aWISH
ANIMAL WELFARE INDICATORS AT THE SLAUGHTERHOUSE

Technologies on-farm and at the slaughterhouse

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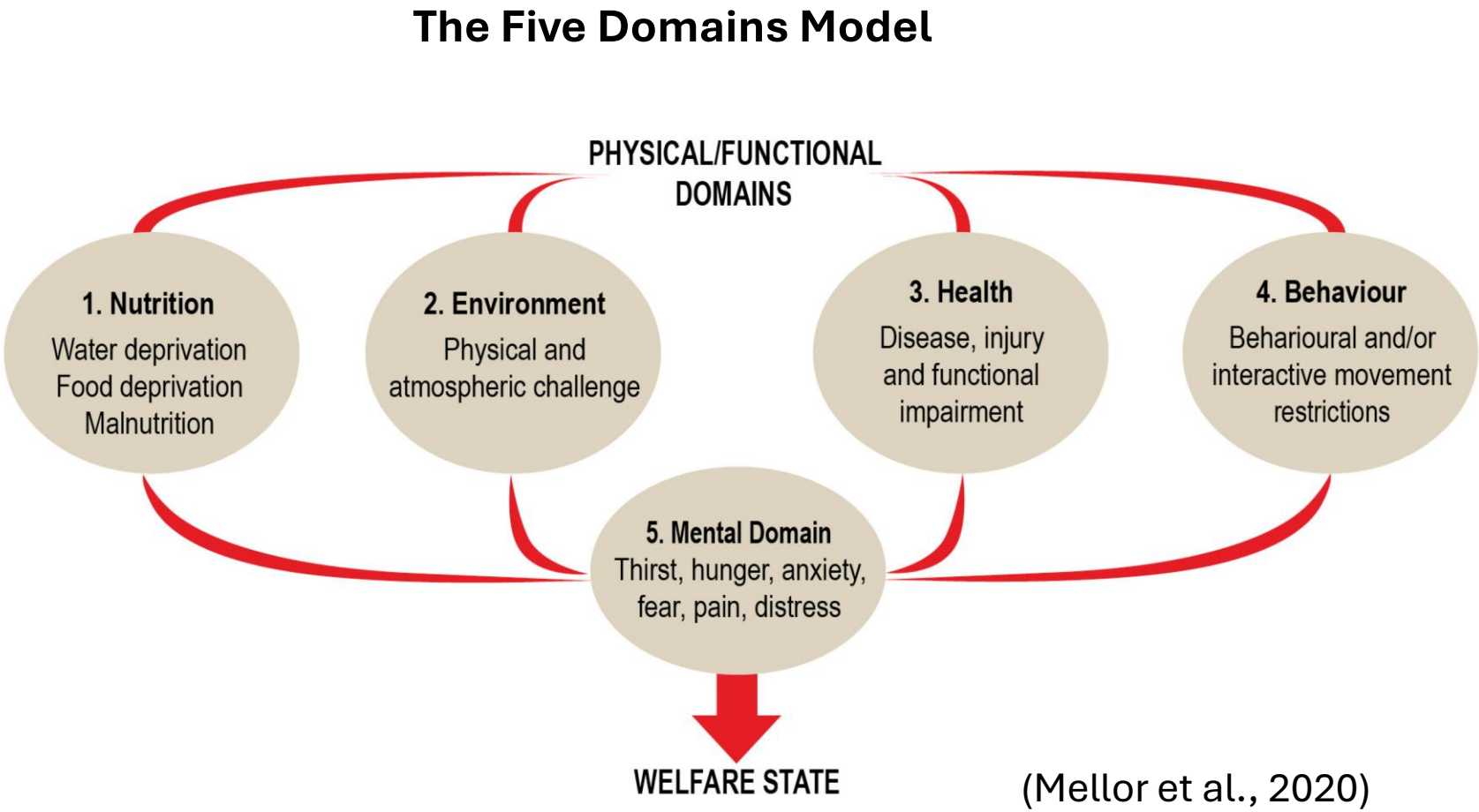
Structure of the lecture:

- Evaluation of animal welfare
- Animal-based indicators
- Methods for evaluating indicators: traditional vs sensors
- On-farm sensors
- Evaluation of animal welfare at slaughterhouses
- Slaughterhouse sensors
- Potential and limitations

Evaluation of animal welfare



(Mellor et al., 2020)

Animal welfare indicators

Indirects

Directs

Environment

- Risk factors
- Easy to measure
  - ✓ Require less time/resources
  - ✓ Require less training
- May not reflect the level of well-being

Management

Animal

- Animal response
- More time and resources
- Greater specificity and sensitivity

Risk factors

Consequences

INPUT

Resources available (resource- based measures)

Management practices (management - based measures)

OUTCOME

Response of animal (Animal-based measures)

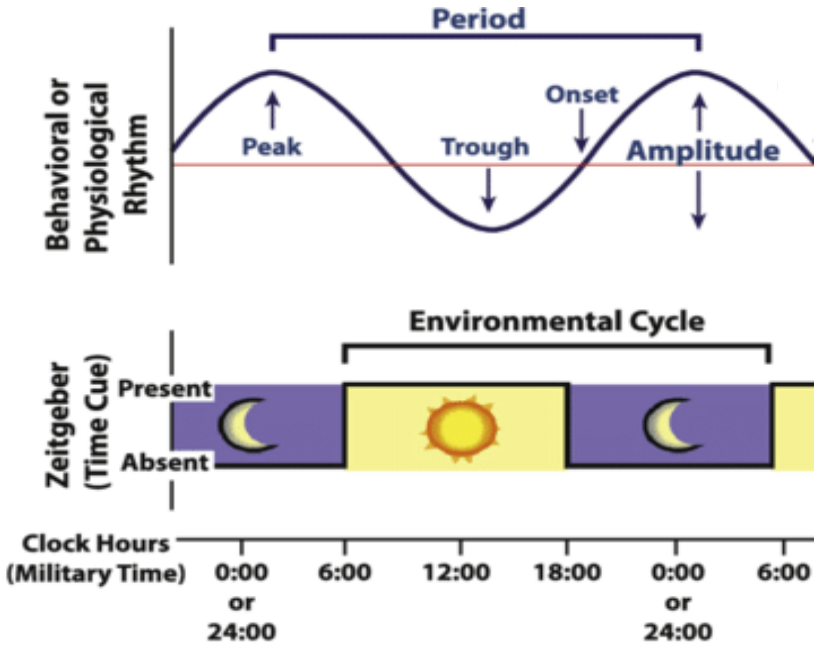
Indicate the animal's welfare (welfare indicator)

EFSA, 2012

Animal-based indicators

Behaviour indicators:

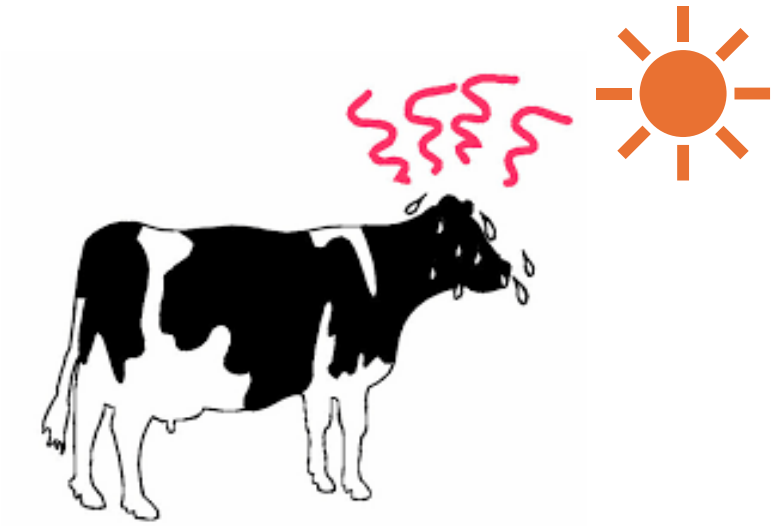
- Patterns of normality (e.g., alimentation)
- Anormal behaviour (e.g., stereotypies)
- Natural behaviour



Organic response indicators:

The phenotype provides information on how an animal adapts to its environment

- Environmental challenges (corporal temperature)
- Animal Health
- Metabolic and physiological status



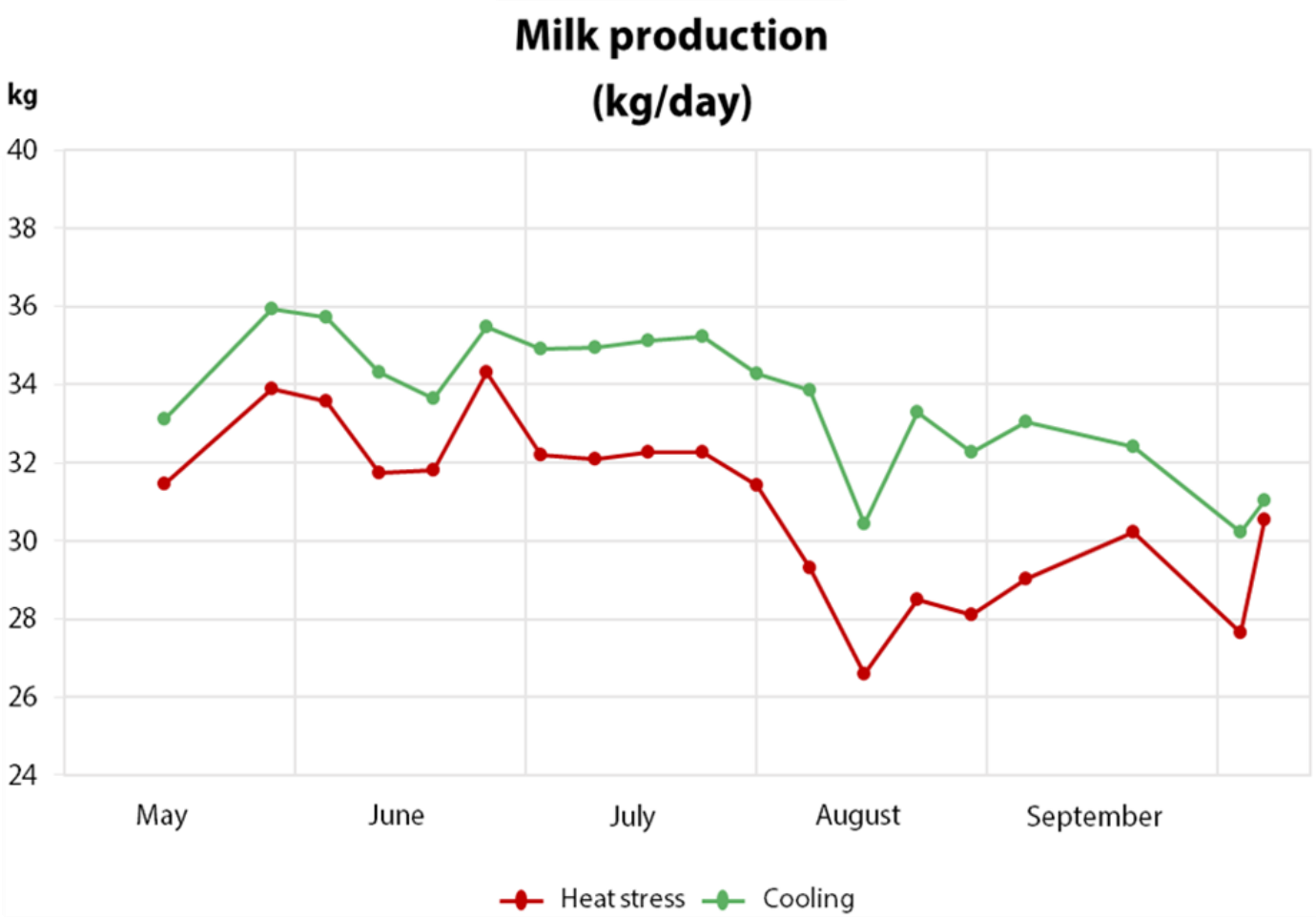
Performance indicators:

- Performance is probably the trait that has been most extensively phenotyped in livestock

- It allows us to infer an animal's adaptability to its environment, based on the principle that a healthy animal produces more

- Milk production (kg/d)
- % protein and fat
- Growth (GMD)

Performance indicators:



Methods for evaluating indicators: traditional vs sensors

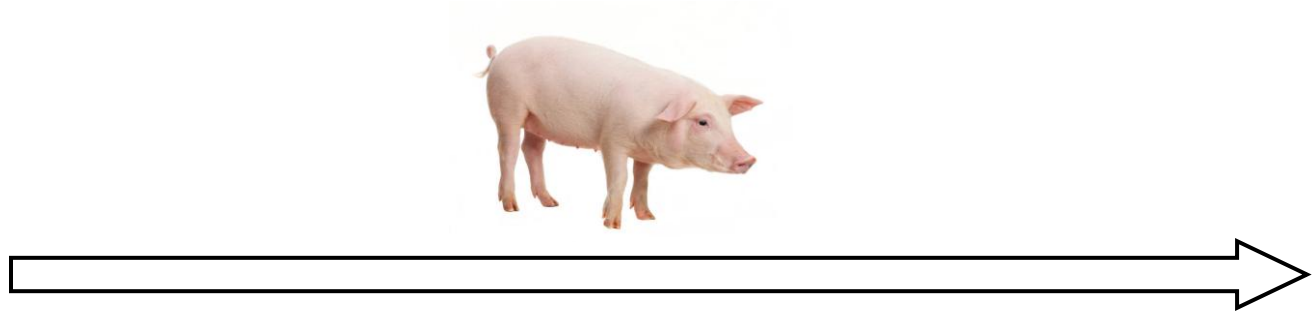
Feeding behaviour

Social behaviour

Activity

Reproductive behaviour

Traditional

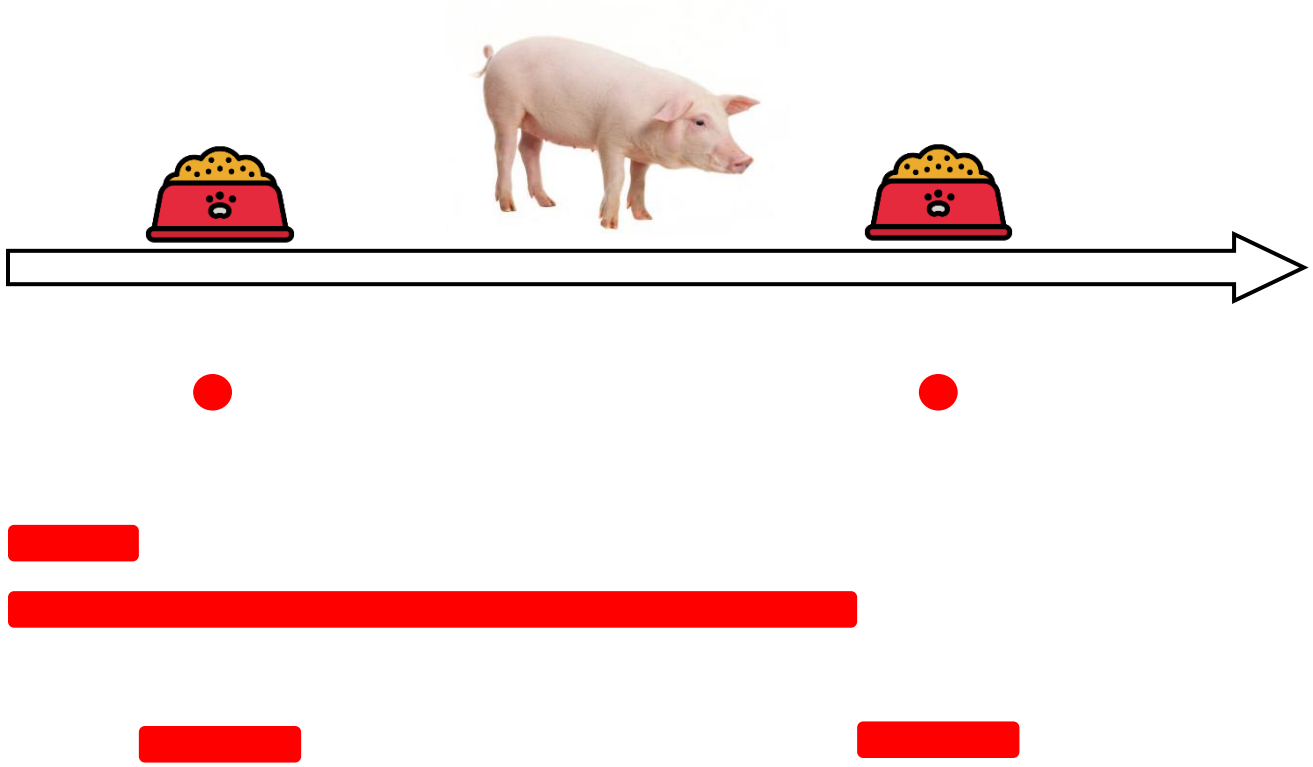


- Continuous sampling
- Focal sampling
- Scan sampling

Traditional

Variables

- Frequency
- Latency
- Duration



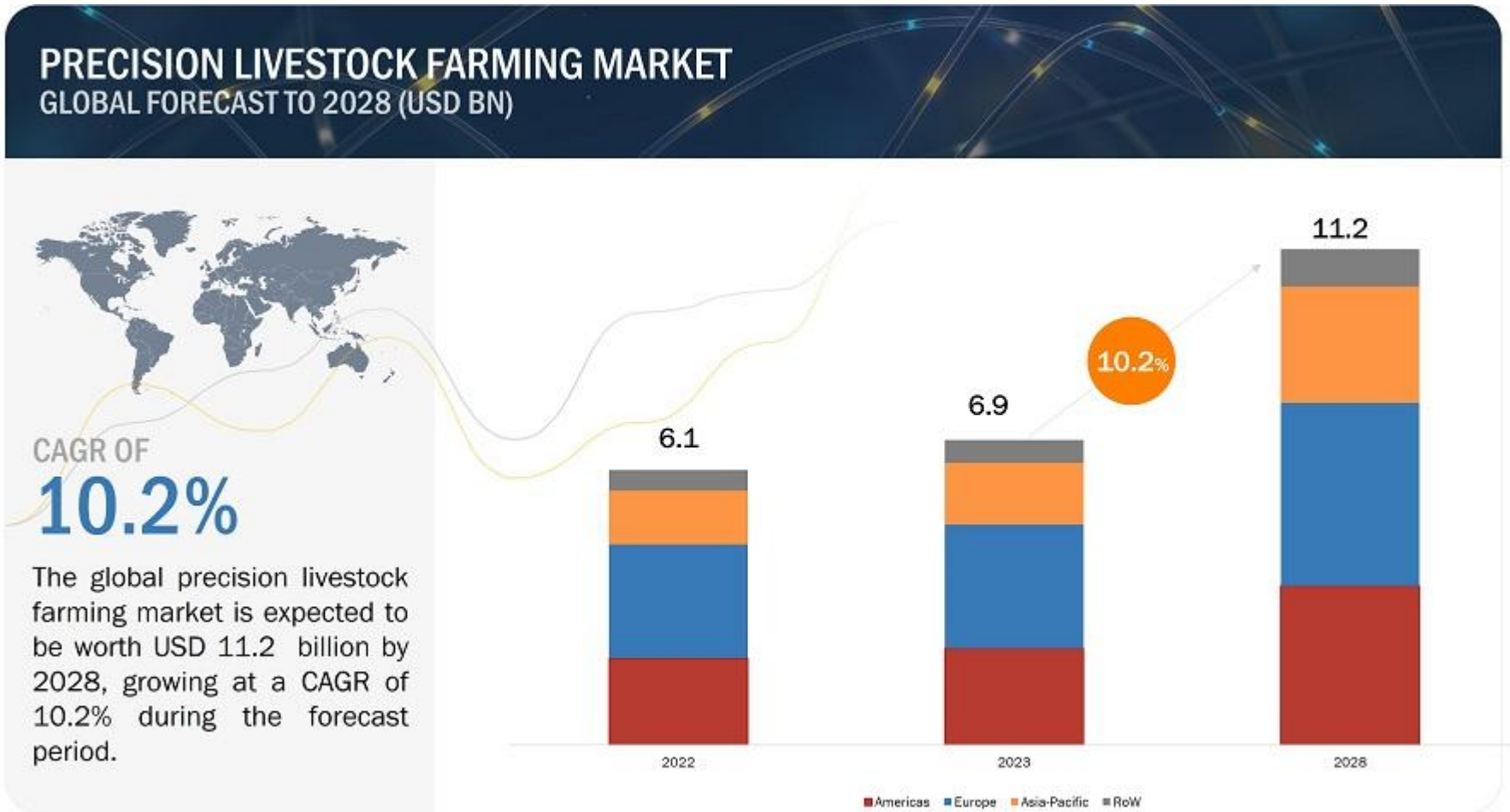
Limitations of traditional observation

- Limited view of the behaviour
- Costly (time and resources)
- Subjectivity
- No predictable
- Group evaluation

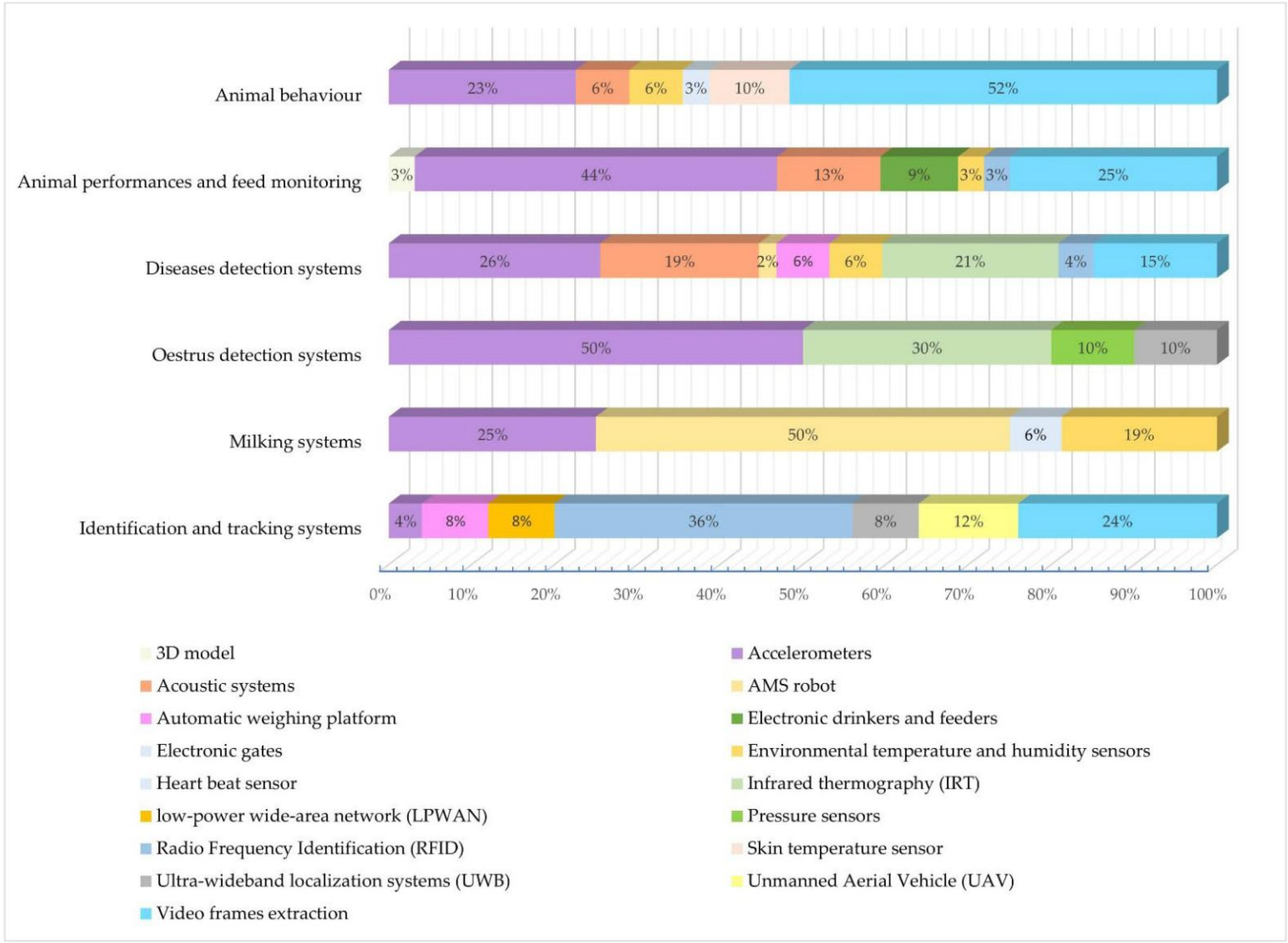
Desirable:

- Continuous evaluation
- Objectively
- Predictable
- Individual evaluation

Sensors

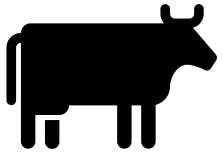

PRECISION LIVESTOCK FARMING MARKET
GLOBAL FORECAST TO 2028 (USD BN)
CAGR OF
10.2%
The global precision livestock farming market is expected to be worth USD 11.2 billion by 2028, growing at a CAGR of 10.2% during the forecast period.
6.1
6.9
11.2
10.2%
2022
2023
2028
Americas
Europe
Asia-Pacific
RoW

Different type of technologies used in livestock farm animals



(Morrone et al., 2022)

On farm sensors



129

Accelerometer

37

Camera

10

GPS

8

Scales

5

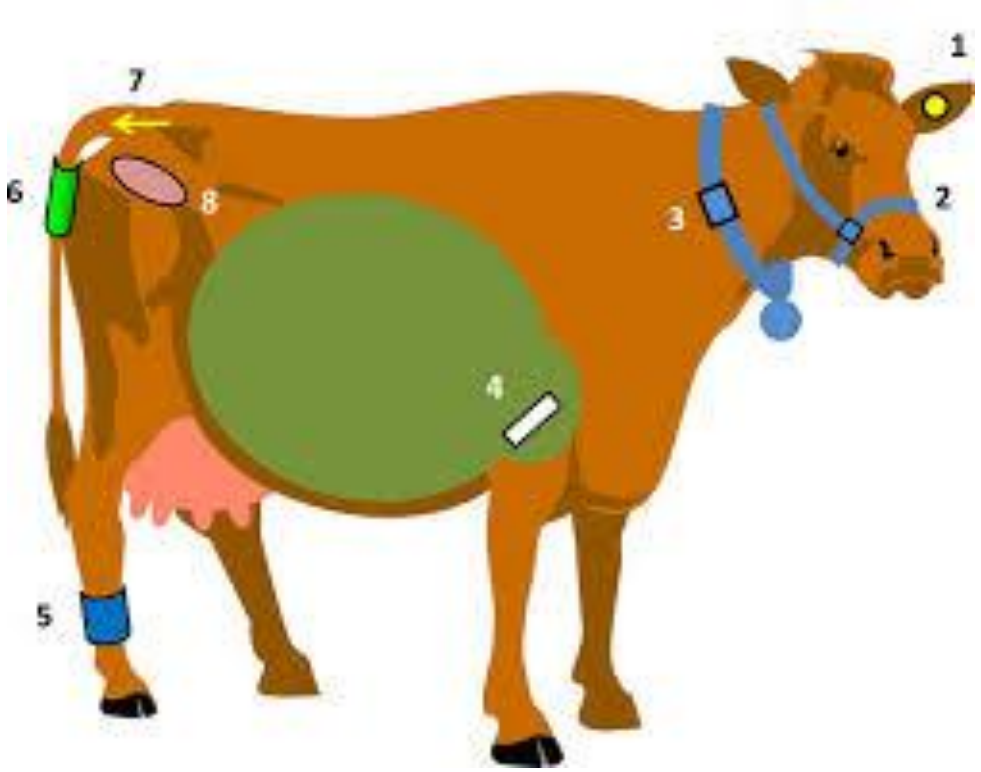
Thermometer

4

Microphone

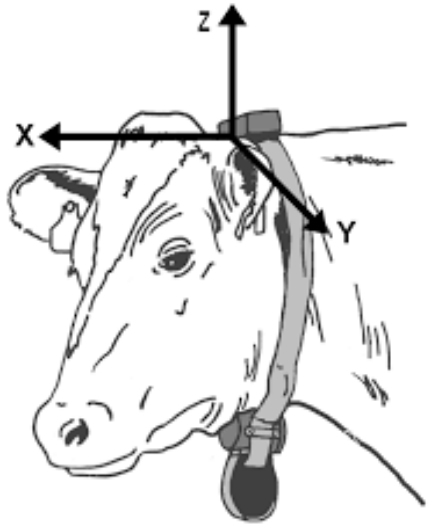
2

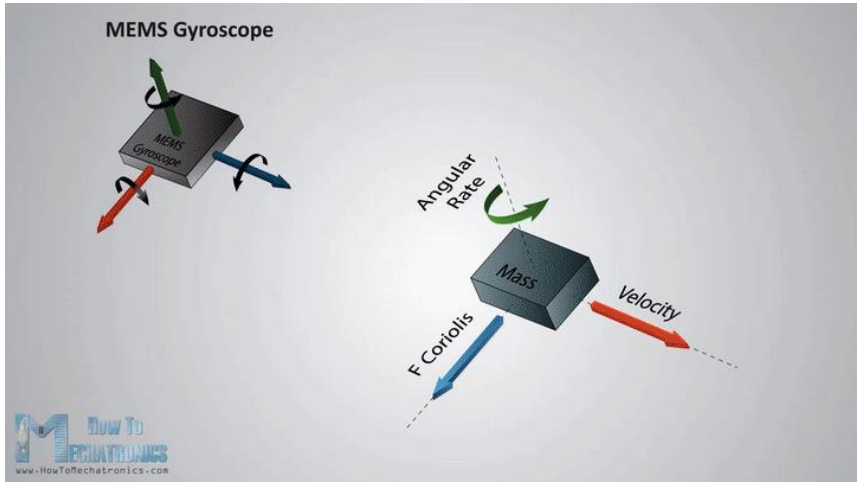
(Stygar et al., 2021)



1. Electronic ear tag
2. Muzzle
3. Collar
4. Rumen bolus
5. Pedometer
6. Rectal bolus

Accelerometers

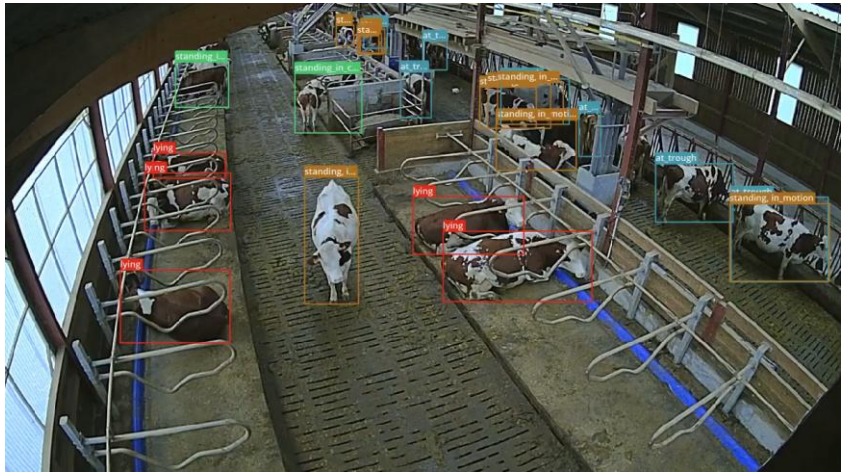




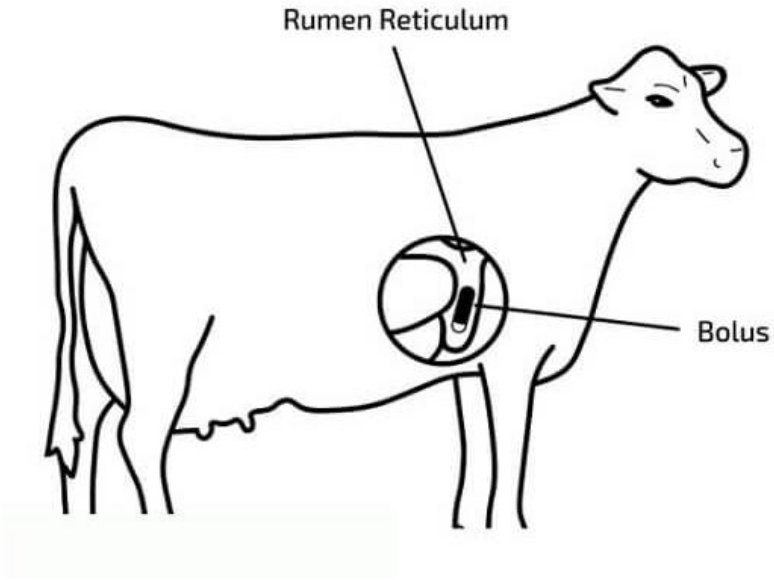
- Number of steps
- Time of lying and resting
- Estimation of other behaviours:
    - Alimentation
    - Ruminating

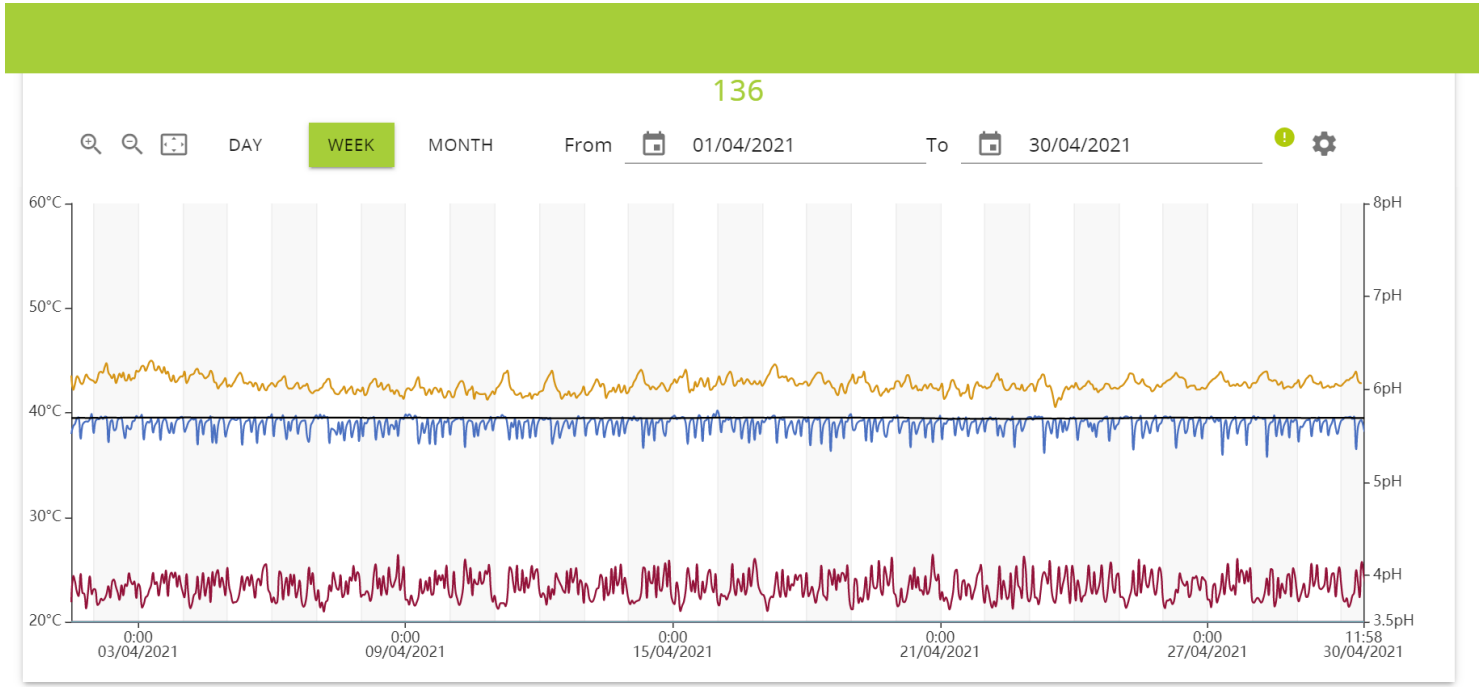
Computer vision

- Activity and behaviour
- Posture
- Pen localization



Rumen bolus

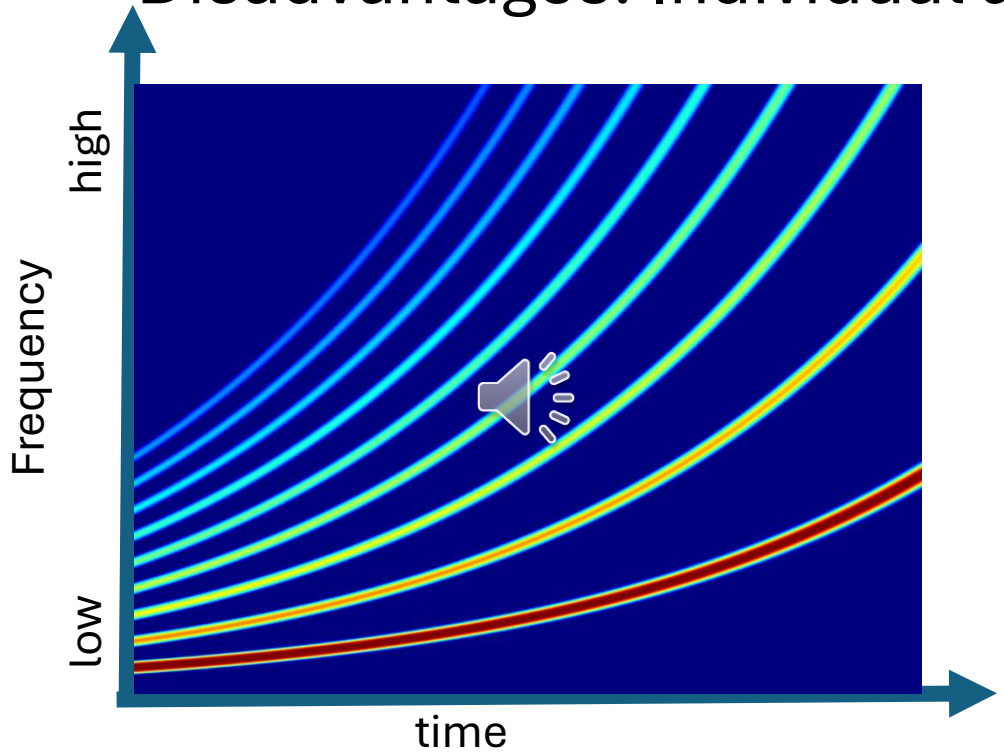


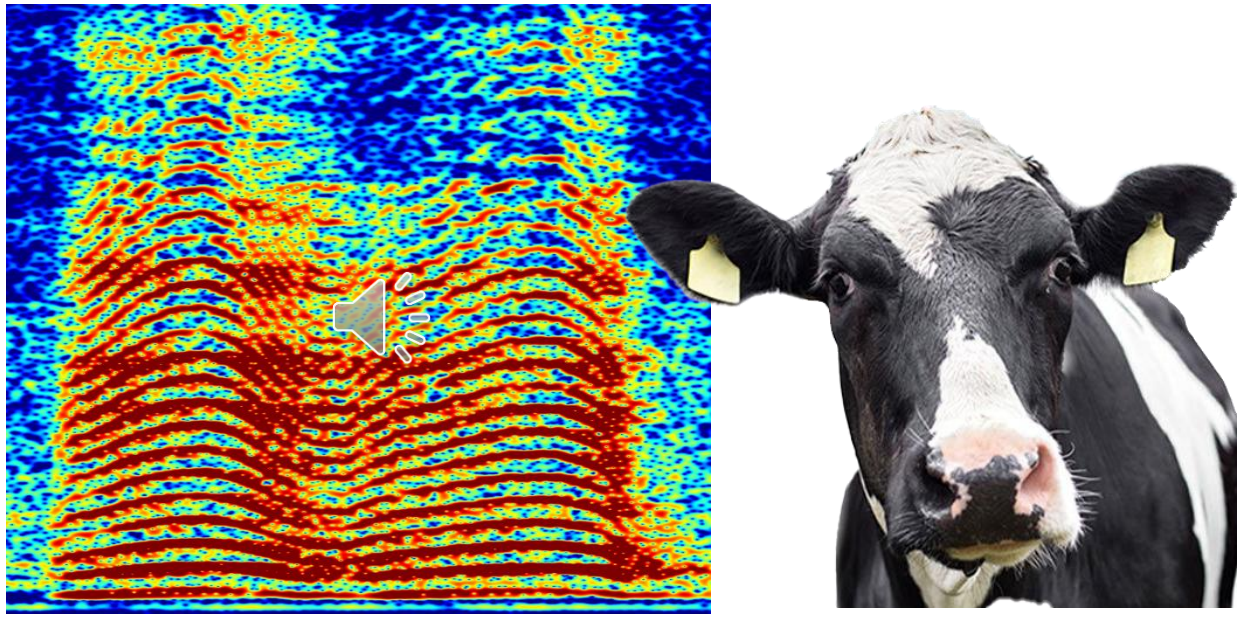


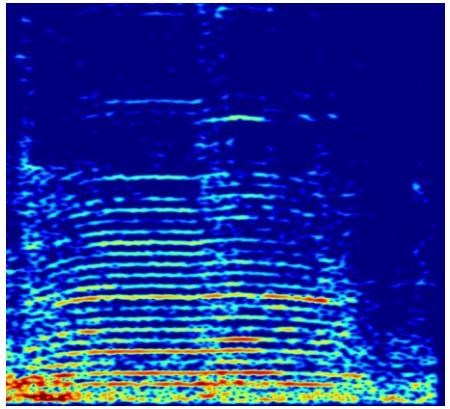
- Rumen thermometer
- Accelerometer
- pH meter

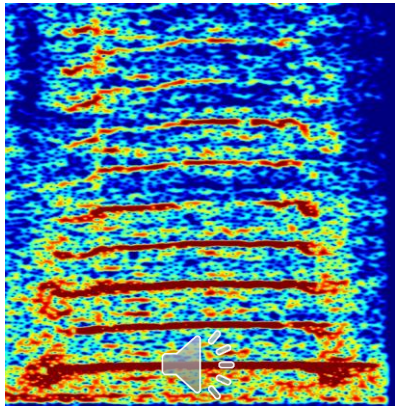
Microphone (emotional stage)

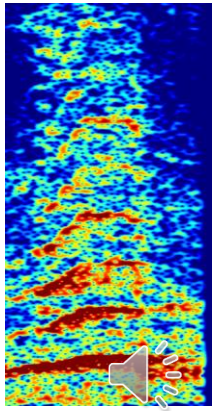
- Early detection of negative emotions (pain, hunger)
- Advantages: Non-invasive, group analysis (low cost)
- Disadvantages: Individual assessment is not currently possible







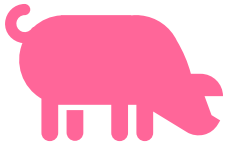




Eating

Calving

Mastitis



83

Camera

45

Accelerometer

14

Scale

28

Microphone

14

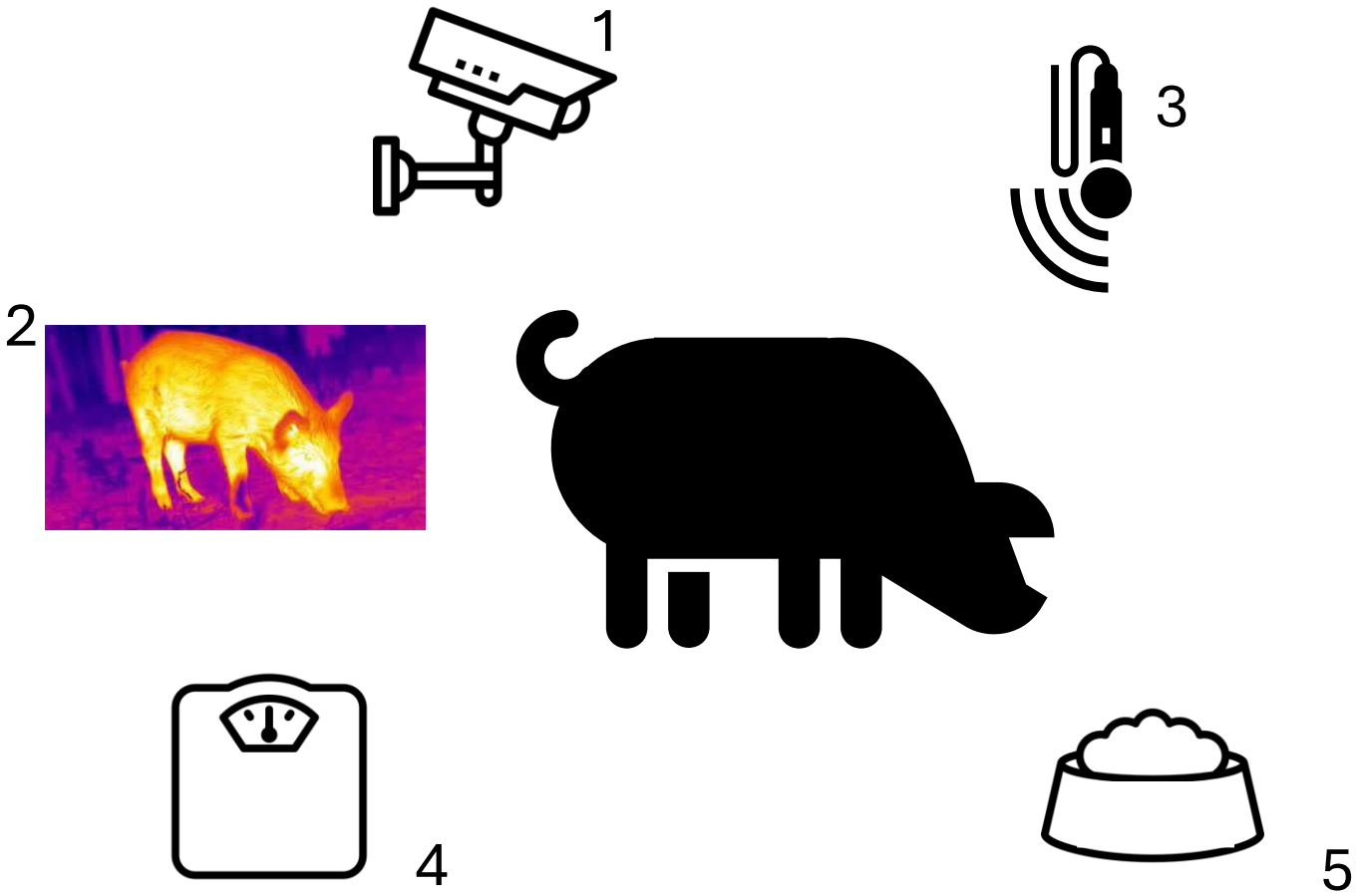
Thermal camera

10

Activity sensor

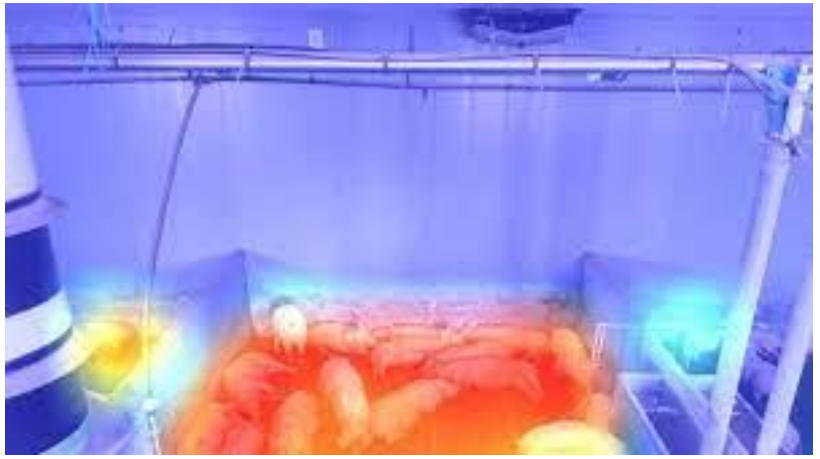
5

(Gomez et al., 2021)



1. Computer vision
2. Thermal camera
3. Microphone
4. Scales
5. Feed intake
6. Water meters

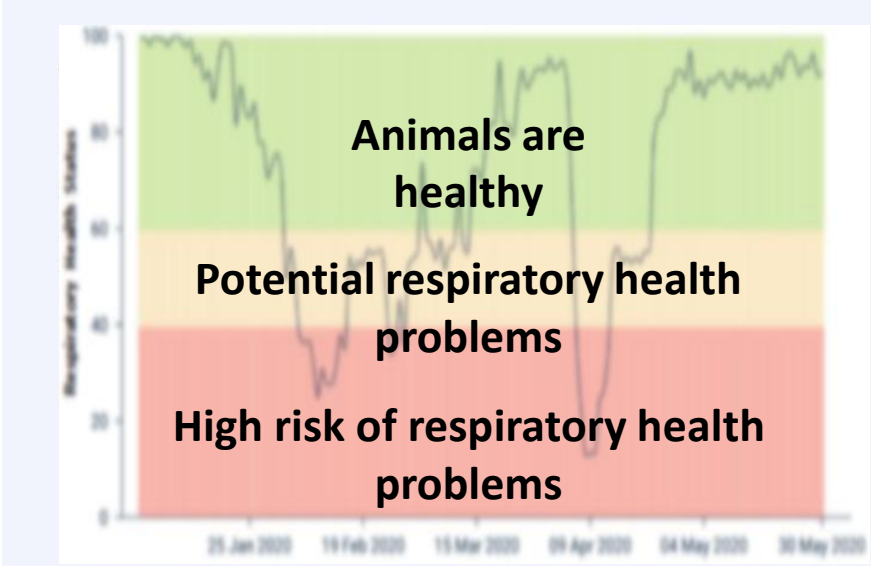
Computer vision



- Activity
- Body weight
- Postures
- Tail biting
- Pen localization

Microphone

- Respiratory health:
  - Cough
  - Sneeze
- Vocalizations



Automatic feeders and waterflow meter

- Feeding behaviour
- Drinking behaviour

Wearable sensors

- Accelerometers attached to ear tags
  - Body postures
  - Activities
- Piglet crushing: wearable sensor and microphone

On farm sensors

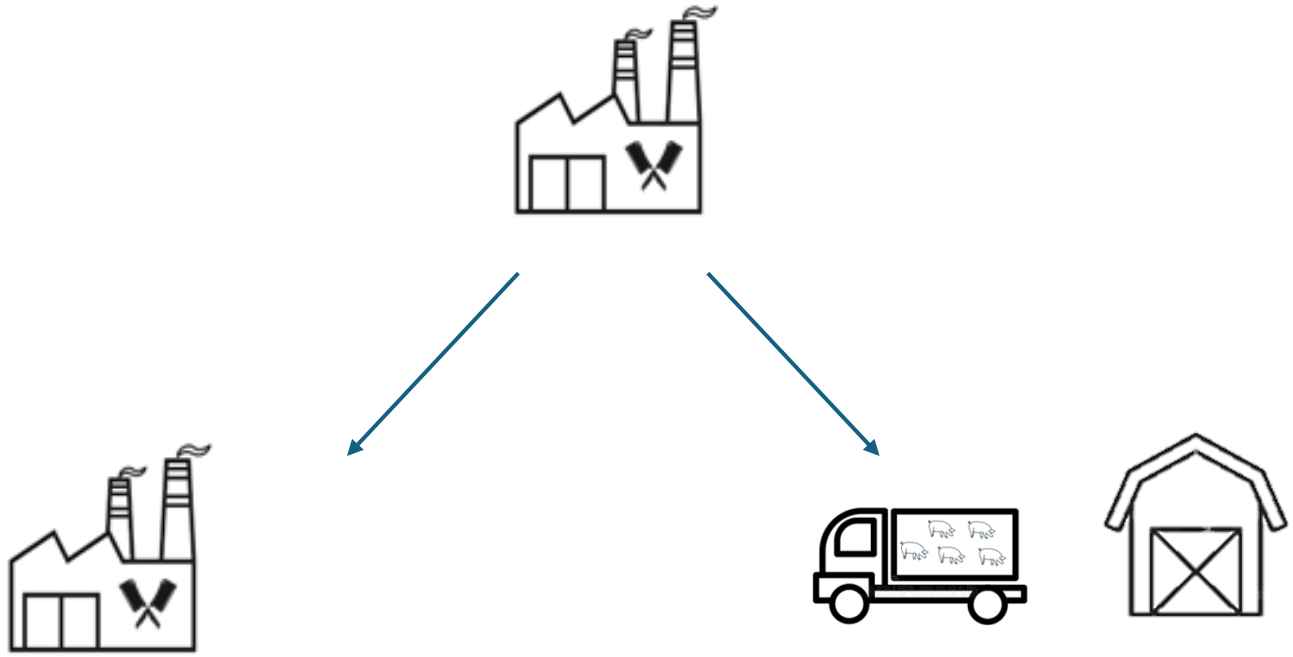
Type of technology	Indicators	Domain
Cameras	Activity, behaviour, postures, body weight	Behaviour, health, nutrition
Microphones	Vocalizations (pain, stress), respiratory disease	Behaviour, mental status, health
Wearables	Activity, postures, temperature, pH ruminal	Behaviour, health
Scales and flow meters	Feeding and drinking behaviour, weight , growth	Health, nutrition
Environmental sensors	Temperature, humidity, quality of air (dust, gases,…)	Environment

Evaluation of animal welfare at slaughterhouses

Antemortem

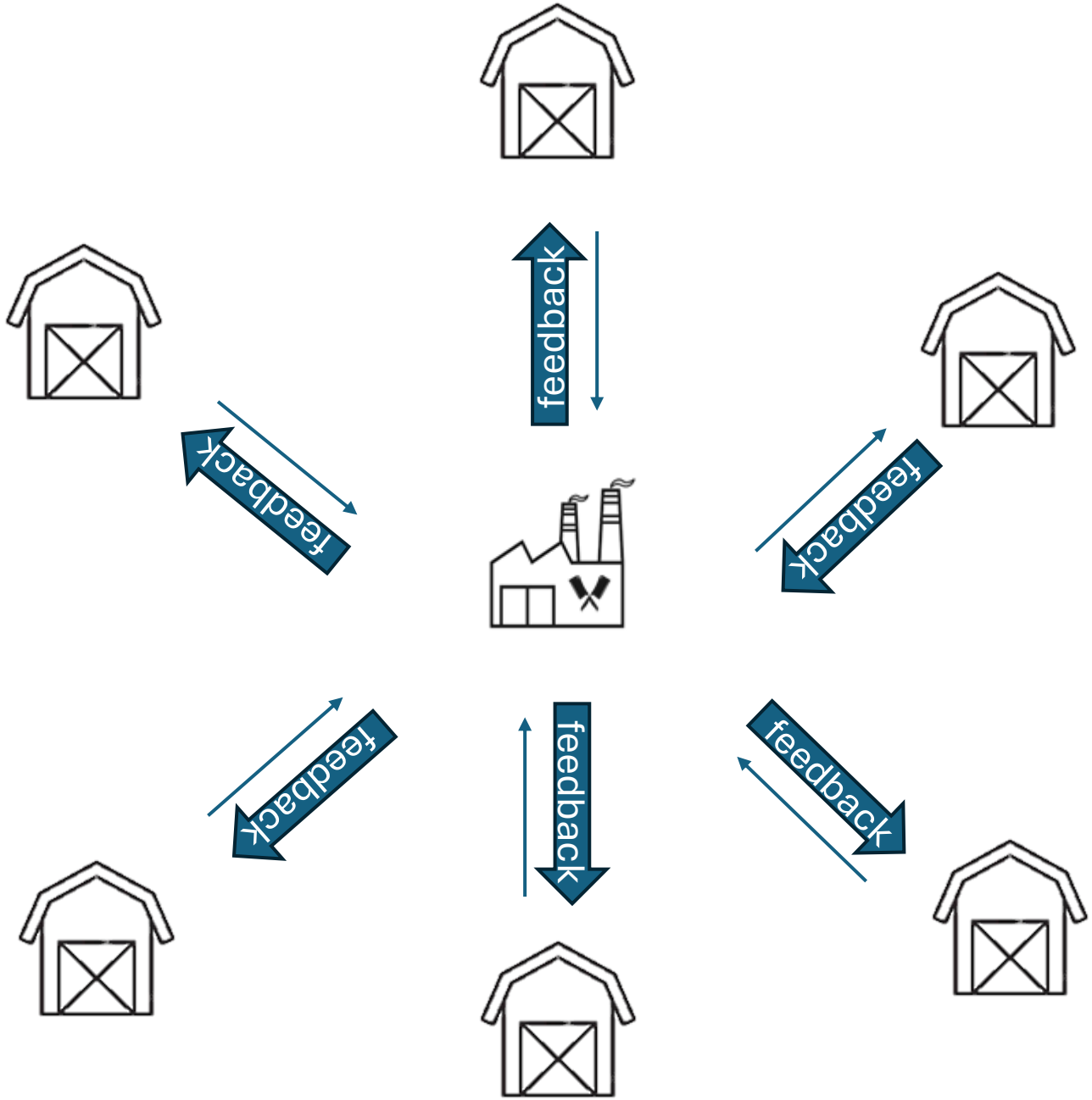
Postmortem

Evaluation of animal welfare at slaughterhouses

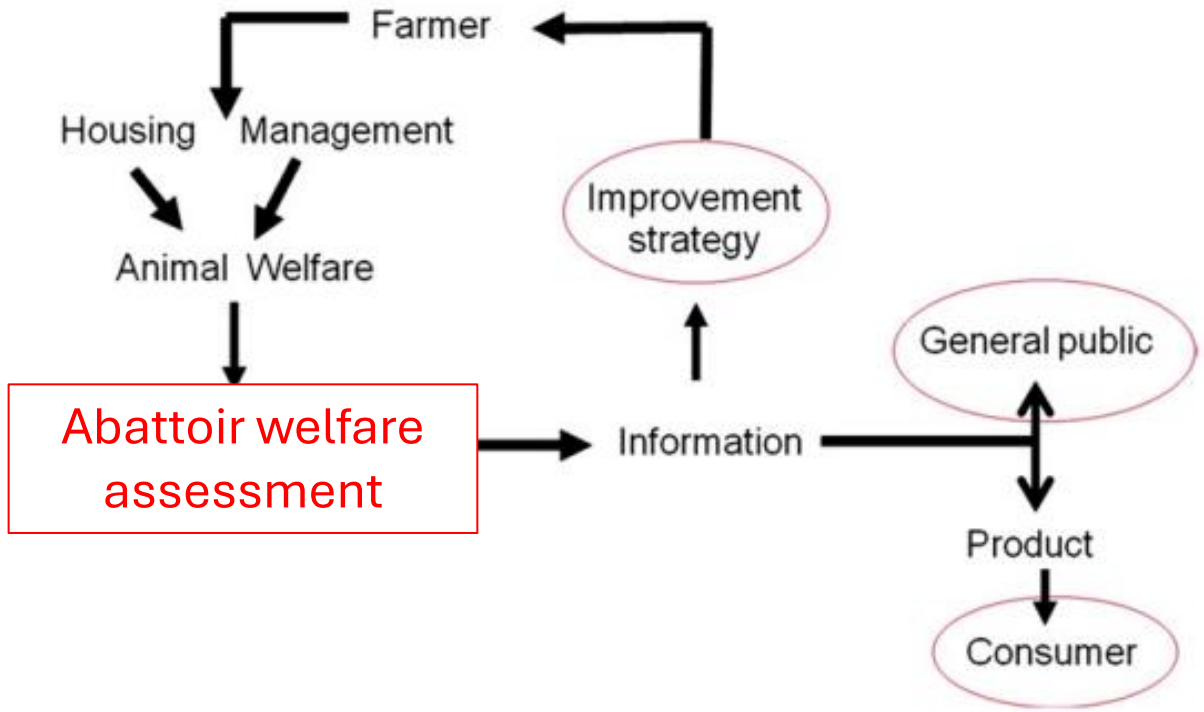


In-situ
(current situation)

Retrospective
(previous production phases)



(Grandin, 2017)



(Dalmau & Velarde, 2017)

In-situ assessment

Welfare principles	Welfare criteria	Measures	Place
Good feeding	Absence of prolonged hunger	Food provision	Lairage
	Absence of prolonged thirst	Water supply	Lairage
Good housing	Comfort around resting	Flooring, bedding	Unloading area and lairage
	Thermal comfort	Shivering, panting, huddling	Unloading area and lairage
	Ease of movement	Slipping, falling, stocking density of lorries, stocking density of lairage pens	Unloading area and lairage
Good health	Absence of injuries	Lameness	From unloading to lairage
	Absence of disease	Sick animals, dead animals	Unloading and lairage
	Absence of pain induced by management procedures	Stunning effectiveness	Stunning area
Appropriate behaviour	Expression of social behaviours	-	
	Expression of other behaviours	-	
	Good human-animal relationship	High-pitched vocalisations	From lairage to stunning area
	Positive emotional state	Reluctance to move, turning back	Unloading area

Adapted from Welfare Quality® (2009)

Retrospective assessment

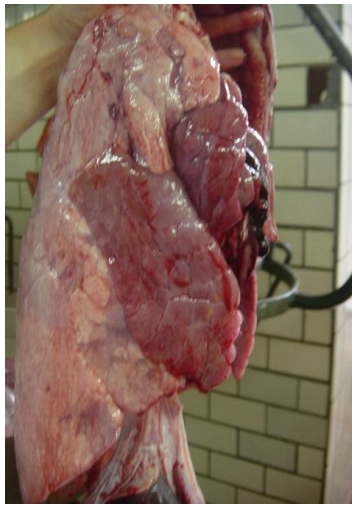
Skin lesions

Aggressions

Short term

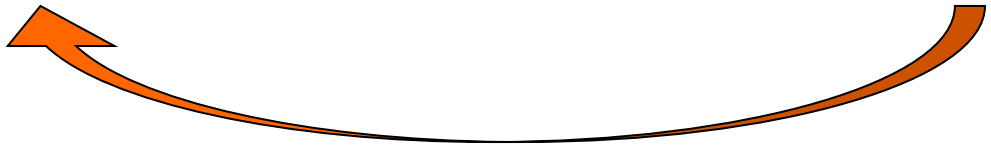
(Dalmau et al., 2009)

Retrospective assessment



Lung lesions

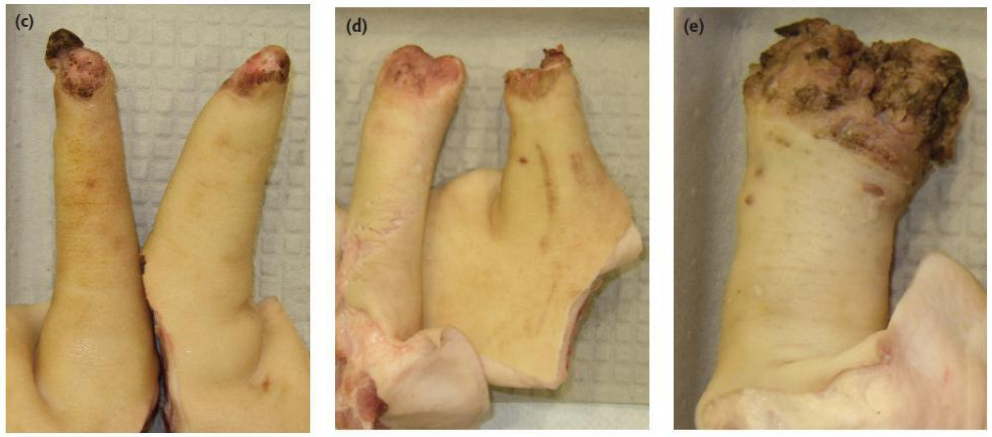
Pneumonia



Long term

(Dalmau et al., 2009)

Retrospective assessment



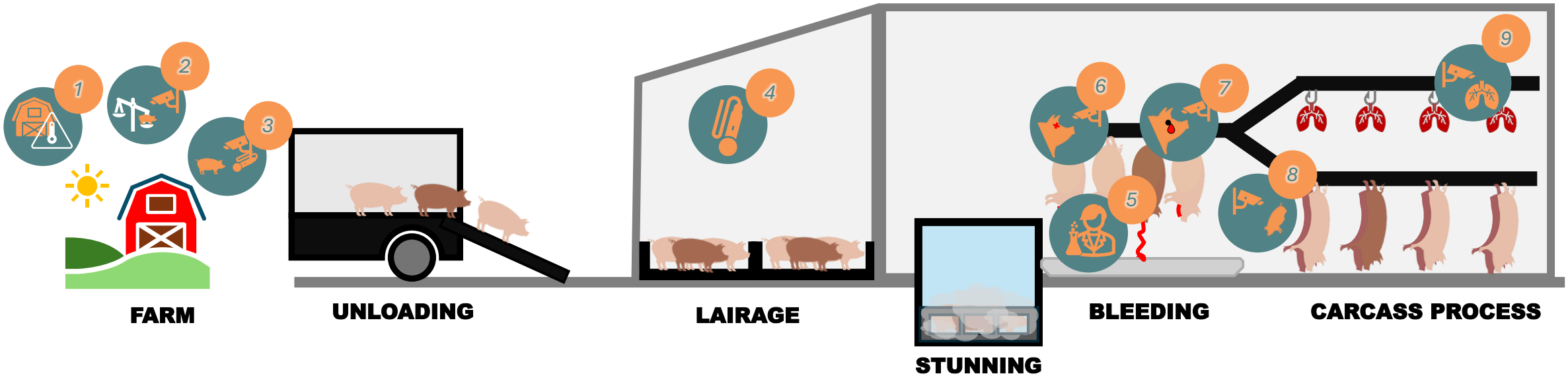
Tail lesions

Tail biting

Long term

(Harley et al., 2012)

Slaughterhouse sensors



4 STREMODO (FBN) – stress vocalizations

5 IGFBPs (FBN) – level of stress (exsanguination blood)

6 BlinkAI (Nuna Solutions) – stunning effectiveness

7 Tear Staining (ILVO)

8 PigInspector (CLK GmbH) – Skin, ear and tail lesions and tail length

9 Lesion-Detect (Innotech) – Lung lesions

Slaughterhouse sensors

Technologies developed to assess welfare of pigs at the slaughterhouse listed per area where they are applied, welfare indicator measured, type of technology, sensor, and provider. Sensors analysing the same indicator are presented in alphabetical order.

Area	Indicator(s)	Type of technology	Name of sensor	Provider
Lairage	Noise	Acoustic sensor	Noise Level Dashboard	Genba Solutions GmbH
	Space availability	Computer vision	Space availability	Genba Solutions GmbH
	Animal handling	Computer vision	AI4Animals	Deloitte
			Argus	Argus
			smaRt counting	Ro-Main
Slaughter area	Stunning effectiveness	Computer vision	CET' Automatique	Wel2be
			Monitoring of the CO_2 stunning	Genba Solutions GmbH
			Signs of life	Argus
	Killing effectiveness	Computer vision	VisStick	Danish Meat Research Institute
		Thermal camera	Bleeding Measurement in Pigs[a]	CLK GmbH
Carcass processing area	Lung lesions and pleurisy on carcass	Computer vision	ADAL	Farm4Trade
	Carcass and viscera lesions	Computer vision	ArtificialVet®	Company Mind
	Tail length, tail and ear lesions, injuries on the abdomen	Computer vision	CLASSIFAI® BOX	Software Logistik Artland GmbH
	Tail length, tail and ear lesions, injuries on the abdomen	Computer vision	CLASSIFAI® BOX	Software Logistik Artland GmbH
	Ear, skin, tail lesions and tail length	Computer vision	PigInspector	CLK GmbH
	Tail length and lesions	Computer vision	TailCam[a]	Danish Technological Institute - PigWatch
			TAILSCAN[a]	Farm4Trade

[a] Sensor technology currently under development.

(Ramon-Perez et al., 2025)

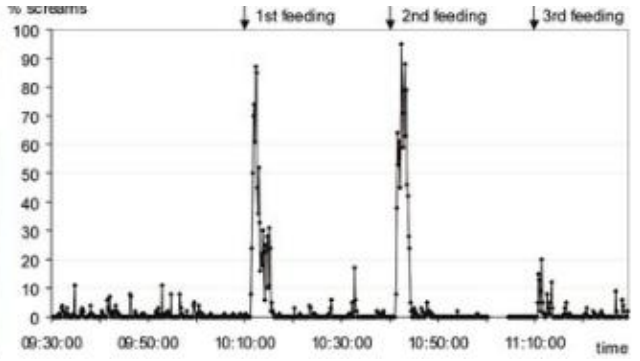
Technologies developed to assess welfare of pigs at the farm with potential for installation in the slaughterhouse, listed according to welfare indicator, type of technology, name of sensor, and provider. Sensors analysing the same indicator are presented in alphabetical order according to their names.

Indicator	Type of technology	Name of sensor	Provider	Observations
Cough Vocalisations	Acoustic sensor Acoustic sensor	SoundTalks ALIS Grunty Sensor[a] STREMODO[a]	SoundTalks NV Greengage Global Research Institute of Farm Animal Biology (FBN)	Multisensor Include environmental sensors
Movements and activity	Computer vision	Dilepix[a]	Dilepix	Count lying, eating, drinking, standing, aggressive behaviour
		Healthy Climate Monitor	Healthy Climate Solutions	Multisensor Include environmental sensors, sound analyser, and thermal camera
		PEEK Analytics	Copeeks SAS	Record the position of the animal within the pen Multisensor Include environmental sensors
		PigGuard	Serket B.V	Record drinking and eating behaviours
Animal handling	Computer vision	PigCounter	PigBrother	Counting pigs automatically
Body weight	Computer vision	Embedded vision prototype for livestock weight monitoring[a]	Lemberg Solutions	
		eYeGrow	Fancom BV	
		FarmSee	FarmSee Ltd	
		Growth sensor	GroStat	No longer commercialised as the company was dissolved
		iDOL 6S camera	Dol Sensors	
		OptiScan	Big Dutchman	
		PigBrother	PigBrother	
		PIGI	Corntec	
		PigVision	Asimetrix	Belong to SMARTFARM solution Combine different sensors
		Pigxcel™ ID	Smart Agritech Solution of Sweden	
		Qscan	Innovent Technology Ltd	
		WeightCheck	Big Dutchman	
		Weight-Detect™[a]	Innotech Vision	
		WUGGL One[a]	WUGGL GmbH	
	Load cells (scale)	ACCU-ARM Survey Scale	Osborne	
		Automatic Pig Weighing	Hotraco Agri	
		CIMA Automatic Marker	CIMA Animal Farming Equipment	
		CIMA Control Pig	CIMA Animal Farming Equipment	
		CIMA Identification	CIMA Animal Farming Equipment	
		CIMA Selection Gate	CIMA Animal Farming Equipment	
		PigScale	PigScale	Sorting scale
		SKIOLD Tristar	SKIOLD Group	Sorting scale
		TriSortPro	Big Dutchman	Sorting scale
Body temperature	Infrared thermometer	EVTSCAN thermometer	EVTSCAN	
		IRT207 The Heat Seeker 8:1	General Tools	
		TN418L1	Metris Instruments	
		YM-558D	Tebru	
	Infrared camera	Degree2act	Degree2act	Software FLIR One camera is required
	Thermal camera	FLIR One Pro LT	FLIR	Require a smartphone
		FLIR E8 Pro	FLIR	
		H4 Intelligent Thermal Camera	Guide Sensmart	
		IR Pad 640	Digatherm	
		IR Pad 320	Digatherm	
		T400	InfiRay	
		T630	InfiRay	
		TR256B	Milesesy Tools	
		TR256E	Milesesy Tools	
		X640D	Yoseen Infrared	
	Camera with temperature sensor	WUGGL One[a]	WUGGL GmbH	
Drinking behaviour	Flow water meter	Sonata Ultrasonic Residential Water Meter	Arad Group	
		Water Monitoring	Fancom BV	
		WMI Water Meter	AgroLogic LTD	
Tail-biting	Computer vision	TAIL[a]	Dilepix	
Tail position		TailTech	Innovent Technology Ltd	Not clear if it is currently purchasable

[a] Sensor technology currently under development.

(Ramon-Perez et al., 2025)

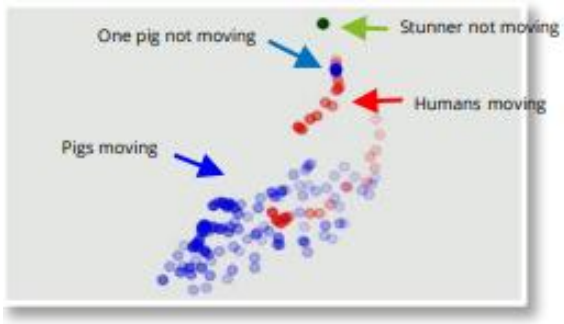
Acoustic sensors

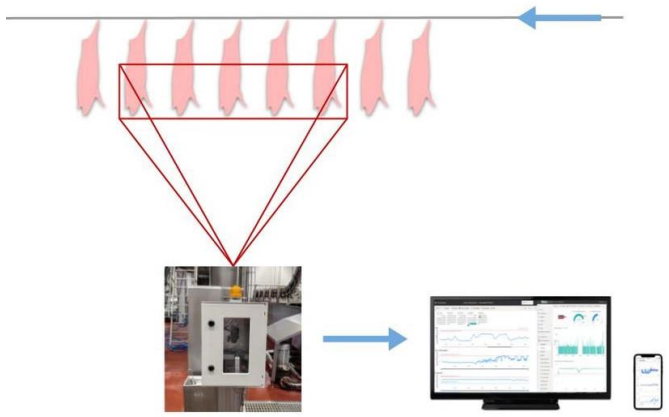


- Noise level
- Vocalisations

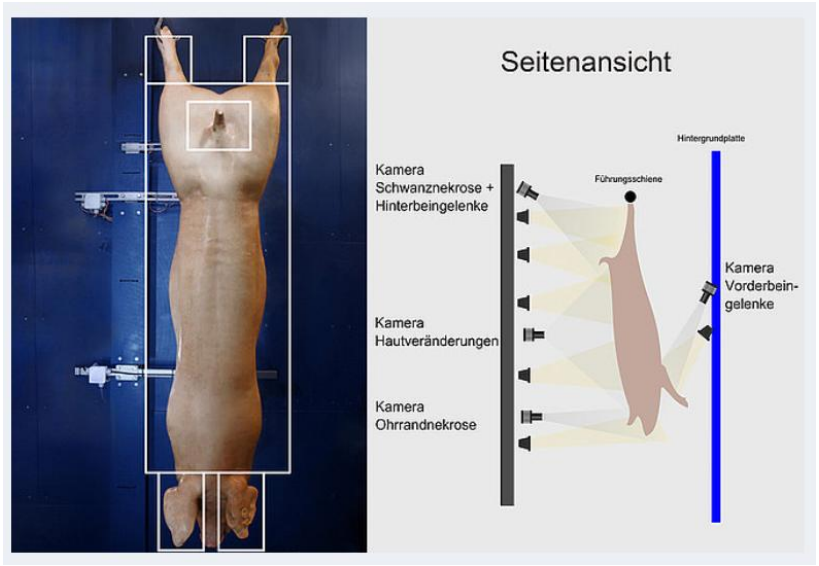
Computer vision

- Human handling
- Space availability
- Stunning effectiveness

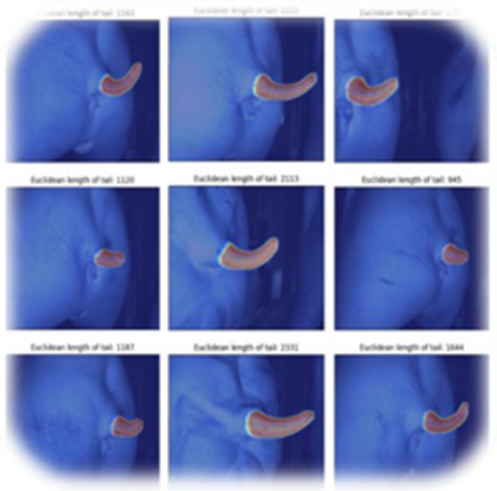




Computer vision



- Tail lesions
- Tail length
- Skin lesions
- Ear lesions



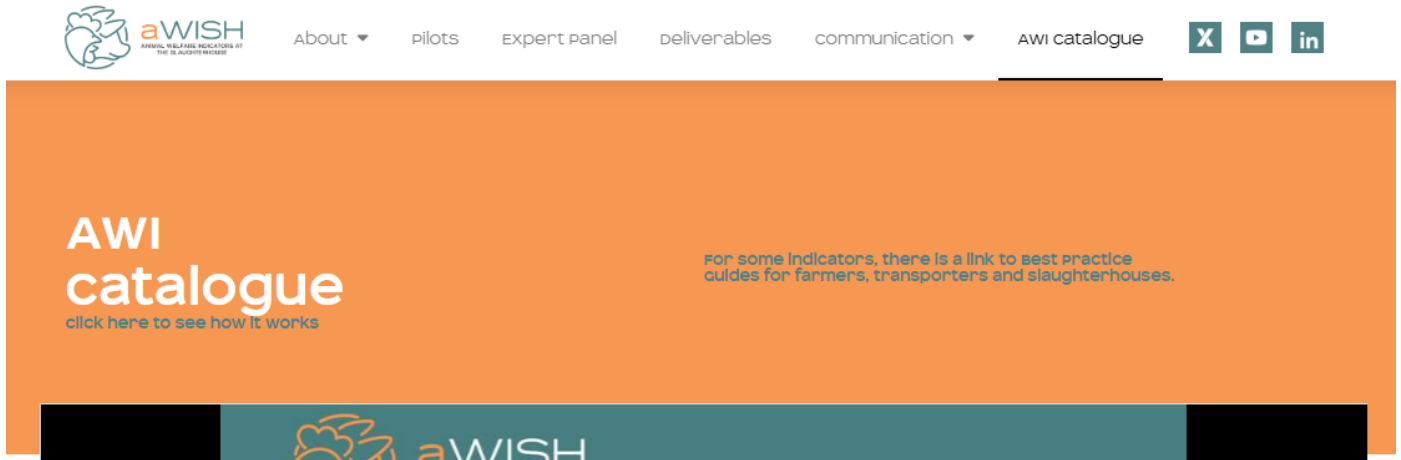
Computer vision

- Lung lesions
- Hockburn lesions
- Foodpat lesions

Animal Welfare Indicators Catalogue

- Interactive online tool
- Compilation of PLF technologies for monitoring animal welfare indicators in slaughterhouses
- Pigs and broiler chickens
- Each section is further divided into three stages:
  - *Pre-slaughter*: covers the period from when the animals arrive at the slaughterhouse until they enter the stunning area
  - *Stunning*: covers the stunning and slaughter procedures
  - *Post-slaughter*: includes all procedures carried out on the carcasses

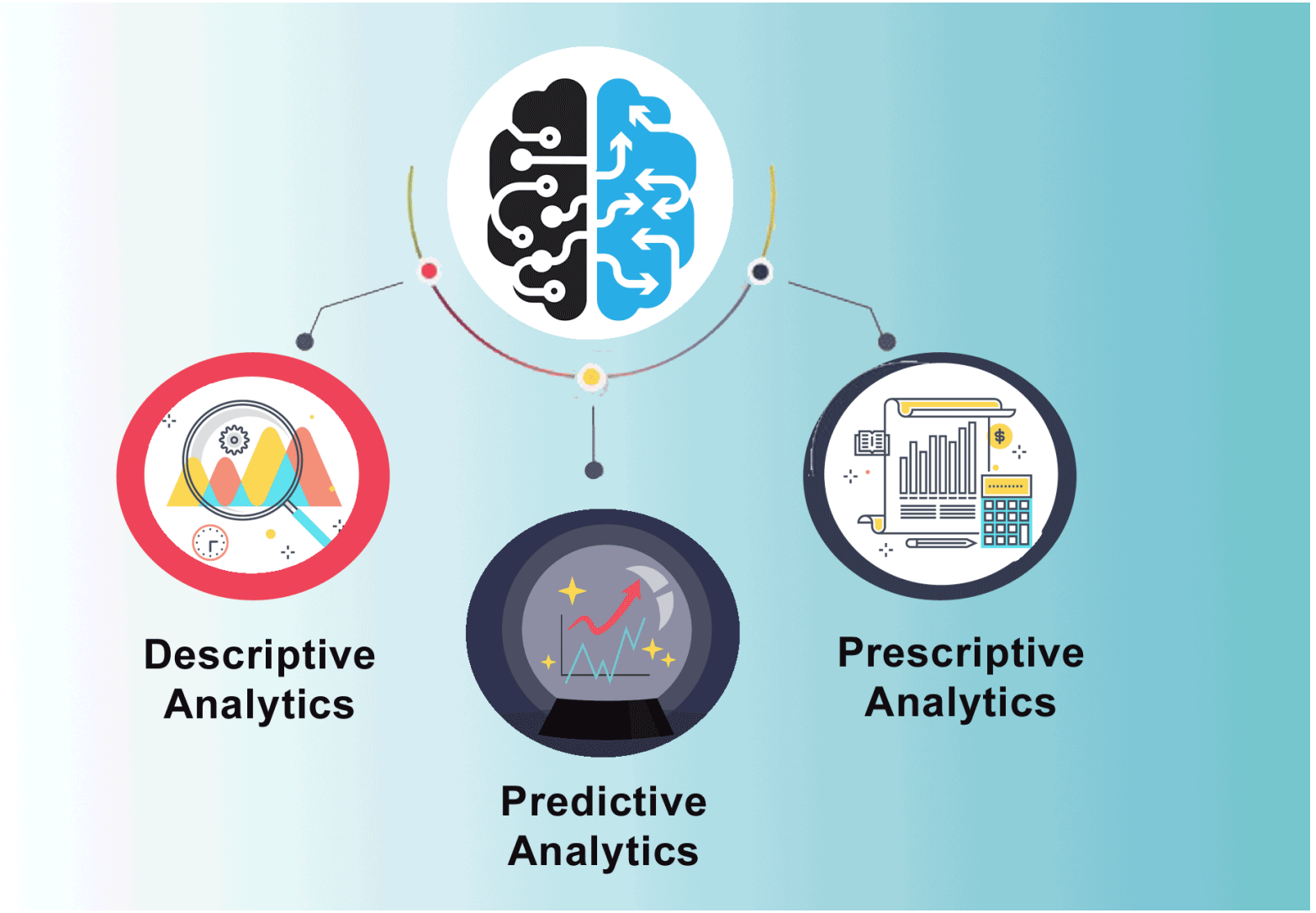
Animal Welfare Indicators Catalogue



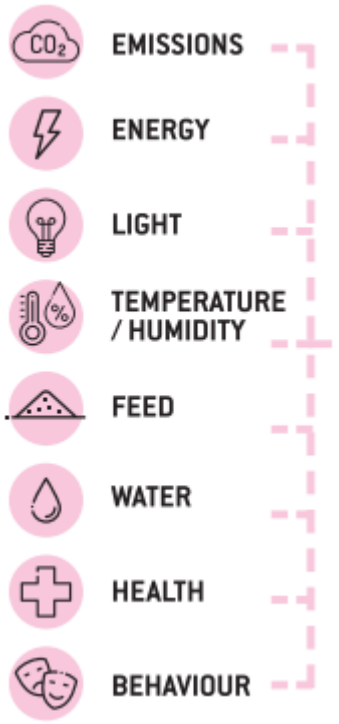
https://www.awish-project.eu/

Potential

- Data from PLF sensors provides a great quantity of information with **ENORMOUS** potential
- It should be analysed using **appropriate mathematical tools**, particularly those based on artificial intelligence algorithms
- This data not only allows us to **monitor the animals' condition** at all times, but also offers **predictive insights** into what might happen in the future, based on current changes
- **Individualisation of the animals** instead of considering the group level welfare


Descriptive Analytics
Predictive Analytics
Prescriptive Analytics

Descriptive analysis




```
1  cow_data_day(43582, '2021-02-01')
```

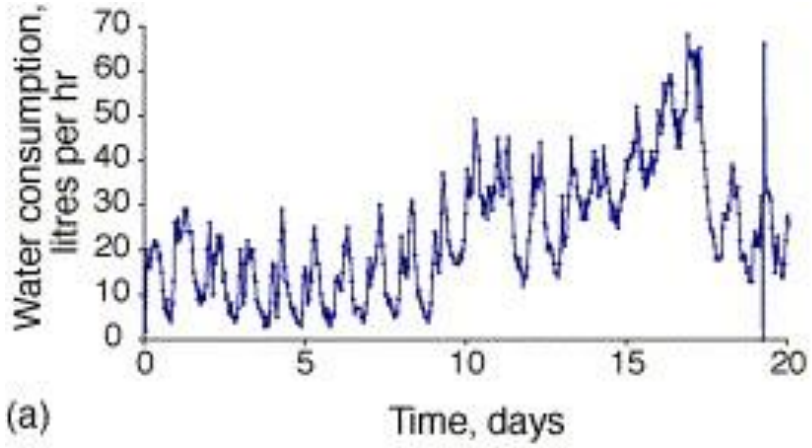
```
==============================
Feeding Score: 7.5
Housing Score: 7.5
Health Score: 8.89
------------------------------
Total Score: 7.96
==============================
eating: 7834.69
ruminating: 14133.38 - Smaller than 15720
temperature: 38.74243
drinking.times: 6.0
lying: 17988.46
standing: 20738.99
walking: 7523.18
pH: 5.93153
SCC: nan - No data
```

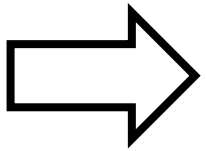
```
1  cow_data_day(101371, '2022-08-29')
```

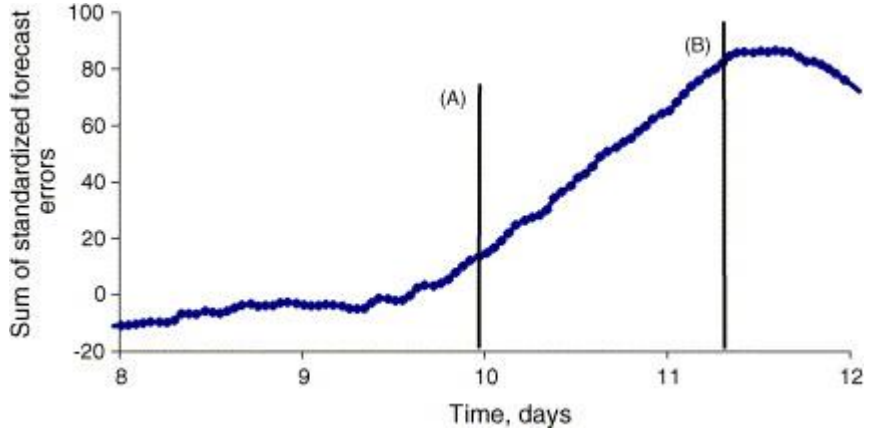
```
==============================
Feeding Score: 10.0
Housing Score: 10.0
Health Score: 10.0
------------------------------
Total Score: 10.0
==============================
eating: 17582.69
ruminating: 29606.23
temperature: nan - No data
drinking.times: nan - No data
lying: 20849.72
standing: 56180.38
walking: 9316.55
pH: nan - No data
SCC: nan - No data
```

Predictive analysis

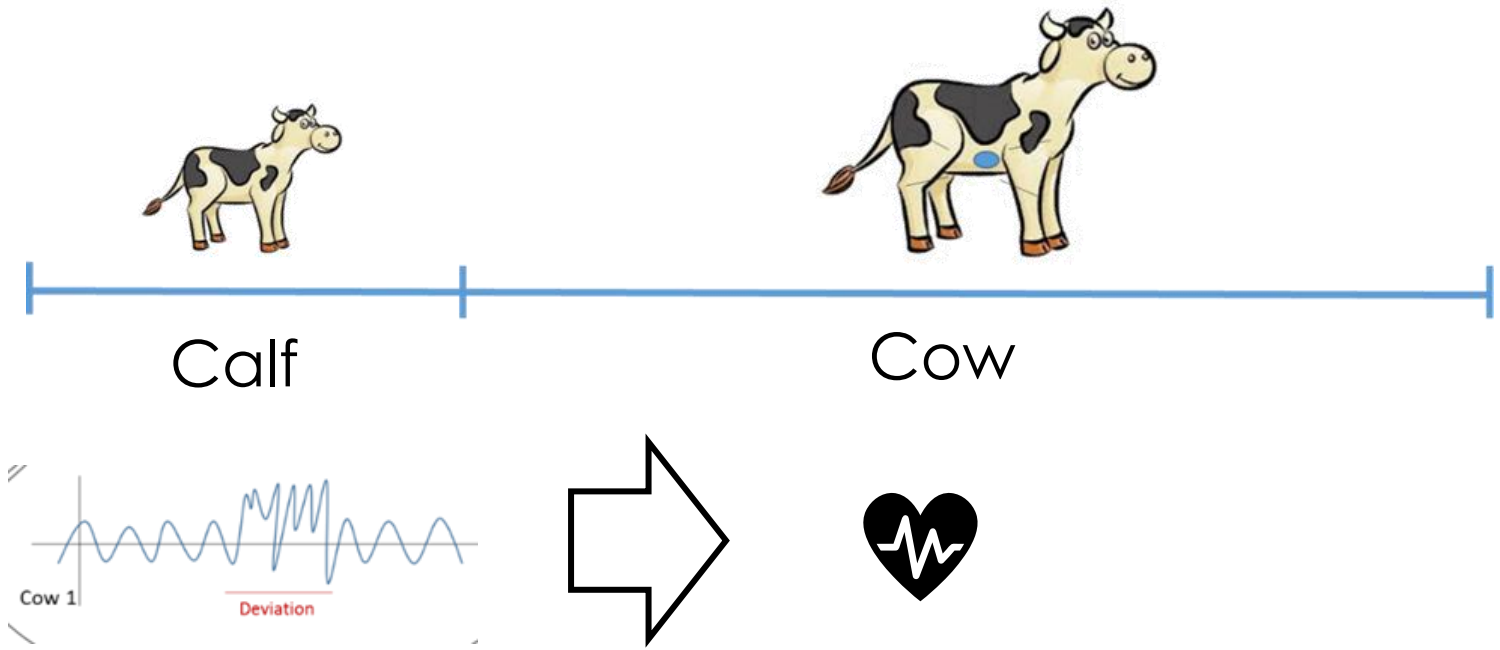
- Water intake
- Estimation of gastrointestinal disease (diarrhoea)







Prescriptive analysis



- Adjust feed and housing
- Closer monitoring of at-risk animals
- Selecting animals with lower-risk traits

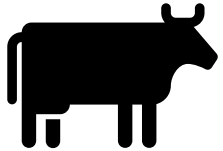
Limitations

- Technical limitations (i.e., internet connection, electricity)
- Animal limitations (adaptability and invasiveness)
- Data protection
- Validation

Validation

Sensors available on the market

Stygar et al., 2021



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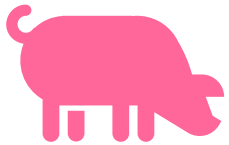

Gomez et al., 2021

83

Sensors independently validated

18

8

Take home messages

PLF sensors herald a new era in animal monitoring

Sensors for livestock animals are set to see strong growth in the coming years

This will increase the demand for staff specialising in data analysis and management

There is great potential for research and innovation in the development of new sensors

… But there are still many challenges ahead

Thank you very much for your attention.
Do you have any questions?

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