U.S. Pork Center of Excellence
Swine Research & Education Experience (SREE)
FINAL REPORT

Project Title: Testing a computer vision system for automatically detecting piglet interbirth interval

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Scientific Abstract:
An apparent opportunity for improvement in the swine industry is preweaning piglet mortality. Preweaning piglet mortality results in economic loss, decreasing productivity per sow, and food waste. One aspect of preweaning mortality, stillborn piglets, can be reduced with timely caretaker interventions to reduce interbirth interval. However, a single caretaker is often in charge of managing many farrowing events concurrently. To address this labor need, piglet interbirth interval could be monitored using thermal cameras. In the present study the performance of a custom image capturing and processing system was evaluated for its ability to identify piglet births. Thermal images of 13 sows in farrowing stalls were collected once every two seconds to compare the image processing algorithm's ability to identify piglet interbirth interval with human observations. Results showed the computer vision system had an overall accuracy of 50%, sensitivity of 65%, and specificity of 43%. For individual sows the accuracy ranged from 19% to 72%. The majority of false positives were attributed to other piglets or sow's legs being incorrectly identified as newborn piglets. With further refinement, the algorithm has the potential to increase accuracy of piglet birthing event identification. The present study demonstrates that computer vision systems can be implemented to monitor piglet birthing events in real-time, allowing caretakers to target their efforts on the most at-risk animals in the farrowing room. This continuous monitoring system has the potential to change the view of farrowing in the swine industry.

Introduction:
Farrowing is a pivotal stage of swine production, as neonatal piglet survival is critical for economic and environmental sustainability. Piglet mortality results in food waste and a decrease in productivity per sow. One opportunity to reduce piglet mortality is to target stillborn piglets, as in the U.S. nearly 1.4 piglets per litter are stillborn or mummies (Stalder, 2017). The prevalence of stillborns is positively related to piglet interbirth interval, which can be influenced by many factors such as birth position, litter size, prolonged farrowing, and poor uterine contractions (Okinda et al., 2018). The factors that contribute to interbirth interval are difficult to identify and control; however, by continuously monitoring the sow, interbirth intervals can be determined and allow for timely caretaker interventions to potentially saving distressed piglets before they asphyxiate (Kirkden et al., 2013).

Due to economic considerations and shortages of quality labor, a single caretaker is often responsible for many sows during the farrowing period, making it impractical for all farrowings to be constantly observed by caretakers. One alternative to human observation is utilizing technology solutions to continuously monitor sows during farrowing. We proposed to monitor piglet interbirth interval by implementing a custom thermal imaging system focused only on the rear of the farrowing stall. Immediately after exiting the birth canal piglet skin temperature is very high, nearly equal to the sow's internal body temperature of 39 °C. Newborn piglet skin temperatures are much warmer than the surrounding environment, allowing the piglets to be identified in thermal images. If the thermal camera system can accurately identify the time of birth of each piglet, then interbirth interval can be calculated and tracked. Utilizing a simplistic algorithm focused only on interbirth interval, these calculations could be performed in real-time with the potential to alert the caretaker to sows who may need assistance to improve sow productivity and piglet survivability.

Objectives:

The distinct project objectives were:

1. Collect a data set of thermal images of 15 sows farrowing under commercial conditions.
2. Compare the image processing algorithm's ability to identify interbirth interval with human observations.
3. Disseminate results via student poster presentations at a scientific conference and industry-oriented swine conference.

Materials & Methods:

Data were collected on two groups of sows in September 2021 and April 2022 at the NCDA&CS Tidewater Research Station. Sows were housed in conventional farrowing stalls from five days prior to anticipated farrowing date to weaning at approximately 21 days in lactation. All sows were commercial Landrace and Yorkshire crossbreeds. For each farrowing group, eleven camera sets were used to collect images. Each camera set consisted of one GoPro Hero8 and one custom thermal imager. Each camera set was mounted approximately 1 m above the floor of the rear of the stall of a sow that was near farrowing. Images were saved once every two seconds until the farrowing process was observed to be completed. Then, the camera set was moved to another sow prior to farrowing. Though many sow farrowing events were captured, only 13 sow image sets were usable due to missing data or improper camera placement.

True piglet birth times were recorded manually by human observers from the GoPro digital video footage. The exact time of piglet birth was evaluated as the moment the entire piglet was expelled from the sow, rounded to the nearest second. All thermal images were processed using the custom image processing algorithm. Briefly, the image processing algorithm identified piglet birth times by calculating the temperature difference between an image and the previous image. The location, size, and magnitude of pixels with temperature changes were evaluated to determine if the image contained a newborn piglet.

To calculate the accuracy of the image processing algorithm, the duration of each sow's farrowing was segmented into 5 min increments. This time increment was chosen to account for any slight discrepancies in time clocks within camera set and helped account for placenta/fluids that were around piglets. If a piglet was identified by both the human observer and the computer vision system in a 5 min increment, this was considered a true positive. The accuracy comparison started one 5 min increment prior to the first piglet and concluded one 5 min increment after the last piglet was born.

Results:

1. Digital and thermal images were collected of 13 sows farrowing under commercial conditions.

Though approximately 27 sow farrowing events were recorded, only 13 sow image sets were usable due to data collection failures or unsuitable camera angles. Only four usable sows were captured in the first group, but improved set-up methods resulted in nine usable sows from the second group. In total, the 13 sows had 154 piglets total born. See Figure 1 for an example image of a newborn piglet.

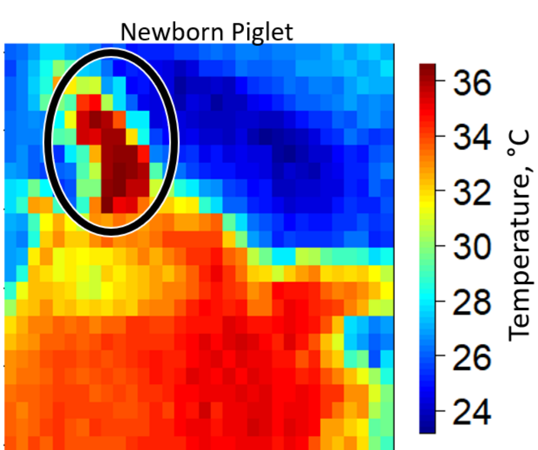

Figure 1. A newborn piglet, highlighted in the black circle, captured by the custom computer vision system.

2. Compare the image processing algorithm's ability to identify interbirth interval with human observations.
Overall, the computer vision system had an accuracy of 50%, sensitivity of 65%, and specificity of 43% (Table 1).

Table 1. Confusion matrix comparing piglet identifications between the human observer and the computer vision system. Data were evaluated as 5 min increments for each sow during farrowing and labeled as "Piglet" if a piglet was born during the timeframe and labeled "No Piglet" if no piglets were born during that period.

		Human	
		Piglet	No Piglet
Computer Vision System	Piglet	79	144
	No Piglet	42	108

Performance of the algorithm varied widely for individual sows, presented in Table 2.

Table 2. A custom image collection and processing system identified piglet birth times. Accuracy, sensitivity, and specificity for individual sows when compared to a human observer are presented.

Sow	Accuracy (%)	Sensitivity (%)	Specificity (%)	Farrowing Duration (min)	Total Number Born
1	40	30	50	100	16
2	59	67	54	110	14
3	47	55	44	180	11
4	72	86	69	195	15
5	57	82	41	140	14
6	64	56	66	235	11
7	57	78	43	115	12
8	19	90	0	235	12
9	38	57	32	130	8
10	31	67	10	80	6
11	65	67	64	130	12
12	42	83	0	60	8
13	52	50	53	155	15

3. Disseminate results via student poster presentations at a scientific conference and industry-oriented swine conference.
Kittle presented her poster titled "Testing a Custom Computer Vision System" at the American Society of Animal Science Midwest Section Meeting in March 2022, where she won first place in the Undergraduate Student division. The poster was also presented at the 2022 NC State University Animal Science Student Research Symposium where Kittle won first place and the people's choice award in the undergraduate division. The poster was presented to an industry-oriented audience at the NC State University Swine Innovation Forum.

Discussion:

The computer vision system had an overall accuracy of 50%, but accuracy varied greatly for individual sows, from 19% to 72%. Longer farrowing duration typically resulting in lower accuracy due to the increased opportunity for false positives. Many of the false positives were attributed to other piglets within the frame or the sow's back legs being mistaken as newborn piglets. Understanding the root causes of the inaccurate identifications will be used to further refine and improve the image processing algorithm.

This image processing system has the potential to increase accuracy of piglet birthing event identification. Computer vision systems could be implemented to monitor piglet birthing events in real-time, allowing caretakers to target their efforts on the most at-risk animals in the farrowing room.

Student Statement:

I am a junior in Animal Science at NC State University. I have been working as a research assistant with Dr. Suzanne Leonard on precision livestock farming projects. At the recent Midwest section meeting of the American Society of Animal Science meeting, I won first place in the undergraduate poster competition for my project titled "Testing a custom computer vision system for automatically detecting piglet interbirth interval". My winning poster discussed my research work developing a custom computer vision system to automatically identify when piglets are born so the interbirth interval can be monitored. In this manner, distressed sows and piglets could be identified by the technology, allowing for timely caretaker notification and intervention to reduce stillborns.

This project has introduced me into the swine industry and working with technology. Through this project I have developed a new ambition by learning about agriculture industries and implementing new ideas to effectively and efficiently work with food animal producers who feed the world. Through this research project I have learned to approach obstacles in a distinctive and strategical manner with the aid of precision livestock farming. Precision livestock farming has extended my knowledge to assessing problems through technology. Technology can be used as a tool to monitor livestock to help the producer as well as the health of the individual animal. This research affects my future endeavors through giving me a strategical approach to answer questions related to animal health, agriculture and producer needs. Moving forward, I plan to continue working with Dr. Leonard on precision livestock farming and applying to veterinary school in the fall of 2022. I am graduating with a B.S in Animal Science May of 2023.

Figure 2. Kittle at Tidewater Research Station setting up the custom computer vision system over a farrowing stall.

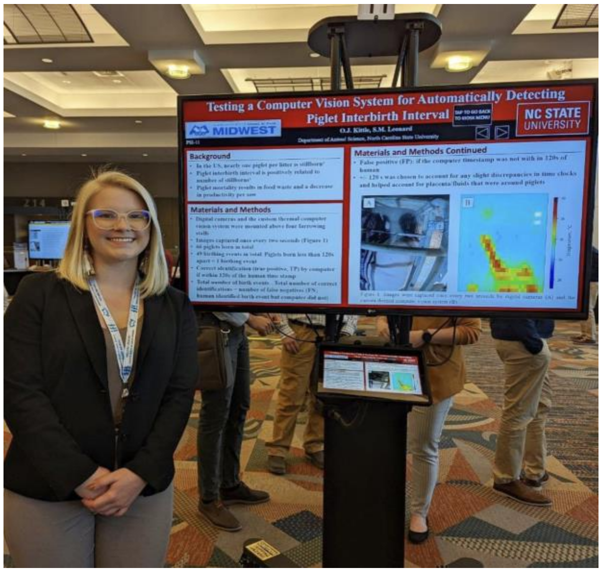

Figure 3. Kittle at American Society of Animal Science Midwest during her poster presentation.

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