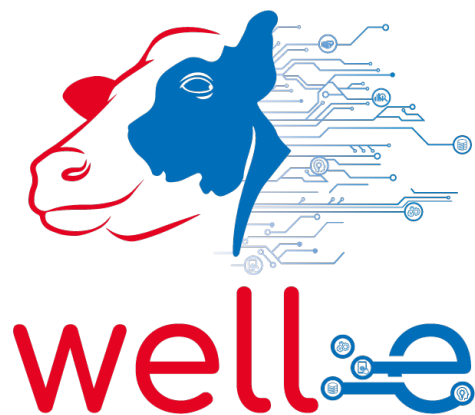




# The **WELL-E Project: Focussing on the cow's experience leveraging AI and IoT**

## Towards an understanding of emotional states for the development of new knowledge on the mental welfare of animals



Nadège Aigueperse<sup>1,4</sup>, Marjorie Cellier<sup>2,4</sup>, Abdoulaye Baniré Diallo<sup>3,4</sup> & Elsa Vasseur<sup>2,4</sup>

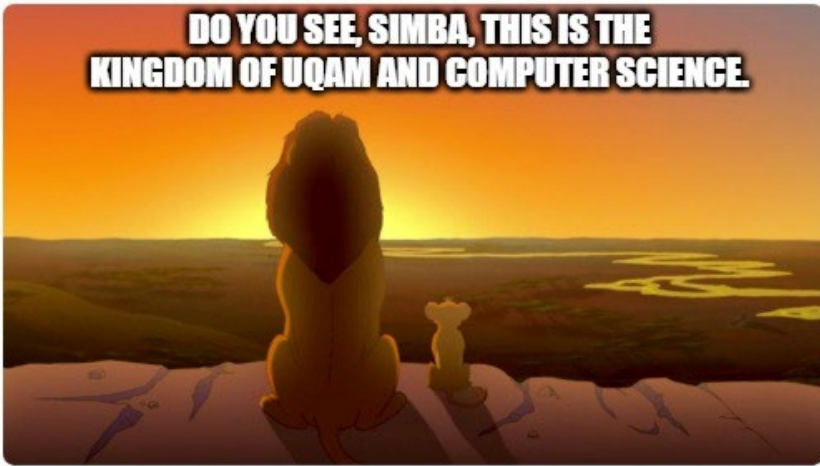
<sup>1</sup> Université Clermont Auvergne, INRAE, VetAgro Sup, UMR Herbivores, F-63122 Saint Genès-Champanelle, France

<sup>2</sup> Department of Animal Science, McGill University, Sainte-Anne-de-Bellevue, Québec, Canada, H9X 3V9

<sup>3</sup> Département des sciences informatiques, Université du Québec à Montréal, Montréal, Québec, Canada, H3C 3P8

<sup>4</sup> Research and Innovation Chair in Animal Welfare and Artificial Intelligence (WELL-E) [www.well-e.org](http://www.well-e.org)

**DO YOU SEE, SIMBA, THIS IS THE  
KINGDOM OF UQAM AND COMPUTER SCIENCE.**



**EVEN THE  
SHADOW THERE?**



**NO! THAT'S  
ANIMAL SCIENCE  
AT MAC  
CAMPUS, YOU MUST  
NEVER GO THERE!**



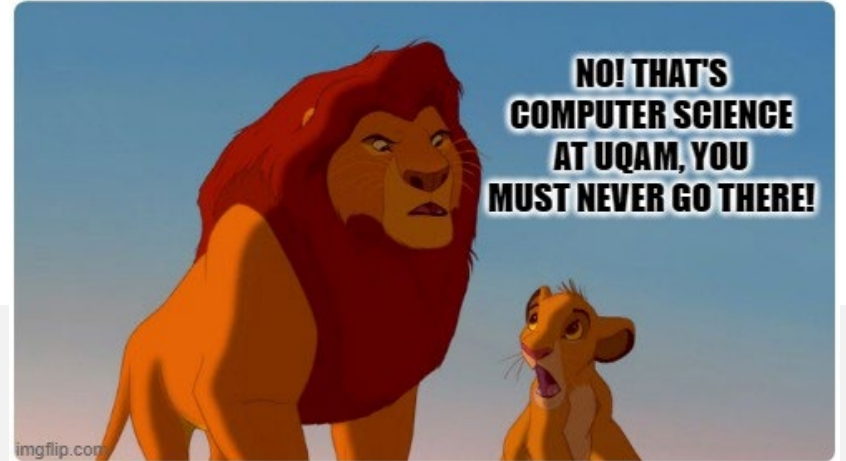
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AT UQAM, YOU  
MUST NEVER GO THERE!**





# WELL-E Genesis



Elsa Vasseur,  
McGill



Abdoulaye Baniré Diallo,  
UQAM



Elise Gosselin,  
Novalait



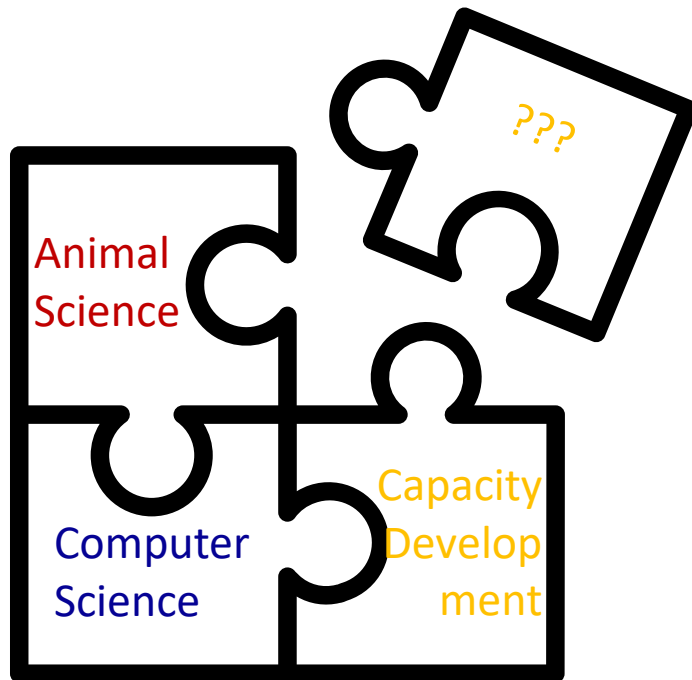
- Focus on animal behaviour and welfare
- Strong industry/stakeholder focus across dairy community
- Previous research chair in dairy welfare
  - Cow comfort, longevity, and opportunities for movement

- Focus on algorithms and methods for biological data integration and analyses
- History of interdisciplinary work and partnerships – personalized medicine, biovigilance, surveillance, dairy management

- President of Novalait – major dairy industry research group
- History of academic partnerships

- Focus on Living Lab Approach
- Co-design of research with domain experts and end-users
- Over 30 collaborators, both academic and industry
- All centered on end-user needs

# Research Areas



## Animal Science

- Use Enrichment to answer fundamental questions about the behavioural needs of dairy cows
- Opportunity for Movement
- Move from individual trials on research farms to a network of commercial farms

## Computer Science

- Big Data Management
- Cybersecurity
- Automation of measures and development of toolkits

## Interdisciplinary

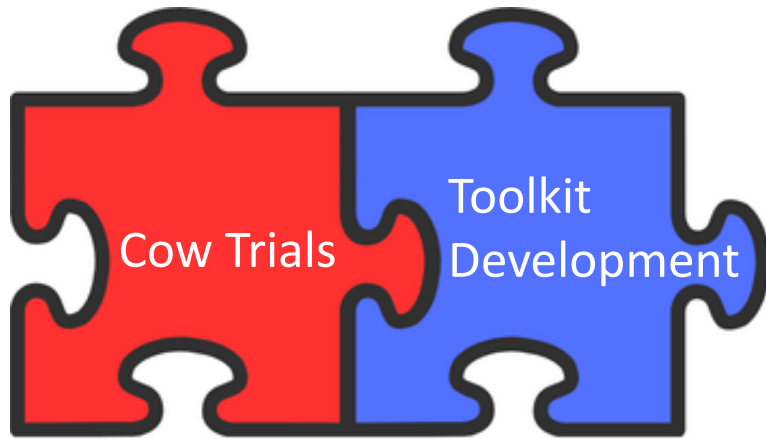
- Best ways to implement training/transitions between systems
- How do individuals learn, and how to best disseminate information

→ Projects fit together to answer multiple questions

# Research Projects

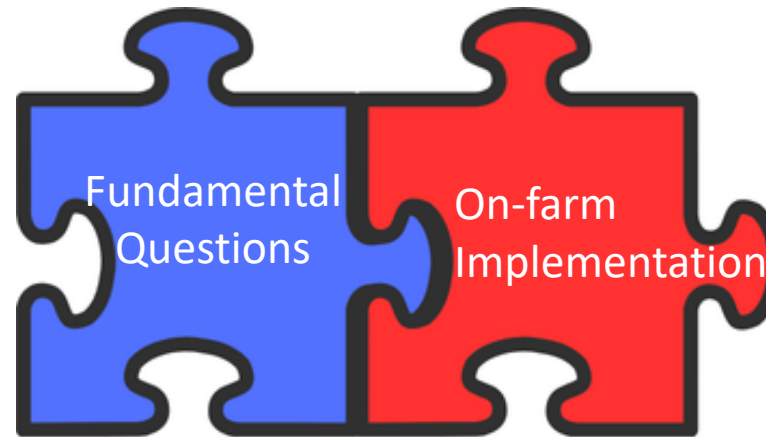


## Animal Science-led Projects



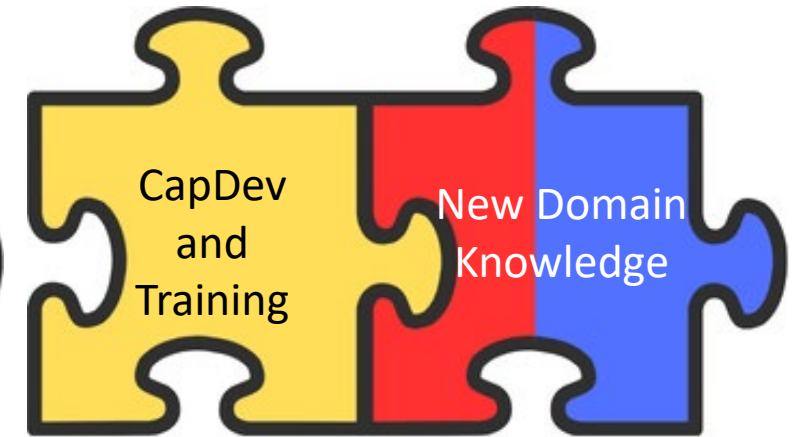
- Social Enrichment
- Environmental Enrichment
- Cognitive Enrichment
- Detection and tracking of individuals
- Automated SNA
- Acceleration of behavioural coding

## Computer Science-led Projects



- Big Data Management
- Cybersecurity and Privacy
- Large number of trials = lots of data!
- Growing network of Connected Farms

## Interdisciplinary Projects

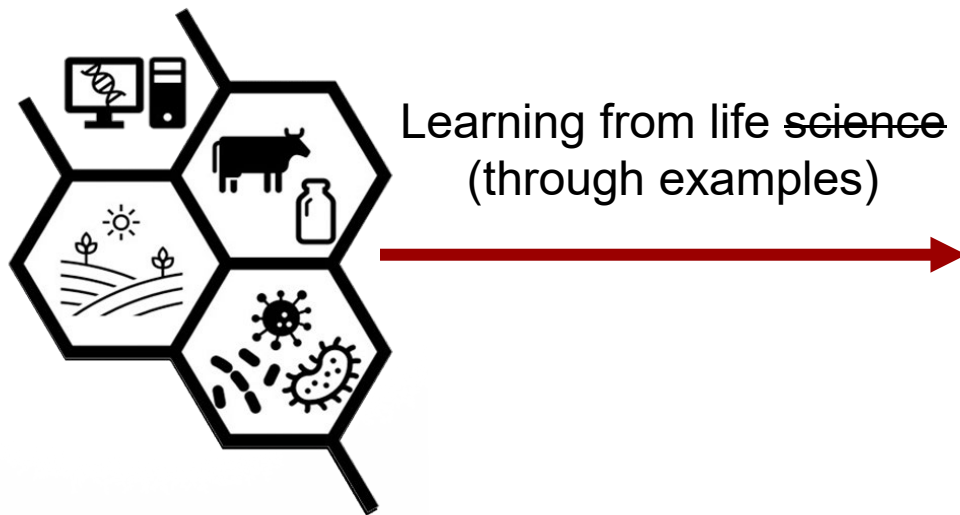


- Transition Implementation
- Training and Learning Needs
- Best practices for KTT
- Emerging Cohort of AI/Animal Science Students
- Digitalization of Dairy Farms

# What makes our work different



- Unique focus on domain expertise for better use of AI and to accelerate the development of knowledge and tools
- Include domain experts/partners in each step of research
- Co-creation of research questions, methods, and knowledge



# Animal Welfare



Adobe Firefly (Beta)  
Image Not for Commercial Use

## Physical Aspect

“ An animal’s well-being is the positive **mental and physical state** related to the **satisfaction** of its **physiological and behavioral needs and expectations**. This state varies depending on the animal's **perception** of the situation ”

Anses (Agence nationale (française) de sécurité sanitaire de l'alimentation, de l'environnement et du travail), 2018



Adobe Firefly (Beta)  
Image Not for Commercial Use

## Mental Aspect



# Introducing the concept of the provision of movement opportunity for the improvement of animal welfare



Physical Aspect



Movement Opportunity



# Changes to the Code of Practice – **movement opportunity in practice?**



- Requirements of the new Code:
  - For tie stalls:
    1. Beginning April 2027: cows must **no longer be tethered continuously** throughout their production cycle (from calving to calving): they must be provided with sufficient regular **opportunities for freedom of movement to promote good welfare.**
    2. **Newly constructed stables** must allow daily, **untethered freedom of movement** and **social interactions year-round.**
  - Calves can only be tethered if they are housed in hutches and must be provided with access to an area outside the hutch

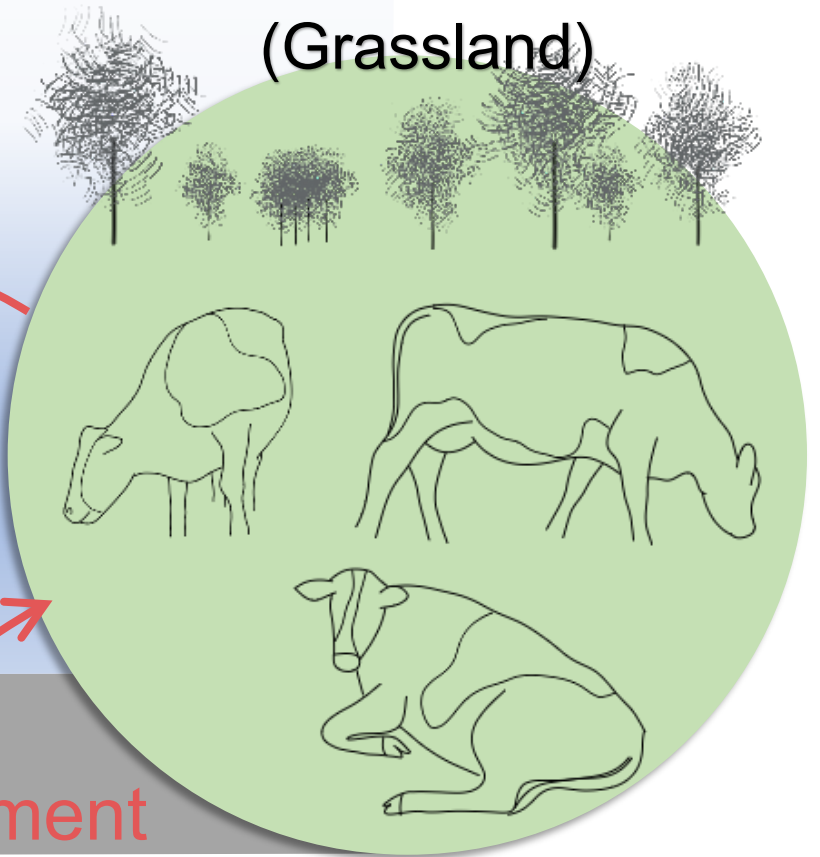
# In summary, make sure cows age well by removing the risk factors for poor longevity in the cow's environment:



Intensive Livestock Farming

Confinement and restriction of movement

Natural habitat  
(Grassland)



Increased opportunity of movement

# Introducing the concept of emotional states for a better compréhension of the global experience of the cow



Physical Aspect



Courtesy of Vasseur's lab

Movement Opportunity



Mental Aspect



# Emotional States – Global Experience



Anticipation



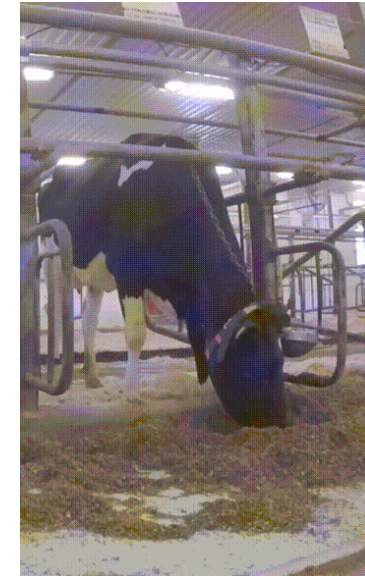
Motivation



Use of exercise yard



Frustration/Satisfaction





# Emotional States – Global Experience



Nadège Aigueperse

**INRAE**

 VetAgro Sup

Anticipation



Motivation



Use of exercise yard



Frustration/Satisfaction



Case Study: Motivation to have access to an outdoor exercise area



# Impact of manipulation on motivation to go out




3 independant trials  
(2019):



Variables:  (locomotor behaviours by cows)

3 levels of human intervention during handling:



 (trip duration: Differences between **Go-out** and **Go-in** trips)

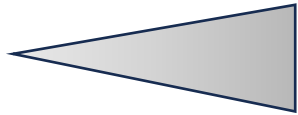


# Assessment of trips on the way out (Go-out) and back to the barn (Go-in)



Component 1

Speed & Running

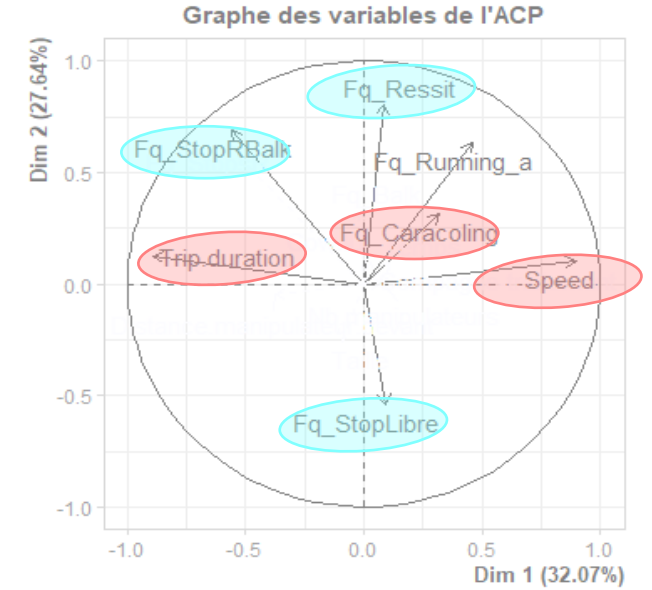
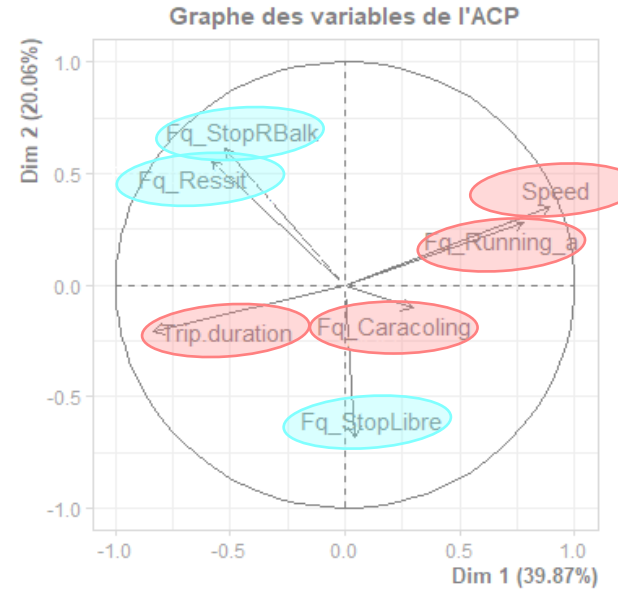
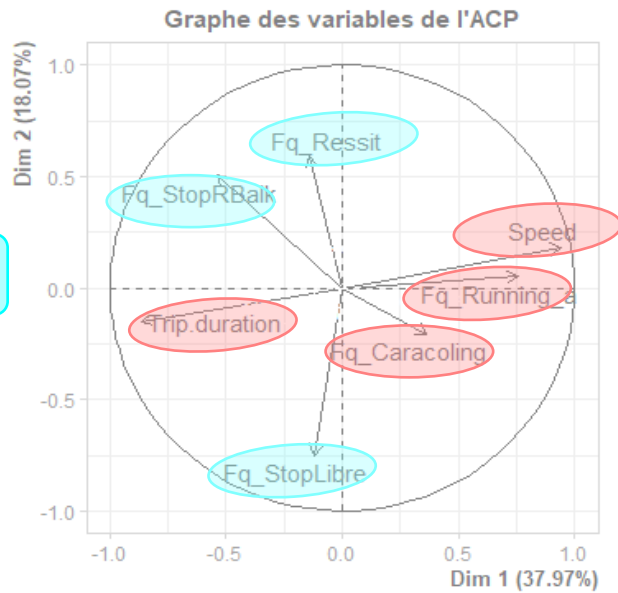
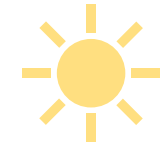


Component 2

Negative interactions



Neutral



# Integrating new technologies: towards the mental health of cows

Increase quantity and quality of analyses to enable more precise understanding of cattle emotions and states



Physical Aspect

Physical integrity

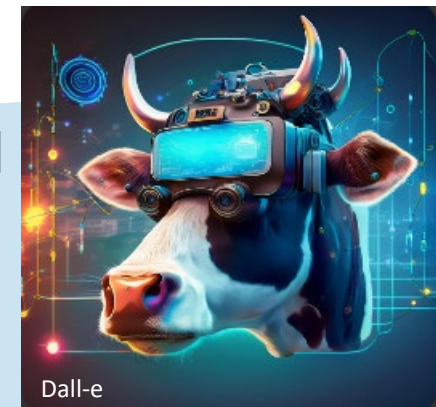
Movement opportunities



Mental Aspect

Handling

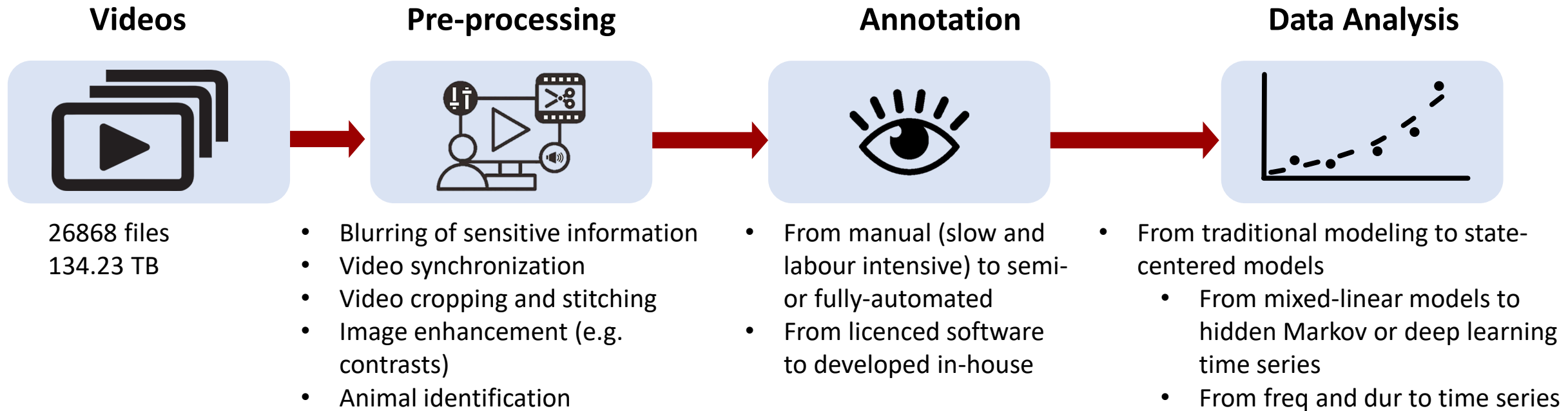
Emotional States



Dall-e

# From Behavioral Videos to Animal Science Results

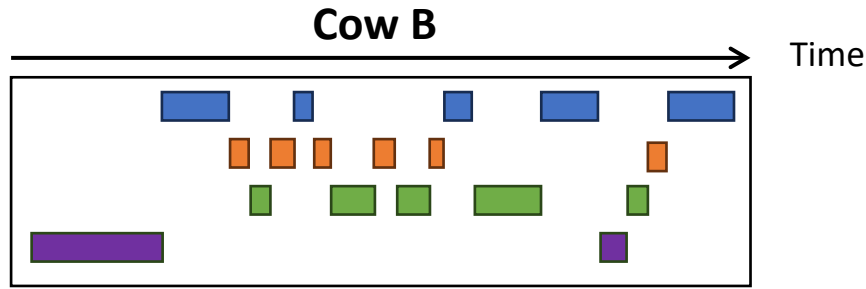
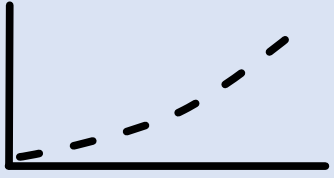
Technologies can be applied at multiple stages of research



**Will impact scale and number of animal science trials, as well as the types of analyses that can be completed and questions that can be answered**

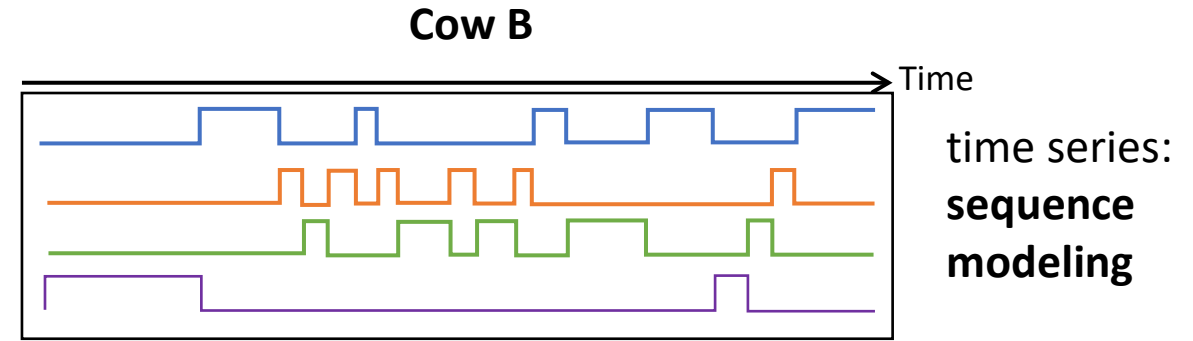


# Data Analysis



Frequency	Cow A	Cow B
Eating	5	5
Drinking	6	6
Sleeping	5	5
Grooming	2	2

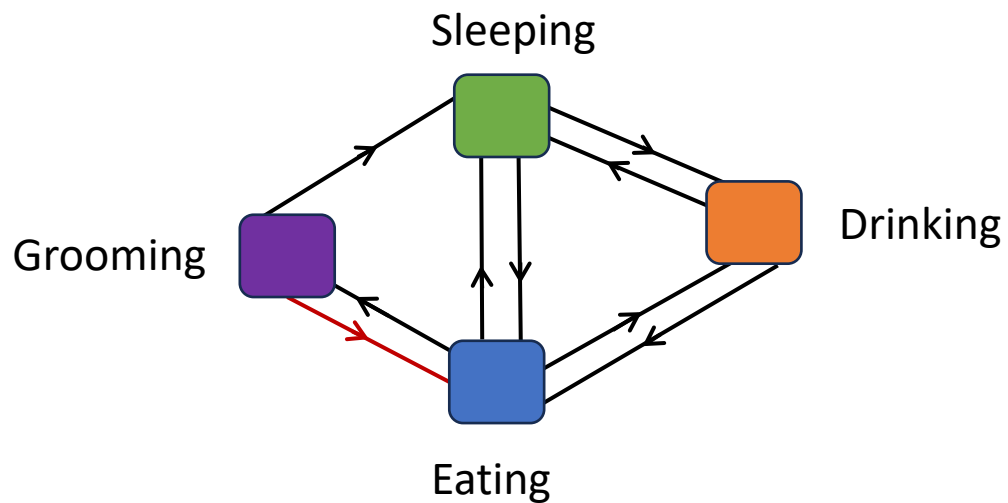
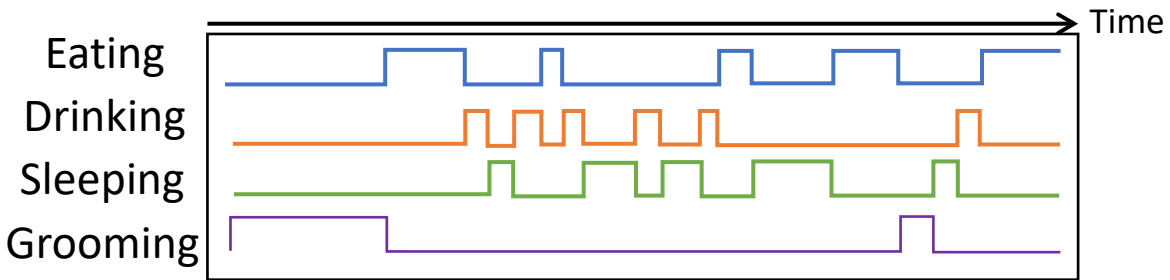
Mixed-Effect Linear Model; PCA



Probabilistic/statistic  
(Markov Models, ARIMA, etc.)

computational/AI/  
machine learning  
(recurrent neural networks, LSTM, etc.)

## Markov Chain Model:



**states** = {Eating, Drinking, Sleeping, Grooming}

Probability **transition** matrix P

	Eating	Drinking	Sleeping	Grooming	
P =	0.5	0.3	0.05	0.05	Eating
	0.3	0.3	0.3	0.1	Drinking
	0.1	0.5	0.4	0	Sleeping
	0.2	0	0.1	0.7	Grooming

**Initialization** Probability S

S =	0.1	0.2	0.15	0.65
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**Real-life example:** Behaviors observed during a 15-minute video (tie-stall cow spontaneous behavior)

**Observed probability transition matrix P**

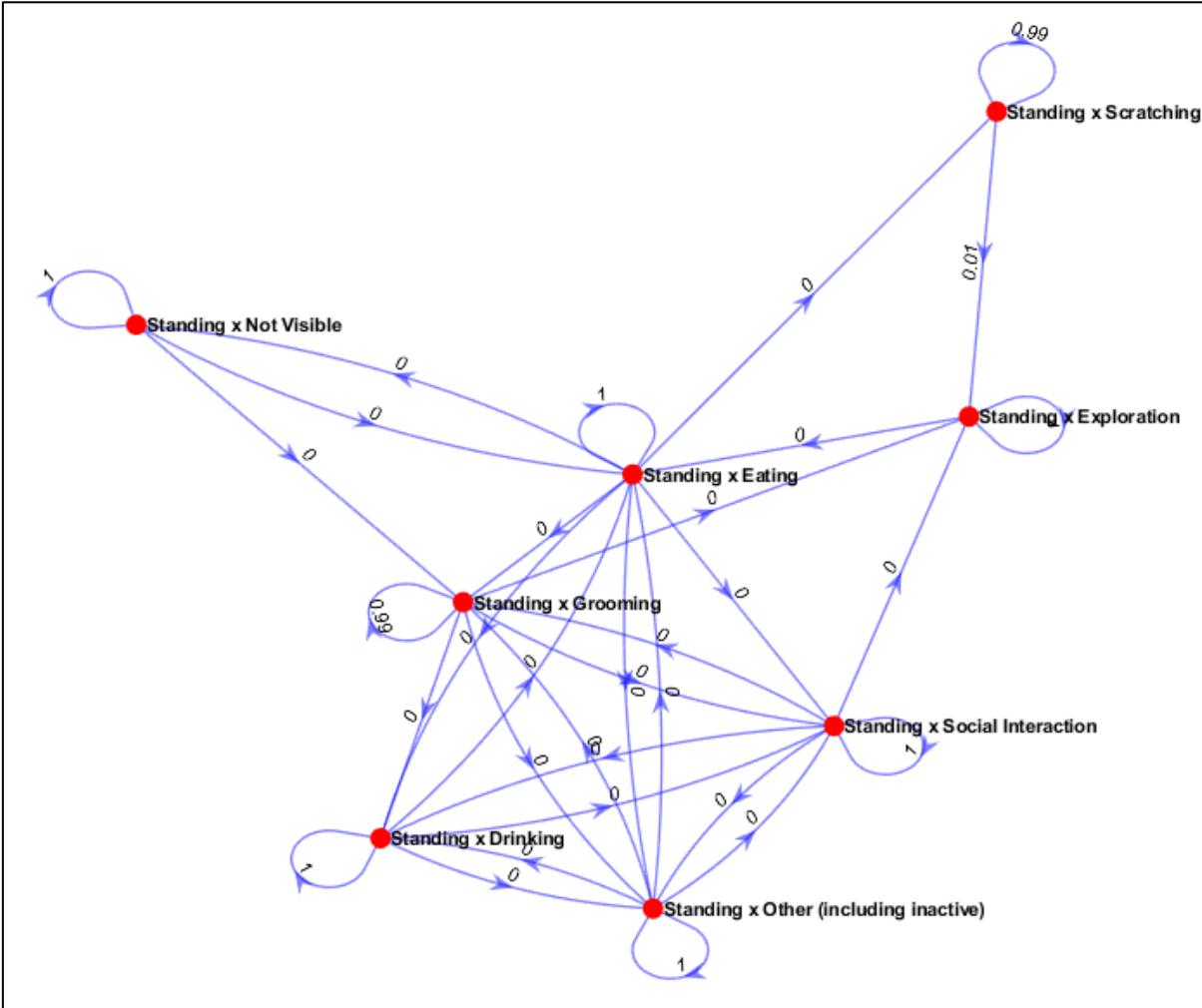
0.9825	0	0	0	0	0	0	0	0.0175
0	0.9630	0.0370	0	0	0	0	0	0
0	0.0002	0.9998	0.0001	0	0	0	0	0
0.0143	0	0	0.9857	0	0	0	0	0
0	0	0	0	0.9979	0	0	0	0.0021
0	0	0	0	0	1	0	0	0
0	0	0	0	0	0.0004	0.9996	0	0
0	0	0	0	0	0	0.0016	0.9984	0
0	0	0	0	0.0002	0	0	0.0002	0.9997

P =

(9 states)

Can be further studied using:

1. the **values** of the connections
2. the **topology** of the graphs (connection patterns)
3. the **flow** along the graphs (direction patterns)
4. etc.



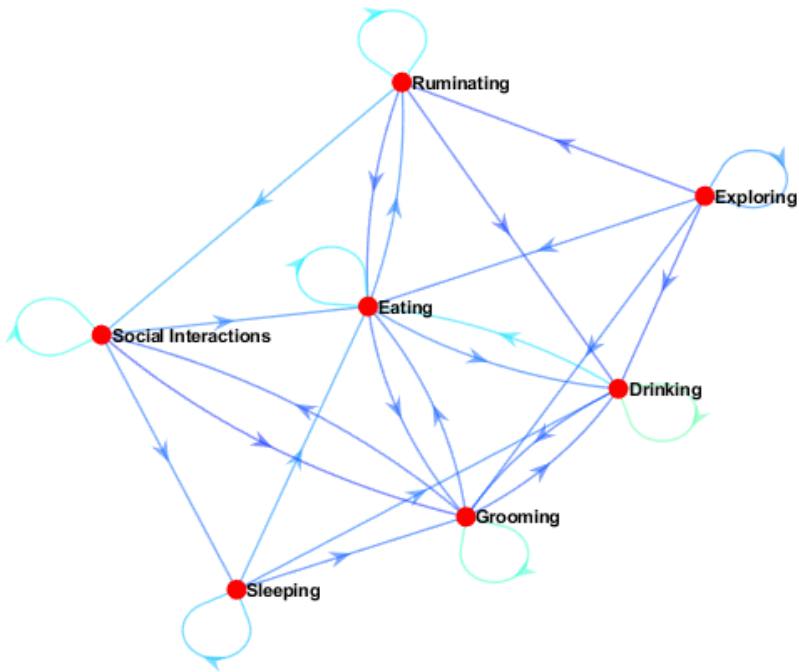


# 1. Map connection value analysis: Example of single cow analysis

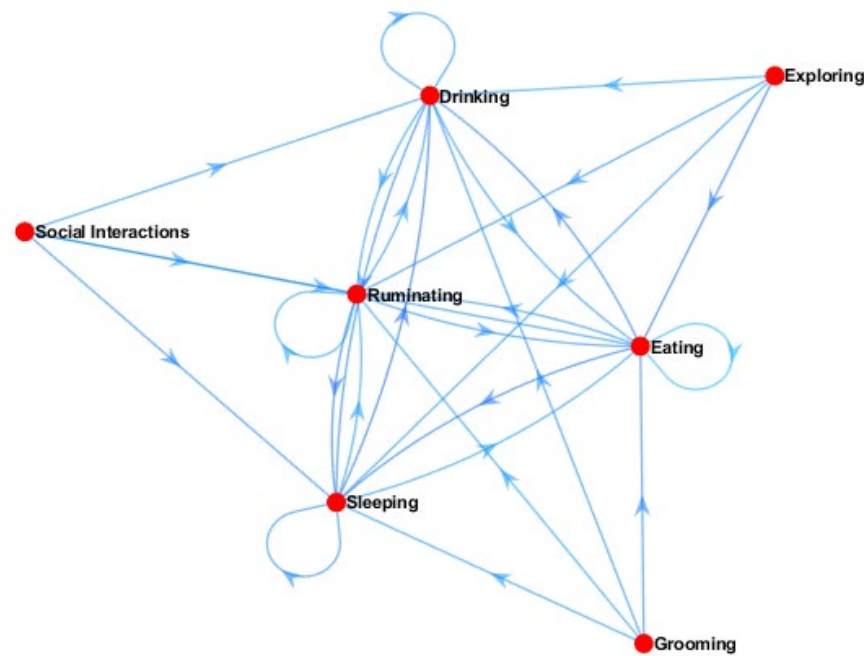


Question: "What are behavior changes before and after exercise?"

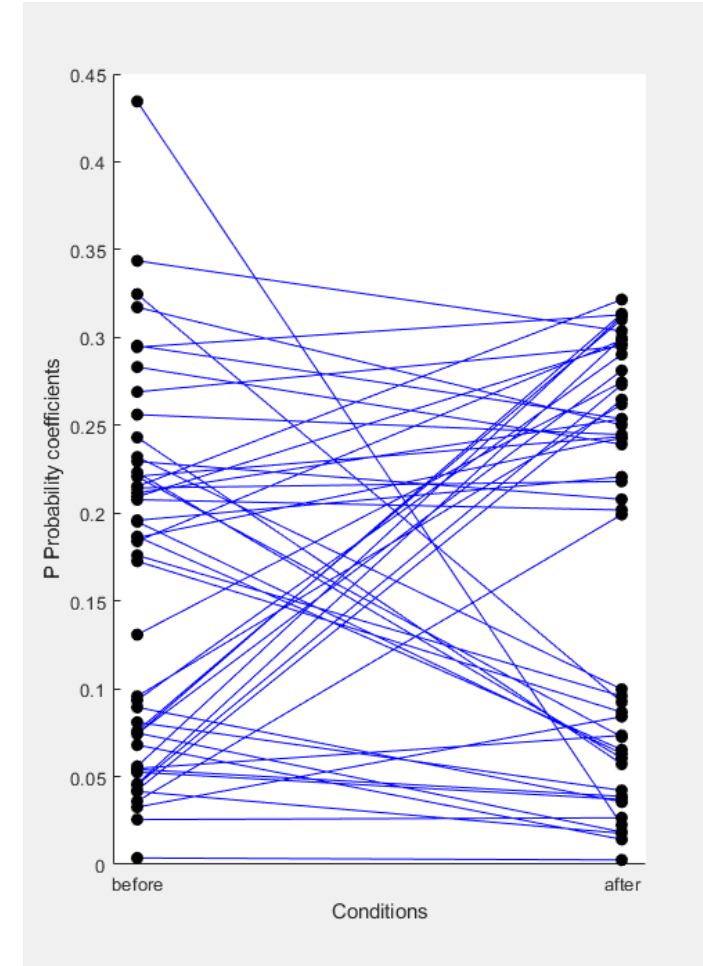
Condition 1: before exercise



Condition 2: after exercise



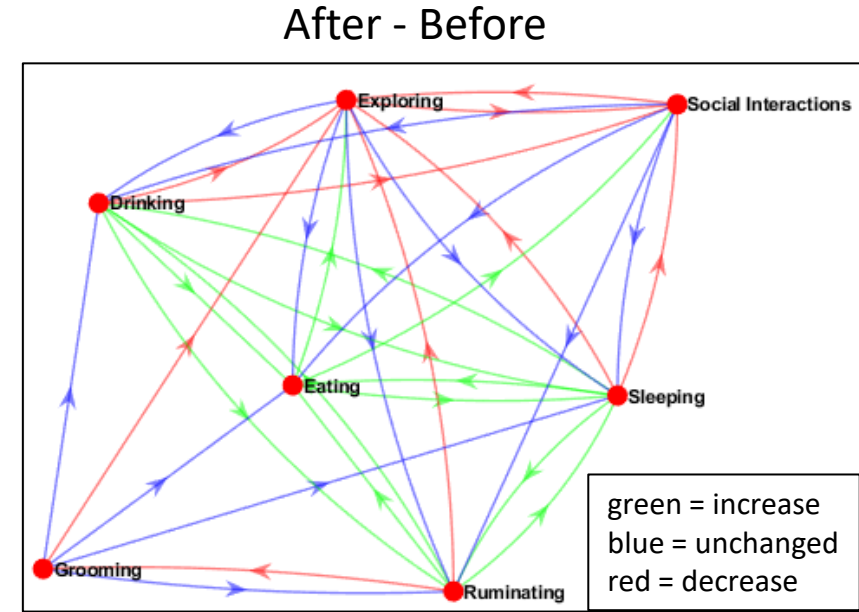
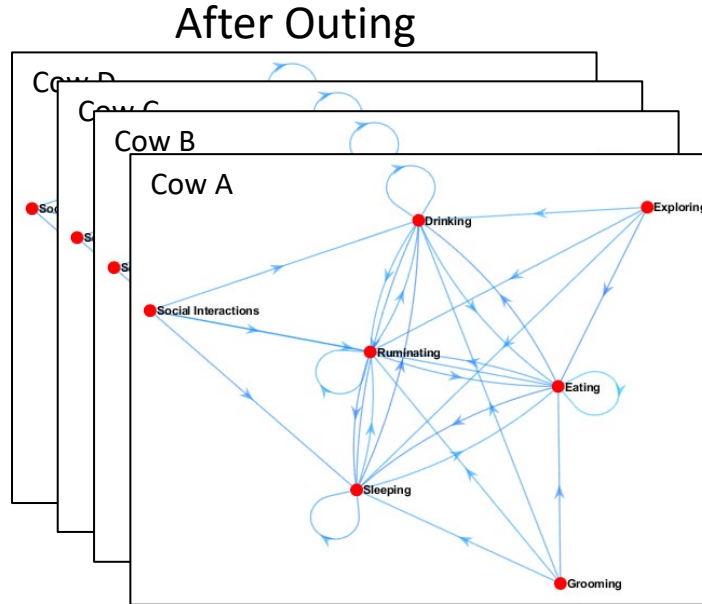
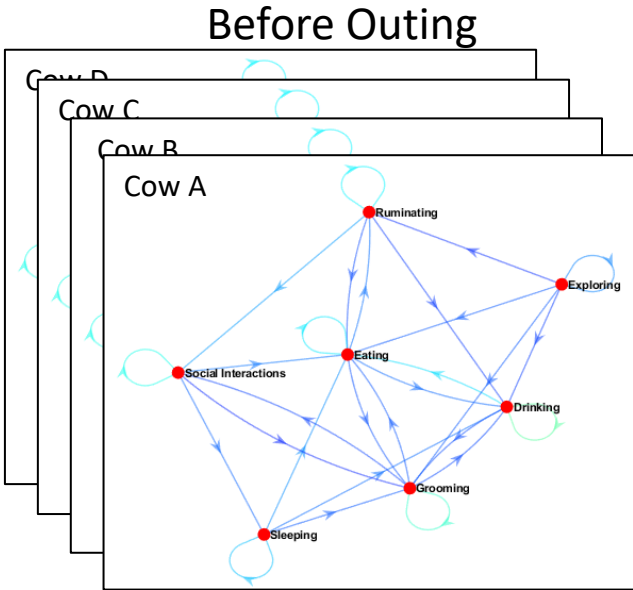
Transition matrix P values can be used in a **mixed-effect linear** analysis or **likelihood ratio** test analysis.



## 2. Herd level analysis: pooled cows for each condition



Question: "What are the behavioral changes before and after exercise at the **group** level?"



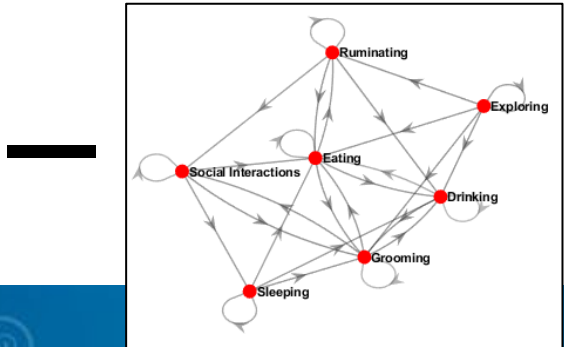
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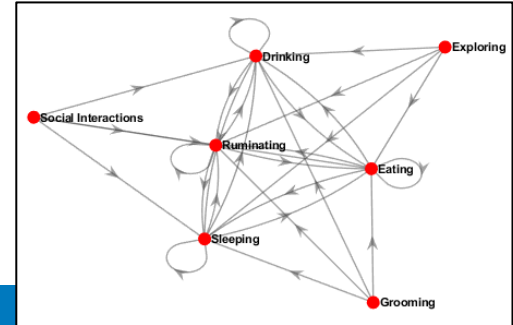
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(mean over each group)



+



=

↑  
Group Mixed-effect  
linear model  
or likelihood-ratio  
test analysis

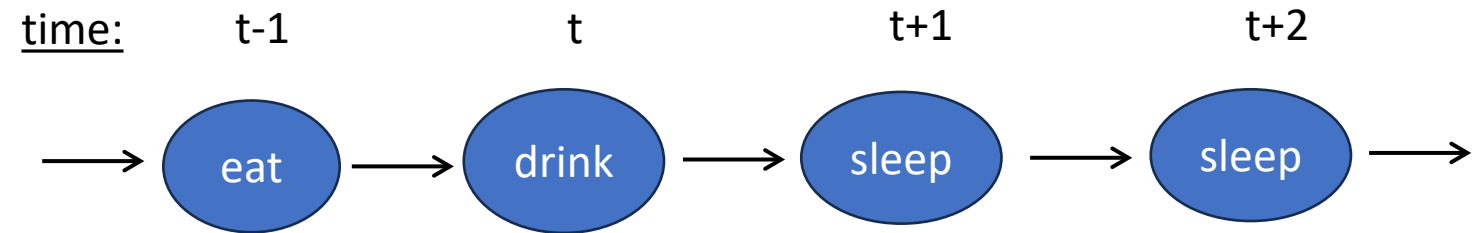




## 4. Extracting the motivations/factors behind observed behaviors: Hidden Markov models

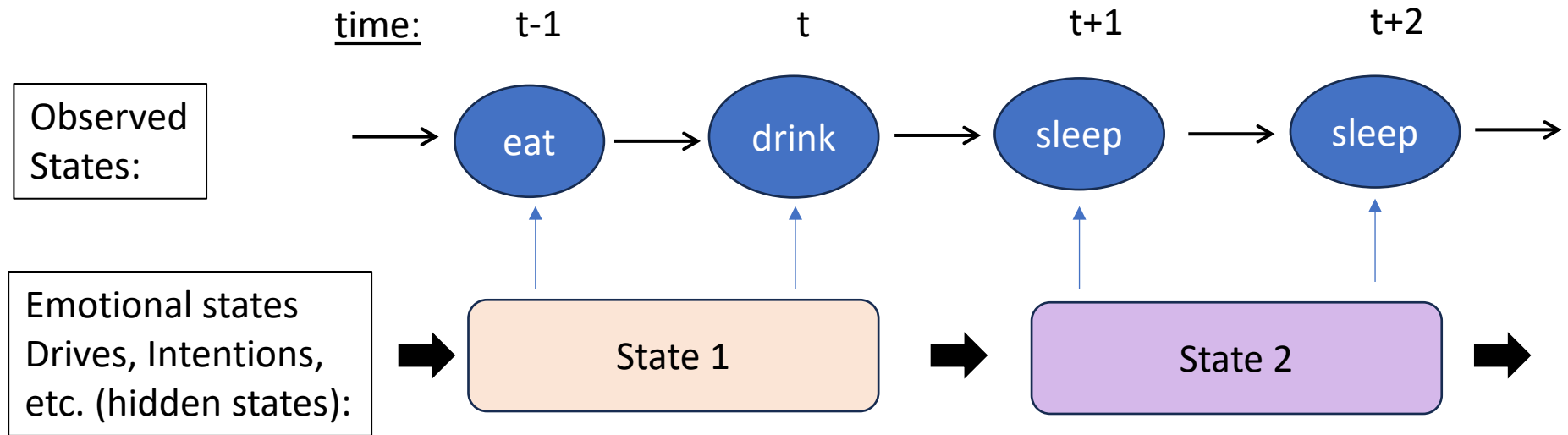
But what are the **motivations** behind the behaviors **expressed**?

Observed States:



## 4. Extracting the motivations/factors behind observed behaviors: Hidden Markov models

Deeper model which looks for **hidden causes** behind behaviors expressed.

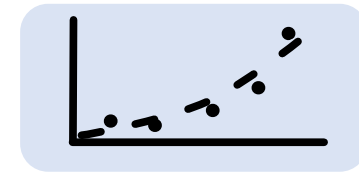


### New perspectives:

1. **Infer** behavioral/emotional states from observation and provide uncertainty measures on predictions
2. **Predict** future behaviors over time
3. Mine **behavioral patterns** associated with the cow's observations
4. Construct different models for **cow classification**



Annotation



Data Analysis

# Toolkits currently under production



## Computer Vision

- Detection across contexts (single model)
- Head, Snout Body Detection
- Identification
- Tracking
- Synchronization

## Behavioural Detection

- FANGIO –Fast ANnotation Gain In Observer
- Behavioural Detection with Hidden Markov Models
- Cow posture inference from detection models



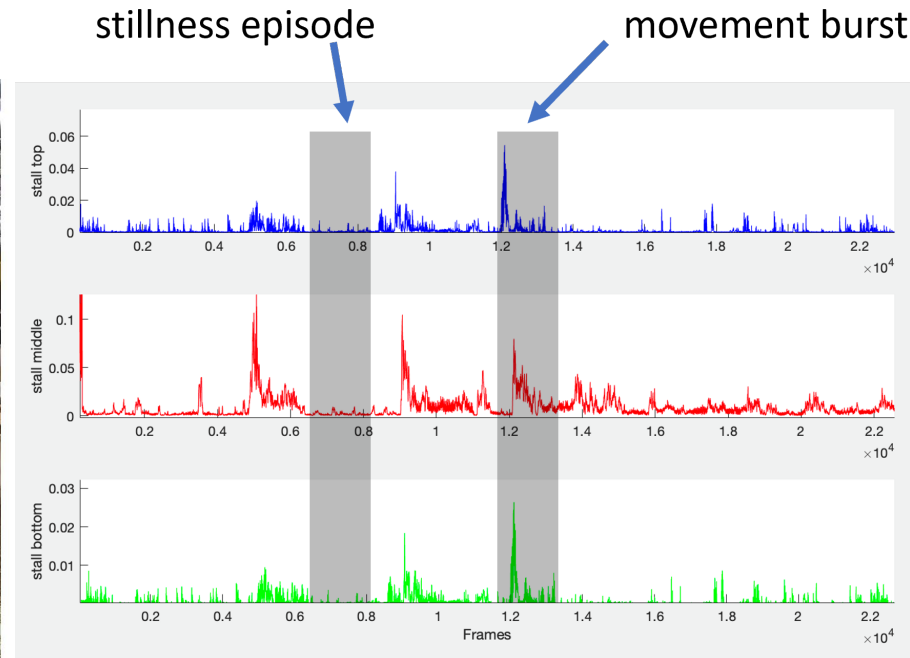
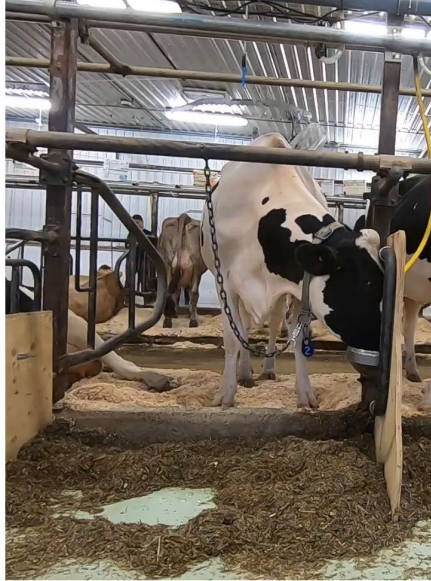
# FANGIO - Fast ANnotation Gain In Observer



Stillness  
(Rumination)



Movement  
(Foraging)



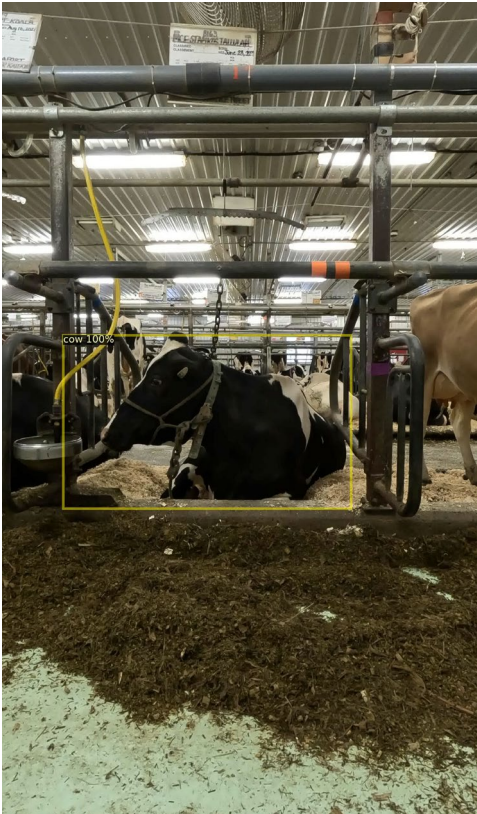
- Speeds up annotations
  - Skip to times of high activity, watch at higher speeds
- Optimizes data storage
  - Reduce file size without losing useful information



# Detection across contexts – single model

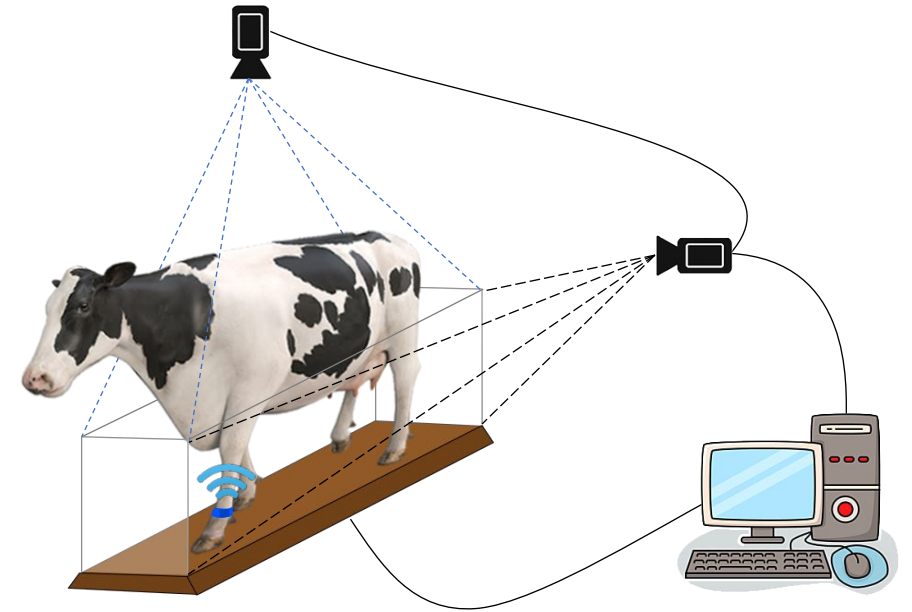


- Allows for application in multiple environments, enables training of subsequent models



# What do technologies bring?

- Automation of measures
- Scaling up to multiple contexts
- Live interface available to producers





Two very different domains → a **unique interdisciplinary expertise**

Follows a **narrowed approach for research and development of technology** tailored to the needs of the field of animal welfare

**Accelerates** the process of training and **reduces** big data requirements for **training of successive AI models**

Allows for a **paradigm change** in how we measure and understand complex measures (ex. emotions), leading to **recommendations** and **practical on-farm solutions**

**Includes end-users** from the conception of research questions to ensure **applicability** and **usefulness** of end results and toolkits developed





well-e

IA au service du bien-être • AI Serving Welfare

[well-e.org](http://well-e.org)

Thank you for your attention!

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Producteurs  
de lait  
du Québec

