Feasibility of a UHF RFID system to identify nursery pigs moving through a hallway

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Abstract

Automatically counting and identifying pigs within a facility can improve worker efficiency and ensure proper placement of pigs, though manual identification can lead to misread tags or a miscount of pigs. Ultra-high Frequency (UHF) Radio-Frequency Identification (RFID) could solve this by reading ear tags within 10 m of the antenna, limiting errors such as incorrect identification. Identifying the room location ensures that pigs are correctly located and provides room identification for each pig. The objective of this study was to evaluate the feasibility of a UHF RFID system to identify nursery pigs moving through a doorway. Two groups of nursery pigs were given Electronic Identification (EID) ear tags and RFID readers were placed at three configurations in a hallway. The pigs were guided along the hallway while the RFID system recorded the scanned ear tags and timestamps. Three configurations were tested and compared for differences in accuracy. Reader Position 1 (RP1) was mounted 0.25 m high on the wall and faced perpendicular to the floor. Reader Position 2 (RP2) was 0.66 m high on the wall and angled 45° downward towards the floor, while Reader Position 3 (RP3) was parallel to the floor and mounted 1.07 m high in the center of the aisle. Results showed that RP2 had the greatest accuracy, 54.18%, compared to RP1 and RP3 (48.60% and 20.84%, respectively). This study evaluated the feasibility of the UHF RFID system to detect pig ear tags when moving along a hallway, as well as revealed areas of improvement.

Keywords: counting, inventory, precision livestock farming, location tracking

Introduction

Keeping record of the number of pigs in a facility is an important part of production management. An accurate history of pig numbers is crucial when examining a farm's production information. There are multiple times in the production cycle in which a pig inventory is necessary. Inventories are required when moving pigs into a new facility, loading onto a truck to be transported, and being loaded off a truck when taken to harvesting facilities. Manual counting of pigs by farmworkers is the most common form of obtaining inventory records when moving pigs, but it is a tedious process that leaves room for error such as missing a pig or double-counting. An automated counting method could replace human counting and provide faster, more accurate data compared to manual counting.

Current commercially available automated counting technologies include systems such as Ro-Main SmaRt Counting, which utilizes a camera to identify and count pigs moving in the camera's view. While a minimum accuracy of 99.9% is guaranteed, the system is not an affordable option for the average producer and requires permanent installation (Conception Ro-Main Inc). A more affordable technology with easier installation requirements could be a better option for some producers. Radio-Frequency Identification (RFID) could be an automatic alternative to the manual counting of pigs.

RFID is a technology that automatically detects RFID tags when in the range of the corresponding reader. The frequency ranges most commonly used in RFID systems are low frequency (125 kHz or 134.2 kHz), high frequency (13.56 MHz), and ultra-high frequency (UHF; 860-960 MHz; Kapun et al., 2020). RFID systems are a tool that can be used in swine production by ear tagging pigs with RFID tags to identify movement and location within the barn, though this use is not widespread in industry. RFID systems are becoming a widely adopted tool in animal science research to better understand and quantify animal behavior. More specifically, RFID systems have been used in the research setting to provide accurate monitoring of drinking, feeding, movement, and social behaviors. These behaviors are difficult to manually identify by visual observation alone (Matthews et al., 2016). The benefit of an RFID system is that it can be used to quantify behavior by recording pigs at an individual level (Andretta et al., 2016), making it a suitable contender for obtaining inventory counts. Though an initial investment, the RFID system's automation could decrease labor costs for farms producers while simultaneously increasing profits by providing real time animal behavior of individual animals (Bouazza et al., 2017). Commercially available RFID readers cost varies from approximately $900 - $2,000 USD and typically require the purchase of additional software licensure. RFID ear tags cost $2 each. Though the reader and ear tag prices are not conventionally cheap compared to standard ear tags, the amount of time saved from the automated counting could improve efficiency of the farm. Readers are relatively easy to install and tags can be put on during the normal piglet processing procedure, meaning this system does not drastically increase required labor to install or use.

When considering what RFID frequency to use, multiple aspects must be considered. Although LF RFID readers are suggested for use in environments with metal and water since there is less sensitivity to electromagnetic interference, these readers have a read range up to 10 cm (GAO RFID Inc.), therefore are not a feasible option for counting moving animals. As most swine hallways are at least 60 cm wide, to accurately track multiple animals that will be at various distances from the reader, a larger range is necessary in this setting. Based on previous scientific successes using RFID systems to quantify pig behaviors, this study aimed to determine the feasibility of a UHF RFID system when used to identify and count the movement of nursery pigs moving along a hallway.

Materials and methods

Animals and experimental design

This experiment was conducted at the North Carolina State University Swine Educational Unit in December 2022 and was authorized by the North Carolina State University Institutional Animal Care and Use Committee. Two groups of nursery pigs (group A = 6 pigs, group B = 7 pigs) were given RFID ear tags located on the left ear with a unique identification number. Pigs were commercial Landrace, Yorkshire, and Duroc crosses. The RFID test was conducted when the pigs were 28.5 ± 0.5 days of age. Three identical UHF RFID readers (Model # 216031, GAO RFID Inc., Ontario, Canada) were placed at different configurations in the aisle of the nursery room to determine the optimal reader positioning for detecting moving pigs. Reader positions were selected based on preliminary testing of the system. The test was conducted by moving pigs through an enclosed hallway in the nursery (10.71 m long × 0.95 m wide; Figure 1).

The reader dimensions were 290 mm × 290 mm × 115 mm and weighed 2.5 kg. All readers were set to a read power of 25 dBm and a frequency of 902-928 MHz, with a reading speed of >400 times per second. Reader Position 1 (RP1) was located near the front of the hallway approximately 2.29 m from the front door and securely fastened to the left side of the aisle at a height of 0.25 m above the floor facing directly outward, perpendicular to the floor. Reader Position 2 (RP2) was placed near the middle of the hallway approximately 3.66 m from RP1 at a height of 0.66 m, facing downwards towards the floor at a 45° angle. Reader Position 3 (RP3) was located at the opposite end of the aisle approximately 1.73 m from RP2 and mounted above the aisle facing directly downward at a height of 1.07 m.

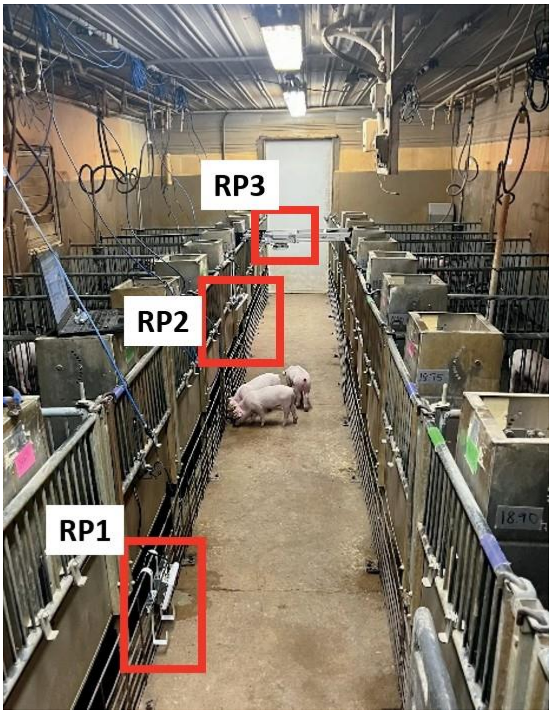

Figure 1: Pigs were walked down a hallway past RFID readers in three different configurations. Reader Position 1 (RP1) was mounted at a height of 0.25 m above the floor facing directly outward, perpendicular to the floor. Reader Position 2 (RP2) was mounted at a height of 0.66 m, facing downwards towards the floor at a 45° angle. Reader Position 3 (RP3) was mounted above the aisle facing directly downward at a height of 1.07 m.

Pig Group A was removed from the nursery pen and placed at the front of the aisle. One at a time, the RFID readers were connected to a computer for data collection. The pigs were walked down the entire length of the aisle using a sorting board, re-grouped, and then walked back to the front of the aisle to pass by the RFID readers again. The pigs were walked down the aisle a total of six times, with the pigs moving in each direction three times. This process was repeated for all three RFID readers. Pig Group B was evaluated using the same process.

Data analysis

Tag numbers registered by the RFID readers were compared to the expected number of tags for each pass in front of the reader to determine reader accuracy. Data were examined for trends.

Results and discussion

Overall, RP2 had the greatest percentage of tags detected at 54.18%, compared to RP1 (48.60%) and RP3 (20.84%; Table 1).

Table 1: Cumulative number (Group A = 6 pigs, Group B = 7 pigs) and percentage of pig RFID ear tags detected for three passes in front of the RFID reader at three different RFID reader positions.

		Reader on Left[a]			Reader on Right[a]		
	Group	# of Pigs	Percentage	SE	# of Pigs	Percentage	SE
RP1[b]	A	17	94.40%	5.67	15	83.30%	9.62
	B	3	16.70%	0.10	0	0.00%	0.00
RP2[c]	A	18	100.00%	0.00	18	100.00%	0.00
	B	13	55.56%	0.20	7	22.00%	0.11
RP3[d]	A	5	27.80%	0.11	0	0.00%	0.00
	B	4	22.20%	0.15	5	33.33%	0.10

[a] RFID tags were in the left ear of all pigs, facing the reader when moving one direction (Reader on Left) and on the opposing side of the pig from the reader when pigs were moving the opposite direction (Reader on Right).

[b] Reader Position 1 (RP1) was mounted at a height of 0.25 m above the floor facing directly outward, perpendicular to the floor.

[c] Reader Position 2 (RP2) was mounted at a height of 0.66 m, facing downwards towards the floor at a 45° angle.

[d] Reader Position 3 (RP3) was mounted above the aisle facing directly downward at a height of 1.07 m.

Reader position 1

Reader Position 1 for Group A had an overall accuracy of 88.85% (Table 2). Comparing the accuracies from moving to the left versus moving to the right, it is evident that the reader had a higher detection rate when the pigs were moving to the left with the ear tags on the same side of the pigs as the reader. Reader Position 1 for Group B also had a higher accuracy when moving to the right (16.70%) compared to moving to the left (0%), although this group had much lower accuracy in general. The RFID reader's greater accuracy rates when the pigs move to the left was expected as the RFID ear tags are located on the left ear of each pig. When walking by the reader, the ear with the tag being closer to the reader most likely allows for easier detection as occlusions can interfere with the RFID signal, such as one pig blocking another pig's RFID tag when walking together past the reader.

Table 2: Group total percentage and positional total percentage of pig RFID ear tags detected.

	Group	Group Total	Position Total
RP1[b]	A	88.85%	48.60%
	B	8.35%	
RP2[c]	A	100%	54.18%
	B	38.78%	
RP3[d]	A	13.90%	20.84%
	B	27.77%	

Reader position 2

Reader Position 2 for Group A had an accuracy of 100% for both moving to the left and moving to the right. Placing the reader at a height 0.66 m proved to still be within range for the system. Reader Position 2 for

Group B had an accuracy of 38.78%, which is substantially lower than the first group's accuracy. This decrease in accuracy for Group B could potentially be attributed to Group B moving past the reader at a faster rate compared to Group A or too many pigs in front of the reader at once.

Reader position 3

Reader Position 3 yielded the lowest detection rates for both Groups A and B (13.90% and 27.77%, respectively). While pig speed and the number of pigs passing at once could have influenced these results, the reader height of 1.07 m seemed to have exceeded the height range for accurate detection of ear tags. The low accuracy indicates that it is not practical to count pigs with this specific RFID system when the reader is at this height or greater.

Considerations

Multiple facility, animal, and human aspects should be considered when determining what configuration will work the best when using an RFID system. The RFID reader tested here demonstrated the greatest accuracy when at a height of 0.66 meters and angled 45° towards the pigs. Another aspect to consider is the size of the pigs that are being tracked. The stage of production that the animals are in may also impact the reader accuracy and detection. Depending on the location of the reader, smaller pigs may be further or closer to the reader compared to larger pigs (Maselyne et al., 2014a). Because of this, the angle may need to be adjusted to follow the growth of the pigs in order to maintain accuracy (Maselyne et al., 2014b). Higher accuracy with the RFID system could be achieved through the implementation of two RFID tags per pig compared to one (Maselyne et al., 2014a). Placing one tag in each ear can increase the sensitivity and specificity of the system, though this decision is a costly one that producers may not be able to afford (Maselyne et al., 2014a). One study placed one tag in each ear and found that the system's sensitivity differed for the left ear tag and the right ear tag, suggesting that the pig's orientation when near the reader can impact the sensitivity (Maselyne et al., 2014a). If the RFID reader is installed on one side of the hallway, ear tags should be on the same side of the pig as the reader, as the present results indicated this positioning produced the greatest accuracy.

Another consideration is the speed of the pigs, as increased pig speed may decrease the system's accuracy. Multiple pigs passing in front of the reader can also interfere with tag detection and decrease system accuracy. In another study using an RFID system to monitor pigs feeding at a trough, a large pig density caused some tags to not be detected accurately, suggesting that pig interference can impact the system's performance (Adrion et al., 2018). Pigs moving slowly and single file, such as sows down a narrow alleyway, would likely result in higher tag detection rates. Future works should explore using the same RFID reader for different positions to explore potential intra-reader variability.

In this study, Group B consistently had lower accuracy compared to Group A for all RP, although there were no notable differences between the pig groups. Further investigation is necessary to understand the discrepancy in accuracy between Group A and Group B. Future work may also test RFID accuracy on groups of 11-12 pigs to better represent commercial usage conditions.

Conclusions

The use of an RFID system to count pigs moving through a hallway demonstrates potential as an alternative to manually counting pigs. Reader Position 2 at a height of 0.66 m and at a 45° *angle* showed the greatest accuracy for correctly identifying the RFID tags. However, further work is needed to improve detection rates before relying on this system for counting pigs. Placing the RFID reader too high confirmed reader-to-tag distance as a limitation of the RFID system. If one side of the hallway must be used, it is recommended to place the reader on the side in which the ear with the RFID tags is closest as it is more likely to detect the tags.

Acknowledgments

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