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STUDY OF NON-CONTACT RESPIRATION AND TEMPERATURE-HUMIDITY INDEX FOR DAIRY COW HEAT STRESS MONITORING

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ABSTRACT

This thesis develops a non-contact system to automatically monitor the respiratory rate of dairy cows, aiming to improve real-time health assessment and management in livestock farming. Respiratory rate is a key indicator of cow health, helping detect heat stress, respiratory illness, and other conditions early. The system uses visible light and thermal cameras to capture synchronized videos, while image recognition algorithms detect and track the nasal region to perform respiratory measurements and calculate breathing in breaths per minute. The experiments at the NCHU Experimental Farm collected thermal video data under different environmental conditions, which were analyzed with the Temperature-Humidity Index (THI) to examine links between environment and respiration. Results show that the system accurately identifies the nasal area and detects temperature changes from inhalation and exhalation, providing reliable measurements. This non-invasive approach supports animal welfare and offers a practical tool for improving dairy cow health monitoring and farm management.

Keywords: Non-Contact, Heat Stress, Thermal Imagers, Temperature-Humidity Index, Respiratory Measurements

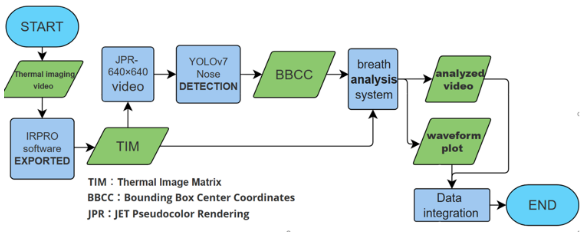
INTRODUCTION

In Taiwan’s hot and humid climate, dairy cows are prone to heat stress, affecting health, reproduction, and milk yield. Traditional monitoring relies on manual, contact-based methods that are labor-intensive and stressful for animals. This study develops a non-contact system that integrates THI with infrared thermography (IRT) and computer vision to estimate respiratory rate in real time. Using a YOLOv7 model to localize the nasal region, the system analyzes temperature oscillations to count breaths and cross-references with environmental data for accurate assessment.

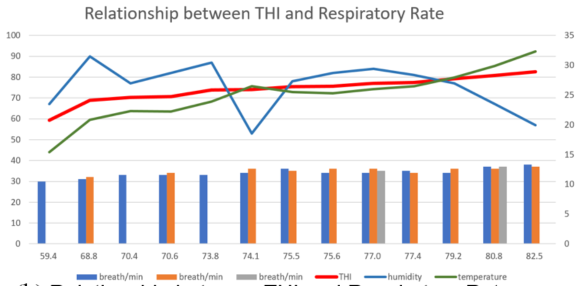
MATERIALS AND METHODS

BREATH DETECTION

This study recorded videos of dairy cows at the National Chung Hsing University Experimental Farm. Using a smartphone as a visible light reference, a thermal imager was placed 1 meter away and filmed two cows simultaneously for 10 minutes. The videos were segmented into 1-minute clips and converted into frame-based temperature matrices, which were then transformed into 640×640 JET pseudo-color images for YOLOv7 to detect the nasal cavity and provide center coordinates. Combined with the temperature data, these coordinates were analyzed using thresholds and bounding boxes to calculate average regional temperature changes and respiratory rate. The final outputs included an annotated video, a peak analysis graph, and an Excel summary. The process is shown in Fig. 1(a). After obtaining the respiratory analysis data, the temperature and humidity recorded during the image capture process were used to calculate the temperature and humidity index (THI) according to Eq. (1) for comparison.



(a) workflow diagram



(b) Relationship between THI and Respiratory Rate

Fig. 1 workflow diagram and Charts

THI was compared with respiration count:

$$THI = (1.8 \times T + 32) - (0.55 - 0.0055 \times RH) \times (1.8 \times T - 26) \qquad (1)$$

where:

THI= Temperature-Humidity Index

T= Temperature (℃)

RH = Relative Humidity (%)

RESULTS & DISCUSSION

Based on the analysis, Fig. 1 (b) shows that cow respiration increased with THI but changed only slightly across a 20-unit difference, indicating a non-linear response. It also shows that THI closely follows temperature rather than humidity, confirming temperature as the dominant factor.

CONCLUSIONS

This study developed a non-contact respiration monitoring system for dairy cows using infrared thermography and YOLOv7-based image recognition. The system effectively detected nasal temperature variations, accurately estimated respiratory rates, and found a positive correlation between respiratory frequency and THI changes. This approach reduces labor and animal stress, enhances health management and productivity, and shows strong potential for future integration with IoT and smart livestock farming.