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Using Convolutional Neural Network for Behavior Classification of Group-Housed Pigs

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Abstract **-** Group housing of pigs is an increasingly common practice in modern agriculture, but it presents challenges in monitoring and ensuring the well-being of the animals and pig welfare. In this study, we propose the use of Convolutional Neural Networks (CNNs) for the behavior classification of group-housed pigs. We collected a dataset of pig behavior images, annotated with various behaviors including drinking, eating, excreting, sleeping, and standing-up behaviors. A CNN model was trained to classify these behaviors, with a focus on identifying stress-related behaviors. The results indicate that YOLOv8 exhibits competence in the classification of group-housed pig behavior, achieving an accuracy rate of 81.7%. Furthermore, it showcases noteworthy proficiency in classifying the "drinking" category with a precision of 96.7%. The model showed promising results to quickly detect and address pig interactions, offering a potential tool for real-time monitoring of pig behavior, thereby promoting better animal welfare.

Keywords**:** Classification; Convolutional Neural Network; Detection; Group-Housed Pigs; YOLOv8

1. Introduction

Group housing of pigs has become a standard practice in the swine industry, driven by animal welfare concerns and legislative changes. However, this practice raises challenges in monitoring pig behavior and ensuring their well-being in crowded environments. Moreover, the environmental impact of group housing systems, including waste management and resource utilization, necessitates careful management. Pigs exhibit various behaviors based on their environment. Pigs spend most of their time eating, drinking, and excreting in typical, comfortable settings. A change in the living environment or a feeling of discomfort may cause pigs to behave abnormally. Behavior classification offers several practical benefits. It helps reduce labour expenses, curtails the potential for disease transmission between humans and animals, lowers the overall costs associated with pig farming, and amplifies the productivity and profitability of the farming enterprise. Consequently, it stands as an essential practice in modern pig farming, contributing to improved animal well-being and sustainable farming practices.

Deep learning techniques have been used recently for object quantification and classification [1][2], achieving higher accuracy than traditional image processing and machine learning techniques. This study explores the use of Convolutional Neural Networks (CNNs) to classify pig behaviors in group housing environments as a means of promoting both animal welfare. Researchers are currently exploring deep learning techniques, with one notable example being the utilization of the You Only Look Once (YOLO) network for object detection and classification. The YOLO algorithm and deep learning framework has gained prominence in the field of artificial intelligence and computer vision. The latest version, YOLOv8, developed by Ultralytics and launched on January 10, 2023 [3], excels in achieving high accuracy and speed in real-world applications [4]. YOLOv8 introduces new features and improvements for enhanced performance, flexibility, and efficiency, supporting a wide range of vision AI tasks such as detection, segmentation, pose estimation, tracking, and classification [3]. This network employs a single neural network by dividing the input image into a grid, processing the entire image simultaneously, and directly predicting bounding boxes and class probabilities. Each cell in the grid can predict a fixed number of bounding boxes based on a confidence score, with weights assigned according to predicted probabilities [5].

Pig behavior classification involves the categorization of various behaviors exhibited by pigs. It involves observing pig behaviors in groups and categorizing them. As a result of this categorization, farmers can identify pigs that may be at risk of social stress and mitigate the risk of injury and mortality proactively [6]. To tackle this challenge, this study explores the feasibility of YOLOv8 for behavior classification of group-housed pigs based on the five behaviors, including drinking, eating, excreting, sleeping, and standing up behaviors. By implementing behavior classification, farmers can significantly

enhance the welfare and health of their pigs. This technique serves as a vital tool for promoting animal welfare, as it empowers farmers to swiftly identify and address interactions between pigs that may lead to stress or injuries.

2. Methodology

2.1. Data Collection

In this study, the original dataset was collected from the pig videos. A dataset comprising images of group-housed pigs was collected in a controlled environment. These images captured a wide range of behaviors, including drinking, eating, excreting, sleeping, and standing up behaviors. Each image was manually annotated with one or more labels corresponding to the observed behaviors.

2.2. Data Preprocessing and Model Performance

The collected images were resized to a uniform resolution, normalized, and augmented to enhance dataset diversity. Data augmentation techniques included rotation, cropping, and flipping were used in this study to mitigate overfitting. The dataset consists of classes of drinking (n = 130), eating (n = 140), excreting (n = 10), sleeping (n = 185), and standing up (n = 190); and the objects are labelled and performed on these five classes as the common behavior of group housing. Then, the model was trained on the dataset using categorical cross-entropy loss and the Adam optimizer. Training was conducted on a GPU-enabled server, and the model's performance is monitored on a validation set to prevent overfitting. After training the models, the performance of each model was evaluated in terms of mean average precision (mAP), average precision, recall, and F1-score. Precision-Recall Curve of YOLOv8 model is given in Fig.1.

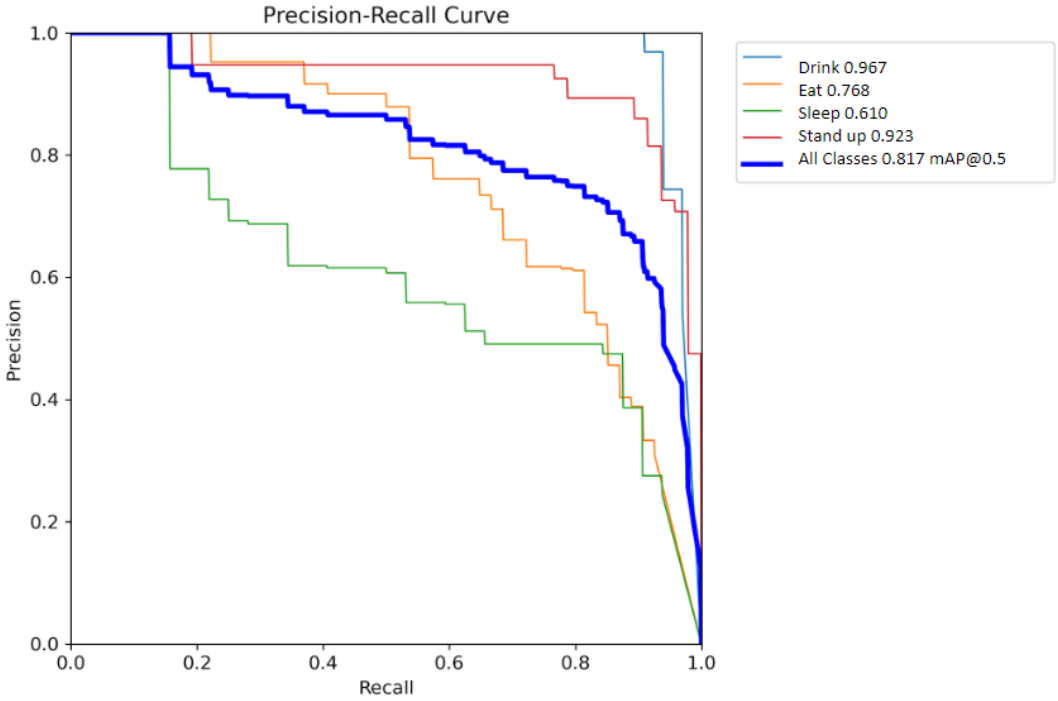

Fig. 1: Precision-Recall Curve of YOLOv8 model.

3. Results and Discussion

3.1. Model performance

The findings demonstrate the competency of YOLOv8 in classifying group-housed pig behavior, with an accuracy rate of 81.7%. Additionally, it exhibits remarkable proficiency in categorizing the "drinking" behavior, achieving a precision rate of 96.7%. The model excels in precision when identifying the "drink" behavior. This high precision indicates that when the model predicts a pig is engaging in "drink" behavior, it is highly likely to be accurate. This is crucial, as accurately identifying hydration patterns is pivotal for pig welfare and resource management. Furthermore,

the model achieves classification rates of 61% for sleeping behavior, 76.8% for eating behavior, and an impressive 92.3% for the "standing up" behavior category. The overall accuracy rate of 81.7% reflects the model's ability to correctly classify pig behaviors across all categories. However, to truly appreciate the model's utility and reliability in the context of group-housed pig behavior classification, it is essential to delve deeper into precision and recall values, as well as the associated behavior categories. Example of images behavior prediction is given in Fig.2.

Fig. 2: Example of detecting pig postures using YOLOv8 model.

Performance metrics specific to behavior reveal crucial insights into the model's classification capabilities. Fig. 3 shows confusion matrix for five classes of pig group housing. The "sleeping" behavior exhibits a classification rate of 66%. While this suggests the model's ability to detect this behavior, further analysis is warranted to determine whether there are specific factors influencing its accuracy. This behavior is particularly complex to capture due to variations in sleeping postures and environmental conditions. The "eating" behavior shows a classification rate of 67%. While this rate indicates a reasonable level of accuracy, there may be opportunities to improve classification, especially considering the significance of accurate feeding behavior monitoring in pig management. The "standing up" behavior category stands out with an impressive classification rate of 94%. This high rate suggests that the model excels in capturing this behavior, which could be attributed to distinct visual cues associated with pigs standing up in group housing settings. The insights gained from the confusion matrix analysis will guide future work on model refinement. Addressing specific challenges associated with behavior classification, such as improving sleep behavior detection and robustness to environmental variations, remains a priority. Additionally, data augmentation techniques and increasing the diversity of the training dataset may lead to enhanced model generalization.

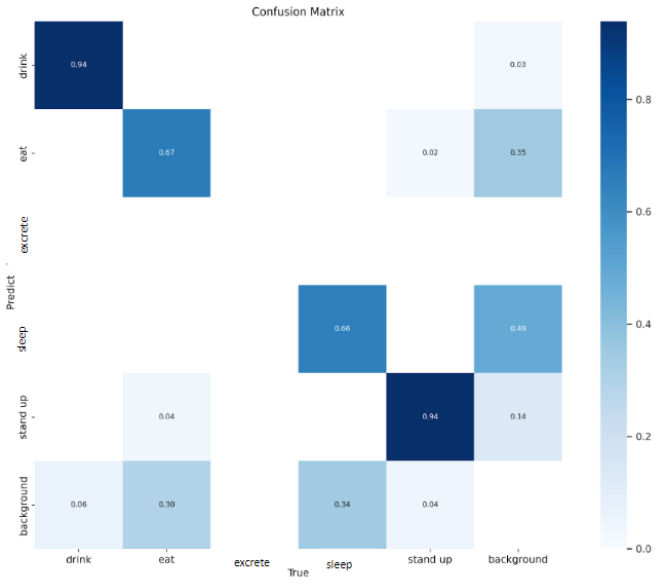

Fig. 3: Confusion matrix for five classes of pig group housing.

4. Conclusion

The application of CNNs for behavior classification of group-housed pigs offers a promising avenue for modern swine farming. The results highlight YOLOv8's effectiveness in classifying group-housed pig behavior, achieving an overall accuracy rate of 81.7%. Notably, YOLOv8 excels in categorizing the "drinking" behavior, boasting a precision rate of 96.7%. In spite of this, in-depth analysis of potential influencing factors is required, especially given the complexity of capturing variations in sleeping postures and environmental conditions. By better understanding and monitoring pig behaviors, we can improve animal welfare and mitigate the environmental impact of group housing systems. This research contributes to the development of tools for sustainable and ethical pig farming practices.

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