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an integrated infrastructure for increased research capability and innovation in the European cattle sector

DETECTION OF COMPLEX ANIMAL TRAITS FROM DATA PROVIDED BY ACTIVITY SENSORS

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement n°730924

Health → behaviour

The sick girl
Ancher Michael (DK) 1882

Sickness behaviour: lethargy, sleeping at a time when normally awake, hyporeactivity, low motivation,…

(Hart 1988; Dantzer & Kelley, 2007, Byrd & Lay 2018)

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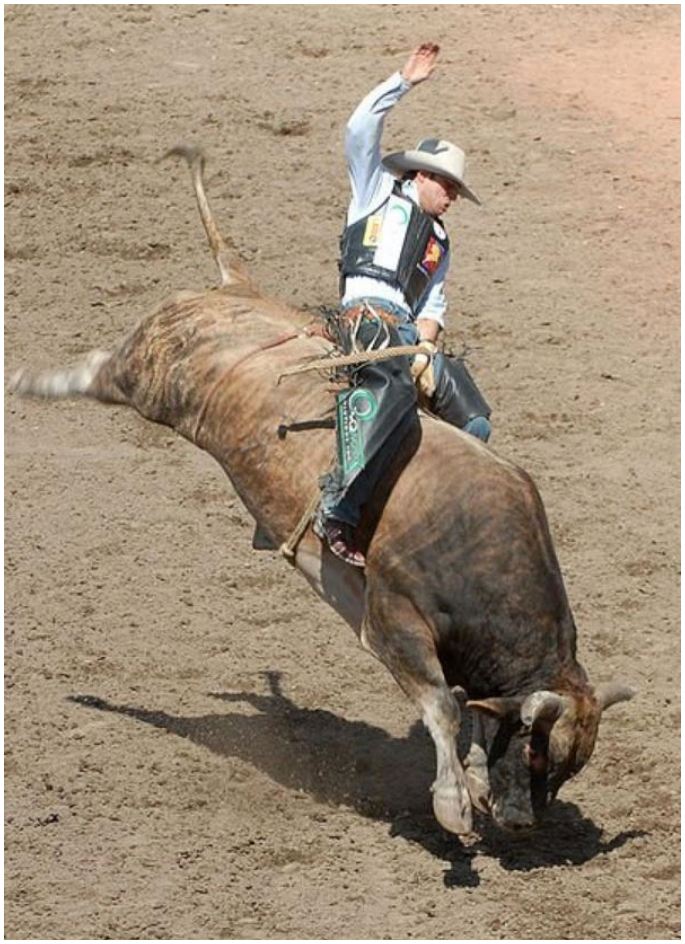
Stress → behaviour



Response to stress: agitation, hyper-reactivity (acute phase)

Behaviour tells us a lot about the internal state of an individual,

Behaviour → health

Rapid ingestion of food in large quantity
may lead to ruminal acidosis

Reduction in the time spent lying over long periods
may lead to lameness

Behaviour impacts on health

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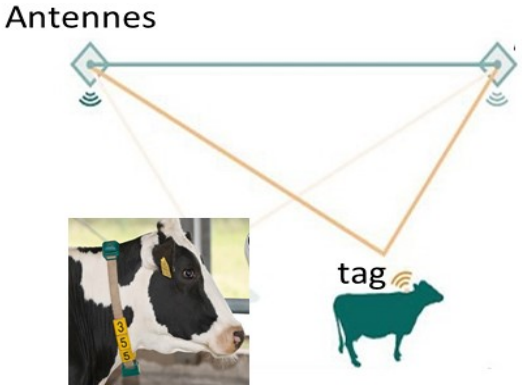
Behaviour, health, stress, welfare

Development of sensors → activity meters are available at least for large animals

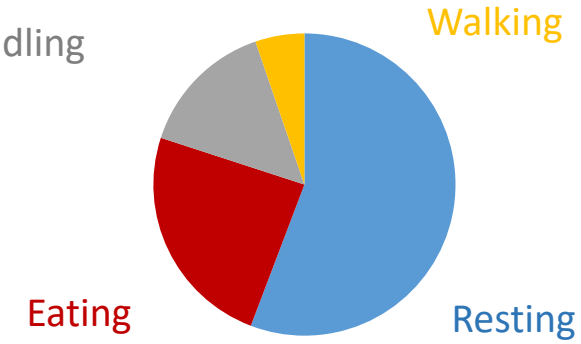
Accelerometer on neck and leg



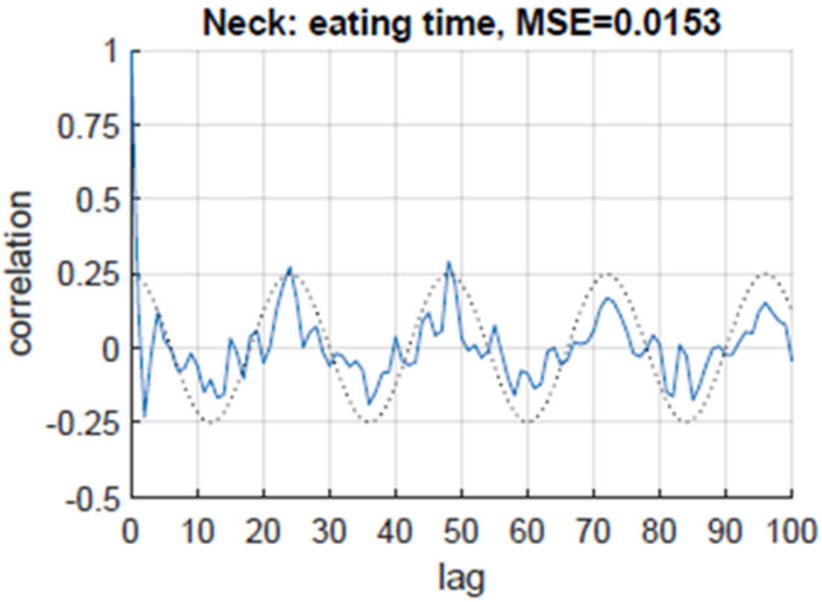
RTLS: location → activity

First step: extracting descriptors of activity from sensor data

- Time budget



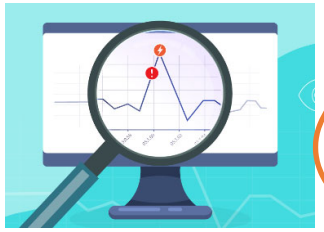
Poster 35590
Van Dixhoorn et al



mean squared error (MSE) of the correlogram with a sinusoid function (dotted line)

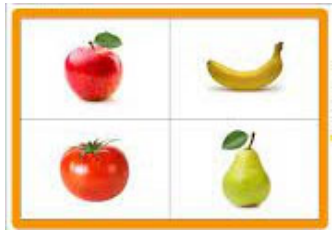
And also

- Activity level: How much active is a cow?
  (Weighted average of time spent in each activity)
- Regularity: Is the activity the same on successive days?
- Periodicity, circadian rhythm: Are there cyclic patterns?
  - Autocorrelations
  - Ad hoc operator for non-periodicity
  - Fourier Transform



- *Potential of using behavior to detect poor cow health and stress states*

  = ***Monitoring to detect changes***



- *Potential to predict future health status from a cow behavioural profile*

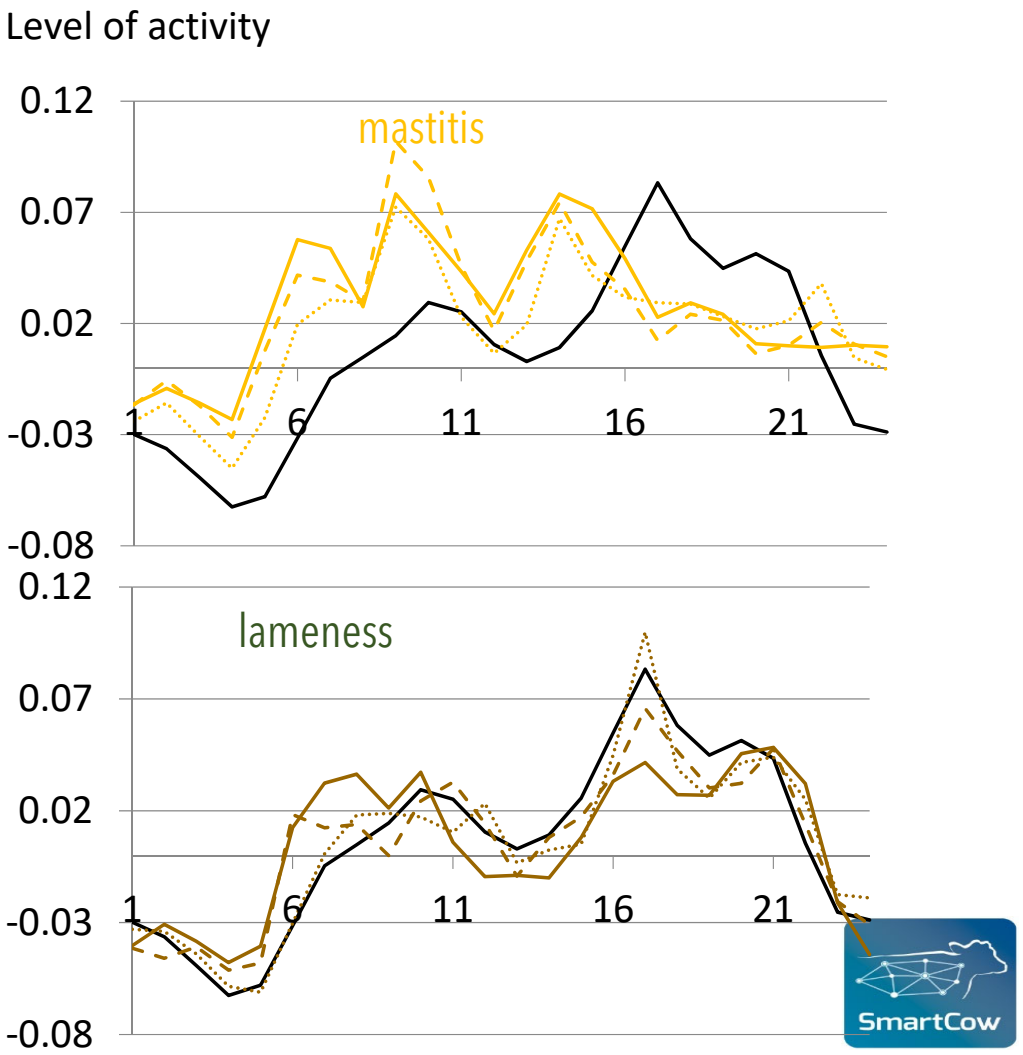
  = ***Phenotyping***

Alteration in circadian rhythm

- 1st statistical results *(Veissier et al 2017)*

control
D0
D-1
D-2

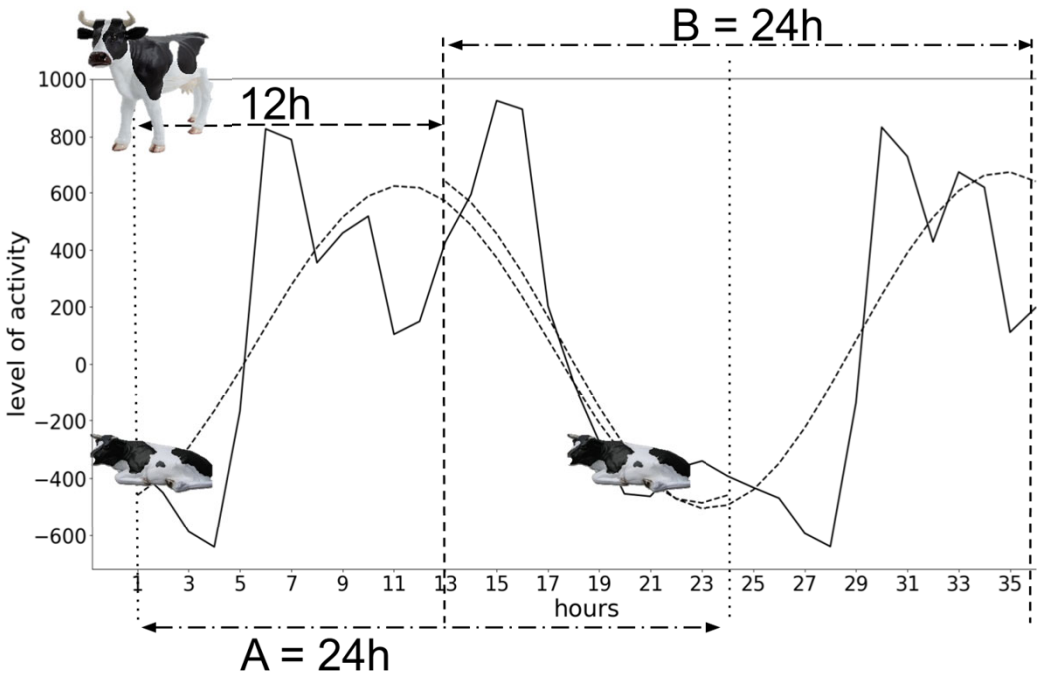
Modifications of the circadian pattern of activity 1-2 d before clinical signs are detected



Detection of rhythm changes – FBAT method

Fourier-Based Approximation with Thresholding

- Use of **Fourier Transform** to model the activity on a specific cow*day (24 h)
- Repeat the modelling 12 h later
- Calculation of the **distance** between the 2 models
- If the distance is above a certain threshold the rhythm is supposed to have changed



A ≠ B or A = B ?

(Wagner et al., 2020 https://doi.org/10.1007/978-3-030-50153-2_43 & 2021 https://doi.org/10.1016/j.ymeth.2020.09.003)

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FBAT method – performances to detect abnormal events

Test on 4 datasets → 120,000 cow*days

Performances

Sensitivity: % events detected
- 60 – 100 %
- 75-100% in case of a health problem

Specificity: % normal days detected abnormal
- 20%
- (5% with fuzzy logic)

% events detected

Events	Datasets			
	1	2	3	4
Accidental events	-	-	-	100
Calving	100	-	-	99.4
Oestrus	95.1	85.7	69.2	91.4
Lameness	100	93.8	-	98.2
Mastitis	100	-	-	87.5
Other disease	80	75	-	90.9
LPS injection	81.5	-	-	-
Ruminal acidosis	-	69	-	-
Mixing	68.3	-	-	-
Disturbance	69	71.7	-	59.3

Large commercial farm

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Does FBAT allows early detection?

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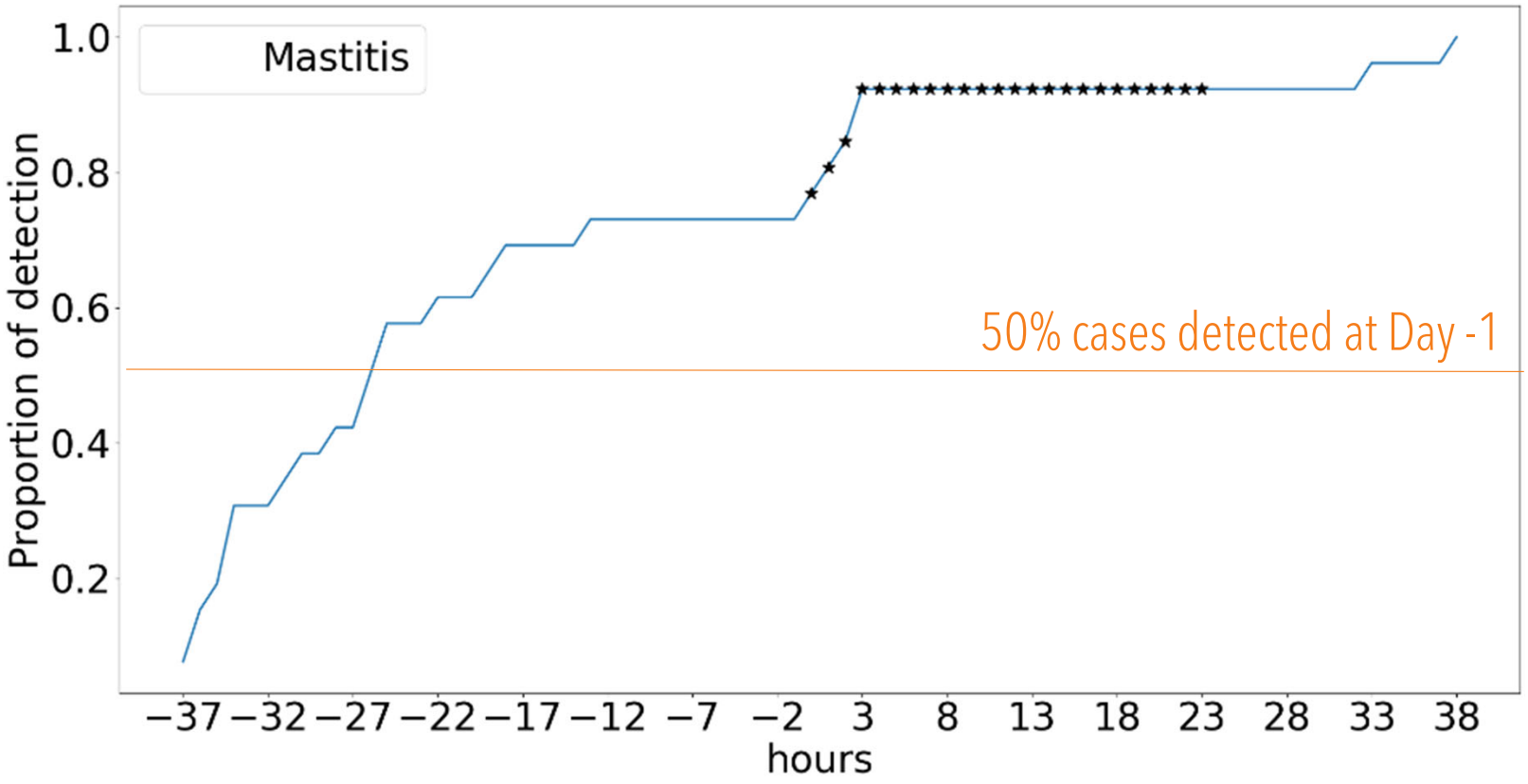
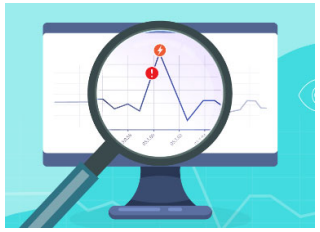
day of detection by caretakers





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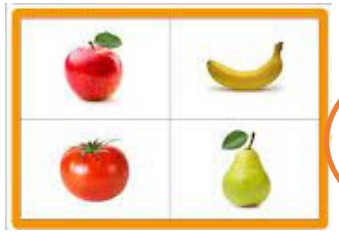

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The objective

Activity recorded before calving
(2 wk)

?

Health after calving
(6 wk)

Clinical observations
+ blood parameters

Health assessment: Total Deficit Score

- Parameters:
  - Clinical aberrations
  - Blood values:
    - Ca, Mg, Phosphorus,
    - BHBA, NEFA,
    - Total Protein, Urea, Albumin,
    - Haptoglobin, IL6, AST, Bilirubin, Gamma GT, GLDH
- 1 point for each alteration →Sum of points = Total Deficit Score

Links between behaviour before calving and health after calving

38% variability in Total Deficit Score explained by

- Nonperiodicity of standing up (no.) $\beta = 4.535$
- Cyclic component (FFT h1-4) of time spent standing -0.384
- Time spent inactive 0.0234

The more a cow show cyclic patterns of activity before calving, the better her health after calving

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In conclusion,

Cows behaviour, health and welfare status are interconnected

Infectious diseases and stress alter the activity of a cow

- rhythm of activity altered in ~90% health disorders and ~60% stressful events

Such alterations can be detected before appearance of clinical signs of a disease

→ operational management: refinement of the daily interventions

The behavioural phenotype of a cow impacts on its further health

- cows which activity is less periodic before calving are more sensitive to health disorders after calving

→ strategic management: use of behavioural criteria for selection

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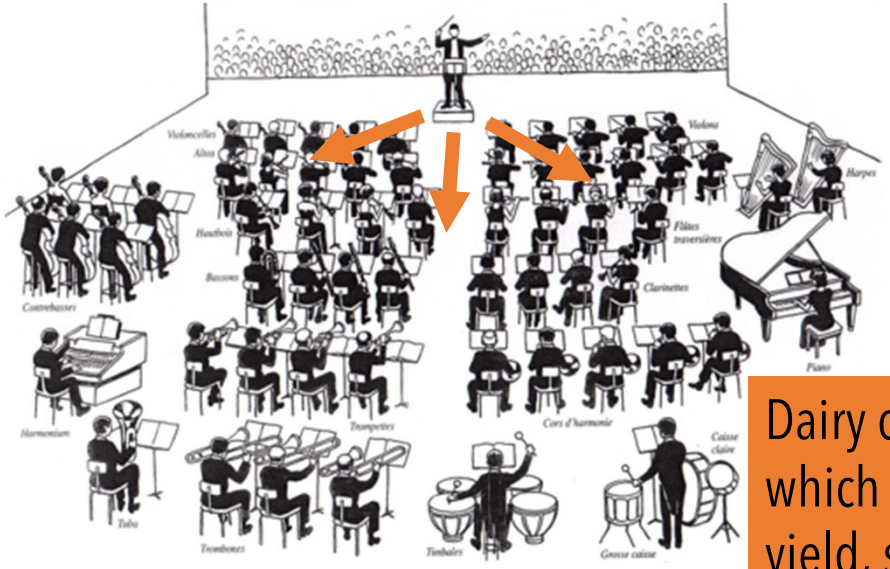
Circadian rhythm

External cues (eg light)

reset



main pacemaker in mammals (~24 h)
in suprachismatic nucleus of hypothalamus

coordination

peripheral clocks in most cells

Dairy cows,
which metabolism needs to be tightly tuned for milk yield, seem especially sensitive

(Koch et al 2017, Yanling et al 2019)

- Organisation of activities
- Regulation of metabolism

} Ensures adequate body functioning

Disruption of circadian rhythm → large negative impacts on physical and mental health (cancer, depression) *(Smolensky et al 2016)*

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Thank you for your attention