A review on implementational gaps and barriers regarding data quality and robustness for AI applications in livestock digital solutions

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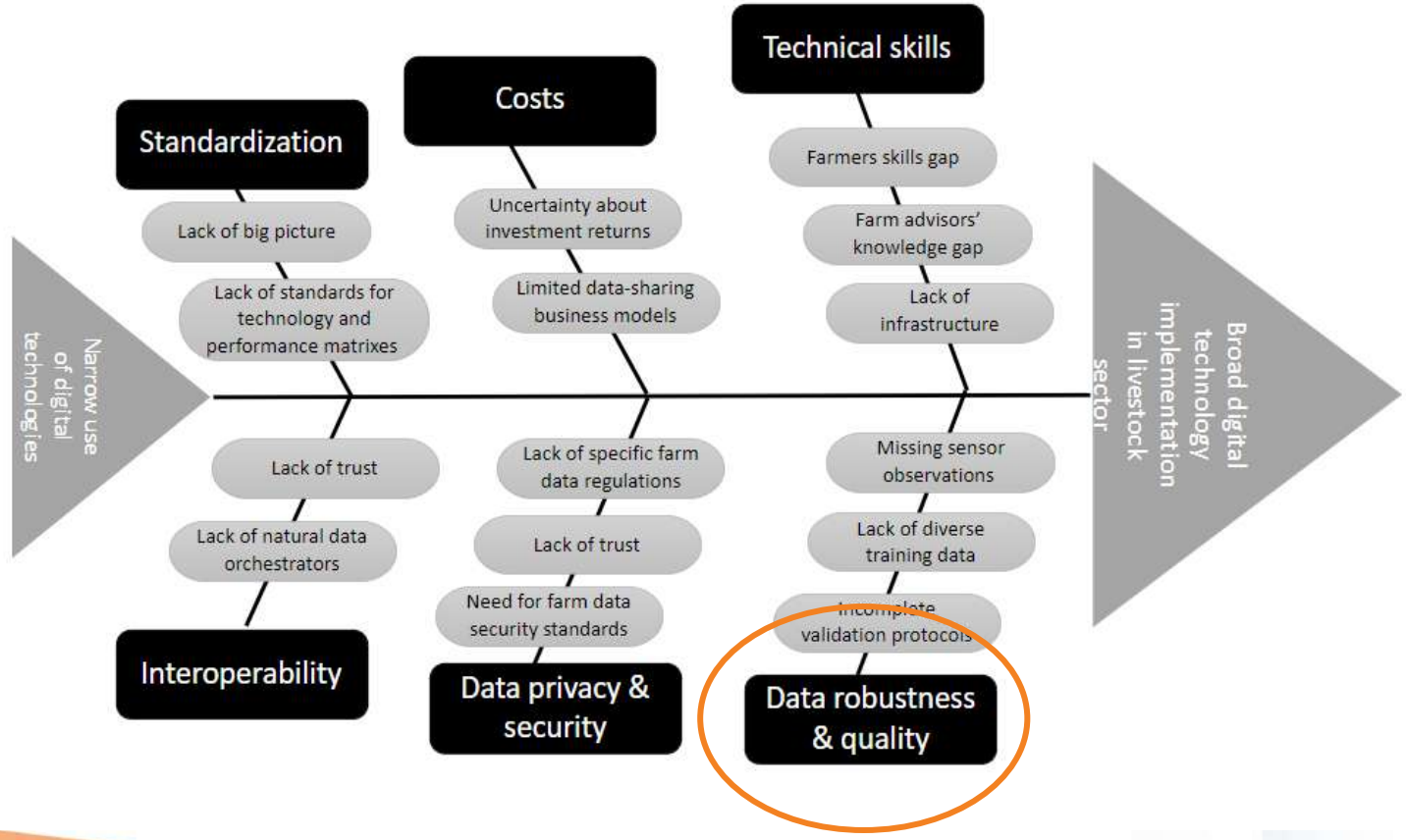
The Digi4live project

Digi4Lives's goal is to help **the European livestock sector** leverage **digital technologies** and data for the **benefit of farmers** and **food** and **technology companies** and to facilitate **public administration.**

Opinion paper on **gaps, barriers and solutions to digital technologies adoption** in the livestock sector



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The Critical Role of Data Quality and Robustness in the AI Era

Artificial intelligence is not magic. **It only knows what it has learned**

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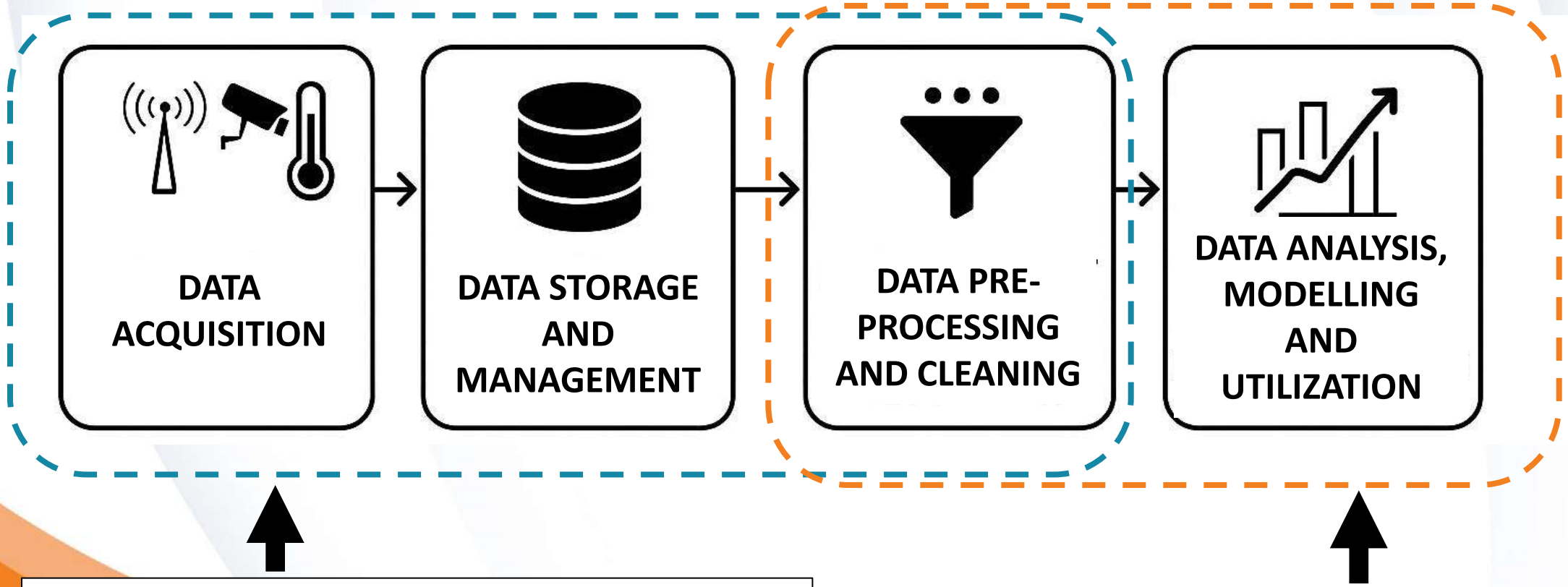
Data quality and robustness : what does it mean ?



Quality = completeness, accuracy, consistency and reliability of data

Robustness = ability of data to stay useful and interpretable even in imperfect conditions

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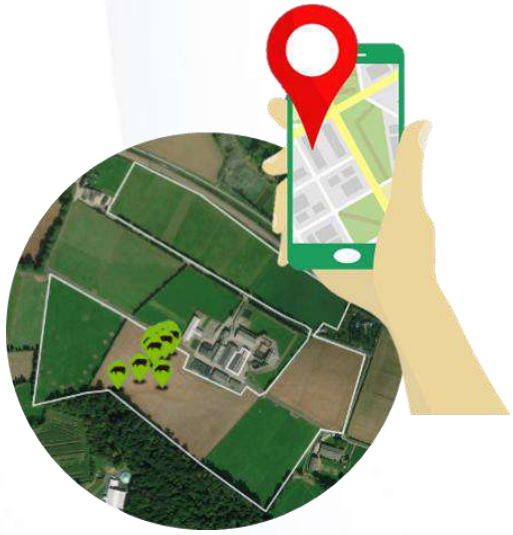
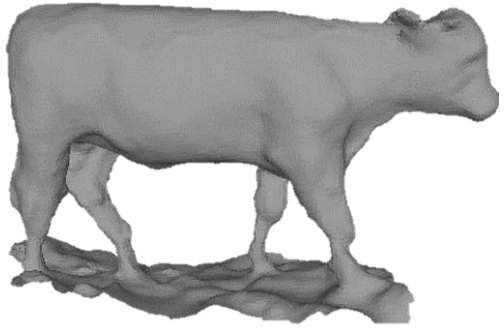
Illustration based on 2 use cases



Grazing traceability with GPS solutions

PHENO3D



High throughput phenotyping based on 3D imaging

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Grazing traceability with GPS solutions

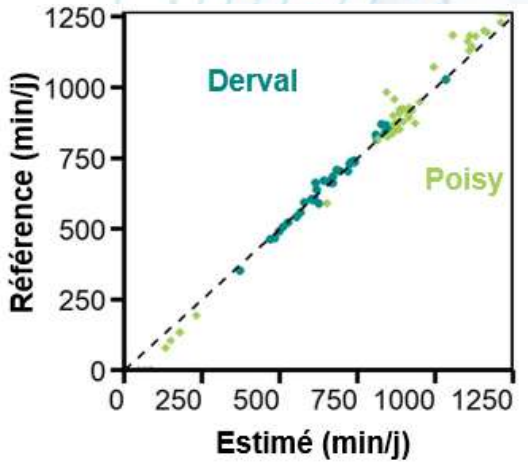
GPS collars

Cow location (LPWAN transmission)

Data preprocessing +
Paddock Detection models

Grazing time calculation models

Paddock grazed
Nb hours/day
Nb days grazed
…



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Grazing traceability with GPS solutions : Incomplete data

Data incompleteness

→ Effect of mountain/sea on Sigfox signals

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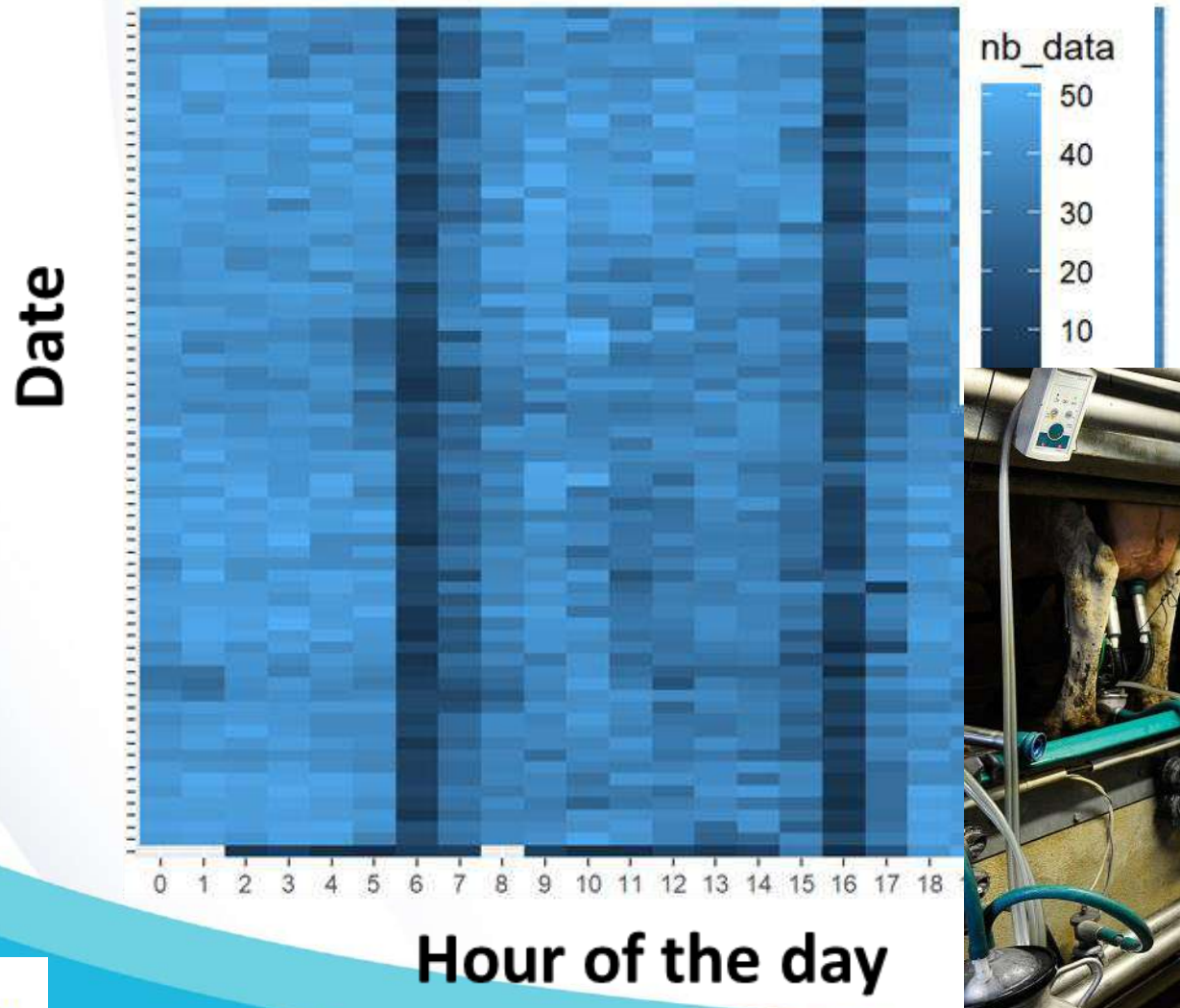
Grazing traceability with GPS solutions : Incomplete data



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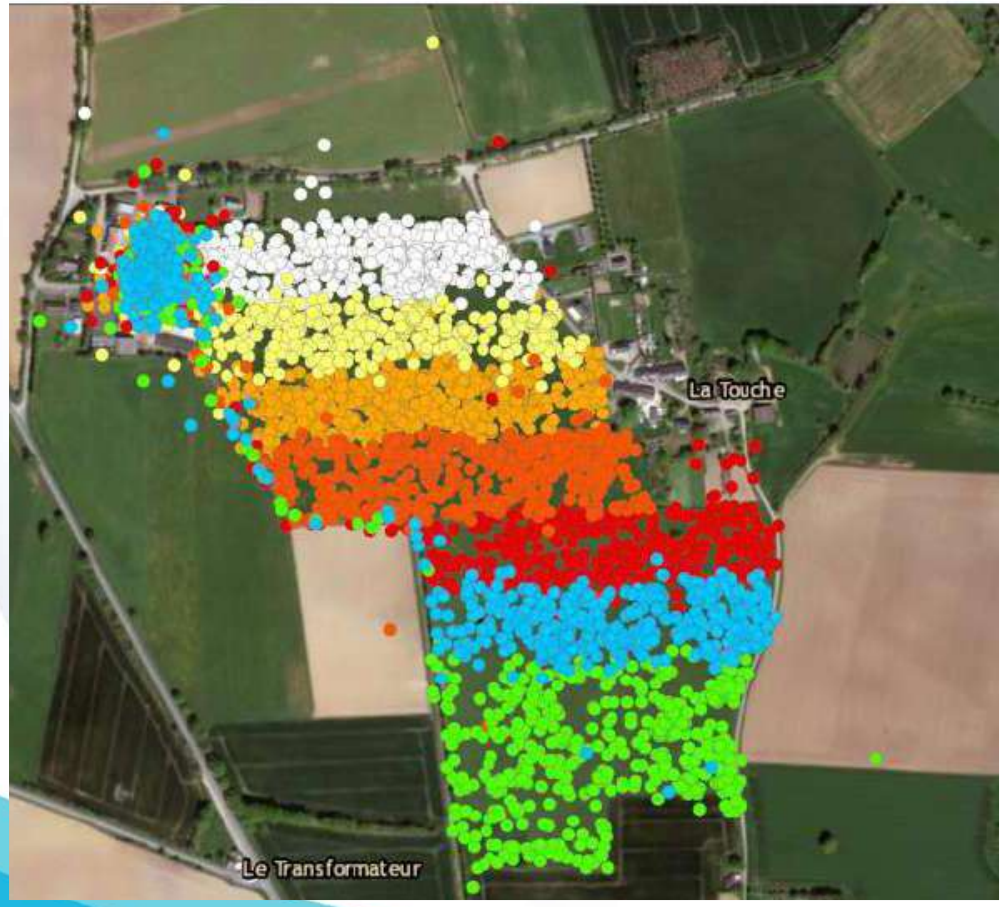
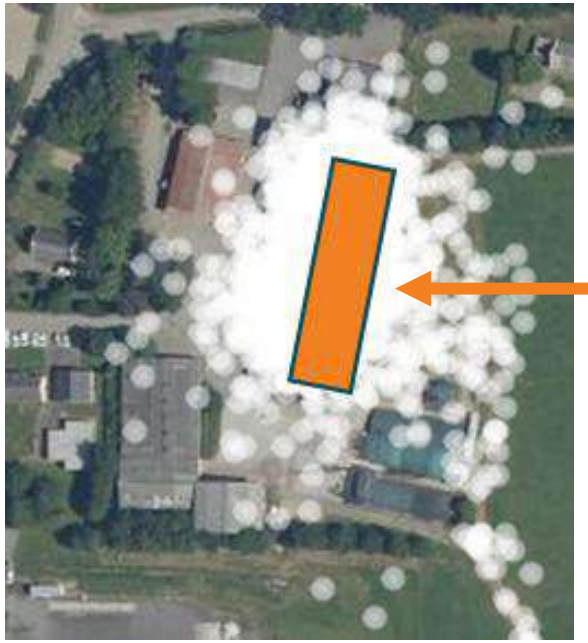
Grazing traceability with GPS solutions : Data inaccuracy





True barn position

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Grazing traceability with GPS solutions : solutions vs. barriers

Use advanced, reliable sensors, and adapted IOT networks ?

- GPS + sigfox
- 3 months disposable battery
- 250 €

- Multi-protocol (Satellite, 5G, LPWAN,…)
- Solar panels
- Buffer memory
- 1000 €

Too costly !

→ **Necessary trade-off** between **improving data quality and enhancing robustness**

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Grazing traceability with GPS solutions : solutions vs. barriers

Expert-driven preprocessing rules

Locations outside any polygons

GNSS inaccuracy due t the barn effect

Kinetic corrections of the labels

PPBPP -> PPPPP

Are GPS sensors and density-based classification suitable to ensure the traceability of dairy cows on pastures? Part I: Development and validation on experimental farms

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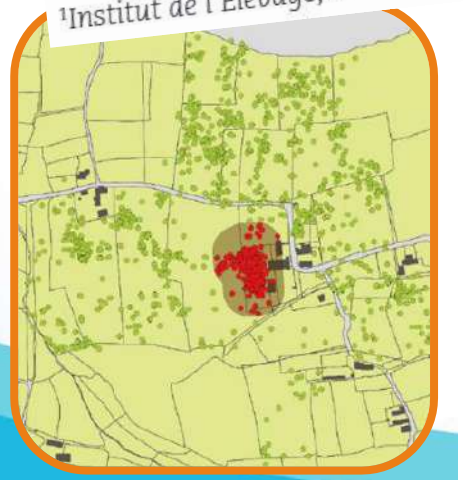

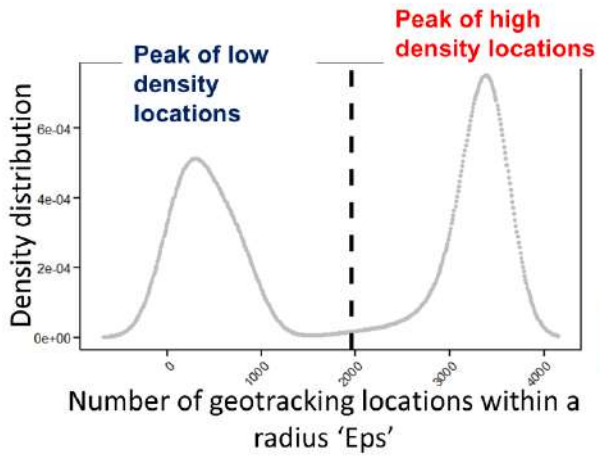

« barn » locations

« pastures » locations

DBSCAN (Hahsler et al., 2019)

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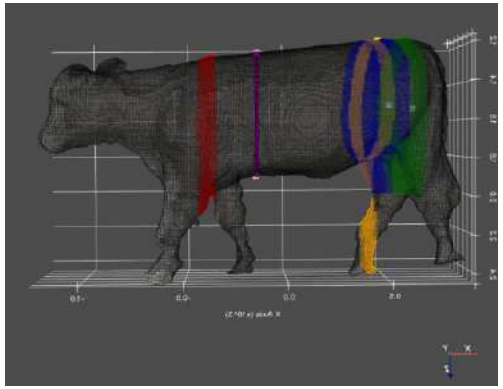
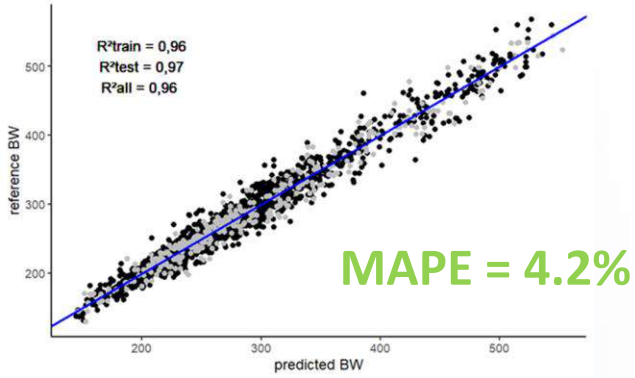
3D imaging phenotyping : Phéno3D project

3D Scan



Data preprocessing
(See Do et al. (ECPLF 2024))



Body weight Prediction
(See Dechaux et al. (ECPLF 2024))

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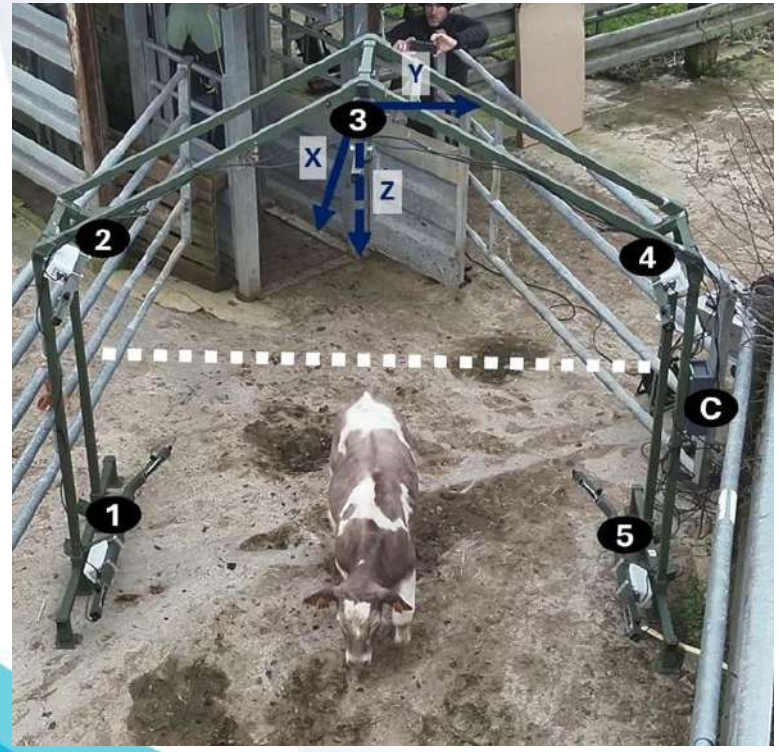
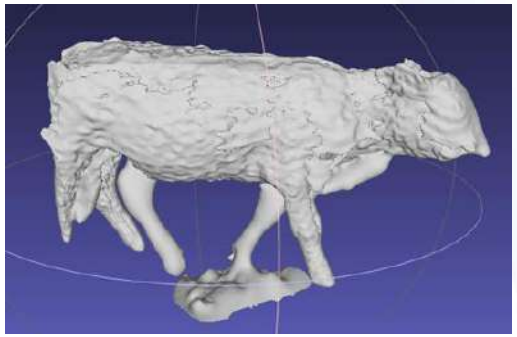
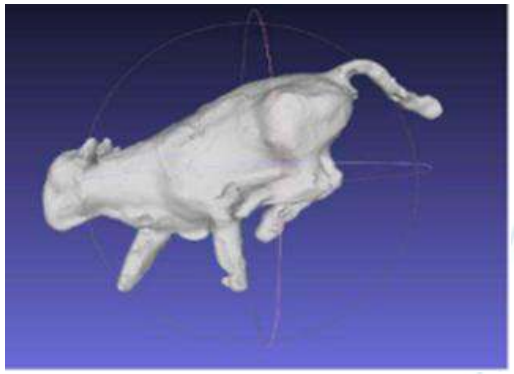
3D imaging phenotyping : how to deal with noise ?



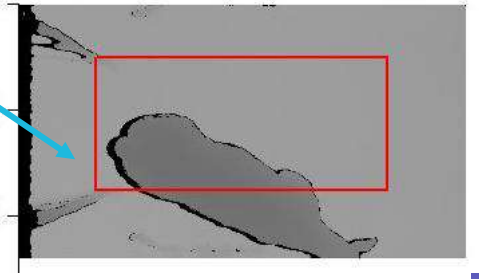
Sun

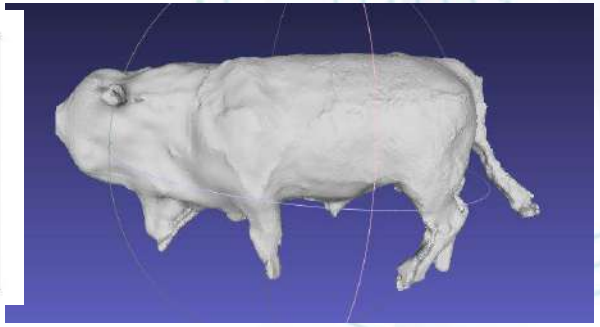


Jump



Not centered





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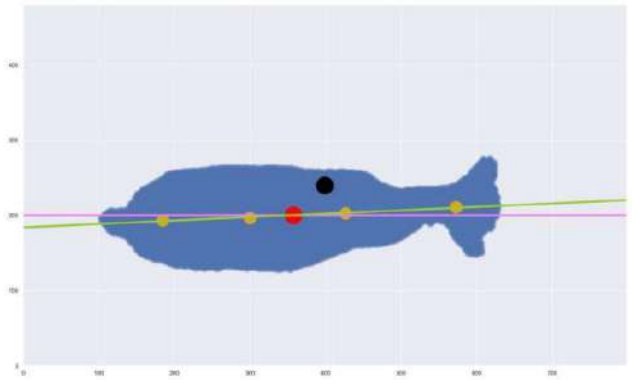
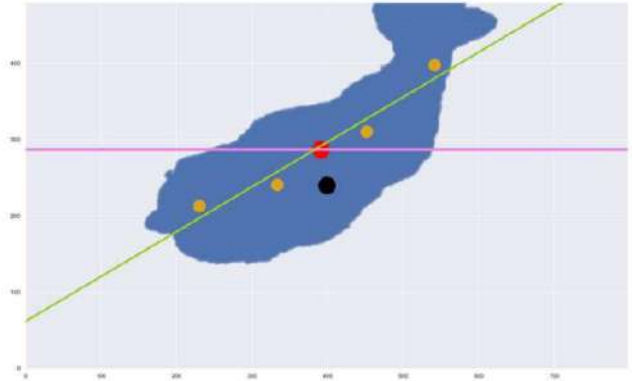
Solutions at the data collection stage

- Improve animal handling

- Develop automatic data quality assesment





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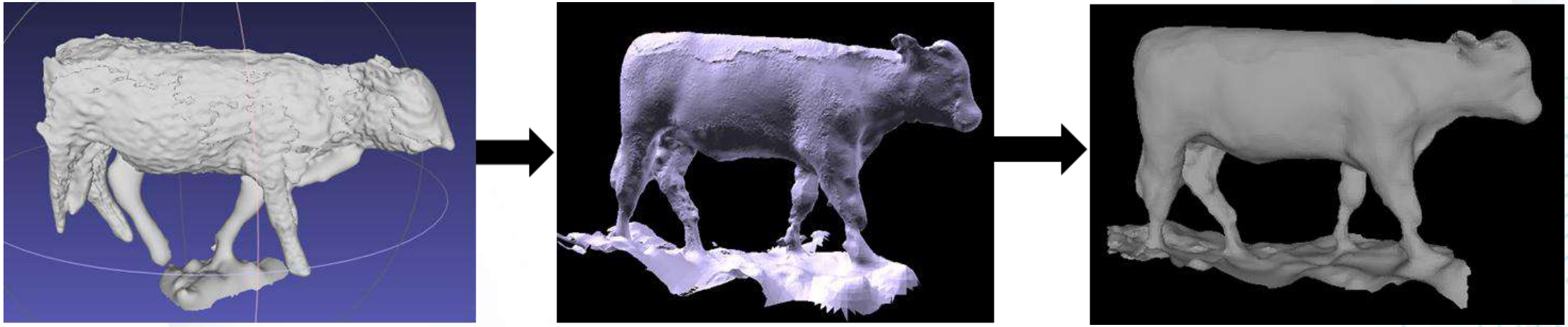
Solutions at the data pre-processing stage

- Improve filtering, smoothing, calibration techniques



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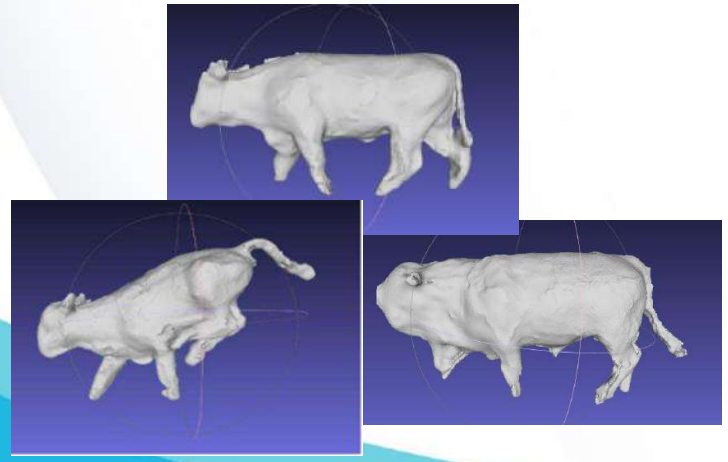
Solutions at the model development stage

Train robust machine learning models with noisy data !

All data (2079 images)

Body weight prediction

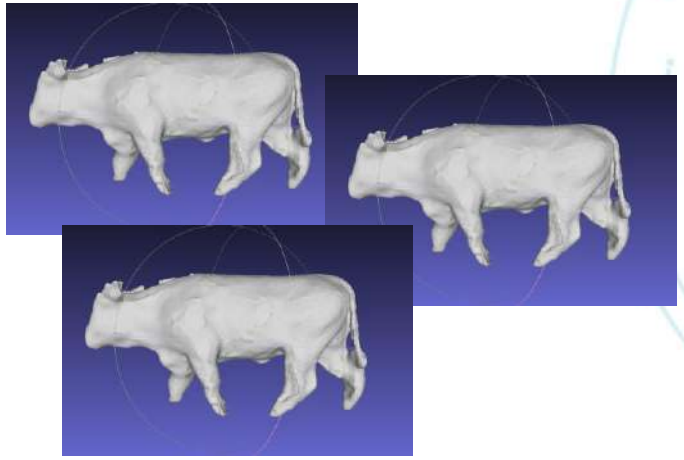
(MAPE = 4.2%)



All data - 25% of worse images

Body weight prediction

(MAPE = 3.9%)



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Conclusion : Please mind the gaps !

- **Quality**
  - ➢ Embedding it in the validation and impact assessment of digital tools in research and practice.

- **Robustness**
  - ➢ As imperfect data becomes the norm, the robustness of AI solutions must rise. Stronger, more resilient Proofs of Concept are essential to ensure real-world reliability and scalable deployment.

Stay tuned – more insights coming soon from the **Digi4Live** project!

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Summary of gaps, barriers and solutions

Gaps	Barriers	Solutions
Incomplete data due to sensor failures, connectivity loss, or low battery life.[36]	High costs of advanced, reliable sensors, and adapted IOT networks. [36]	Enhance energy storing, connectivity, buffer memory; redundancy & interoperability for cross-system validation [36]
Lack of best practice guidance in dealing with noise.	High costs of advanced, reliable sensors; lack of proper calibration and maintenance.	Use advanced data preprocessing techniques to clean and correct anomalies.
Precision and accuracy - poorly calibrated sensors or sensor drift. [37]	Data analysis strategies effect on data accuracy and precision (statistical vs. machine/deep learning) [39]	Regular sensor recalibration and maintenance; on-farm validation for robustness in real conditions. [39]
Temporal synchronization and interoperability – Inconsistencies [37]	Difficulty in aligning multiple sensor outputs; challenges in ensuring seamless interoperability. [37]	Standardized protocols for synchronization. Encouraging interoperability between systems. [37]
AI Data Robustness -Limited diversity in training datasets, bias and overfitting. [40]	High costs and difficulty of collecting diverse, high-quality datasets; over-reliance on quantity rather than quality. [40]	Follow "Ethics guidelines for trustworthy AI"[35]. Foster shared datasets, incorporate data of various regions and conditions; prioritize variance & quality [40]
Tool Validation - Incomplete protocols for completeness or repeatability.	Limited on-farm validation and adoption of comprehensive validation protocols.	On-farm validation under variable conditions; Promoting broader validation standards.
Stakeholder Engagement – How data quality impacts farms and stakeholders.	Lack of training and awareness about digital tools and their potential consequences.	Training of farmers and stakeholders; promote clear communication and equipment maintenance.

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Thank you!

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