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NIGHTTIME PIGLET DETECTION USING DEEP LEARNING

Bo-Ren, Chen[1], Yan-Fu, Kuo[1]

[1] Department of Biomechatronics Engineering, National Taiwan University, Taipei, Taiwan.

*Corresponding Author: ykuo@ntu.edu.tw

ABSTRACT

In 2023, Taiwan's pig industry was valued at over NT$85.1 billion, representing nearly 40% of total livestock production. However, effective piglet management remains a challenge due to environmental variability, frequent aggressive behaviors, and labor shortages—especially during nighttime. Traditional monitoring methods rely on manual observation, which is time-consuming, subjective, and impractical for continuous surveillance. To address this, we propose an automated nighttime piglet detection system using deep learning. An image dataset was constructed by extracting frames from nighttime video recordings captured in a commercial pig nursery in Linkou, Taiwan (6 p.m.–4 a.m., 5 fps, 1280×720 resolution). A total of 357 images were annotated using rotated bounding boxes to capture piglet positions and orientations. The dataset was split 8:2 for training and validation, with YOLO11 models trained on 640×640 pixel RGB inputs. The model was optimized using AdamW over 80 epochs with a batch size of 32.The trained model achieved an AP@0.5 of 0.995, recall of 0.997, and an inference speed of 172 FPS. Despite slight performance drops under low-light and overlapping conditions, the system demonstrated robust real-time detection capability. This study highlights the feasibility of deploying deep learning models for nighttime piglet monitoring and lays the groundwork for future developments in individual tracking and infrared-based enhancements.

Keywords: Piglet Detection, Nighttime Monitoring, Deep Learning, YOLO11, Precision Livestock Farming

INTRODUCTION

Conventional approaches for monitoring piglets, such as manual observation and farm staff inspection, are time-consuming, labor-intensive, and highly dependent on human expertise, which limits their practicality under large-scale or nighttime conditions. To address these challenges, this study proposes an automated detection framework based on the YOLO11 deep learning model, trained on video frames captured in low-light environments. By leveraging image-based features and advanced object detection techniques, the system aims to provide a scalable and objective solution for nighttime piglet monitoring and farm management.

MATERIALS AND METHODS

Nighttime piglet videos were collected at a farm in Linkou, New Taipei, with a resolution of 1280 × 720 pixels, 5 fps, and a recording period from 6 p.m. to 4 a.m. Each video lasted one minute. From the recorded material, several videos with relatively stable lighting and clear piglet visibility were selectively chosen to ensure higher data quality. Representative frames were then extracted from these selected videos to construct the dataset. The frames were annotated using rotated bounding boxes to capture piglet orientation and ensure precise labeling. In total, 357 annotated frames were obtained and divided into training and validation subsets with an 8:2 ratio. All images were resized to 640 × 640 pixels for model input. A YOLO11 architecture was adopted for piglet detection, trained using the AdamW optimizer with a batch size of 32 for 80 epochs.

RESULTS & DISCUSSION

The YOLO11-based detection model achieved an AP@0.5 of 99.5% and a recall of 99.7% on nighttime piglet images, demonstrating both high precision and real-time inference speed of 172 FPS. The model effectively identified piglets under most conditions, showing strong potential for practical farm applications.

However, performance decreased in scenarios with extremely low illumination or when piglets were heavily overlapped, leading to occasional misdetections. These challenges highlight the need for incorporating additional modalities, such as infrared imaging, and expanding the dataset to improve robustness and generalizability.

CONCLUSIONS

This study demonstrates the feasibility of applying deep learning models for automated nighttime detection of piglets in farm environments. The YOLO11-based approach achieved high accuracy and real-time performance, showing strong potential to assist livestock management. Nonetheless, limitations remain under low-light conditions and when piglets overlap extensively. Future improvements through larger and more diverse datasets, infrared imaging, and individual tracking will be essential to enhance robustness and practical applicability.

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