball is that it requires little to no maintenance or changes in producers' processes. Swine production systems are a highly corrosive and harsh environment, making durability of the Activity Ball an extensive problem to address. The Activity Ball will help researchers collect data on animal behavior and their environment to help producers get the most out of their feed, improve the animal environment, and aid in identifying health issues in their early stages.

2 GOAL STATEMENT

Main Objective and Specific Objectives

The main objective was to develop a product to house an existing sensor package to collect data based on animal activity and their environment utilizing the NimbeLink Asset Tracker, an existing sensor package. Specifically, the objectives of the project included:

- (1) Design of proposed solution(s) that meets all client criteria and constraints:

  - Minimize interference with the sensor package.
  - Be constructed to withstand the harsh environmental conditions of a swine facility.
  - Maintain a low cost for manufacturability.
  - Communicate with a limited low-cost infrastructure to the outside world.
- (2) Fabricate a prototype of the proposed solution(s):
  - A budget of $5,000.
- (3) Testing and analysis of proposed solution(s):
  - Tests duration of 1 week
  - Identify the level of interference with the sensor package
    - Compare accelerometer data with animal activity.
    - Compare collected temperature data with existing barn controller data.
    - Compare accelerometer data with collected temperature data. Identify any correlation.
  - Identify the level of cellular connectivity with the sensor package.
  - Recommendation for improvements to tested design based on test data and issues identified.

Rationale

The prototyped solution will be utilized by the client to collect animal activity data in market hogs. The data collected will be utilized to raise questions on the significance of animal activity and feed consumption, conversion, and any significant health effects of specific feed rations. Based on the results and the questions raised from the collected data, more units may be produced for further data collection and analysis.

3 PROJECT PLAN/OUTLINE

A. Methods/Approach

- **Reference Materials**
  - While working on this project we found the insight of both Dr. Hoff (Hoff, 2018) and Dr. Ramirez (Ramirez, 2018) to be instrumental in gathering insight regarding the atmosphere of swine production systems and swine behavior.
  - Evaluation and characterization of swine enrichment activity balls to monitor pig activities in an environmental research building were helpful in learning more about infrared uses with swine production.
  - The materials posted on NimbeLink.com was helpful in learning more about their sensors. Contact with NimbeLink's technical support was also been helpful in the process of developing the enrichment ball.
- **Data collection**

  Data was transferred from the Asset Tracker to a web-database by means of a Verizon cellular connect. Raw data was then retrieved from the Asset Tracker Dashboard. Temperature data was also collected from the Roadway Weather Information System (Iowa DOT RWIS, 2018) to determine the outside temperature of the facility. Data was evaluated and charted in Activity Ball Test 1 (Figure 5, Figure 6).

- **Skills and Relevant Courses**
  - *TSM 116: Introduction to Design Technology* in designing the housing sensor housing.
  - *TSM 214: Managing Technology Projects* in strategic scheduling and planning.
  - *TSM 240: Introduction to Manufacturing Processes* provided us with a background in manufacturing the product and prototype.
  - *TSM 327: Animal Production Systems* provided understanding for the environment that this technology is implemented and animal housing requirements.
- **Solutions**

  Three proposed solutions, described below, were designed and evaluated.
  - Design 1, as shown in Figure 1, consists of a two-part molded shell. The shell is assembled using bolts and molded in nuts. The inside of the shell is filled with low-density polystyrene (Styrofoam), which is formed to fit around the sensor. Upon evaluation, it was determined that this design required a large investment in molds to build a prototype. Also, the polystyrene inserts would act as an insulator and thus affect the temperature reading.
  - Design 2, as shown in Figure 2, begins with an existing 10-inch enrichment ball. This ball is modified by adding an opening to fit the sensor and two stainless-steel rods to support the sensor. A lock was added to the cap to retain the sensor in place. This design was prototyped and tested.
  - Design 3, as shown in Figure 3, begins with three standard 6-inch PVC fittings. These three fittings include a rounded cap, a male cleanout, and a cleanout cap. Each of these fittings can be found in-stock at most hardware stores. This was the simplest and easiest to manufacture of the three designs, with an assembly time of fewer than 10 minutes. This design was prototyped and tested.

  Designs 2 and 3 were prototyped and tested. Upon evaluation, it was determined that design 3 was the fastest to manufacture as well as the cheapest when time and equipment were considered. It was noted that Designs 1 and 2 may be easier to market as a product, as most producers can build the device in design 3, however design 3 may be marketed as more of a service rather than a product. It should also be noted that due to the cylindrical geometry of design 3 and the capabilities of the NimbeLink Asset Tracker, there is a limited number of axis positions that may affect activity level readings.

  See Figure 4 - Design Matrix below for an analysis of the three designs.

- **Organization**

  A structured agenda was assembled as a group. Within the weekly group report, we made a timetable for upcoming project goals and major milestones. Weekly meetings allowed us to plan out an itinerary for the week ahead. Each member was welcomed to share their thoughts during the meeting, and tasks were distributed based on our team members strengths and input. Following a pattern of brainstorming, researching, designing, prototyping, testing, and meeting with insightful sources continually moved us toward a solution. The team was in contact with both Dr. Hoff (Hoff, 2018) as well as Dr. Ramirez (Ramirez, 2018) on a weekly basis as well. We have notified Mr. Guyer, our client contact,

on significant milestones as they were accomplished. Major milestones for the project with set anticipated competition dates included:

1. Identify Constraints and Needs – 11/1/2017
2. Design Container for NimbeLink Tracker – 11/15/2017
3. Testing Analysis of Ball/Components – 3/1/2018
4. Final Report/Poster/Presentation – 4/20/2018

B. Results/Deliverables

The completion of this project includes delivering three designs that have been evaluated for cost, manufacturability, and effectiveness. Also delivered are prototypes and test results of designs 2 and 3. The results of these tests include data retrieved from the sensor as well as recommendations for improvement to the design. We did have some trouble with the NimbeLink Asset Tracker; we have included recommendations for improvement for this sensor package as well.

4 BROADER OPPORTUNITY STATEMENT

The Activity Ball seeks to provide the swine industry with a product that helps producers become more knowledgeable of their herd behavior and health. Changes in behavior may signify potential health issues, that can be addressed in earlier stages. The Activity Ball can also monitor the living environment of the animals. Currently, the Activity Ball monitors temperature at the same height of the animals. The Activity Ball connects producers with their facilities and animals wirelessly, resolving an issue of rural telecommunications infrastructure, in a way that requires little to no added effort by the producer.

The effects of improving animal health have its own effects as well. By improving animal health, producers can better supply the global food market with safe, wholesome pork. Producers also benefit from improved herd health through more effective medication use, faster weight gain, better quality products, and decreased mortality.

Unlike some existing monitoring systems, the Activity Ball does not utilize cameras. Cameras in production systems have scared many producers in the United States due to unintended negative social consequences. One of these systems is the eYeScan by Fancom. Fancom is a developer of IT and automation systems for the livestock industry. The eYeScan utilizes a camera to weigh market hogs each time they enter the feed area. The data collected from this product could potentially be used to analyze eating and behavior habits.

5 PROJECT SCOPE

Prairie Systems gave us the opportunity to work with them on creating an activity monitoring device that will be placed with a group of market hogs.
Needs of the project include:

- Design a device that will protect the NimbeLink Asset Tracker.
- Build prototypes of our best designs that work with our constraints.
- Constraints Include:
    - The device must not affect the data that will be collected from the Asset Tracker
    - The device must not affect the cellular connectivity of the Asset Tracker

  - Protect the Asset Tracker from hazards inside a swine production barn
- Test the prototype in a variety of swine production environments.
- Analyze test results for accuracy in data and evaluate the durability of the enclosure.
- The enclosure must be manufacturable and relatively low cost.

The client provided us with the intent of this project and how it will be used in the industry of swine research as well as what the final product must accomplish when finished. This information was included to give the team a better understanding of what we need to focus on when designing the project.

This project does not include extensive data analysis of the activity in relation to feed consumption and animal health; this will be the focus of Prairie Systems following the completion of this project.

6 GRAPHICAL ABSTRACT

7 REFERENCES

Hoff, Steven. Personal communication.

Iowa DOT. (n.d.). RWIS Atmospheric Data. Retrieved April 16, 2018, from http://data.iowadot.gov/datasets/rwis-atomospheric-data

Jones, Don D.; and Friday, William H. "Environmental Control For Confinement Livestock Housing," *Purdue University Cooperative Extension Service*: AE-96. Available at: https://www.extension.purdue.edu/extmedia/AE/AE-96.html

Koziel, Jacek. Personal communication.

MWPS. (1983a). Structures and environment handbook. MWPS-1. Ames, Iowa: Midwest Plan Service.

Ramirez, Brett. Personal communication

Sadler, Larry J.; Johnson, Anna K.; Newton, John; Stalder, Kenneth J.; and Dekkers, Jack C.M. (2009) "Grow-Finish Pigs Activity Levels When Fed Using a Feed Intake Recording Equipment (F.I.R.E.) Feeder," *Animal Industry Report*: AS 655, ASL R2468. Available at: https://lib.dr.iastate.edu/ans_air/vol655/iss1/90

Stinn, John P.; and Xin, Hongwei, "Heat and Moisture Production Rates of a Modern U.S. Swine Breeding, Gestation, and Farrowing Facility" (2014). Agricultural and Biosystems *Engineering Publications*. 610. Available at: https://lib.dr.iastate.edu/abe_eng_pubs/610

Vanstrom, Joseph. Personal communication.

8 APPENDIXES

8.1 DESIGN

Figure 1 - Initial Concept

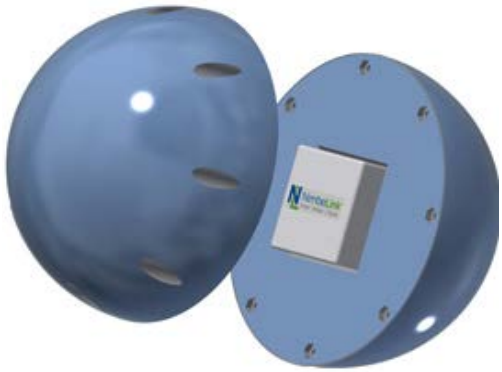

Figure 2 - Modified Enrichment Ball

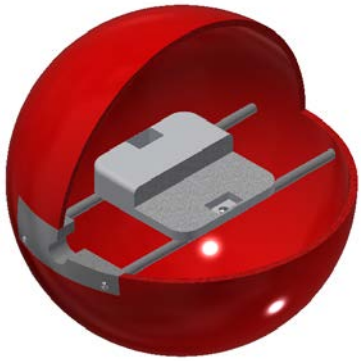

Figure 3 - PVC Capsule

8.2 ANALYSIS

Figure 4 - Design Matrix

Design Matrix

Prototype	Cellular Connection	Activity Collection	Temperature	Durability	Sensor Protection*	Sensor Access	Portability	Parts Cost	Construction Cost	Construction Time	Total
PVC Capsule	2	1	2	3	0	2	2	1	3	2	**18**
Enrichment Ball	2	2	2	2	0	3	2	2	1	1	**17**

0- Failed
1-Did not meet constraints
2-Met constraints
3- Exceeded constraints

8.3 Bill of Materials

Table 1 - PVC Capsule Bill of Materials

Bill of Materials - PVC Capsule			
Item	*Quantity*	*Unit Price*	*Total*
6-IN PVC CAP	1	$ 12.99	$ 12.99
6-IN PVC CLEANOUT ADPTR	1	$ 11.48	$ 11.48
6-IN PVC CLEANOUT PLUG	1	$ 6.38	$ 6.38
#8 ROUND-HEADED BOLTS	2	$ 0.05	$ 0.10
#8 HEX NUTS	2	$ 0.03	$ 0.06
		Total	$ 31.01

Table 2 - Modified Enrichment Ball Bill of Materials

Bill of Materials - Modified Enrichment Ball			
Item	*Quantity*	*Unit Price*	*Total*
JOLLY BALL 10"	1	$ 15.50	$ 15.50
5-PIN TUMBLER LOCK	1	$ 5.18	$ 5.18
#8 ROUND-HEADED BOLTS	4	$ 0.05	$ 0.20
#8 HEX NUTS	2	$ 0.03	$ 0.06
PLTEDSTLRND 5/16X3	1	$ 4.78	$ 4.78
		Total	$ 25.72

8.4 Collected Data

The following tables were graphed from data collected by the NimbeLink Asset Tracker utilizing the PVC Capsule design. The test included 48 hours of data, beginning on March 2nd, 2018 at 4:00 pm to March 4th, 2018 at 4:00 pm.

Barn temperature is the temperature collected from the NimbeLink Asset Tracker. Barn temperature was collected every 5 minutes. RWIS temperature was collected from the Roadway Weather Information System (RWIS) maintained by the Iowa Department of Transportation. The local station of Fort Dodge, IA was utilized.

Figure 5 displays the activity level as described by the Asset Tracker's orientation of each axis (x, y, z). The orientation was collected every 5 minutes. The orientation is described as 0 being horizontal, 1 being upright, and -1 being upside down. Any level outside of 1 and -1 describes the Asset Tracker as in motion. Figure 6 displays the activity level as described by a prepared representation of the changes in orientation. The preparation was based on the number of movements recorded in a 2-hour period, with 24 movements possible. To be considered a movement, the orientation of the ball had to change by one-quarter turn in any direction from the previous known orientation.

In the timeframe of collected data, we can see that the barn had responded to the changes in outside temperatures. The activity level increased during daylight hours and was nearly silent during the night.

Figure 5 - Activity Ball Test 1 Raw

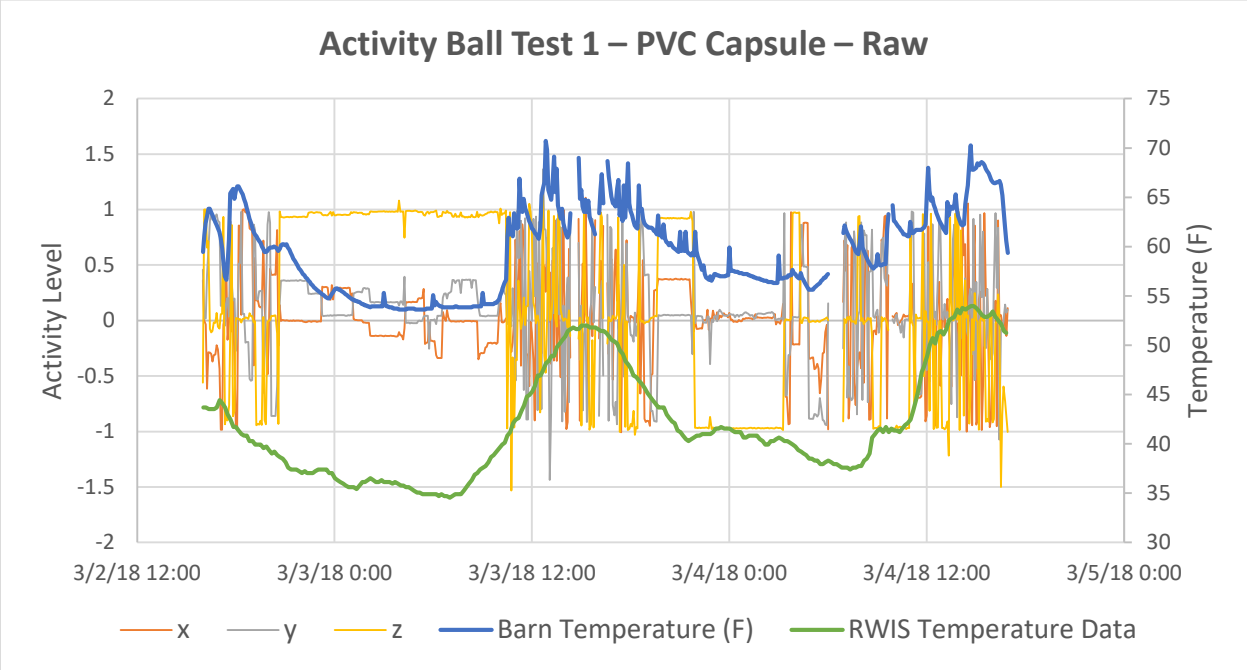

Figure 6 - Activity Ball Test 1 Prepared