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AUTOMATED ANALYSIS OF DAIRY COW BEDDING BEHAVIOR PATTERNS BASED ON DEEP LEARNING TECHNOLOGY

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Abstract

Stalls are among the most frequently used facilities for dairy cows. Their design and use directly affect the cows' health, comfort, and willingness to lie down. These factors are closely associated with both animal welfare and milk production. Therefore, monitoring stall use provides a practical basis for evaluating stall design and barn environment quality, in line with the Five Freedoms of Animal Welfare. This study proposes an automated system based on deep learning to analyze stall use by dairy cows. A controllable camera system was installed in a 48 × 10 square meter enclosed barn in Taichung, covering 11 activity points for high-producing cows. The cameras regularly capture images and videos, and automatically rotate to observe cow postures. Each image is masked to define stall and feeding areas, then analyzed using YOLOv12 (You Only Look Once version 12) to detect standing and lying postures. The model achieved a precision of 0.827 and a recall of 0.803. Three indices were calculated: Cow Comfort Index (CCI), Stall Standing Index (SSI), and Stall Using Index (SUI). This study focuses on SUI as the primary indicator, using it to quantify lying behavior over time and to investigate its relationship with animal health and milk yields. The indicators were also visualized to detect anomalies. The goal is to provide practical insights to support better stall design and improved dairy cow welfare.

Keywords: dairy cows、stall use、animals welfare、deep learning、Yolov12

INTRODUCTION

With the rising demand in the dairy market, balancing production efficiency and cow welfare has become essential. Cow lying and standing behaviors are linked to health and milk yield, and stall use is a key welfare indicator. Traditional manual observation is time-consuming and subjective, limiting long-term accuracy. This study applies a controllable camera system with deep learning to monitor cow postures. Three indicators were calculated: Cow Comfort Index (CCI), Stall Standing Index (SSI), and Stall Using Index (SUI). Among them, SUI was the main focus, used to quantify stall use and explore its relationship with milk yield(Table 1). Daily and hourly data were visualized to establish reference curves, providing insights for welfare evaluation and farm management.

Table 1 Definition of Stall Using Index (SUI).

Cow Welfare Indices	Definition
Stall Using Index	$\frac{\Sigma Cows\ lying\ in\ stalls}{\Sigma Non-feeding\ cows} \times 100\%$

MATERIALS AND METHODS

The study site was a semi-open barn at a farm in Houli District, Taichung, illuminated by LED lights and natural sunlight, with hanging fans and natural ventilation for cooling. Holstein cows, the most common dairy

breed in Taiwan, were raised in the barn. Observation areas included high production stalls. The monitoring device was a Global-King GK2941C-X42-RPE network camera (Global-King International Co., Taiwan) with built-in infrared lighting, capable of capturing clear images in low-light or nighttime conditions.

Fig.1 Holstein cows

Fig.2 Global-King GK2941C-X42-RPE

The controllable camera allows 360° horizontal rotation and 90° vertical tilt for wide-area dynamic monitoring. Cameras were installed at approximately 5.7 m above the ground and set to 11 cruise points, staying 5 seconds at each point to ensure focus before capturing images. Videos were recorded every hour, and images were transmitted in real-time to a backend system for evaluation by researchers and farm managers. This study employed YOLOv12 (You Only Look Once Version 12) as the core detection model, with barn images annotated using Roboflow. The high-yield group consisted of 60 cows, and on average about 55 cows were detected per image, with a small number missed due to occlusion or camera angle limitations. Before analysis, masks were applied to define the regions of interest (ROI), including stalls and feeding areas, and cow postures within the ROI were identified. The Stall Using Index (SUI) was then calculated and compared with daily milk yield. Data on milk yield were provided by the farm.

RESULTS & DISCUSSION

The trained model effectively identified cow behaviors, achieving a precision of 0.897 and a recall of 0.84. Observations showed that the SUI increased significantly after feeding. A two-week analysis comparing the daily average SUI with milk yield revealed no clear linear relationship, which may be related to the conditions of the experimental barn, such as cows being healthy and able to produce milk efficiently. In addition, hourly averaged SUI values were used to generate a daily reference curve, establishing a reference range for stall use in this barn.

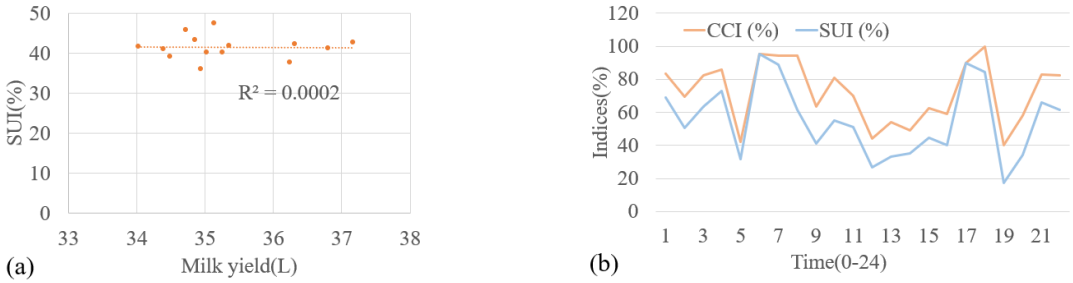

Figure 3. (a) Scatter plot of daily average Stall Using Index (SUI) and milk yield from June 17 to June 30. 、(b) Daily variation of Cow Comfort Index (CCI) and Stall Using Index (SUI).

CONCLUSIONS

This study combined controllable cameras and deep learning techniques to successfully quantify stall use. The YOLOv12 model achieved a precision of 0.897 and recall of 0.84, effectively identifying standing and lying behaviors. Using CCI, SSI, and SUI, reference curves for stall use were established, providing scientific guidance for assessing cow welfare and improving barn design. However, daily maximum SUI values did not show a clear linear relationship with milk yield.