ETH zürich

Use of AI in dairy farming and research

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SVT Conference 2025

Artificial Intelligence 4 Animal Science

Home Programme Abstract submission Venue Accomodations Contacts Registration

ai4as.eaap.org

Word cloud made based on titles of the submitted abstracts

What is artificial intelligence (AI)?

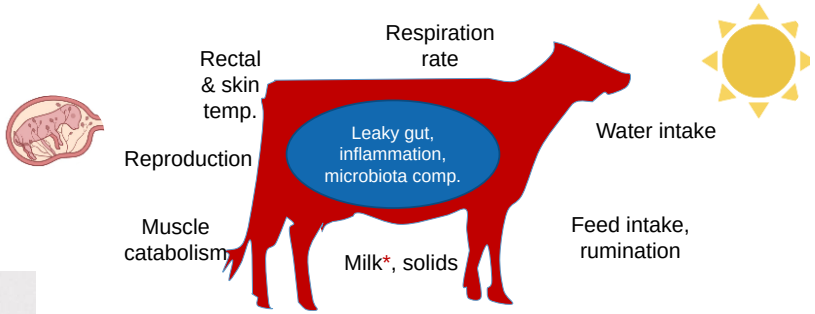
- Ability of machines or computer systems to perform tasks that typically require human intelligence, or, **the capability of machines to mimic human intelligence**.
  - Learning
  - Problem-solving
  - Decision-making
  - Pattern recognition
  - Robotics
  - Smart feeding stations
  - …

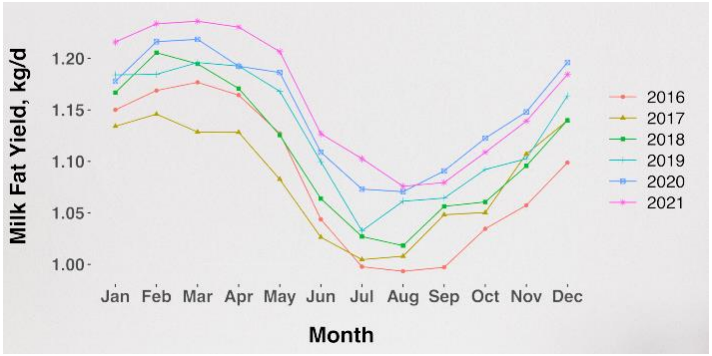
- AI research cases
- Key components for the use of AI in dairy farming

Interdisciplinary research at ETH Animal Nutrition group to improve animal welfare

Livestock

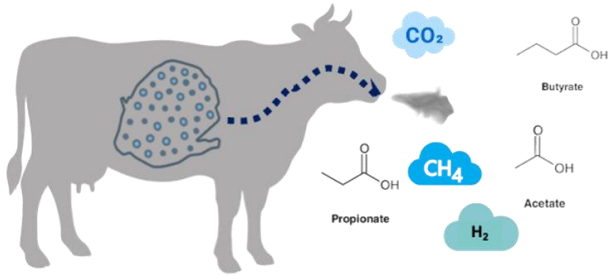
Environment





Optimizing nutrition to counteract the impact of heat stress

Better monitoring and assessment on animal behavior and welfare



Non-invasive exhalomics and breathomics approaches to reveal nutritional physiology and health

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Case #1: Prediction of respiratory rate

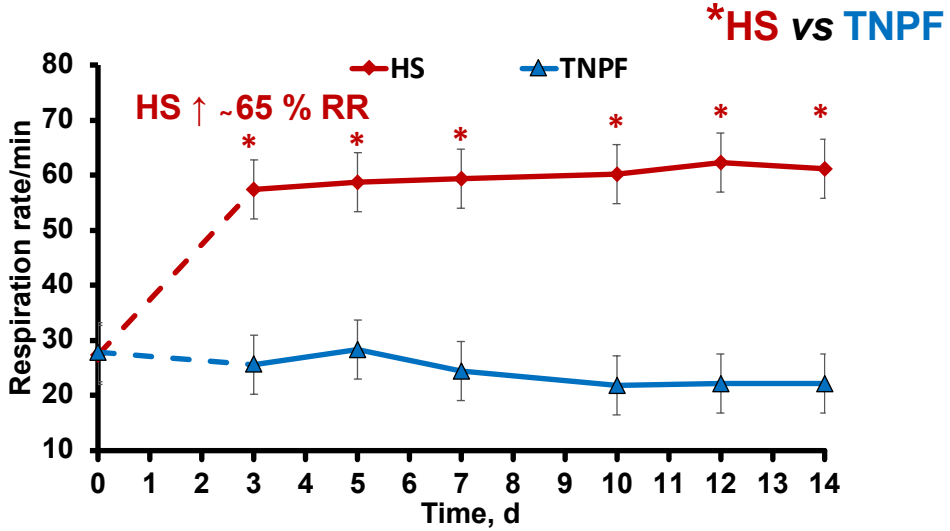
The importance of respiratory rate (RR) in health and welfare

Respiratory diseases

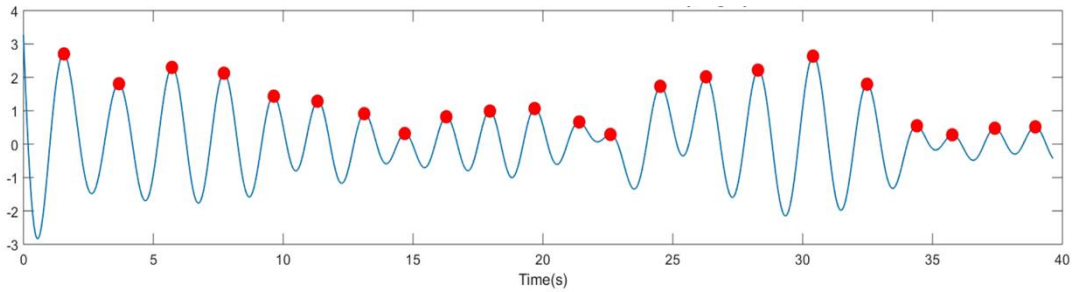
- Mainly affect young animals
- Reduce growth, risk of mortality

Heat stress

- Change of animal behavior
- Reduce feed intake and milk production, increase water intake…



Measurement of RR



(Wang et al., 2024)

Traditional approaches RR measurement

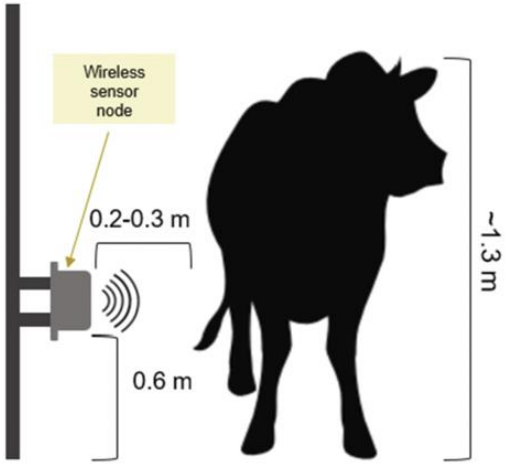
Labor-intensive

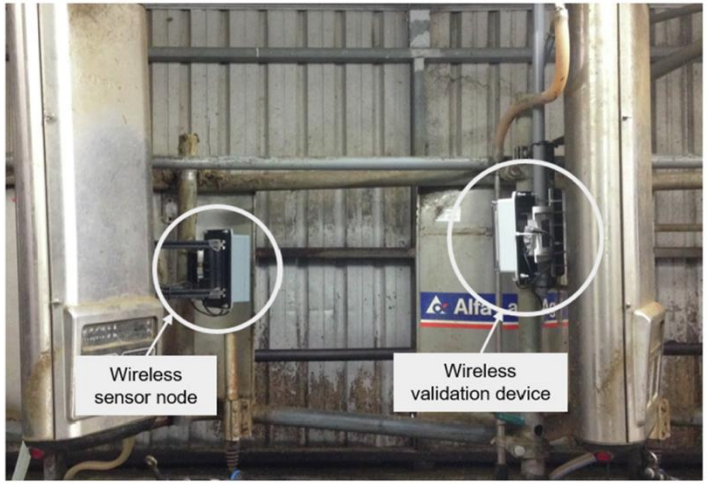
Not applicable to large number of animals

Other approaches?

(Wang et al., 2024)

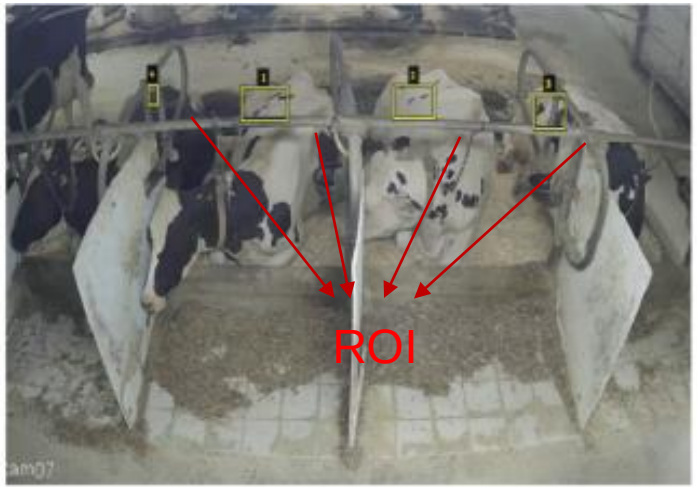
Recent developed alternative methods to measure RR





Radar-based system

Signal of interest can be disturbed



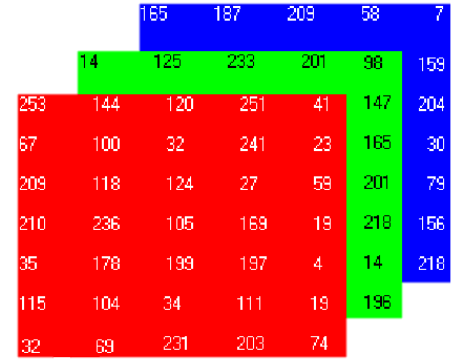
Camera-based system

Manual selection of short videos of the Region of Interest (ROI)

Objective: to develop an end-to-end model to predict RR of cows using RGB videos without manual selection of ROI.

(Tuan et al., 2022; Mantovani et al., 2023)

Respiratory patterns



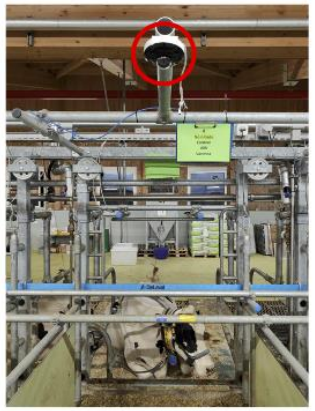
- Respiratory patterns are visible in RGB videos.

(Wu et al., 2012)

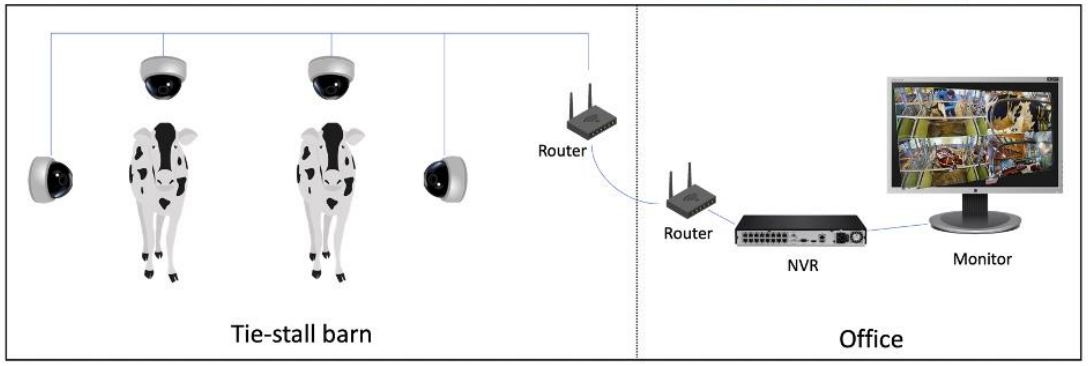
Experiment: data collection in the tie-stall barn

(a)

(b)



(c)

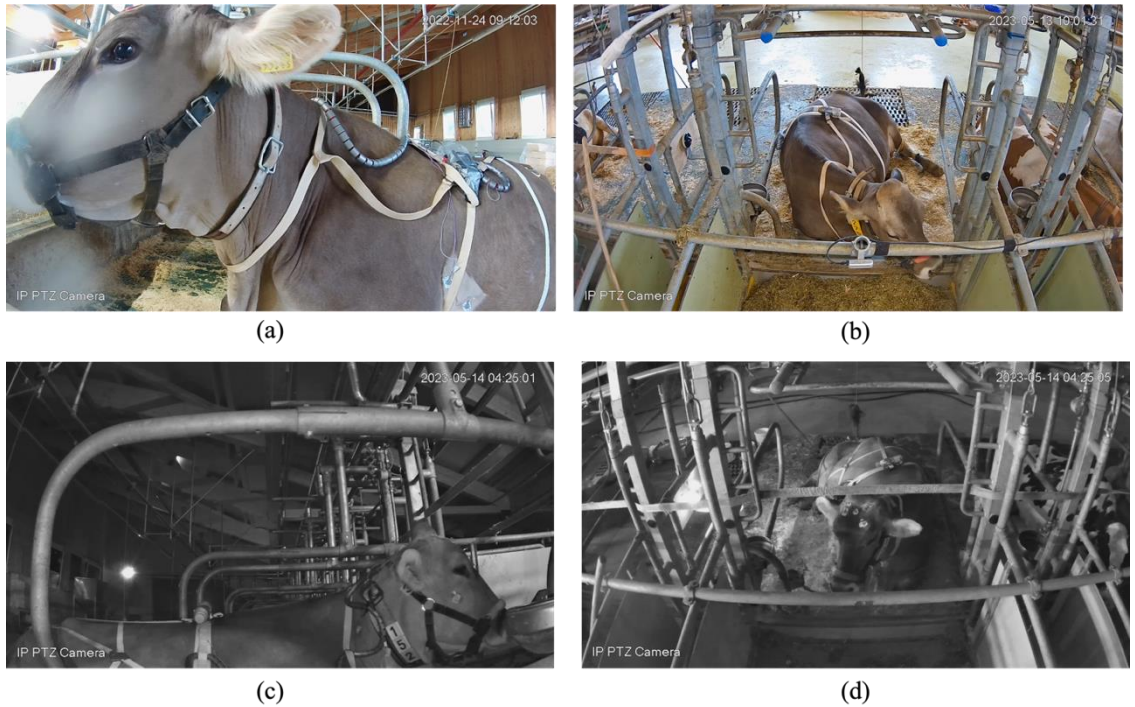


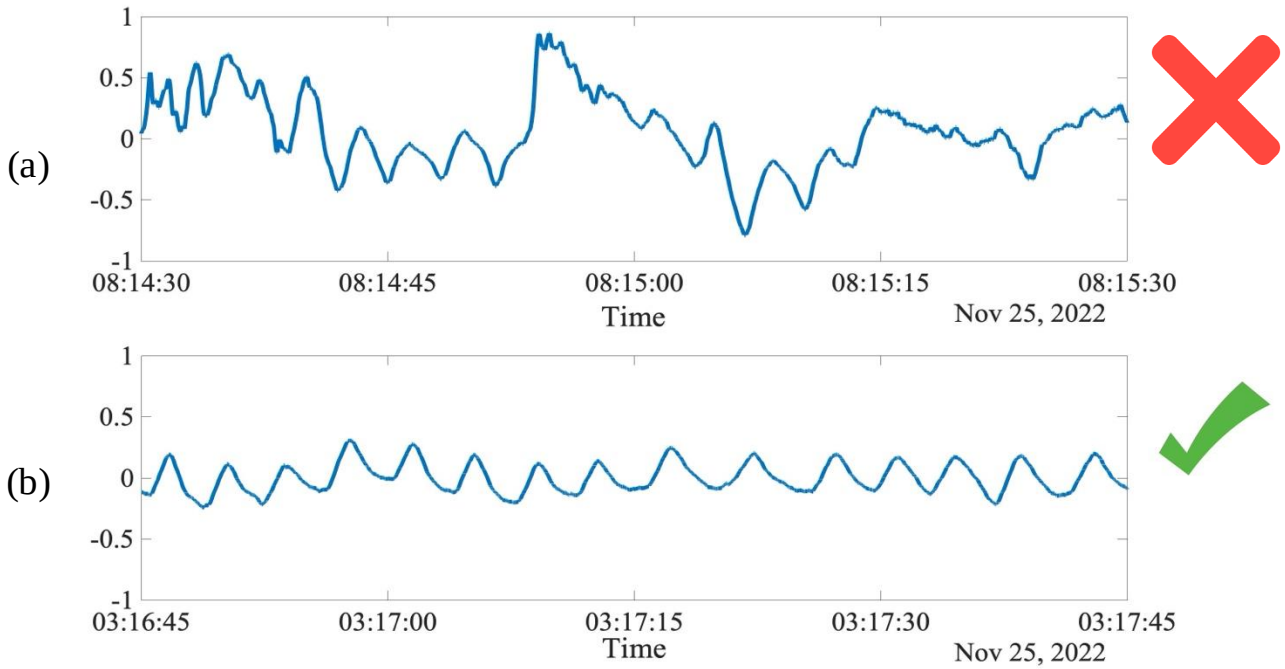
Gold standard:Embla
XactTrace Respiration Belt

- Video recording: 2 RGB cameras for each cow, 6 cows, 24 hours

(Wang et al., 2024)

Data selection





Video slected from top and side views, day and night

Video seclection: 18 videos (18 min 11s ± 13 min 44s)

Gold standard when the cow is:
(a) significantly moving; (b) the cow is resting

The cow is in resting status with minimal movement

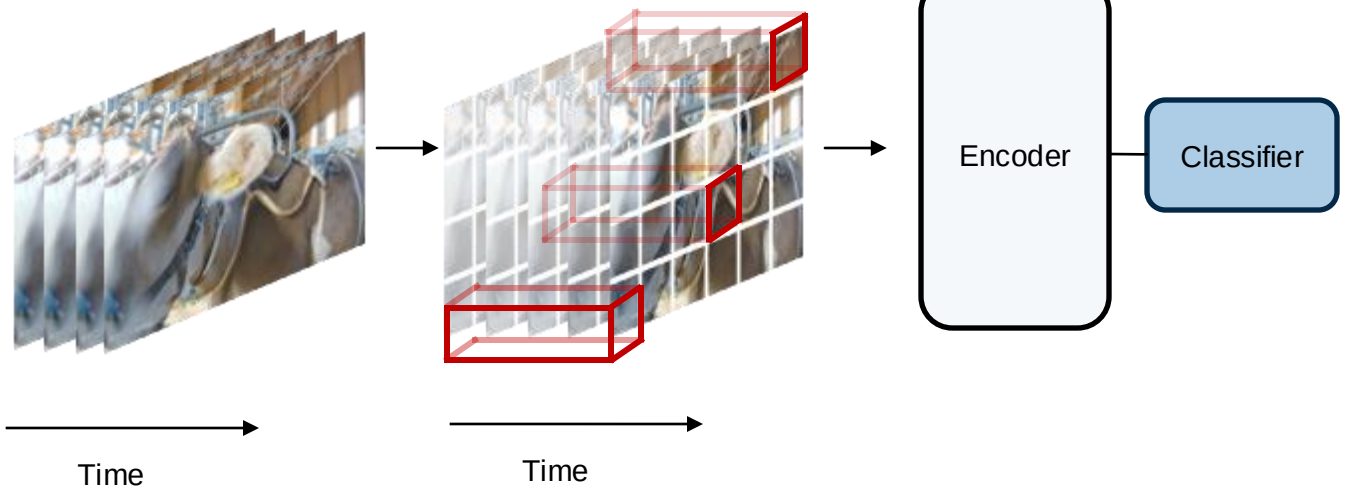
(Wang et al., 2024)

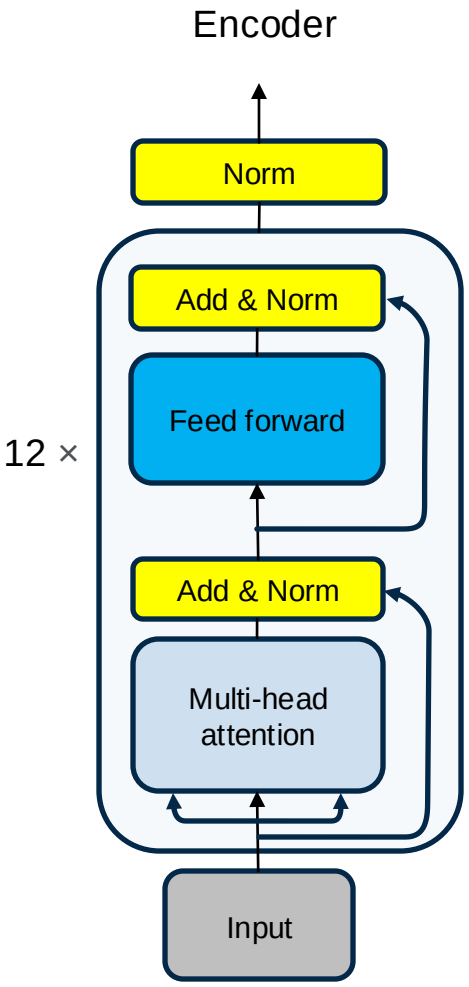
Development of the end-to-end method

Training: data from 4 cows

Validation: data from 1 cow

Test: data from 1 cow

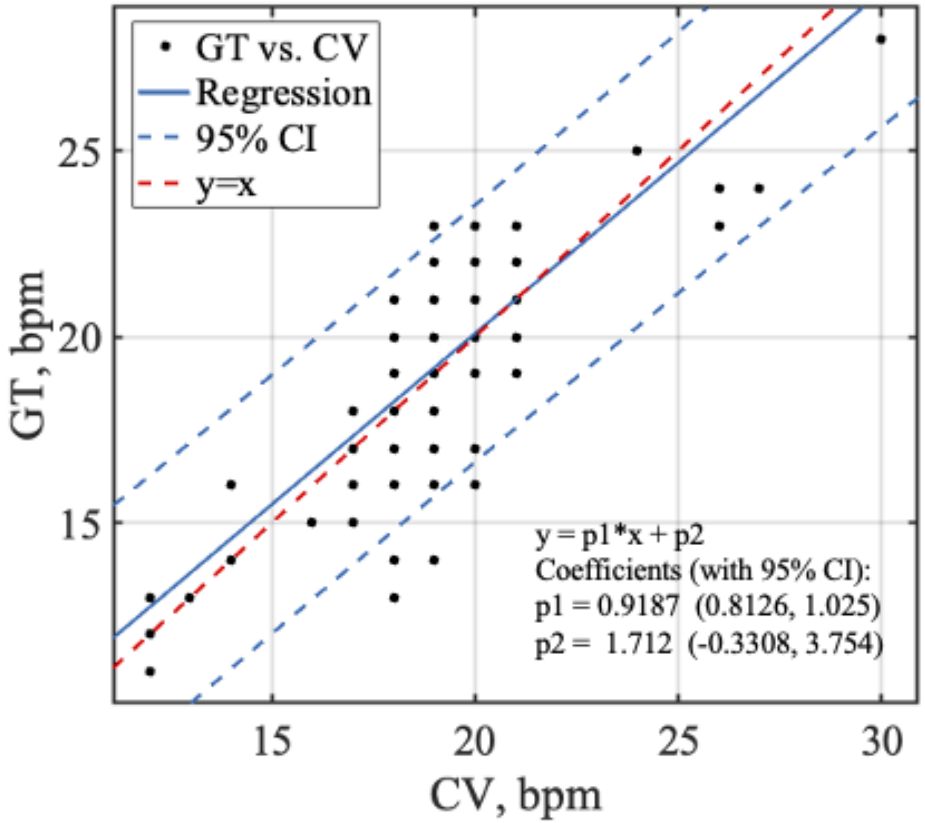


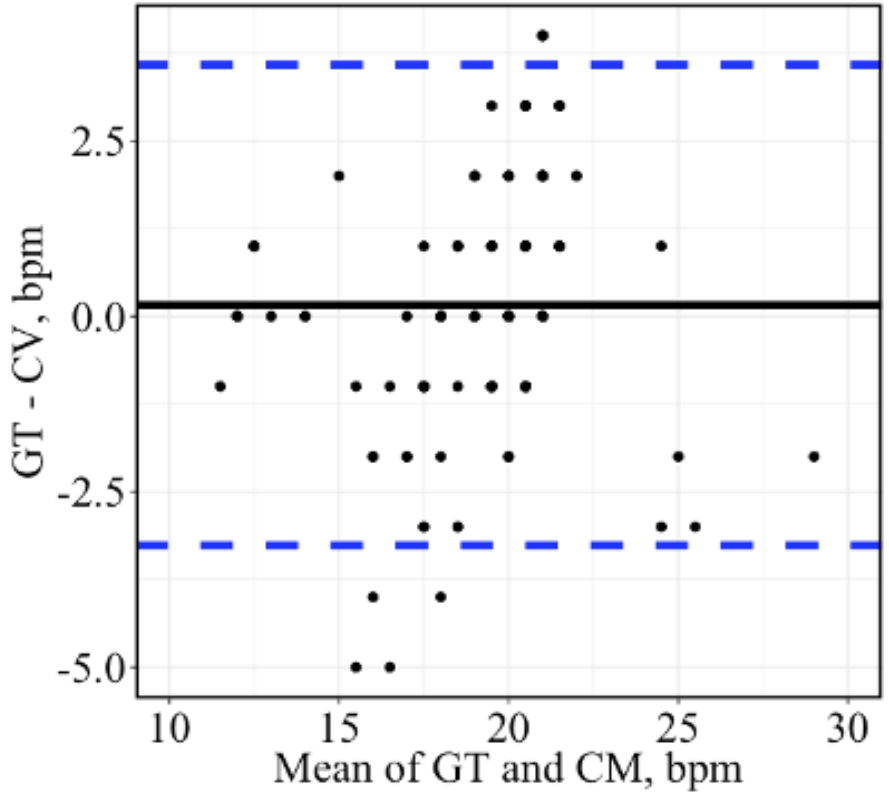


Transformer model: VIdeoMAE

(Tong et a., 2022; Wang et al., 2024)

Results – on test set



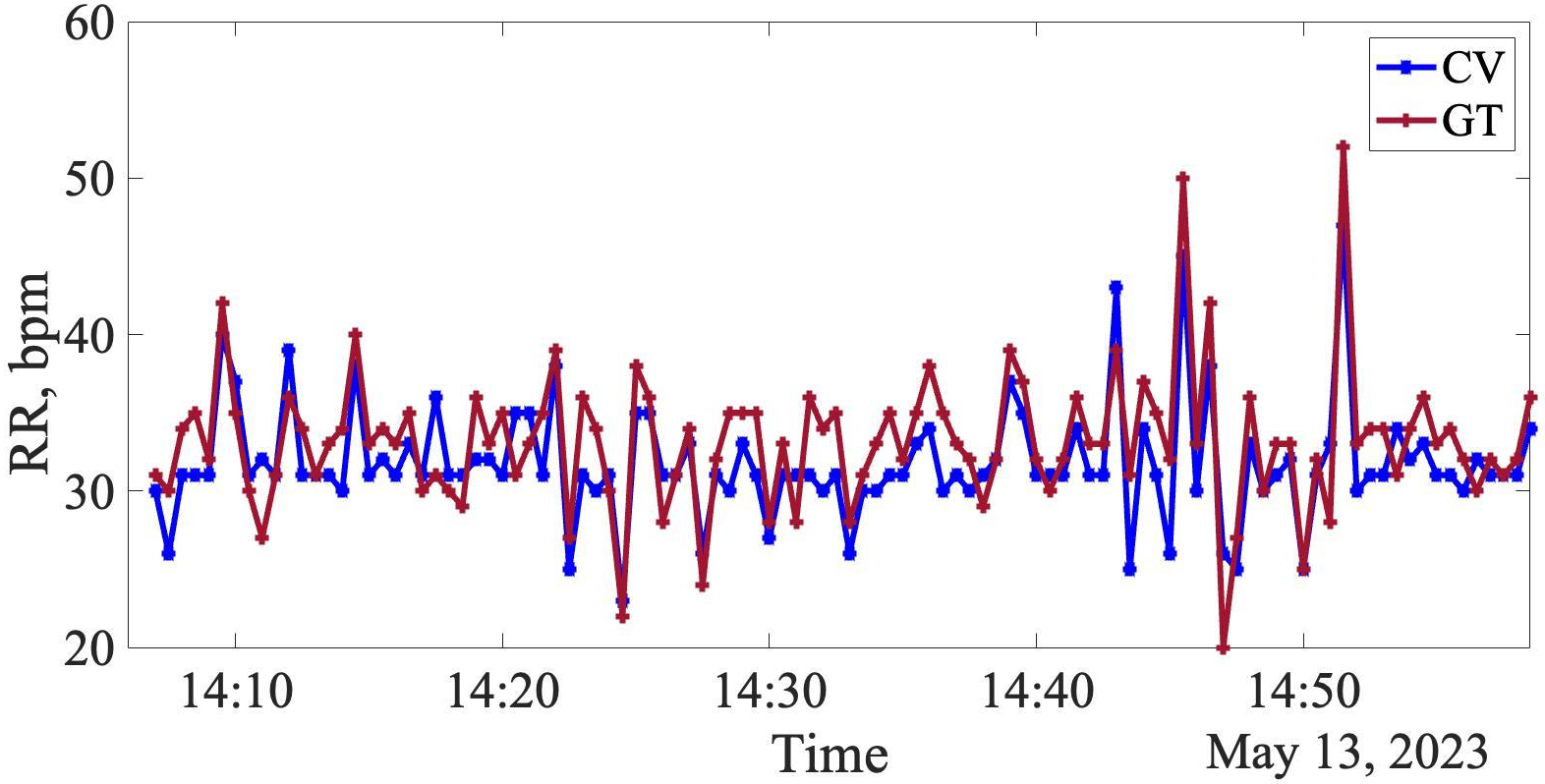


Mean absolute error (MAE): 2.58 breaths/minute (bmp)
Root mean square error (RMSE): 3.52 bpm

Root mean squared prediction error: 15.03%
Pearson correlation: 0.86

(Wang et al., 2024)

Results – on a long video



Mean absolute error (MAE): 2.49 breaths/minute (bmp)
Root mean square error (RMSE): 2.91 bpm

Root mean squared prediction error: 8.78%
Pearson correlation: 0.74

(Wang et al., 2024)

Case #2: Continuous tracking of dairy cows

Video-based tracking – A prerequisite for further applications?

- **Identification** at time t
- **Position** at time t
- **Trajectory** during Δt

Also called: **M**ultiple **O**bject **T**racking **(MOT)**

- Behavioural analyses
- Early detection of health problems
- Early detection of management problems

(Wang et al., submitted)

Knowledge gaps and objectives in objective tracking

Knowledge gaps

- **Reappearing** animals are subject to misidentification.
- Poor performance on **long videos (≥ 30 minutes), night?**

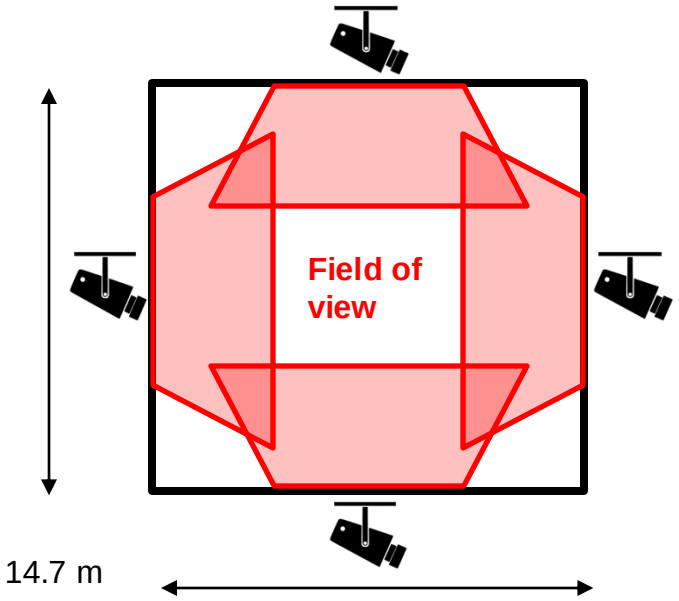
Objectives

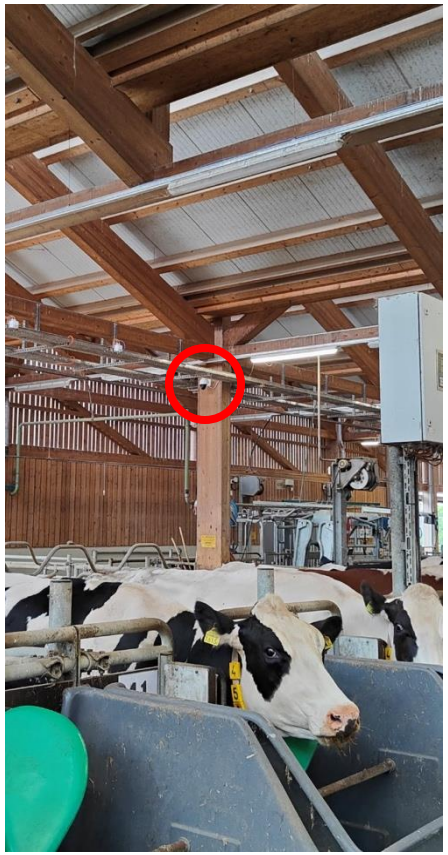
1) Provide the correct identification (ID) to **reappearing animals**.
2) Evaluate **performance** compared to established tracking algorithms.

(Wang et al., submitted)

Data collection set-up

- **13 dairy cows**
  - 7 Holstein, 6 Red Holstein
- **Continuous recording**
  (August – September 2023)
- **4 camera angles**, 15fps, 2560 x 1440





(Wang et al., submitted)

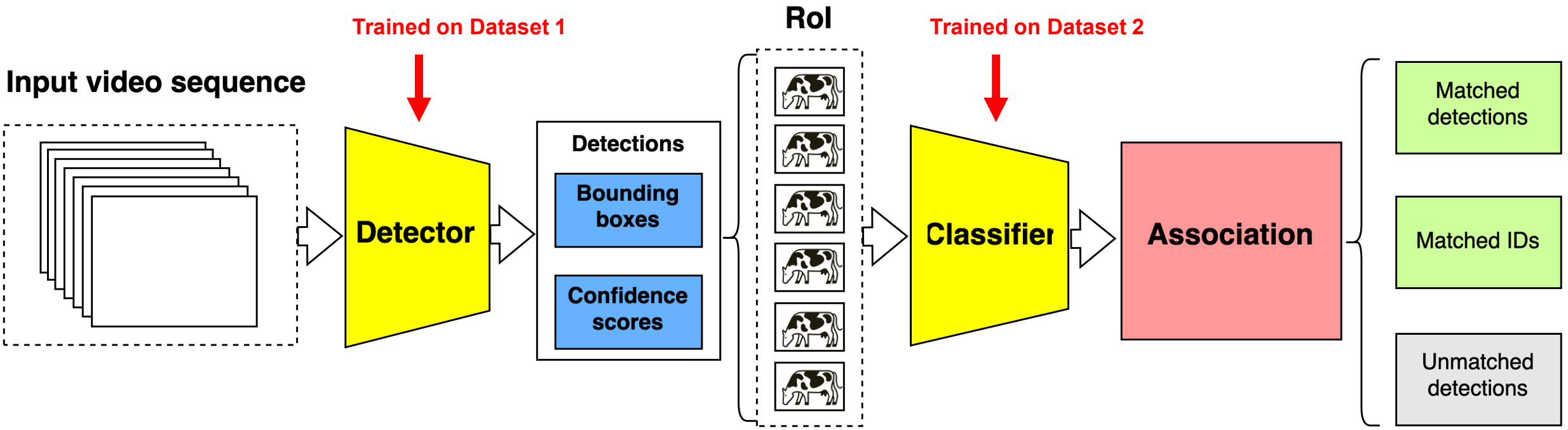
Tracking approach

Object detector	• Goal: Recognise and localise cows in frame • Model: YOLOv8 • Trained on: **Dataset (1)**
Image classifier	• Goal: Generate classification probabilities • Model: YOLOv8 Classify • Trained on: **Dataset (2)**
Association	• Two rounds of Hungarian matching with thresholds (Kuhn, 1955)

YOLOv8 model: https://github.com/ultralytics/ultralytics

(Wang et al., submitted)

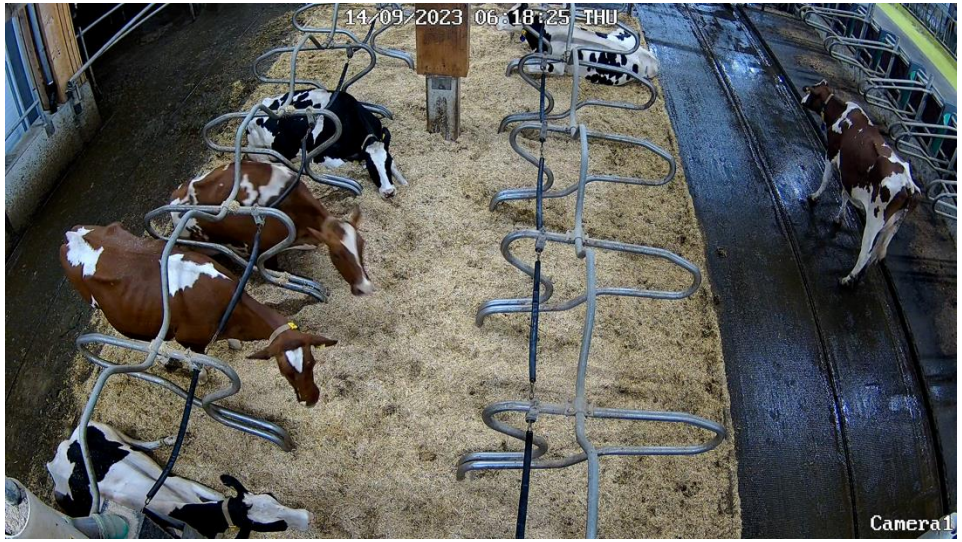
Tracking approach



Scheme of the proposed model

(Wang et al., submitted)

Input – Output



(Wang et al., submitted)

Datasets for training and testing

Dataset (1): Object detector

	# Frames	# Instances
Training	672	3,830
Validation	333	2,256
Total	1,005	6,086

Dataset (2): Image classifier

	# Instances	# Classes
Training	6,139	13
Validation	1,750	13
Total	7,889	13

Dataset (3): Test videos for tracking

# Video	# Camera	Duration (hh:mm:ss)	Time	# Animals	# Reappearances	Start time
1	1	00:05:00	Day	13	0	17:55:26
2	2	00:05:00	Night	10	4	04:11:36
3	2	00:30:01	Day	11	12	14:48:55
4	1	00:30:00	Night	11	10	20:18:36
5	2	01:00:01	Day	11	29	13:29:37
6	1	01:00:01	Night	13	32	01:19:36

(Wang et al., submitted)

Proposed method performs better in case of reappearances

Method				SORT			DeepSORT			Developed method		
Video	**Time**	**#Animal**	**#Reap.***	**MOTA↑****	**IDF1↑**	**HOTA↑**	**MOTA↑**	**IDF1↑**	**HOTA↑**	**MOTA↑**	**IDF1↑**	**HOTA↑**
Test 1	Day	13	0	0.7180	0.8114	0.7972	**0.8810**	0.8447	0.8747	0.8702	**0.9305**	**0.9158**
Test 2	Night	10	4	0.8586	0.9233	0.8924	0.9352	0.9653	0.9632	**0.9434**	**0.9712**	**0.9686**
Test 3	Day	11	12	0.9180	0.8126	0.8349	0.9752	0.7887	0.8463	**0.9771**	**0.9883**	**0.9828**
Test 4	Night	11	10	0.7367	0.7396	0.7533	0.7607	0.7937	0.8103	**0.7725**	**0.8918**	**0.8701**
Test 5	Day	11	29	0.7846	0.7276	0.7161	**0.9432**	0.6875	0.7425	0.9381	**0.9666**	**0.9421**
Test 6	Night	13	32	0.7719	0.5496	0.6164	**0.8900**	0.5117	0.6293	0.8635	**0.9261**	**0.8925**

Bold values are the highest for each video.
* number of reappearances
** ↑ means the higher the better

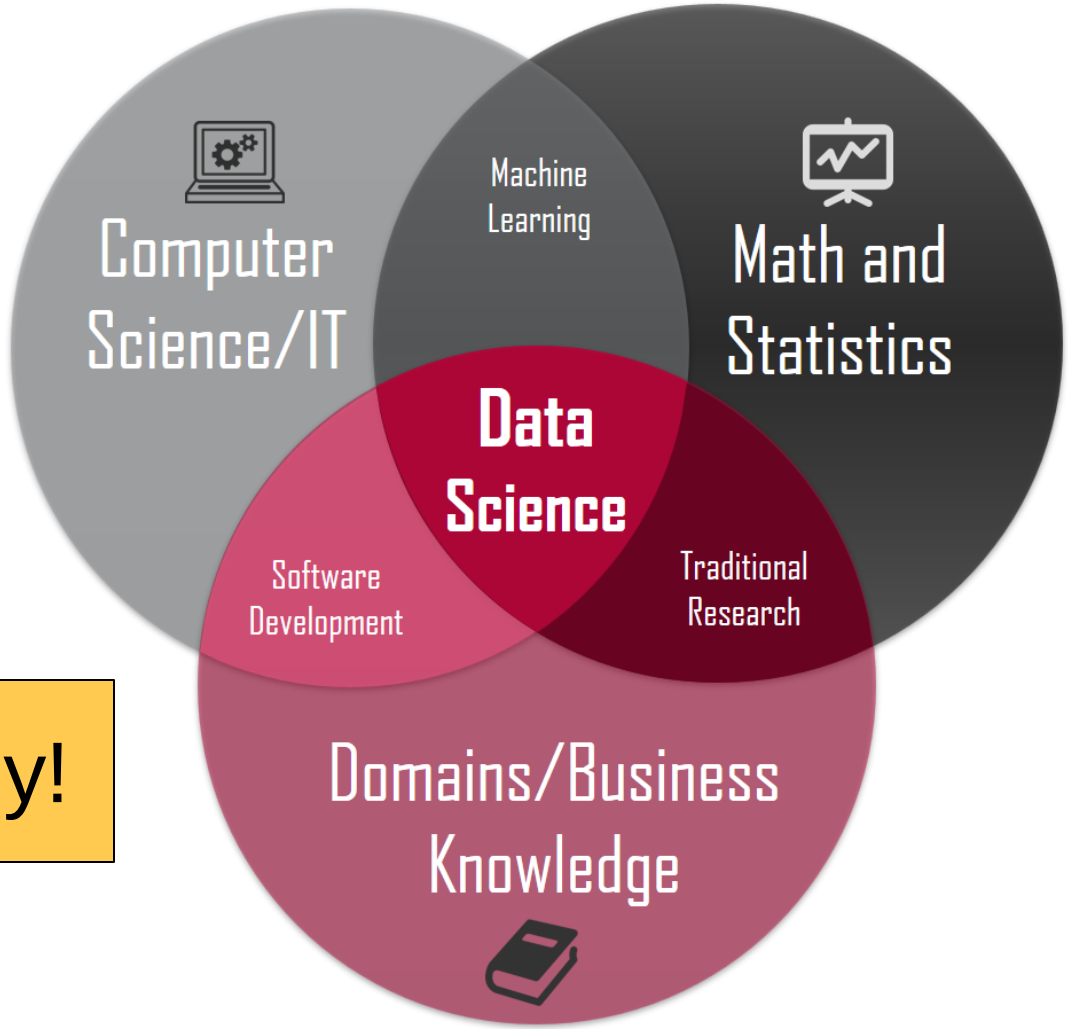
- **MOTA**: Matching at the detection level.
- **IDF1**: Matching at the trajectory level.
- **HOTA**: Balanced indicator for detection and association accuracy.

- The developed method showed promising performance, especially on videos with long duration and more times of re-entering the FOV.
- the proposed method showed significant improvements in long videos.

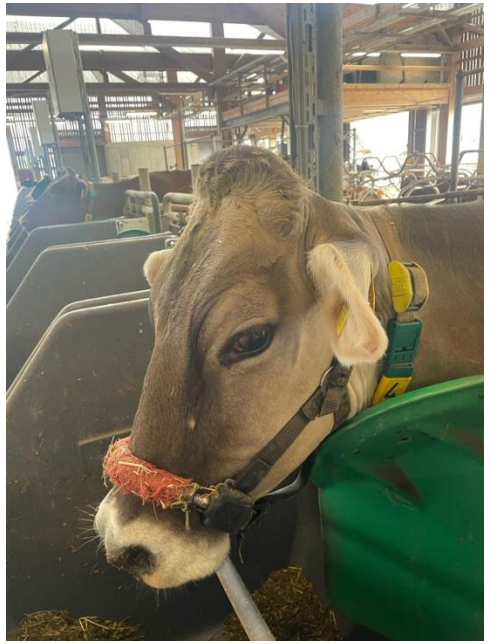
(Wang et al., submitted)

Take home message

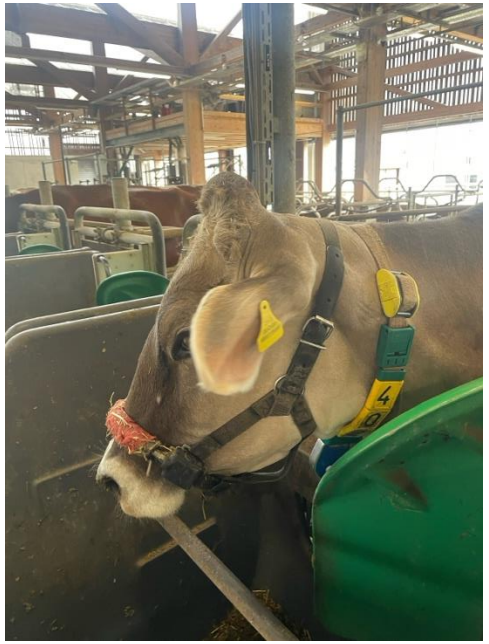
- **Having a clear objective!**
- **Final adequate methods to apply!**
- **Have/collect good quality data!**

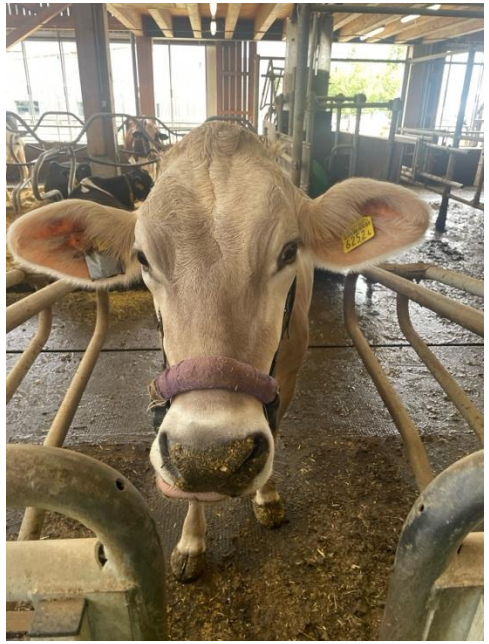
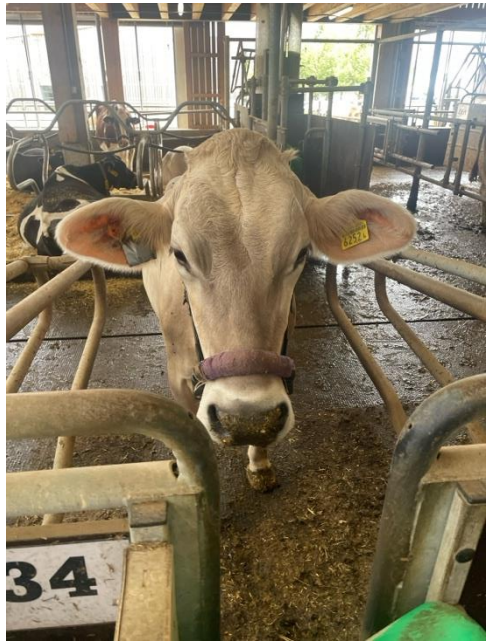


Data and data integation is key!



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Data Sources

- Herd management software
- IoT devices and sensors
- Feed management systems
- Genetic evaluation systems
- Milk analysis labs and diagnostics
- Environmental monitoring systems
- Manual records

Data Collection

- Aplication Programming Interfaces (APIs)
- Edge devices
- Cloud Solutions
- Manual upload

Data Integration

- Centralized data hub
- Data decoded
- Data cleaned
- Data homogenized
- Data standarized
- Data aggregated

Data Processing and Analysis

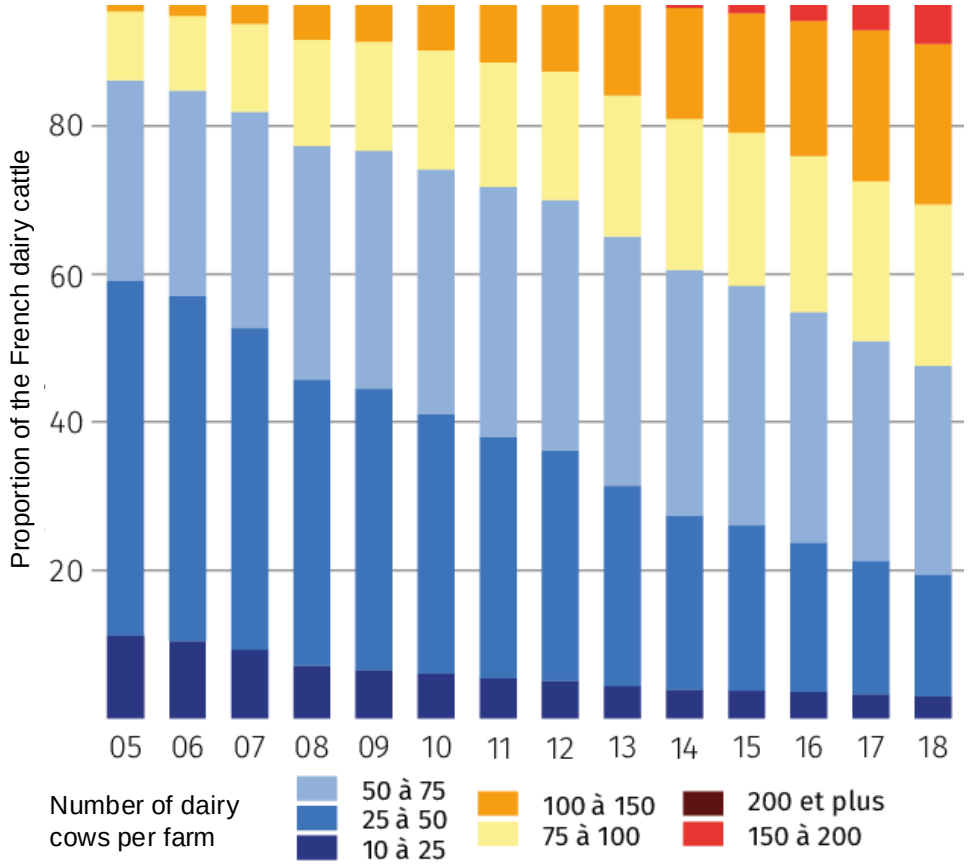
- Descriptive analytics
- Predictive analytics
- Prescriptive analytics
- Statistical tools for pattern identification
- Machine Learning and Artificial Intelligence

Decision Support Tools

- Actionable insights
- Health monitoring
- Reproductive management
- Feed management
- Sustainability measures

(Cabrera et al., 2025)

Ongoing intensification in the dairy sector



Change in the distribution of dairy cows by farm size in France, from 2005 to 2018 (Forget et al. 2019).

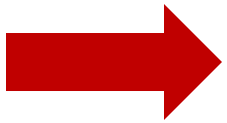
Country	2002	2006	2010	2014	2018	Increase since 2010 (%)
Denmark	2.2	8	22.5	24	22	–2
The Netherlands	2	4	11	18	23	109
Germany	~0	0.5	2	6.5	15	650
Norway	~0	1	6.5	13.5	23	254
Sweden	1	5	13	23	30	131
Canada	~0	0.5	2	5	11.5	475

Sources: Barkema et al. (2015), Hansen (2015), Tse et al. (2017), CDIC (2019), and Vik et al. (2019).

Percentage of dairy farms with AMS in selected countries (Eastwood and Renwick, 2020).

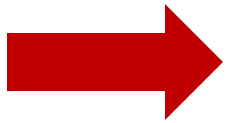
Localized AI tools for future dairy farming?

- Learning
- Problem-solving
- Decision-making
- Pattern recognition



Data-Driven Intelligence

- Precision nutrition and feed management
- Disease detection and health monitoring
- Productivity and reproduction optimization
- Sustainability and resource efficiency
- Robotics and intelligent systems



Objective-driven AI applications

Thank you!

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