Mitigating Heat Stress in Dairy Cattle using a Physiological Sensing-Behavior Analysis-Microclimate Control Loop

Younghyun Kim, Christopher Choi, Jennifer Van Os, and Sabrina Brounts
Purdue University and University of Wisconsin–Madison
Presenter: Hien Vu, UW-Madison

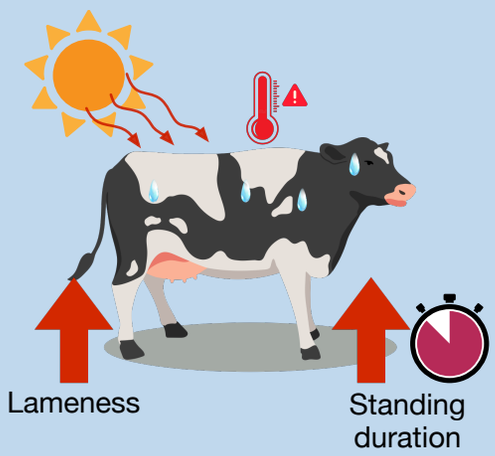
INTRODUCTION

Heat stress in dairy cattle threatens animal well-being and the sustainability of dairy farming

Cattle behavior changes provide important indications of heat stress

There is a lack of open datasets for cattle physiological and behavior monitoring in real-world environment

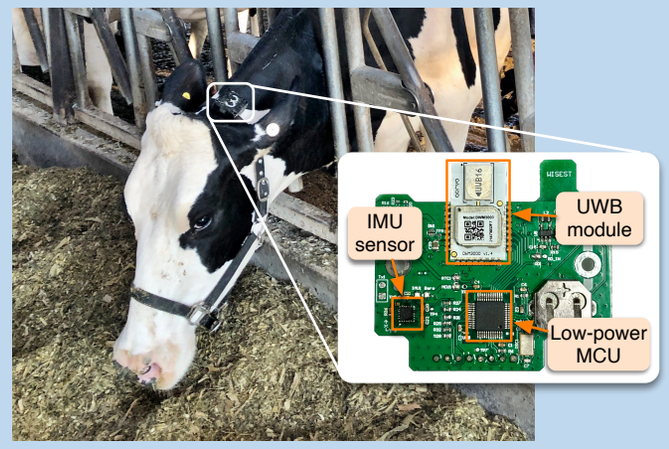
Cows stand longer to cool down when ambient temperatures rise, which also increases the risk of lameness [1, 2]



Sensors for data collection

- Neck sensor: 3D location and head direction
- Ankle sensor: resting duration
- Vaginal sensor: body temperature
- Log of milk yield
- Isometric-view cameras: visual references
- Environmental sensor: indoor temperature-humidity index (THI)
- Outdoor weather station

Deployed on 10 Holstein cows for 14 days at UW-Madison's Arlington Agricultural Research Station



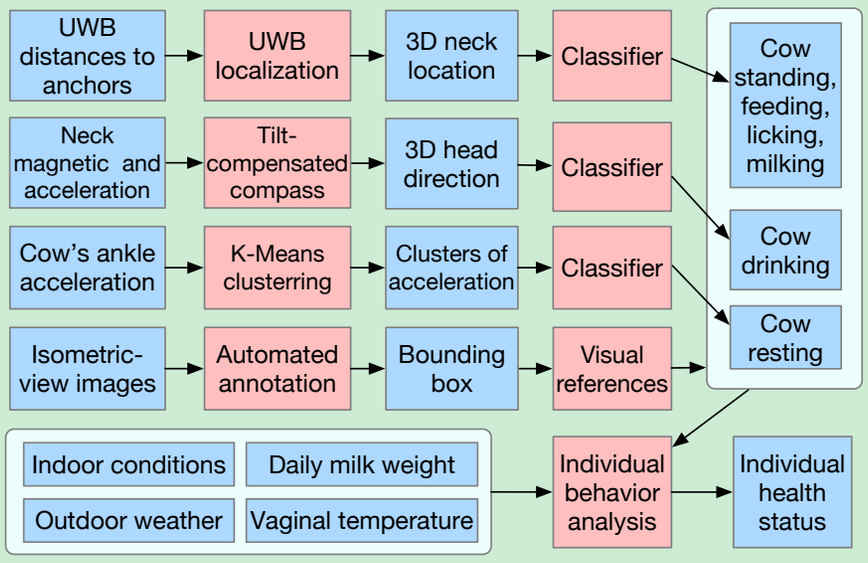
Custom neck-mount UWB tag for collecting cow's 3D location and head direction

DATASET

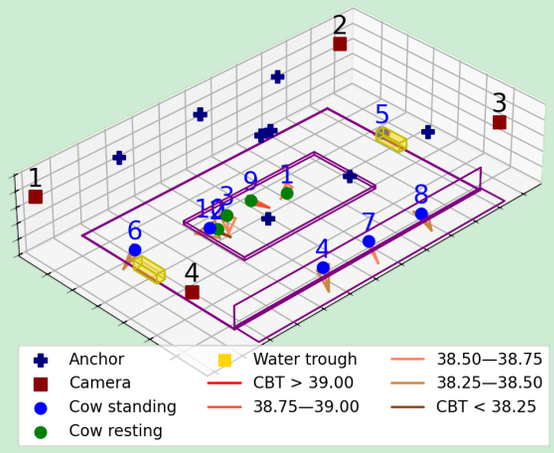
This dataset provides synchronized data of ten Holstein cows including:

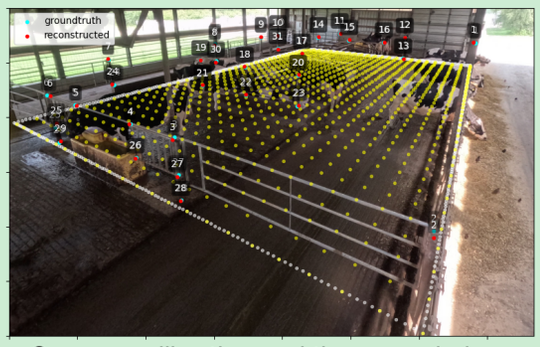
- Neck 3D location, acceleration, magnetic field, and air pressure
- Ankle acceleration and vaginal temperature
- Daily milk yield of each cow
- Isometric-view images of the cows from four pen corners
- Indoor temperature and humidity
- Outdoor weather

Data utilization for dairy cattle health monitoring

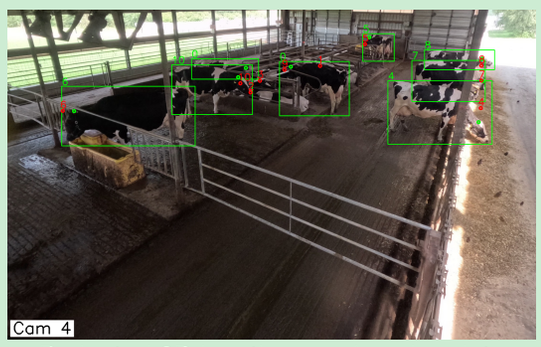


Visualization of 3D locations of cows in the pen from UWB tags





Camera calibration and the ground plane



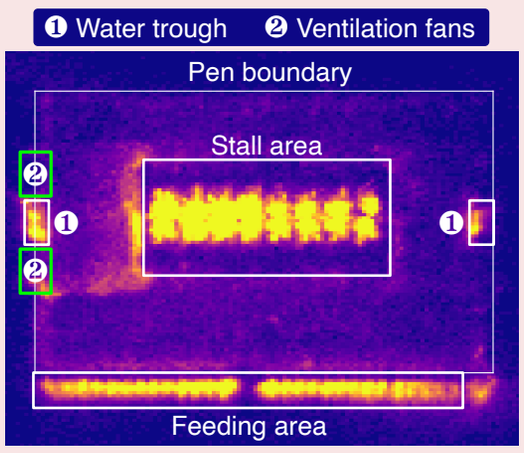
Projected 3D locations and neck points

EVALUATION

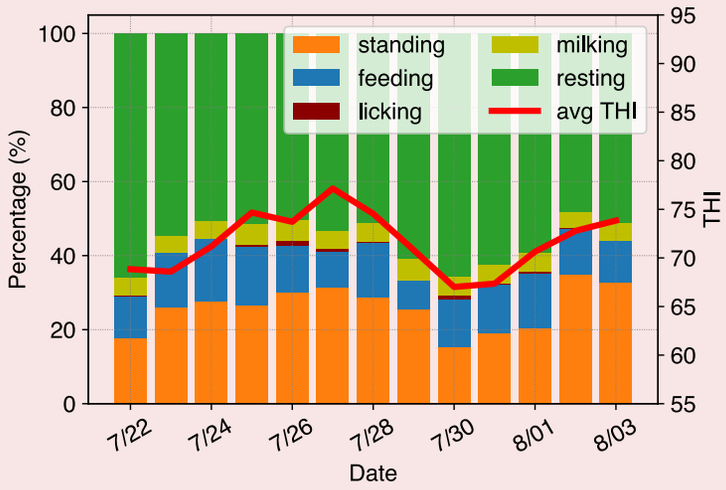
Evaluation of cattle's behaviors as baseline for further research:

- Standing duration increases corresponding to indoor THI: R = 0.79 (cow #9)
- Classifying standing/resting from UWB location: accuracy 97%
- High-milk producing cows often spend more time feeding

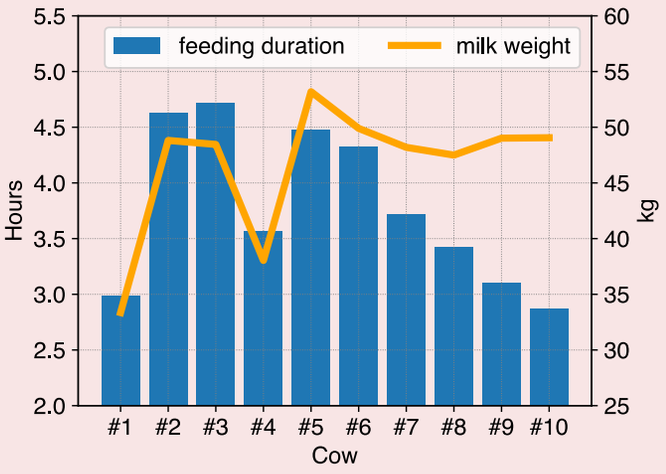
Occupancy heatmap of cows from 3D locations



Behaviors of cow #9 vs indoor THI during 14 days of the experiment



Average time spent on feeding and average milk production of the cows



IMPACTS

We present the first large-scale multimodal dataset that allows comprehensive monitoring of dairy cattle and better understanding of how their behaviors change under the effects of ambient conditions

Impacts on Society:

- Address public concerns on environmental sustainability and animal welfare
- Improve economic sustainability of dairy industry

Impacts on Education and Outreach:

- Offer opportunities to learn embedded computing, animal welfare, and machine learning
- Promote participation of underrepresented students in engineering majors

Potential Impacts

- Eliminate labor and financial costs in collecting real-world data of dairy cows
- Provide baseline for advanced monitoring systems in dairy barns

[1] Allen, J. D., et al., Journal of Dairy Science, 2015.
[2] Cook, Nigel B., et al., The Veterinary Journal, 2009.

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