Precision detection of farrowing onset and distress using advanced artificial intelligence technologies

M. Hagonob[1, 2], A. Alvaredo[1, 2], and B. Predicala[1, 2]

Alvin Alvarado

Bernardo Predicala

INSIGHT FOR PRODUCERS

Application of AI technologies can assist in the management of various stages of production. Using AI to monitor farrowing may reduce early piglet losses.

SUMMARY

Farrowing is a critical stage in pork production, however barn workers may not be present for the onset or duration. Use of detection systems may improve health and welfare in this period. Over 1,000 annotated and labelled images were collected from surveillance cameras and used as dataset for training YOLOv5 model variants (artificial intelligence technology). To train the model, three classes of posture and locomotion behavior (standing/walking, lying and sitting) were used as initial indicators of activity level of pigs in a group-housed system. Mean average precision (mAP) and number of parameters employed were used as evaluation metrics to assess the overall performance of the models. The most promising model for monitoring and detection of posture and locomotion behavior was YOLOv5S, which was capable of achieving a mAP of 83% and more efficient than the other model variants. The YOLOv5S model performed poorly in detecting sitting behavior compared to standing/walking and lying behaviors, which could be due to the large disparity in the number of images used to train the mode. Additional datasets with relatively equal proportion of standing/walking, sitting and lying behaviors are being compiled, and different hyperparameter combinations are adjusted to determine the best weights for the final object detection model. In addition, collection of farrowing videos is currently underway to detect the onset of farrowing and identify sows in distress.

INTRODUCTION

The application of AI (artificial intelligence) contributes to the application of precision livestock farming. Image processing and computer vision are examples of technologies that have been used as non-invasive methods of data collection in livestock production, including weight prediction, water usage, behaviour recognition and classification, lying patterns to evaluate the thermal environment, localization of animals, locomotion assessment, gait assessment, and animal counting. However, some accuracy, cost, and stability limitations still require further development. In swine, AI has been investigated for its potential application for prediction and identification of disease, analysis of growth performance, and monitoring of specific behaviours.

Farrowing is one of the most critical stages in pig production. Various means of predicting the onset of farrowing were investigated such as the use of detection systems such as photocell systems, force sensors, or acceleration sensors combined with different analysis algorithms. However, these sensor-based systems require specific and quite complex installations in the barn. Thus, most of these technologies are still in development stage and have not been implemented in commercial swine barns. Ths project investigates the use of AI technology to detect the onset of farrowing based on machine-vision monitoring of the increase of activity levels in sows due to nest-building behavior within hours prior to farrowing. It is hypothesized that an AI-based technology coupled with computer vision will track changes in sow activity and behavior as well as potential farrowing distress situations. Subsequently generating a warning signal that can be sent to designated barn staff to alert them of the farrowing onset or potentially distressed sows that require attention.

For this project, we have utilized a software application (OneCup AI), which has previously been used to develop AI-based applications for dairy cattle management. Ultimately, the goal of this project is to develop appropriate AI algorithms that can automate the monitoring and detection of the real-time conditions of nursery and grower-finisher pigs as well as sows. We are aiming to develop AI-based technology that can recognize patterns and behvaious such as individual pig identification, production performance, disease indicators, movement characteristics and gait abnormalities, and onset of farrowing, among others. Real-time data collection and analysis of data based on parameters routinely monitored in current barns can provide an accurate representation of the ongoing situation in the barn, hence allowing barn staff to identify priority tasks and optimize time and resource management for the workday. Application of AI technology with accessible monitoring equipment may revolutionize swine management.

1 Prairie Swine Centre Inc, PO Box 21057, 2105 8th Street East, Saskatoon SK S7H 5N9
2 Department of Chemical and Biological Engineering, University of Saskatchewan, 57 Campus Drive, Saskatoon SK S7N 5A9

Figure 1. Qualitative analysis of YOLOv5S model showing ground truths (top) vs predictions (bottom).

EXPERIMENTAL PROCEDURES

Animal Behavior Monitoring and Detection

Posture and locomotion behavior were used as indicators in determining the activity level of pigs in a group sow housing system. Three classes of posture and locomotion behaviour were investigated: standing/walking, sitting, and laying. The system model was developed and improved using pre-trained object detection to optimize its overall performance.

Model Selection

A previously developed YOLOv5-based detection model was utilized to monitor pigs' individual behavior.

Video Acquisition and pre-processing

Pig behavior monitoring was carried out where video footage was used to train, validate and test the AI models. The videos were converted to still images, then annotated and labelled based on the three classes of posture and locomotion behavior.

Datasets and Training Set-up

Annotated images were used to train the model to identify the different classes of posture and locomotion behavior. The dataset was randomly split using a 70:15:15 ratio; 70% were used for training, 15% for validation, and the remaining 15% for testing the model. The dataset used to test the models was independent of training and validation (Figure 1).

Detection of Farrowing Onset and Potential Problems

At least 100 sows in farrowing will be involved in this experiment. Data on their activity and behavior starting from 7 days prior to the anticipated farrowing date until actual farrowing were collected and analyzed to formulate the AI algorithm that marks the onset of farrowing. Additionally, indicators of farrowing distress leading to pig loss were documented and used in developing the AI algorithm to recognize such situations.

RESULTS

Model Development

Results showed that increasing the dataset size for model training improved detection performance. When using YOLOv5S with a dataset size of 100 images, detection performance was lower than that of larger dataset sizes and higher-weight variants. This outcome is expected given the smaller number of training images and hyperparameters used. On the other hand, YOLOv5L achieved higher accuracy than the other YOLOv5 variants, which could be attributed to the higher hyperparameter used. In addition, YOLOv5L outperformed other versions, indicating that it is less prone to overfitting and has a better generalization capability than other models.

YOLOv5S model performed poorly in detecting sitting behavior compared to standing/walking and lying behaviors, indicating that the model learned to detect standing/walking and lying behaviors more accurately than sitting. This could be due to the large disparity in the number of images used to train the model between different classes; the number of sitting images was substantially lower compared to standing/walking and lying images. To improve the accuracy of YOLOv5S model in detecting posture and locomotion behavior of pigs in subsequent experiments, a more balanced dataset between the different behavior classes will be used to train the model.

Detection of Farrowing Onset and Potential Problems

For this reporting period, videos are being collected continuously to detect the onset of farrowing and identify sows' distress situations. All farrowing videos were carefully analyzed based on the activity and behavior of sows from 7 days before the anticipated farrowing date until the actual farrowing. Additionally, indicators of farrowing distress leading to pig loss were also documented. The observation data and videos collected were directly sent to OneCup AI server for further analysis, which will be used to develop a model to detect the onset of farrowing and potential problems

Further development of the YOLOv5S model is ongoing. More models will be trained, validated and tested in subsequent experiments to improve accuracy and to determine the most accurate model for detecting animal behavior. Videos from the farrowing rooms continue to be collected and analyzed. Following completion of model development using the farrowing dataset, testing and validation will be done in-barn using live video feeds. Further, a cost analysis will be completed and specific recommendations for use of the technology in industry will be developed.

IMPLICATIONS

Previous studies have shown that AI-based technology through machine vision has the great potential to address current challenges in swine production (e.g., labour shortages, production inefficiencies.) however, further research is needed before they can be implemented in swine barns. Development of reliable AI detection technologies will not only increase profits but will also improve animal health and welfare. The generated data stream can also help guide new facility designs and genetic improvement.

ACKNOWLEDGEMENTS

This project is supported by the Saskatchewan Agriculture Development Fund. The authors would also like to acknowledge the strategic program funding provided to Prairie Swine Centre by Sask Pork, Alberta Pork, Ontario Pork, the Manitoba Pork Council and the Saskatchewan Agriculture Development Fund. In addition, we wish to acknowledge the support of the production and research technicians at Prairie Swine Centre that make it possible to conduct this research.