Automated Body Measurement of Sows in Feeding Stations Using Multiple Cameras

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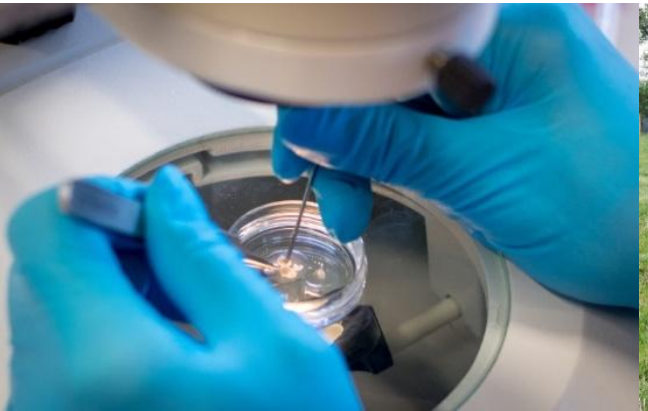

Photos: Stephanie Scholz/Vetmeduni, Michael Bernkopf/Vetmeduni, Thomas Suchanek/Vetmeduni, Nike Havranek/Vetmeduni

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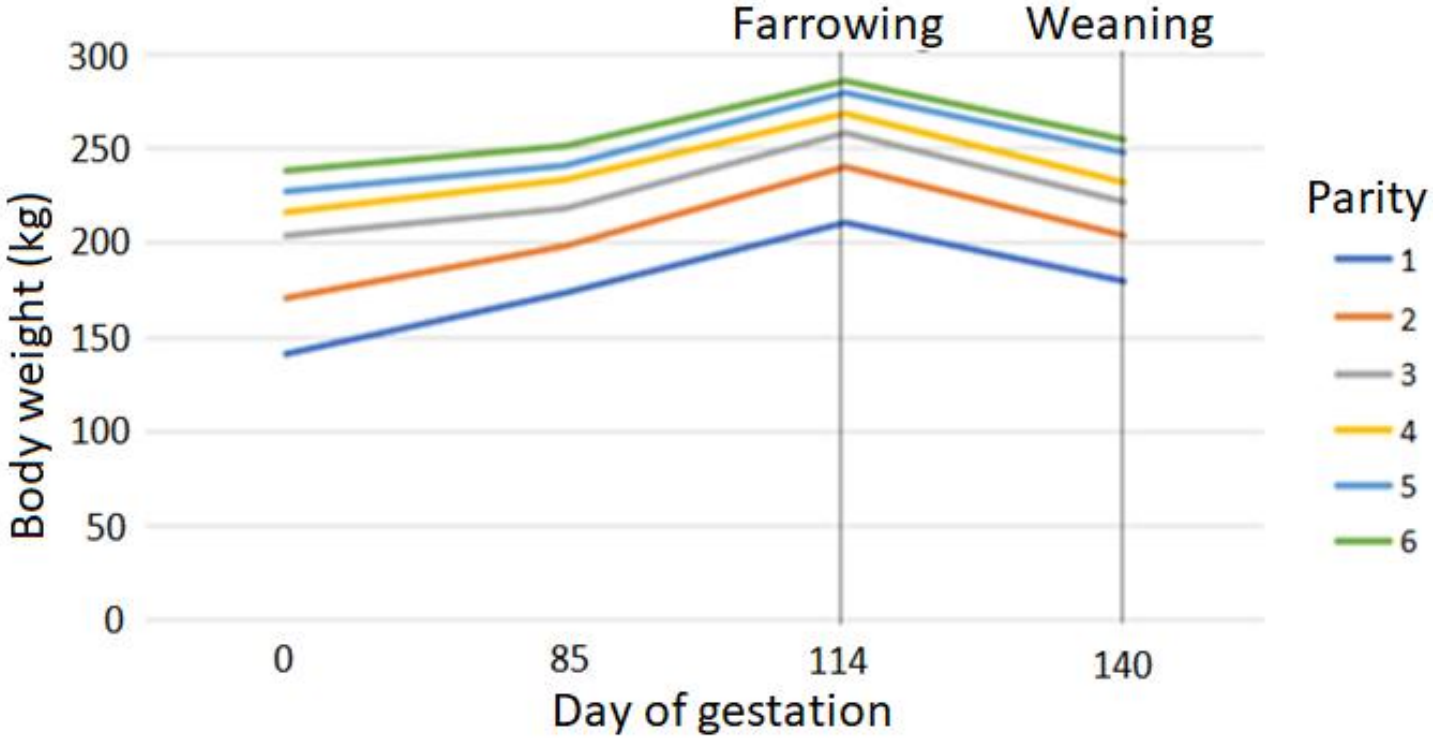
Body Condition

- Defined as energy reserves stored in the body
  - Lipids and protein
- Affected by nutritional intake
  - Impacts body weight and back fat thickness
- Higher parity and age leads to larger body dimensions



Aggregate data from several sources
(Boyd et al., 2002) (Close, Cole, 2000) (Danish Genetics) (German Genetics)
(LFL Bayern 2024) (Müller, 2007) (Topigs TN70, 2023)

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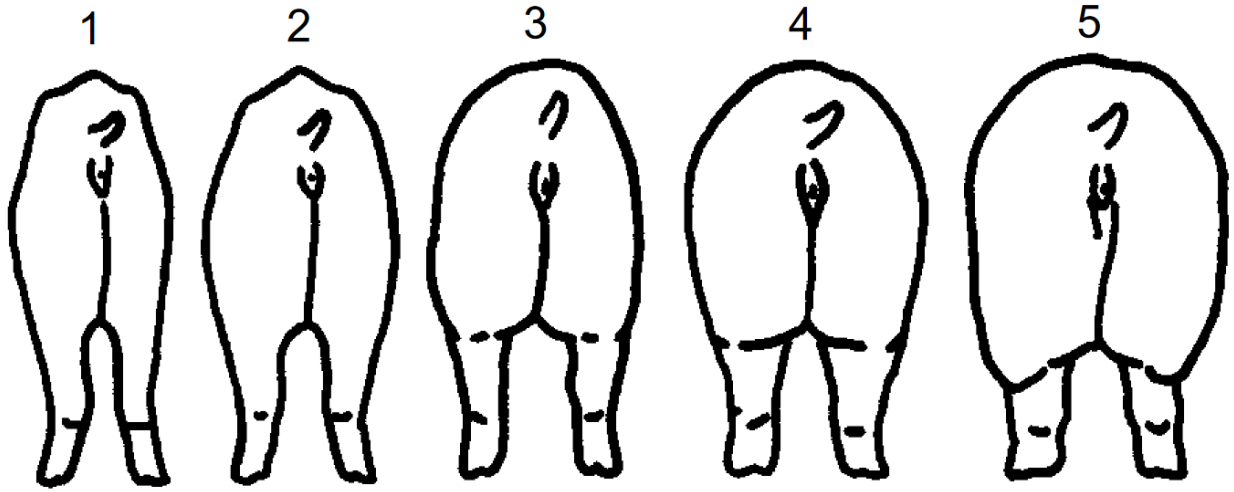
Body Condition Scoring (BCS)

- Numerical value representing an animal's body condition
- Assessed through visual and physical examination

- Maintaining optimal condition leads to benefits:
  - More live-born piglets
  - Better lactational yield
  - Higher longevity of sows

- BCS is done manually:
  - Often with weeks between evaluations
  - Labour intensive, requires training
  - Inherently subjective and prone to errors



Visual examples of BCS

(Assessing Sow Body Condition, Coffey et al., 1999)

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Objective

1. Identify possible measurements which can be used to define an objective body condition of sows

2. Gathering of video data from multiple farms and pig breeds, manual body measurements to use as ground truth

3. Development of an **automated**, **objective**, and **computer-vision**-based algorithm to estimate the identified body measurements

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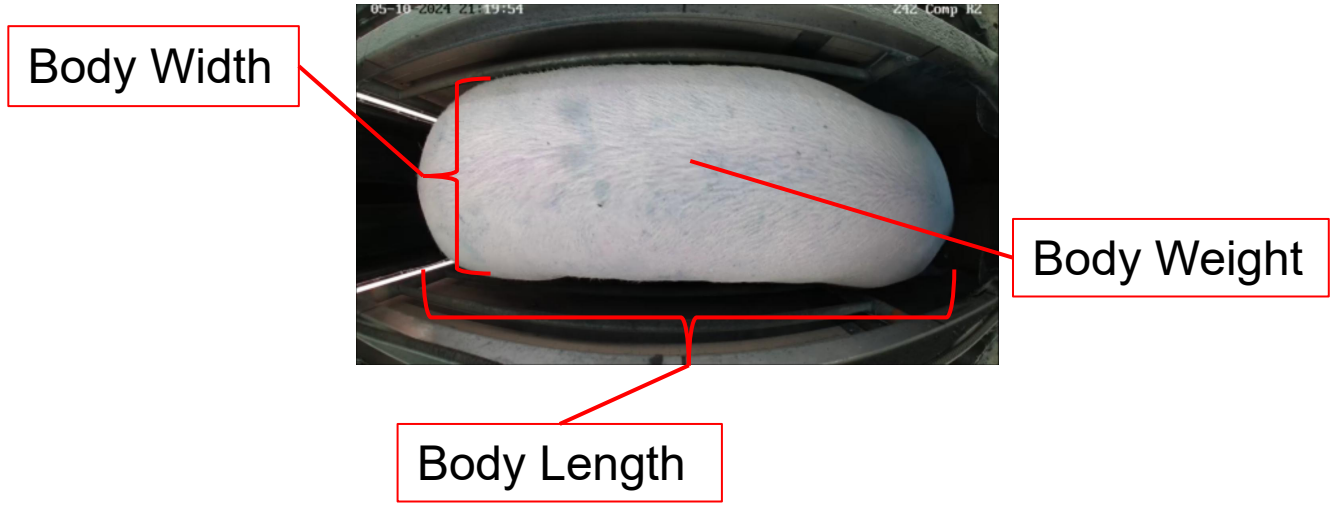
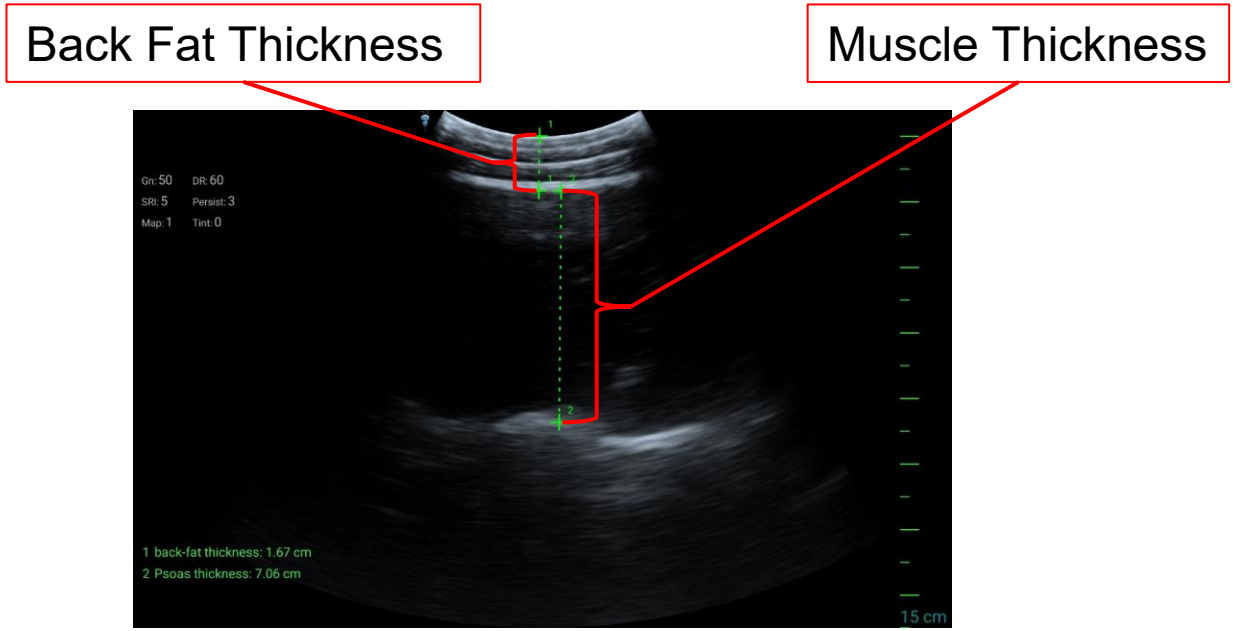
Body Measurements

- Objective indicators identified in literature:
  - Body weight
  - Back fat thickness
  - Muscle thickness

- Additional measurements to adjust for breed and genetic differences:
  - Body width
  - Body length





Measured using KUBUS ultrasound scanner

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Data Collection – Farms

- Data was collected at three different pig farms:
  - Larger dataset
  - Increase in sow diversity

Farm 2
Commercial farm

Farm 1
Vetmeduni research farm

Farm 3
Commercial farm

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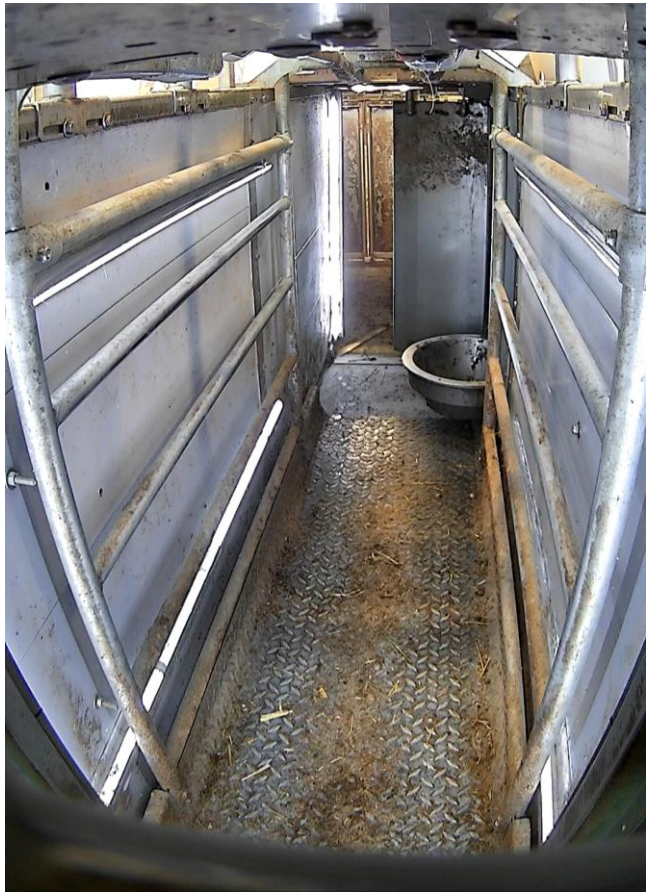
Feeding Station

- **Schauer Compident®** electronic sow feeding station is used at all three farms



- Sows are identified using RFID tags

- Floor scale automatically measures body weight with each feeding

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Camera Setup (1)

- Three cameras positioned inside of the feeding station
- Camera setups are identical across the three farms

Back-left

Back-right

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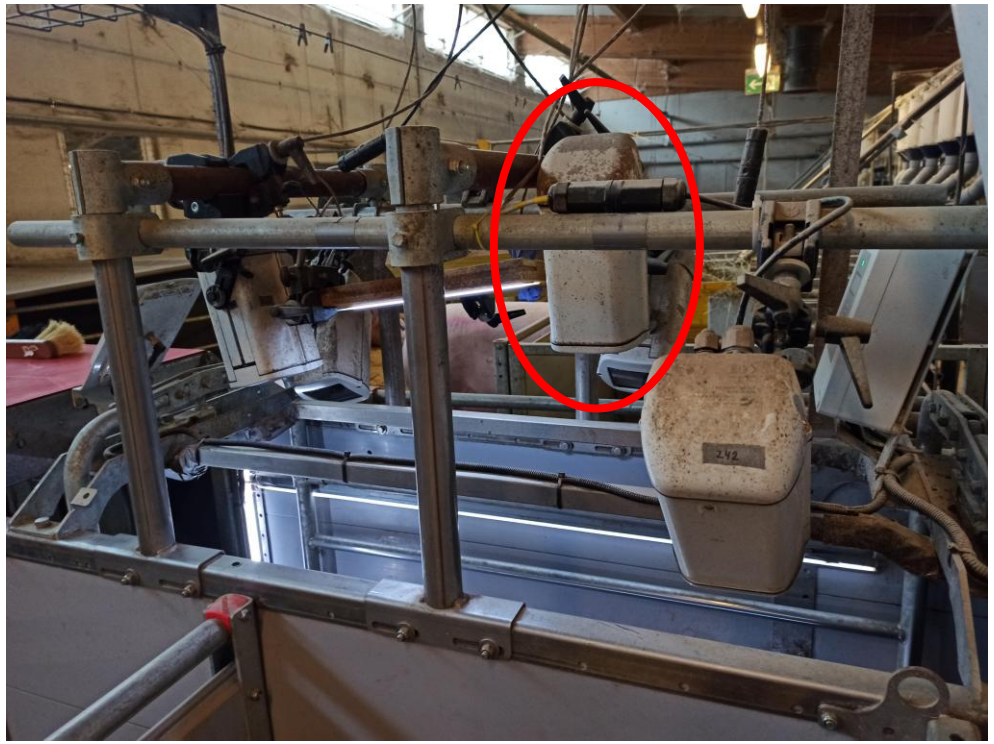
Camera Setup (2)

- Three cameras positioned inside of the feeding station
- Camera setups are identical across the three farms



Top-view

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Data Collection

- Videos recorded between August and December 2024
- Five minutes of video footage of each feeding
- Manual measurements every three weeks
- Additional data used:
  - Date of birth
  - Parity
  - Day of pregnancy

Farm	Feedings	Recorded Sows
Farm 1	1033	54
Farm 2	2861	69
Farm 3	2091	77
Total	**5985**	**200**

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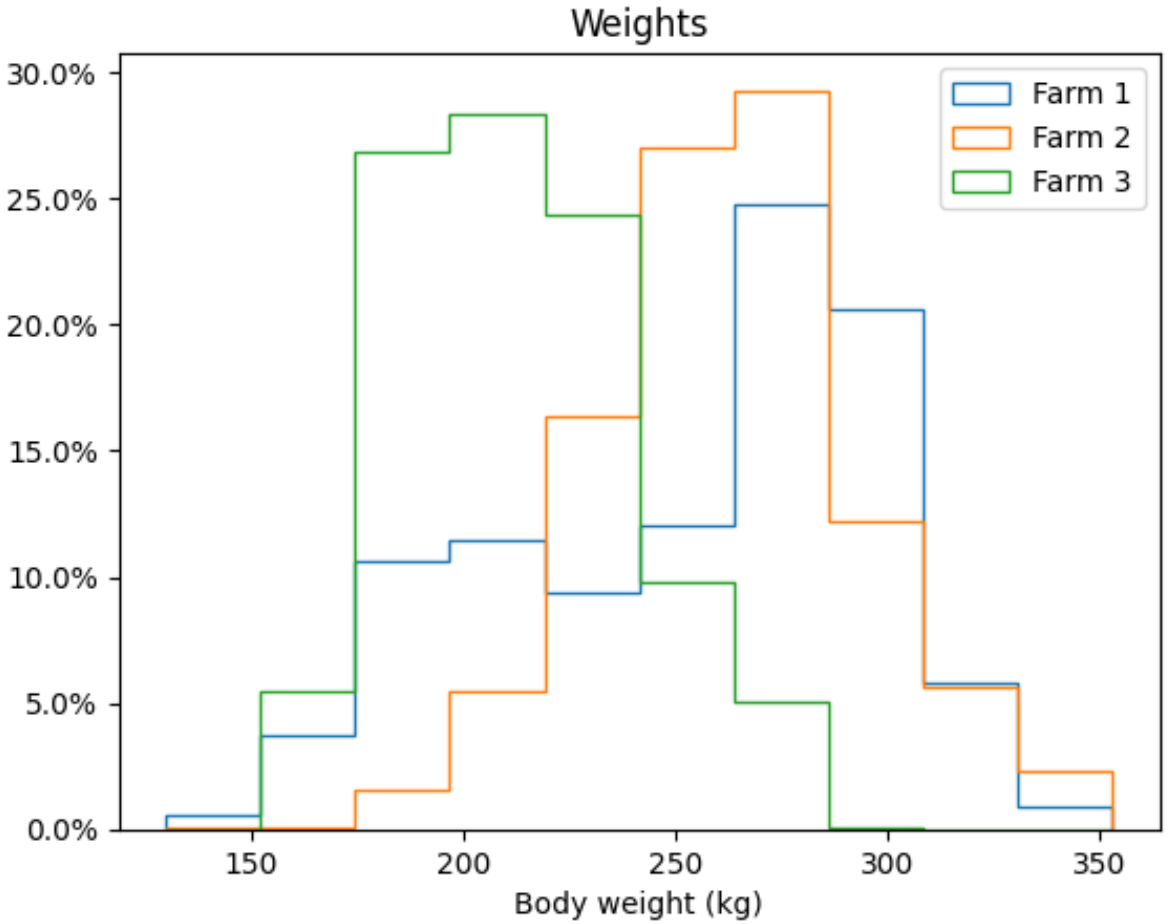
Differences between Farms

- Clear differences in the sow populations of the three farms
  - Weight distribution
  - Different breeds:
    - Farm 1:
      - Large White
    - Farm 2:
      - Large White, Landrace, Crossbreed
    - Farm 3:
      - Large White, Crossbreed



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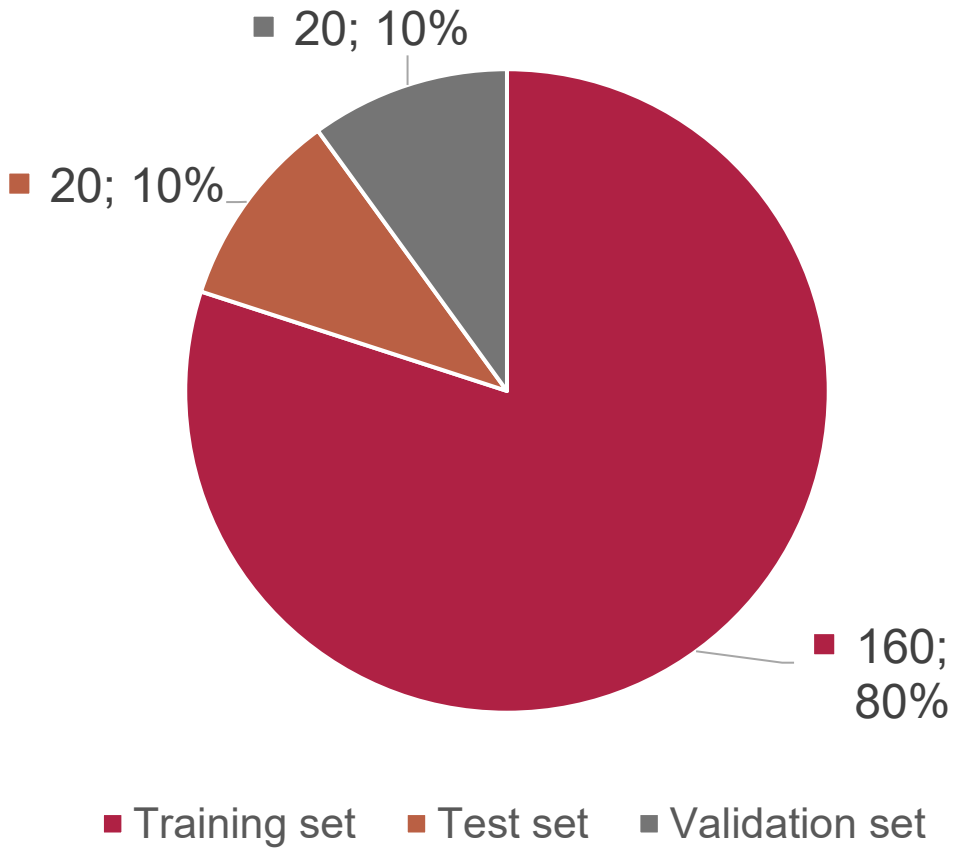
Data Preparation

- Dates without manual measurement were filled using linear interpolation:
  - Allows usage of all video recordings
- First 10 seconds of each feeding were excluded:
  - Sow is positioning herself at the feeding trough
  - Posture is different to the rest of the video
- 80% of sows from each farm were used for training



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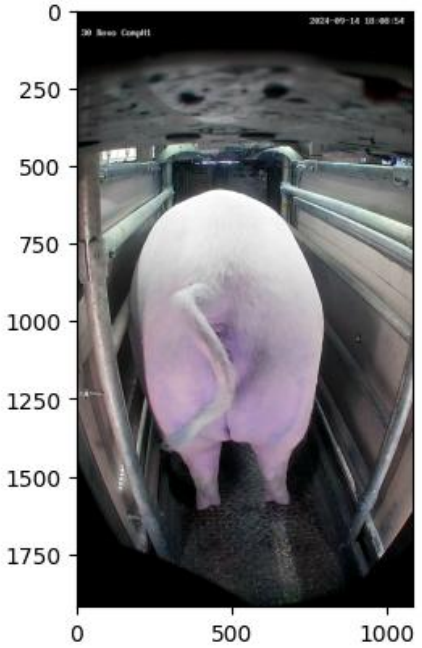
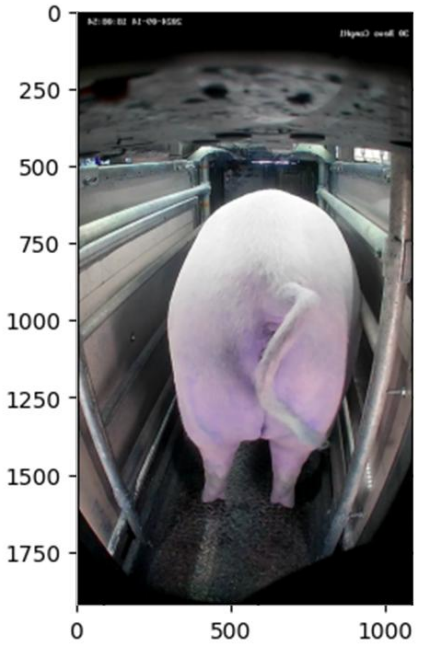
Data Augmentation

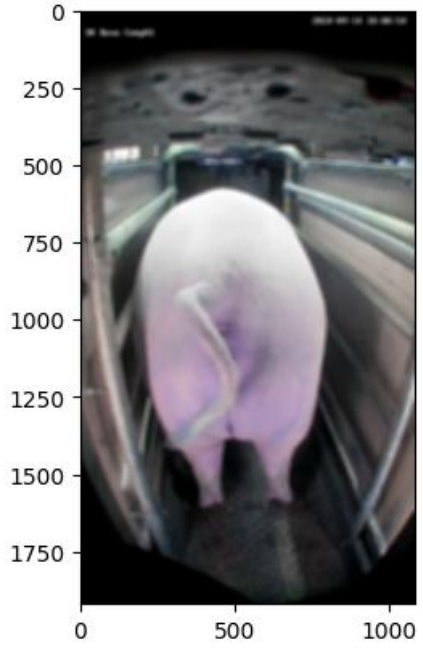
- Synchronised frames are randomly sampled from the dataset
- Frames are randomly augmented during training
- Frames of the three cameras always receive the same augmentation



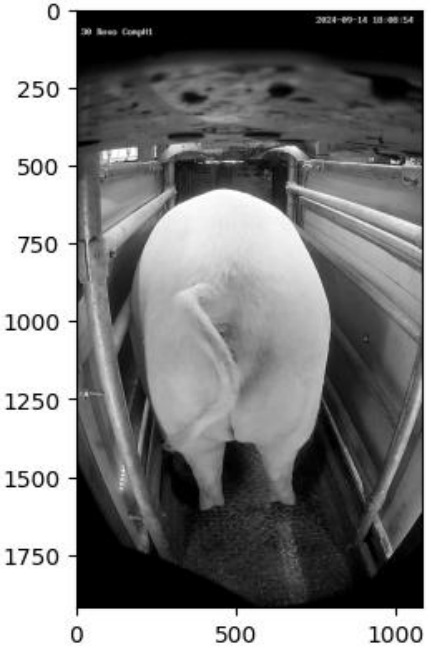
Default frame



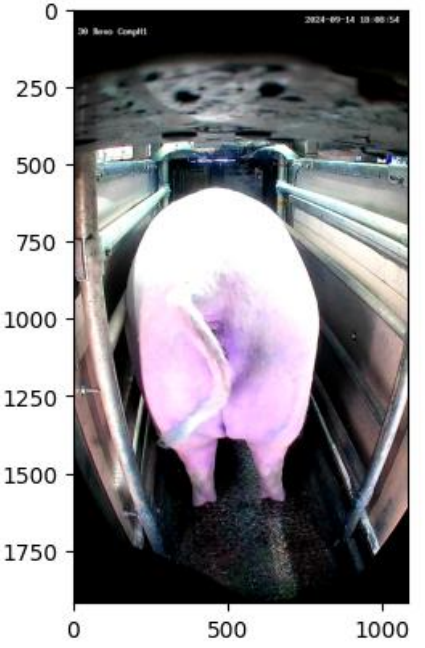
Horizontal Flip, p=0.5



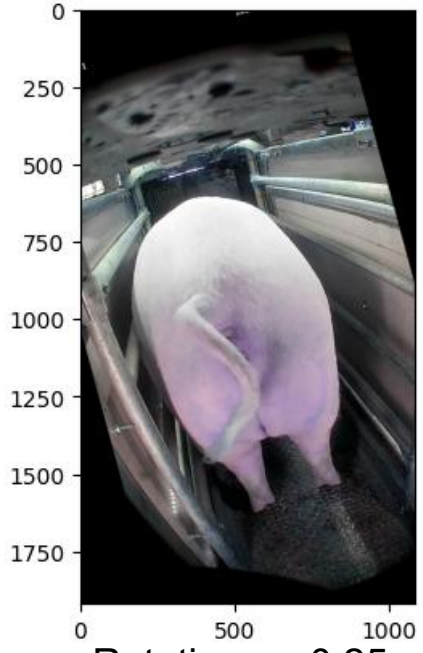
Gaussian Blur, p=0.5



Grayscale, p=0.25



Color Jitter p=0.25



Rotation, p=0.25

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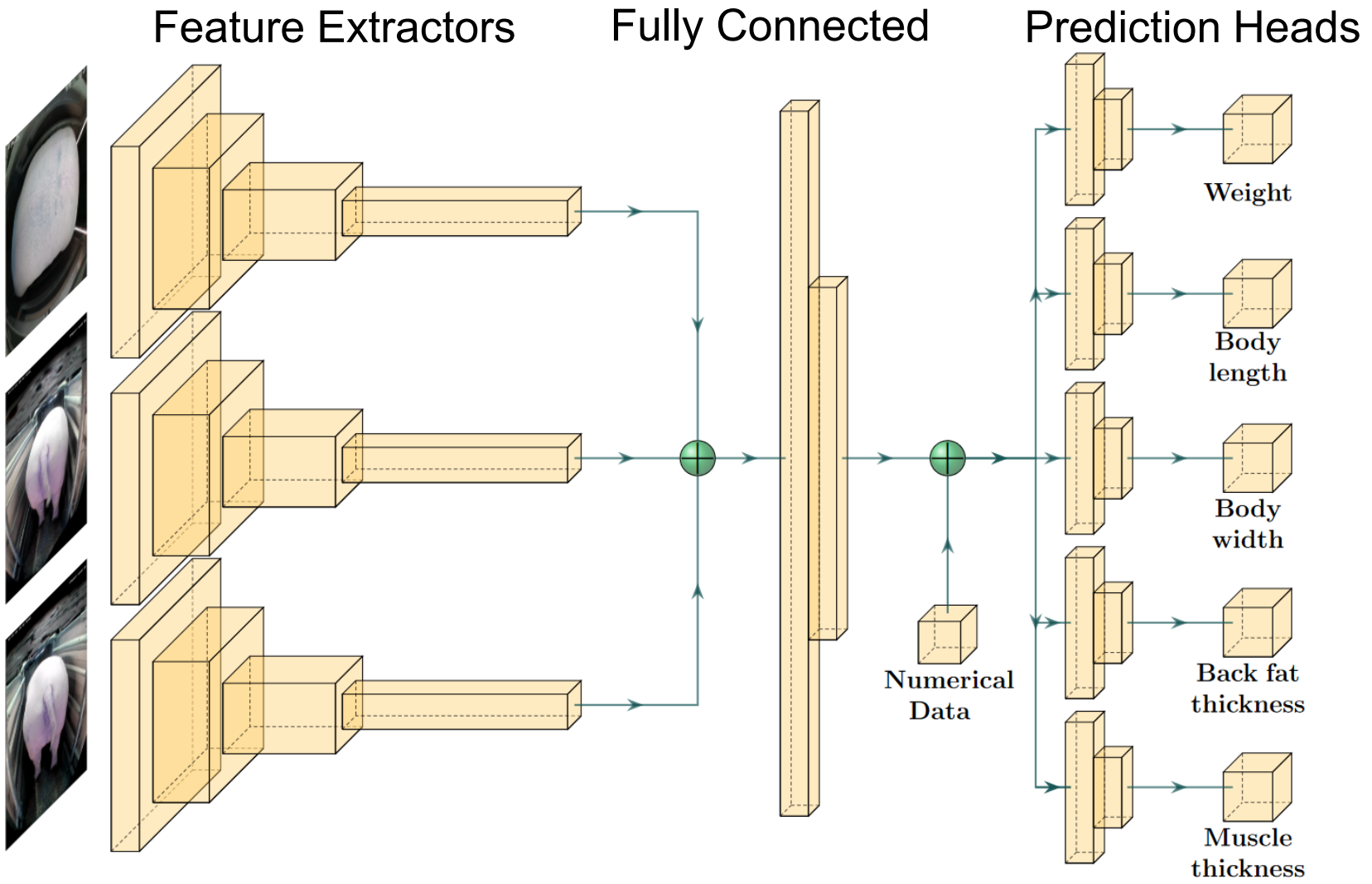
Neural Network Architecture



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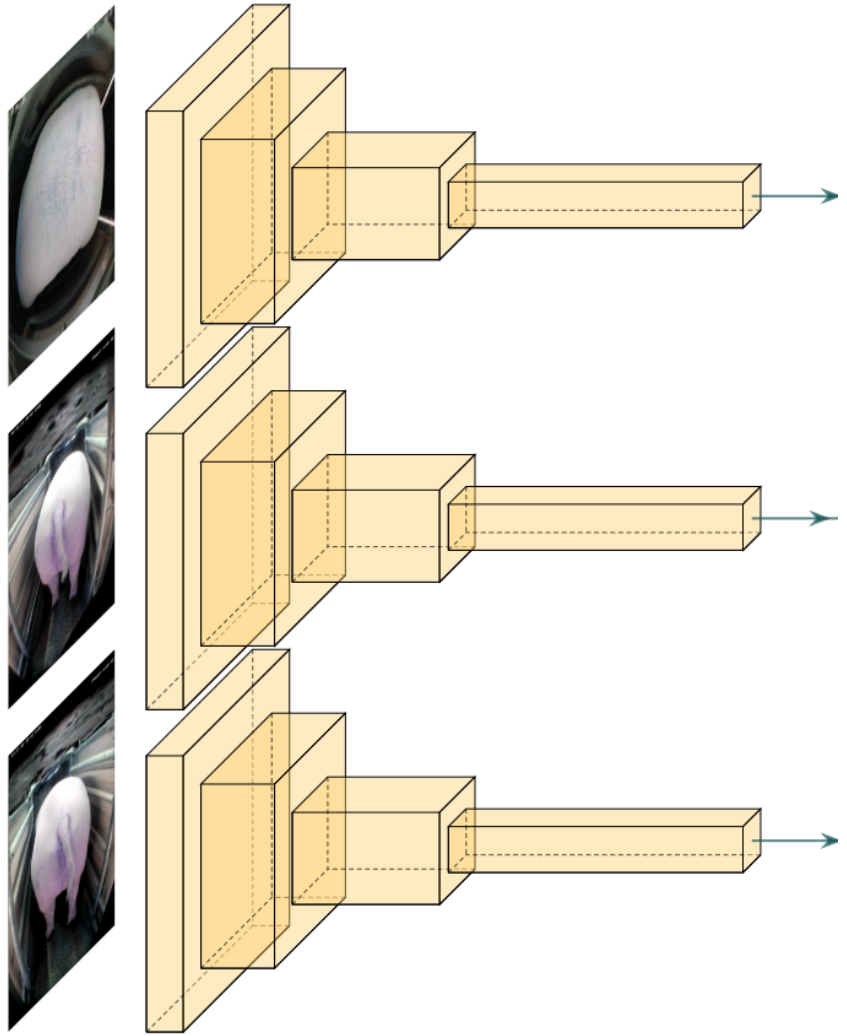
Feature Extractors

- Three EfficientNetV2-M models
  - Pretrained weights provided by PyTorch (ImageNet-1K)
- A separate model is used for each camera position
- The first 20 blocks of each network are frozen during training



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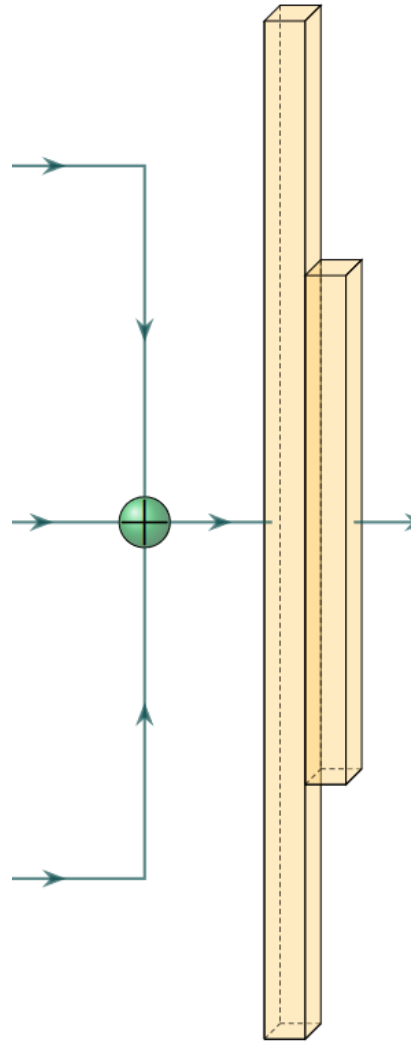
Fully Connected Layers

- The extracted features are flattened and concatenated
- The size of the vector is gradually reduced until a final vector size of 1024 is reached



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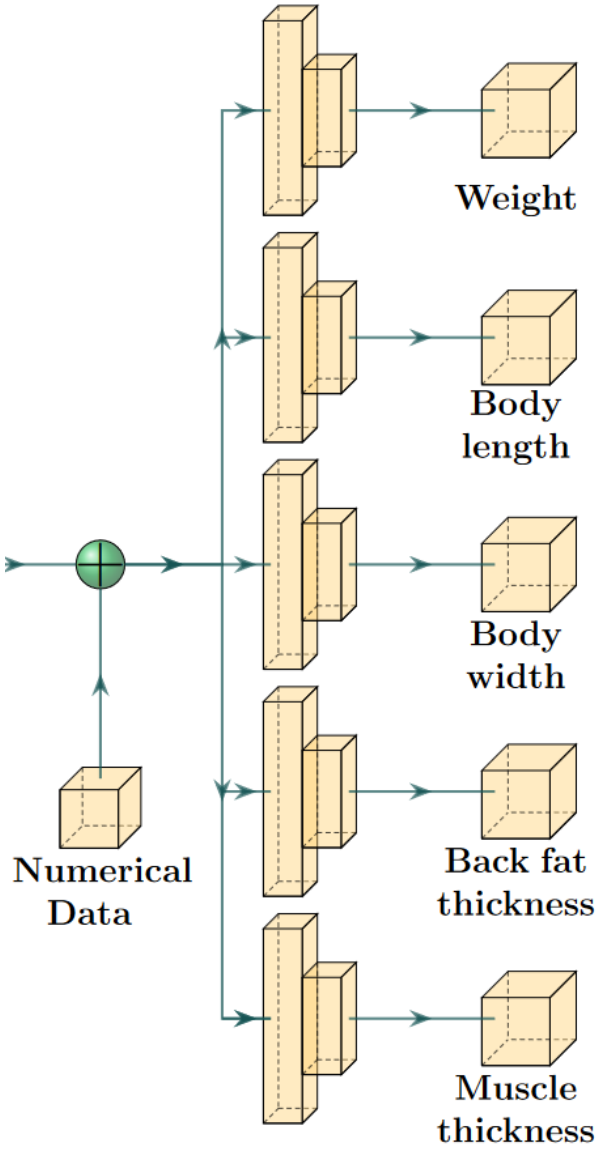
Prediction Heads

- For each predicted body measurement, a separate prediction head is applied
- Additional numerical data, i.e. age of the sow, pregnancy day, and parity is also added
- The result is a floating-point number for each of the measurement



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Estimation Results

- The model is trained to estimate the five body measurements
- The table presents the average error across the test data set of all three farms

Measurement	R^2 Score	Average Error	Percentage Error
Body weight	0.93	7.34 kg	3.1%
Body length	0.79	3.02 cm	1.7%
Body width	0.61	1.00 cm	2.6%
Back fat thickness	0.64	1.89 mm	10.3%
Muscle thickness	0.19	0.66 cm	12.5%

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Estimation Result – Per Farm

Measurement	Average Error			Percentage Error		
	Farm 1	Farm 2	Farm 3	Farm 1	Farm 2	Farm 3
Body weight (kg)	7.89	7.83	6.29	3.3%	3.1%	2.9%
Body length (cm)	2.15	3.33	2.83	1.3%	1.8%	1.7%
Body width (cm)	1.40	1.01	0.83	3.7%	2.6%	2.1%
Back fat thickness (mm)	1.91	2.04	1.61	10.4%	9.3%	12.0%
Muscle thickness (cm)	0.29	0.68	0.80	4.6%	11.7%	17.2%

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Conclusion & Future Work

- Promising results for estimation of body weight, length, and width

- Errors for back fat and muscle thickness need to be analysed
  - Potential issues with manual measurements

- Possibility to finetune estimation using additional incomplete datasets
  - Example: Dataset with just video recordings and weight measurements

- Estimation of body measurements is not equal to Body Condition Score

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Thank you!

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