# *MmCows: A Multimodal Dataset for Dairy Cattle Monitoring*

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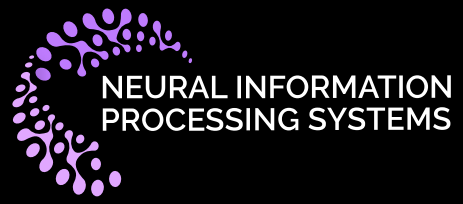




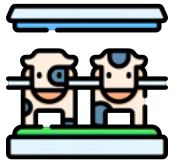

# *Challenges in Dairy Farming*

**270 millions**
**dairy cows worldwide**

Economic sustainability

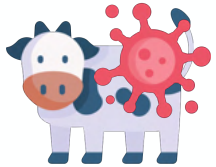

Production losses and output fluctuations, compounded by rising costs, result in significant reduced profits

Environmental sustainability



Massive water and electricity consumption place higher demands on resources

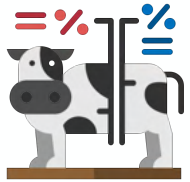
Social sustainability



Infectious diseases and health problems degrade cattle well-being, raising widespread social concerns

# *Precision Livestock Farming*


Economic sustainability



Tracking the productivity of individual cows to improve profit margins

Environmental sustainability

Evaluating the needs of particular cows to minimize resource consumption

Social sustainability

Monitoring cattle health to enable timely mitigation of health issues

# Precision Livestock Farming

Economic sustainability

Tracking the productivity of individual cows to improve profit margins

**AI/ML models in precision livestock farming are on the rise**

Environmental

Evaluating the needs of particular cows

**We need a multimodal synchronized dataset**

Social sustainability

Monitoring cattle health to enable timely mitigation of health issues

# *Data Collection*

MmCow is a multimodal dataset with nine synchronized modalities

**Wearable and implantable sensors**

Neck-mount tag

- Location
- Movement and direction
- Ambient air pressure

- Core body temperature
- Ankle direction

**Stationary sensors**

- Isometric multi-view RGB images
- Indoor temperature and relative humidity

**Records**

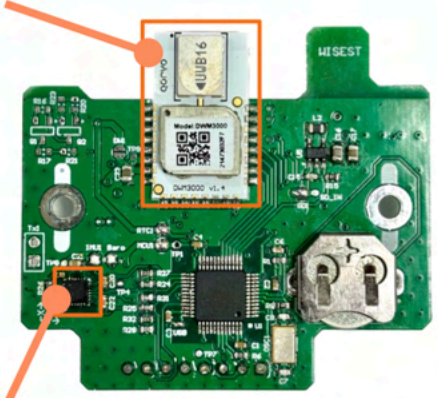
- Outdoor weather conditions
- Milk weight

Wearable Sensors
Stationary Sensors
Weather & Records

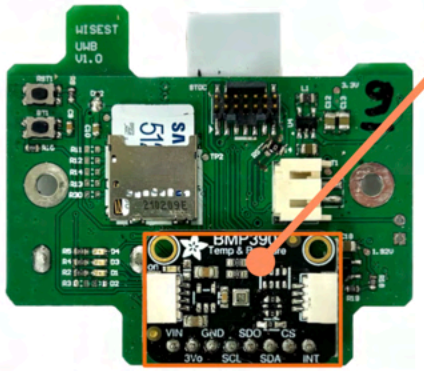
# *Data Collection*

MmCow is a multimodal dataset with nine synchronized modalities

**UWB sensor**
(measuring distance for head location)



Tag PCB top view



Tag PCB bottom view

**Pressure sensor**
(measuring air pressure for neck elevation)

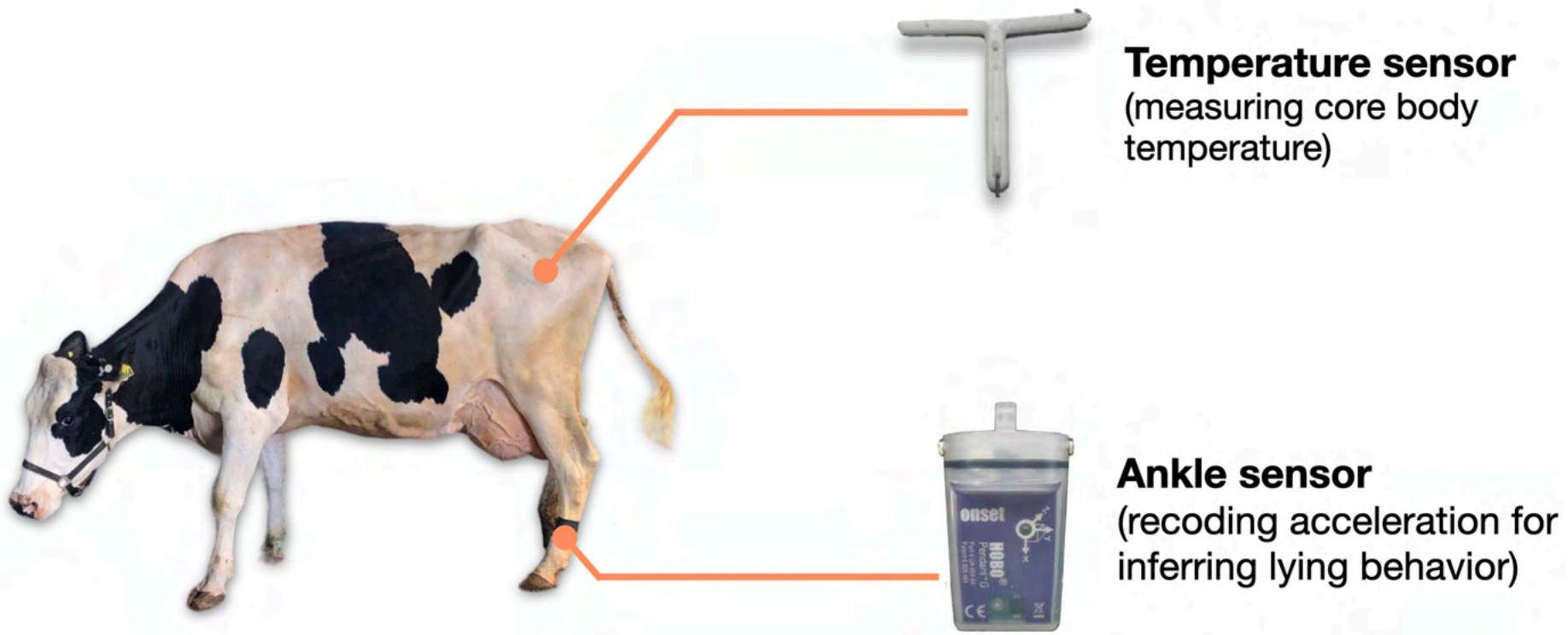
**IMMU sensor**
(recording acceleration and magnetic for head direction)

Neck-mount device

Wearable Sensors
Stationary Sensors
Weather & Records

# *Data Collection*

MmCow is a multimodal dataset with nine synchronized modalities



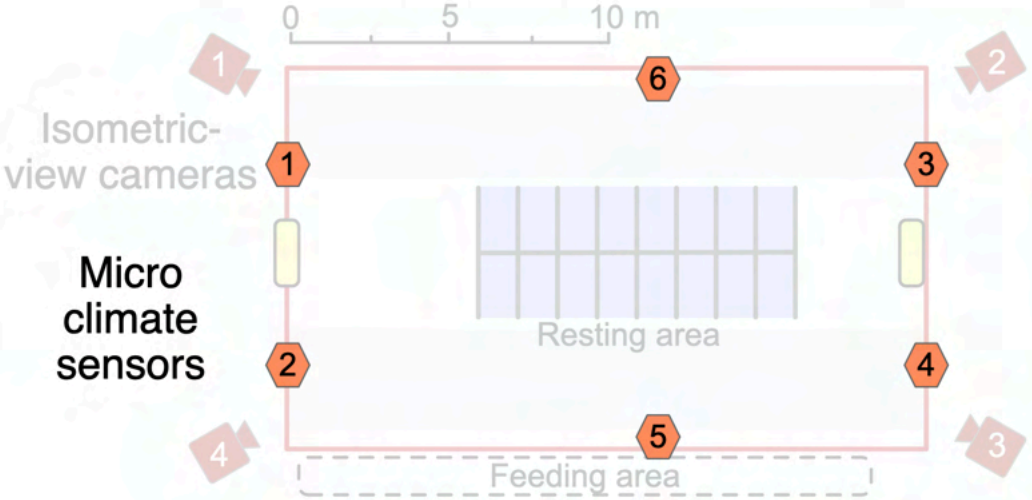

**Temperature sensor**
(measuring core body temperature)

**Ankle sensor**
(recoding acceleration for inferring lying behavior)

# Data Collection

Wearable Sensors
Stationary Sensors
Weather & Records

## Sensor installation map





## Multi-view images of the cow pen



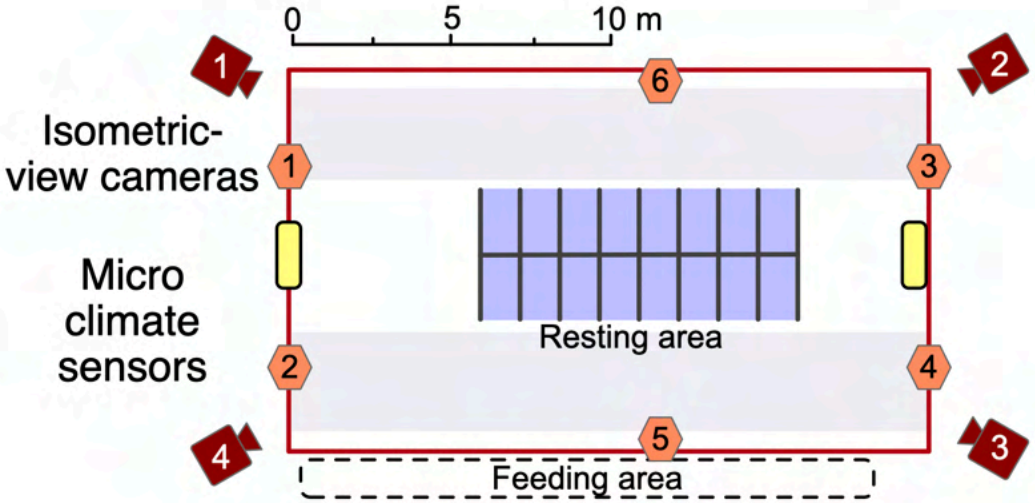

# Data Collection

Wearable Sensors

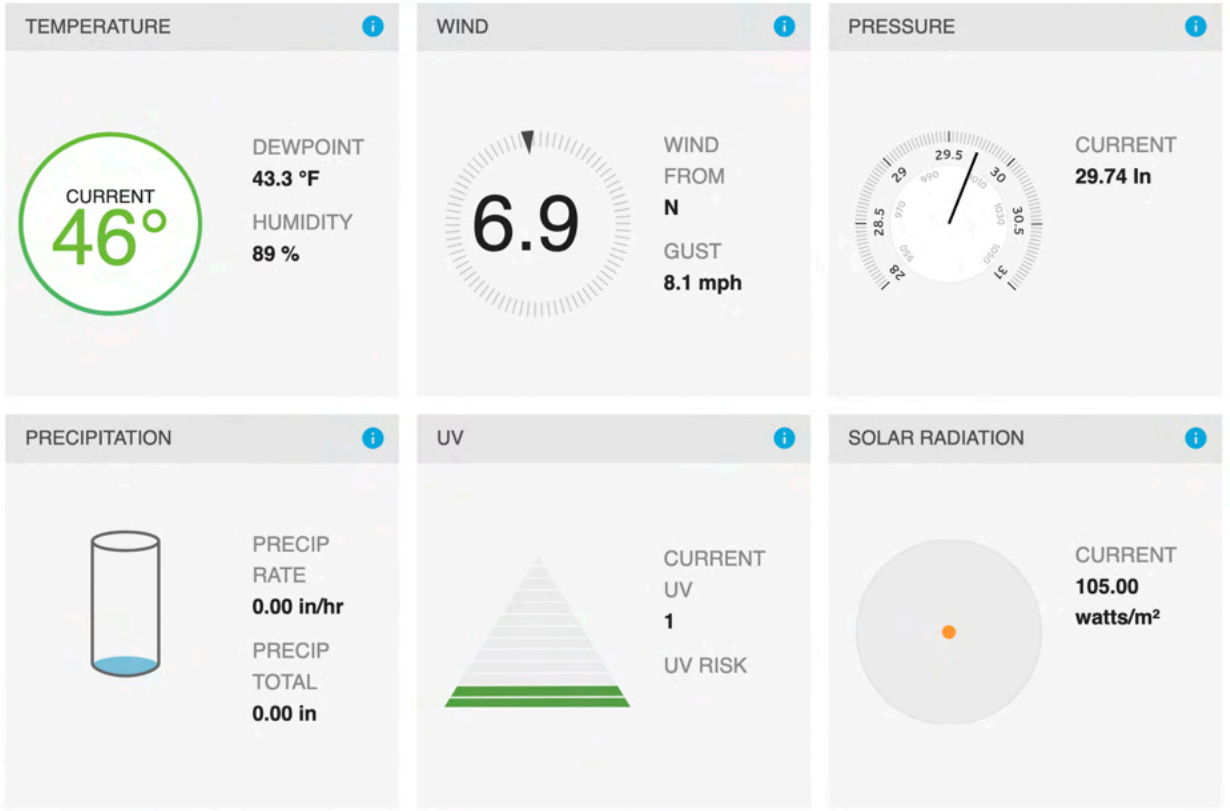
Stationary Sensors

Weather & Records

## Sensor installation map



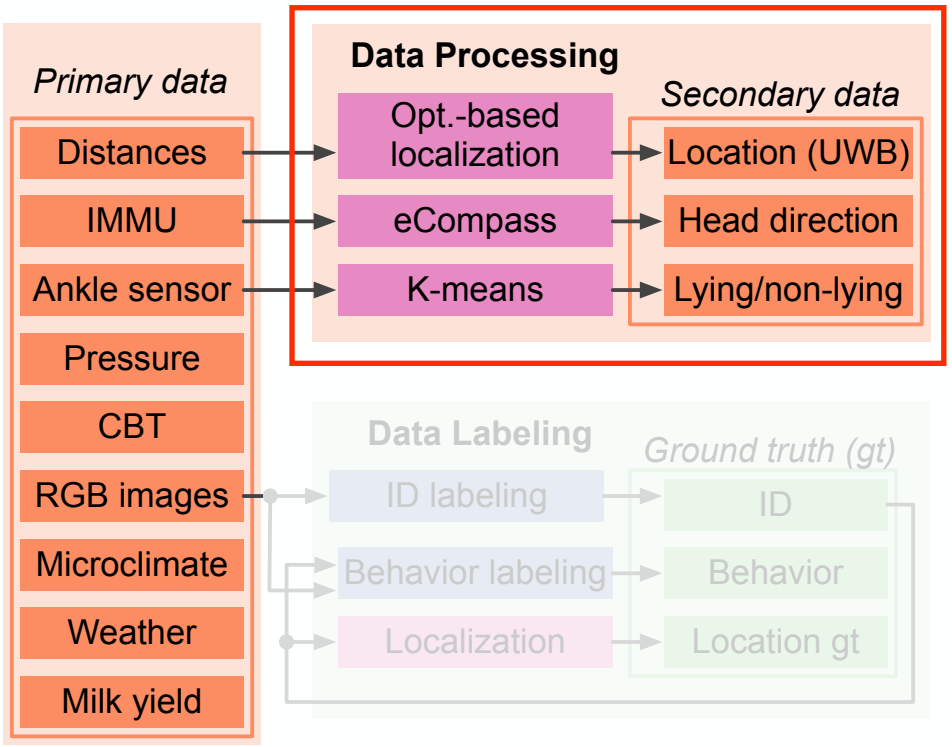

## Weather conditions from a nearby weather station




## Data records:

- Daily milk yield of each cow in kg
- Health records of each individual cow

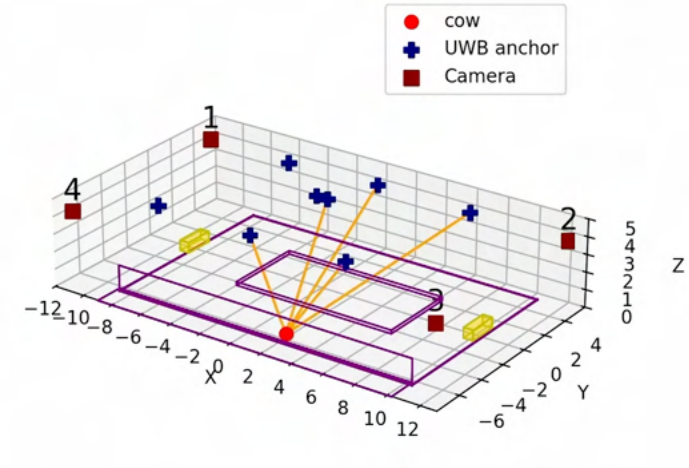
# Data Processing




Data processing pipeline of MmCows

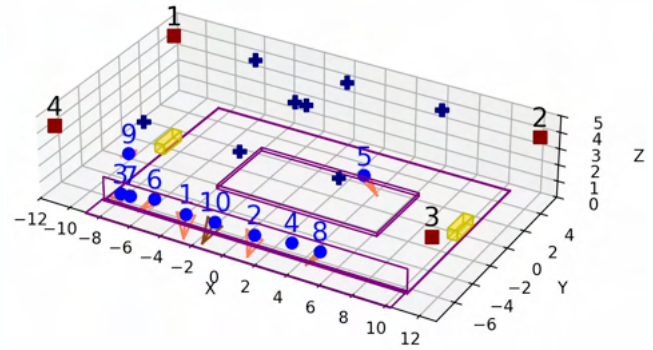
## Location (UWB)

- The location is calculated based on the distances from the cow to the stationary anchors



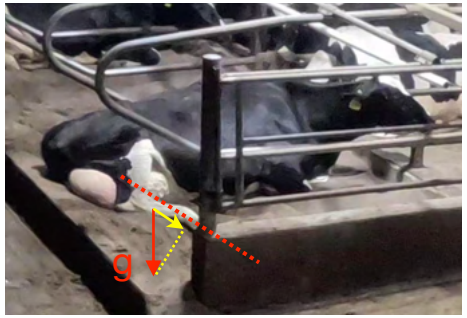

## Head direction

- Earth's gravity and magnetic field are used to estimate the 3D head direction

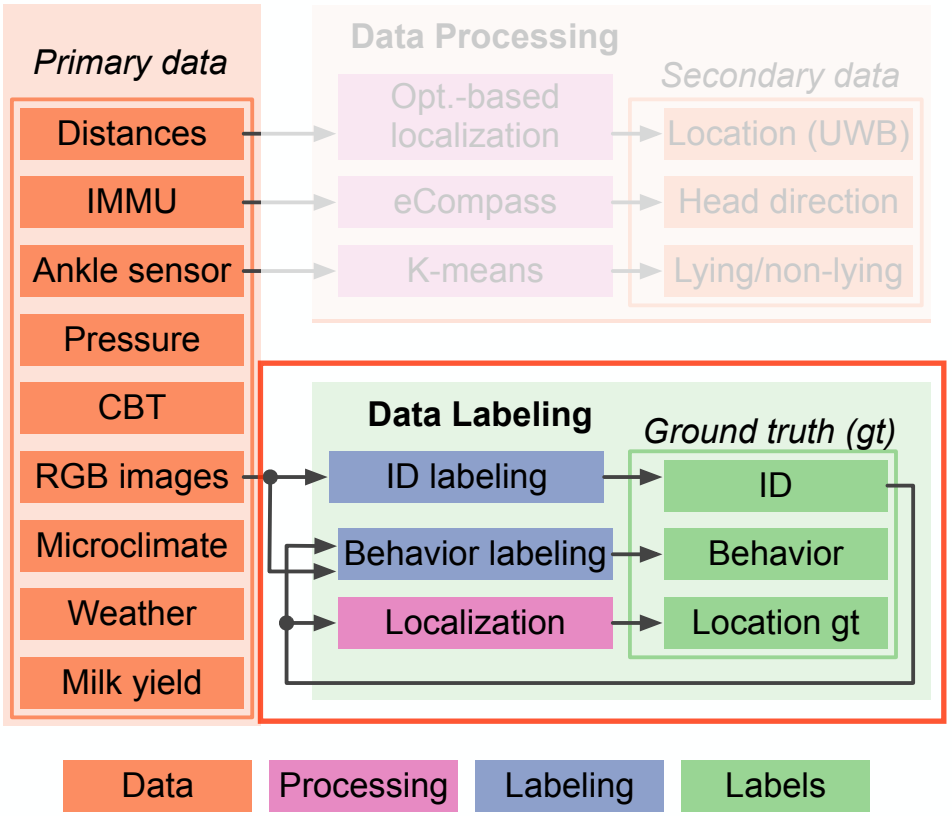



## Lying/non-lying behavior

- The gravity vector creates two clusters along the leg direction that indicate lying behavior



# Data Processing



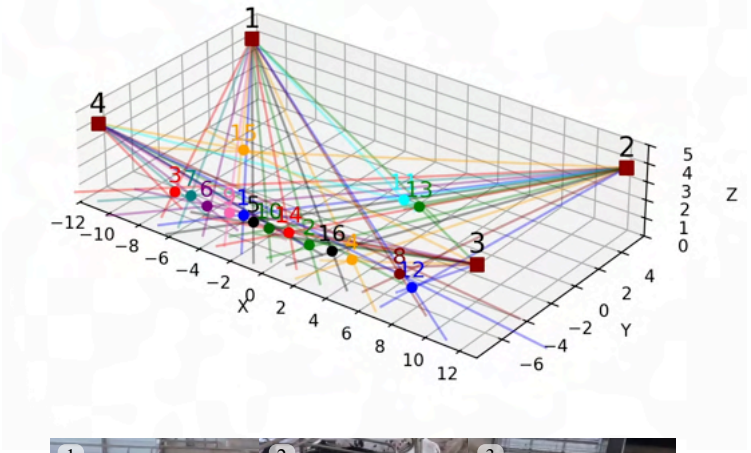

Data processing pipeline of MMCows

## Cow ID ground truth

- Synchronized views of 4 cameras
- 20,000 frames in 1 day
- 213,000 bbox of 16 cows

## Location ground truth

- Estimating the 3D body location using annotated bounding boxes across overlapping views

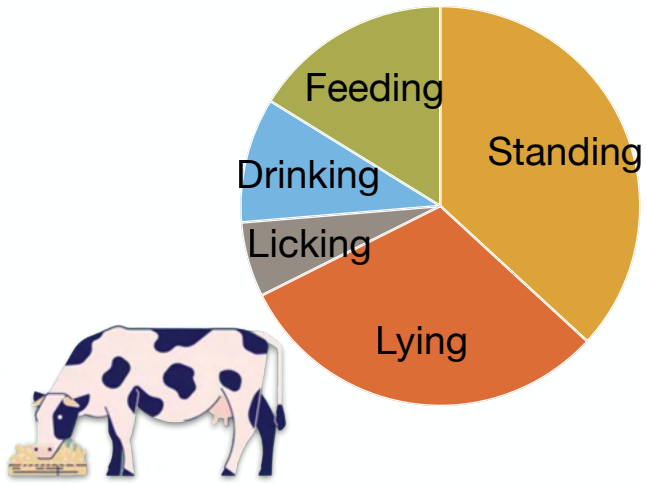


## Behavior label ground truth

- 7 common behaviors of 16 cows
- Duration of 1 day at 1-second intervals

# *Applications of MmCows*

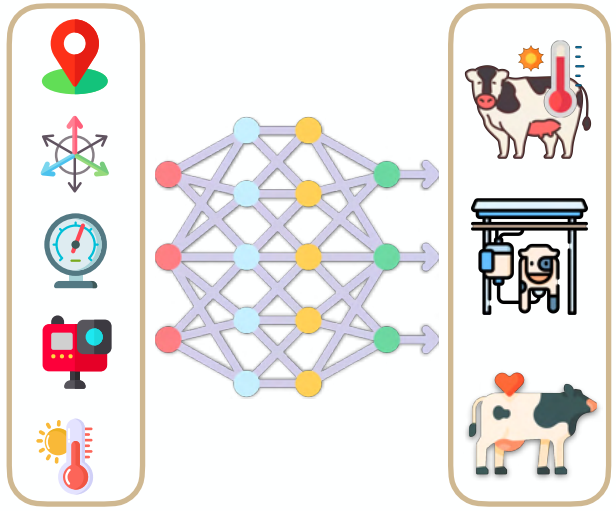
## Behavior monitoring




Monitoring cattle behaviors can help optimize barn design to reduce resource consumption

**Improving environmental sustainability**

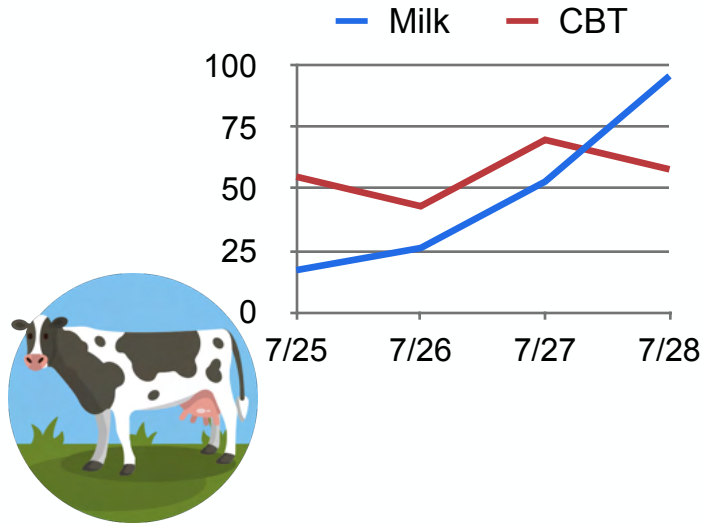
## Health issue assessment



Early detection of stress and health problems can help improve cattle well-being

**Enhancing social sustainability**

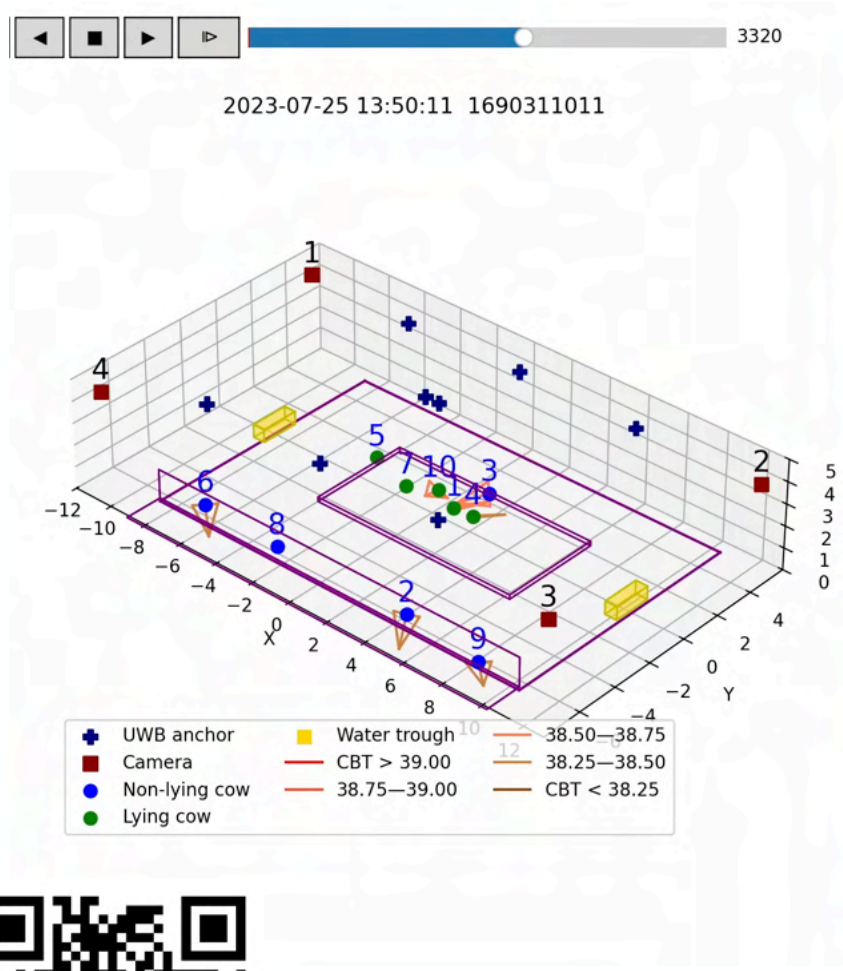
## Productivity management

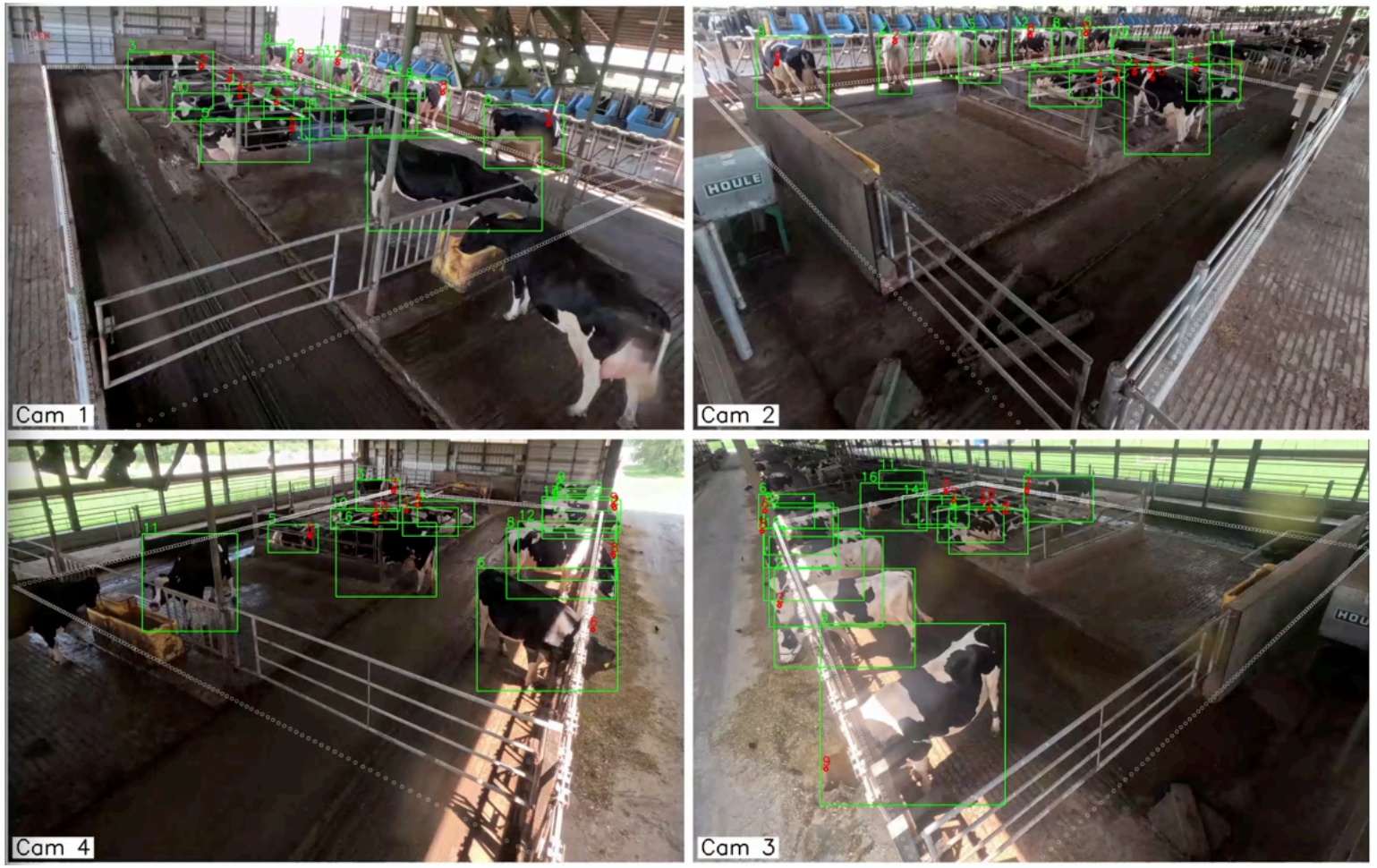



Active monitoring for productivity prediction can help maximize efficiency and increase profits

**Boosting economic sustainability**

# *MmCows Dataset*




https://github.com/neis-lab/mmcows

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