The promises of 3D imaging for phenotyping the morphology and innovative traits in ruminant sectors

Lebreton, A., Fischer, A., Depuille, L., Delattre, L., Bruyas, M., Lecomte, C., Gautier, J.-M., Leudet, O., Allain, C.

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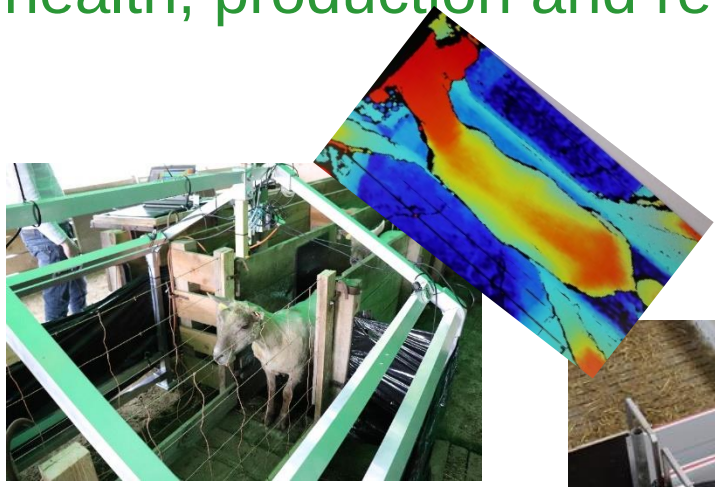
CONTEXT : WHY USING 3D IMAGING ?

Monitoring/Phenotyping morphological traits (BCS, LW, measurements …) allows optimal management of animal health, production and reproduction performances.

Manual Measurements



3D imaging

Automatic Scale

Precision / Accuracy / Reproducibility - **Cost**

Animal handling risks

OBJECTIVES

Review :

1. The current 3D imaging performances
2. The challenges to overcome

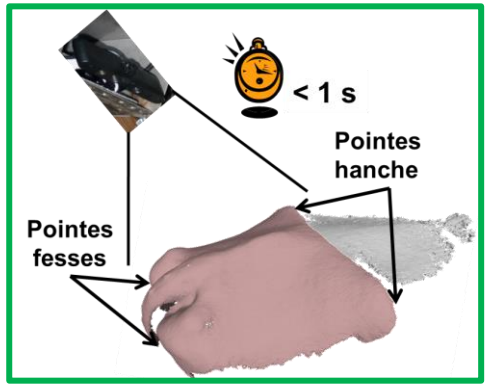
Illustrate :

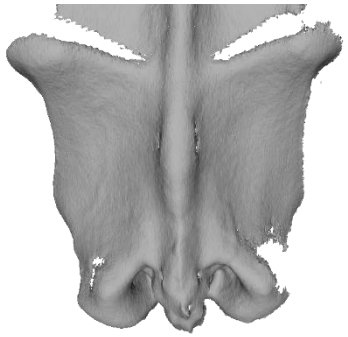
3. The near perspectives : the PHENO3D project

Focusing on the work of our research group since 2014

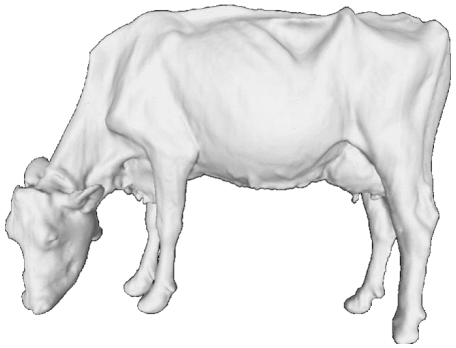
Evolution of the technology over the past years

Fischer *et al.* (2015)

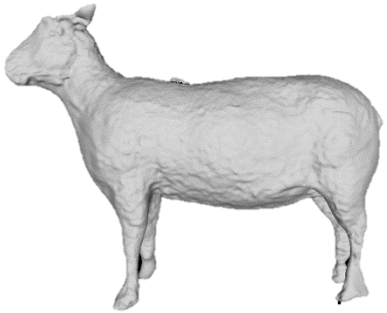




Le Cozler *et al.* (2019)



Depuille *et al.* (2022)

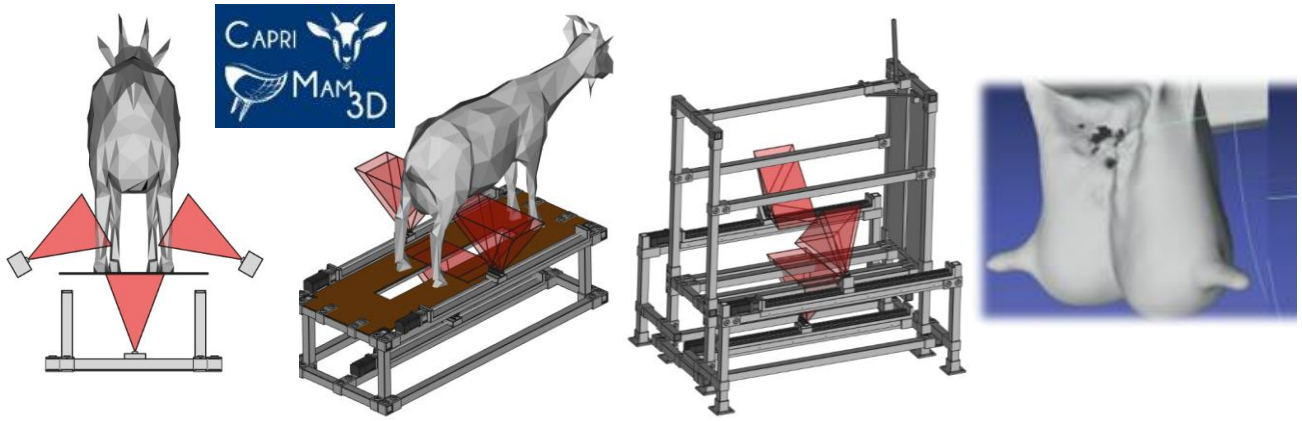


Using several depth sensors (and lasers) to acquire the whole animal body with high resolution

« One shot » collection to improve usability of the scanner

REVIEW : THE CURRENT 3D IMAGING PERFORMANCES II

Available on all species but there are not « off-the-self » scanners



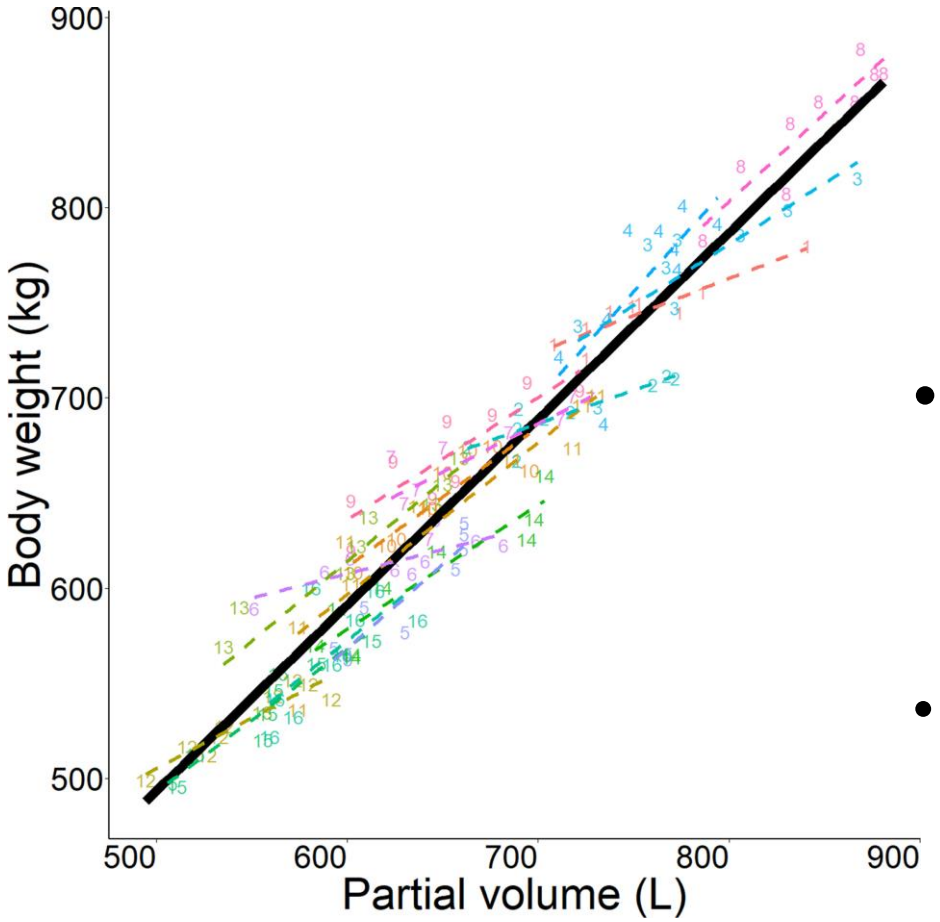
Adaptation to a specific area of interest

Accuracy vs High-throughput scans

Adaptation to animal dimensions

Accuracy vs **High-throughput scans**

Applications : estimation of body weight (Xavier et al., 2022)



Partial volume = volume without the head

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The use of 3-dimensional imaging of Holstein cows to estimate body weight and monitor the composition of body weight change throughout lactation

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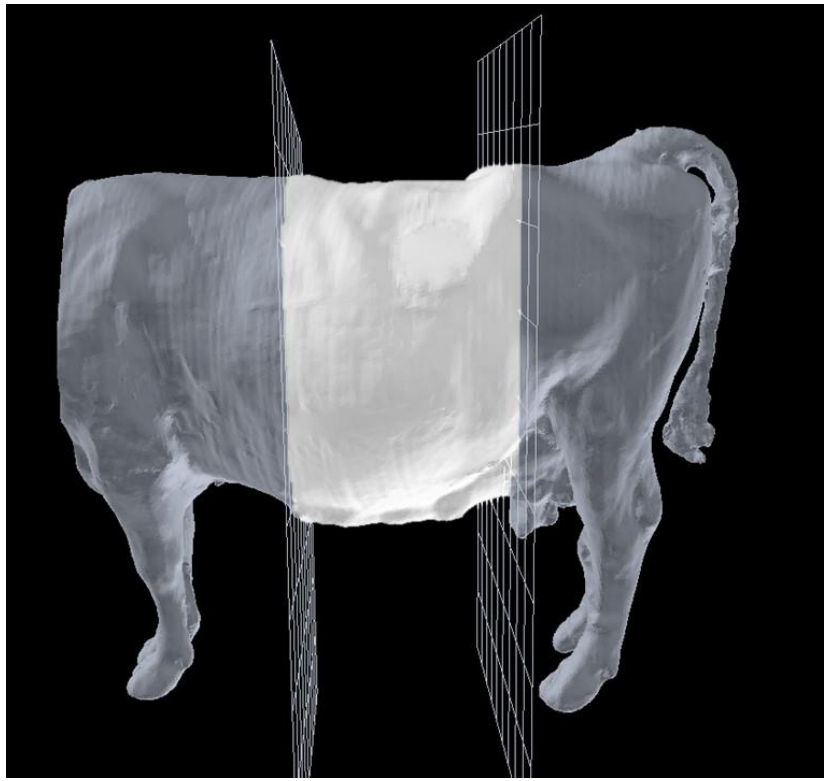
- **Estimation of the BW**
  - Partial Volume alone: RMSE = 25.4 kg, CV= 3.9 %
  - Partial Volume with random effect of individual: RMSE = 14.3 kg, CV= 2.2 %
- **Difference in slopes between animals** might be due to differences in animal density (Body Condition, gut fillling…)
  - Can 3D imaging explain this variability of animal density ?

Applications : phenotyping/monitoring the abdomen volume



- Xavier *et al.* (2022) **decomposed the BW gain in 3 main components** (Growth, Body Condition, Gutfill)
- Lebreton *et al.* (2021) demonstrated the potentiality to monitor **the variations of gutfill**
- Faverdin et al. (2021) showed preliminary results of **the interest of the abdomen volume as a proxy of feed efficiency**

Remaining challenges regarding 3D imaging in Research and R&D

1. Facilitate the data collection
   - Increase the **usability** and the ability to phenotype **high-throughput**
     - Mobile Scanner
     - Scanner with adjustable dimensions and reconstruction algorithms able to deal with that
   - **Automate** image analysis

2. Make 3D scanners accessible on a variety of experimental facilities to link 3D images or 3D features with data of interest (DMI, RFI, THI …)

3. Investigate the opportunities given by using Deep Learning techniques on the 3D images
   - Need of a large volume of data and a large variability

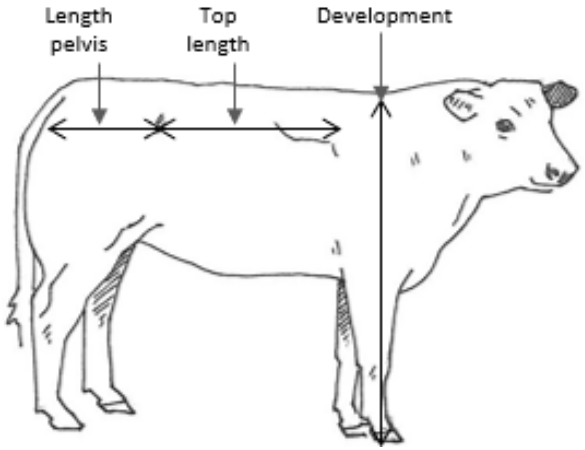
Remaining challenges regarding 3D imaging in commercial farms

3D BCS is available on farms since 2015 but the tech is not really spreading

- Lack of calibration when animals are not the average Holstein cow ? (Mullins et al., 2019)
- No clear/tangible applications for the farmers/advisors that are not used to BC scoring ?

- **We need to :**
  - Pass from **raw BCS data to useful and usable information** for the farmers
  - Paire 3D BCS with other indicators already available (BW, milk indicators) to better understand the overall picture

Tackle all the challenges with a first use case : Phenotyping calves at weaning through automatic 3D image collection and instantaneous processing



Context :

- In France a large population of beef calves are phenotyped at weaning (LW and 19 morphological scores)
- Manual scoring (very expensive, lack of reproducibility)

Objective : Automation of the phenotyping by :

- Developing a scanner and the AI to predict morphological scores and BW
- Co-desigin of the phenotyping service

PHENO 3D : development of a mobile scanner for on-farm phenotyping

Scanner specification :

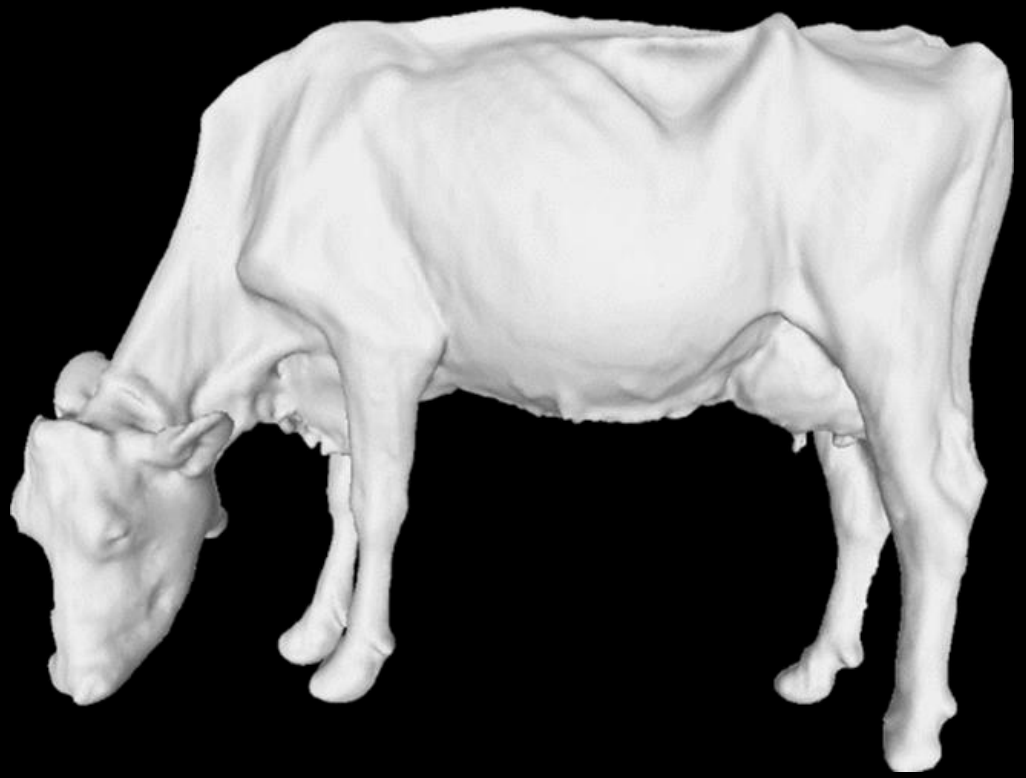
- Set up in under 20 minutes
- Adapted to most farms
- Works inside or outside

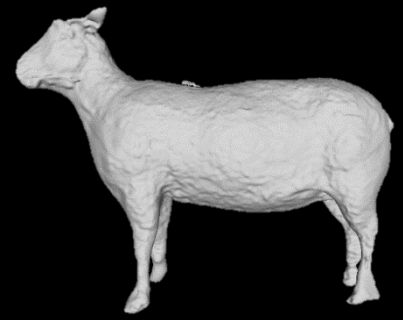
CONCLUSION / PERSPECTIVES

- 3D imaging is no more a technique with potential but an **available and cost-effective** technique
- 3D image : one phenotype BUT a variety of indicators
  - Making existing and specific indicators available on farm + high throughput
  - Supporting the development of new indicator
- 3D imaging applications will flourish in the next years
- Farmers have already the tech available but there is a lack of tangible applications for the new indicators :

➔We have to **build with them useful and useable applications**

Thanks for your attention





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