Low-cost machine learning algorithms to predict growth and carcass traits in pigs

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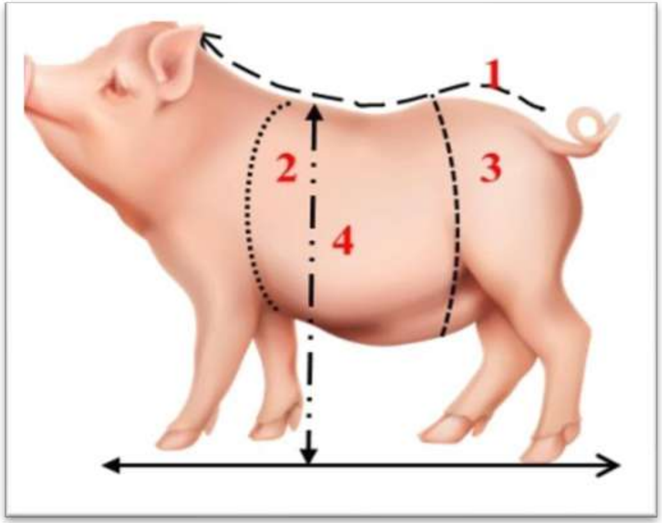
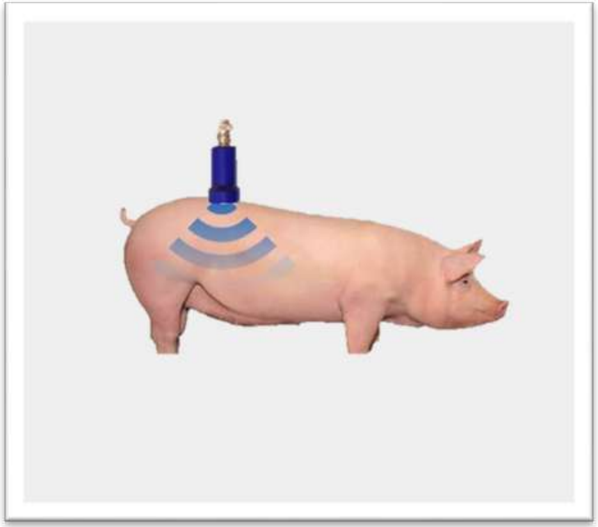
Introduction

Direct measurement



Key point measurement



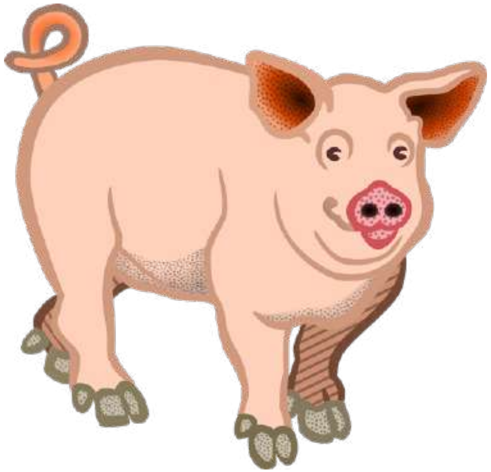
Ultrasound (Back Fat and Loin Depth)

Introduction

- **Objective**
    - Develop a low-cost machine learning pipeline based on 2D images to predict
        - Body weight
        - Backfat thickness
        - Loin depth

- **Benefits**
    - Less time-consuming
    - More cost-effective
    - Tracks daily gains, nutritional status, and health performance
    - Contributes to breeding and genetic management programs

Outline of Materials and Method

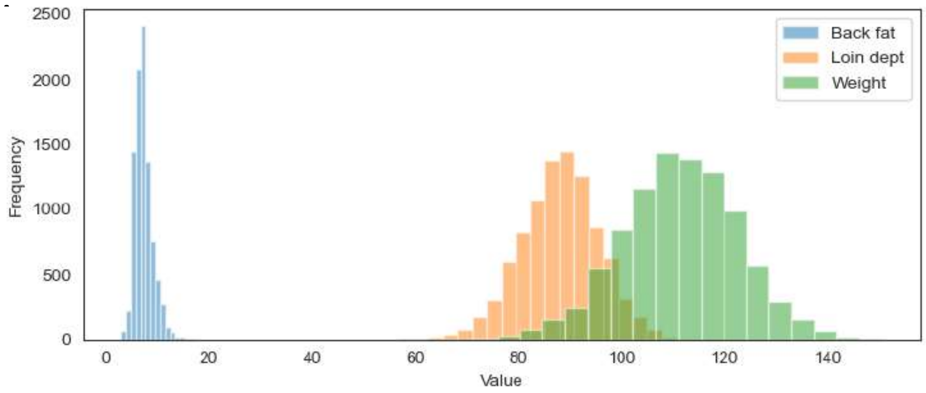


- Image acquisition
- Image processing
- Feature extraction
- Prediction

Image acquisition – by PIC

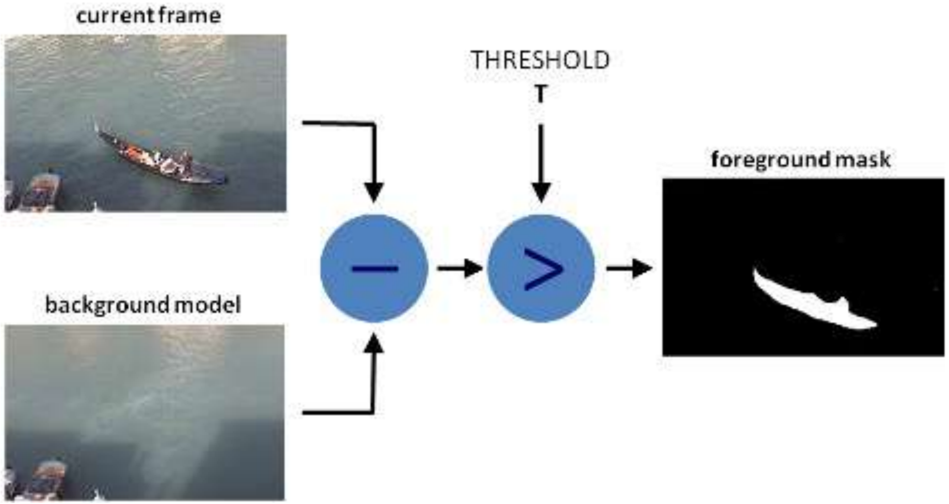
- ❖ Uncontrolled 2-D side view of pigs
- ❖ Recorded 9K individuals at 60 frames per second
- ❖ Average recording duration was 7.19 seconds

- ❖ Measurements taken for each individual:
    - ❖ Body weight (WT)
    - ❖ Backfat thickness (BF)
    - ❖ Loin depth (LD)



Distribution of body weight, back fat, and loin depth

Image processing: body segmentation (OpenCV)



Background/foreground segmentation using OpenCV

https://docs.opencv.org/3.4/d1/dc5/tutorial_background_subtraction.html

Image processing: body segmentation (OpenCV)

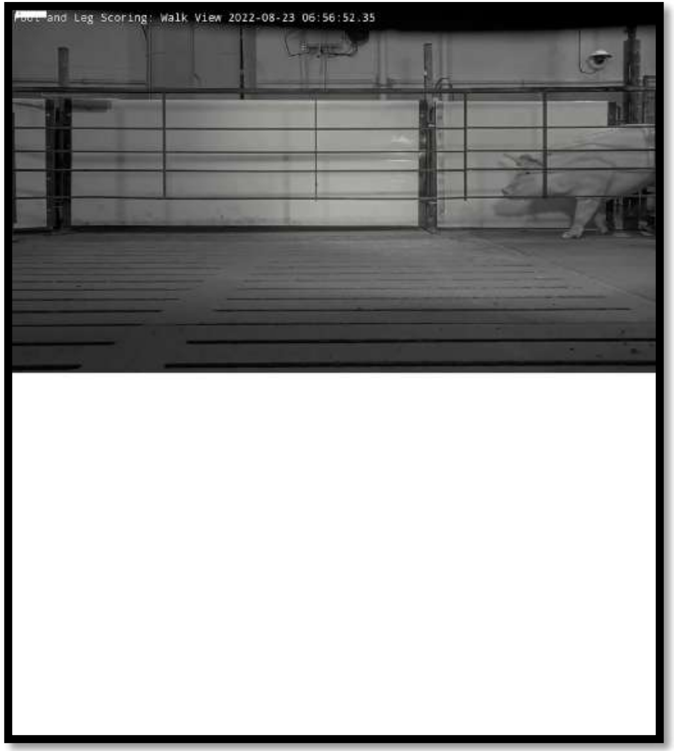
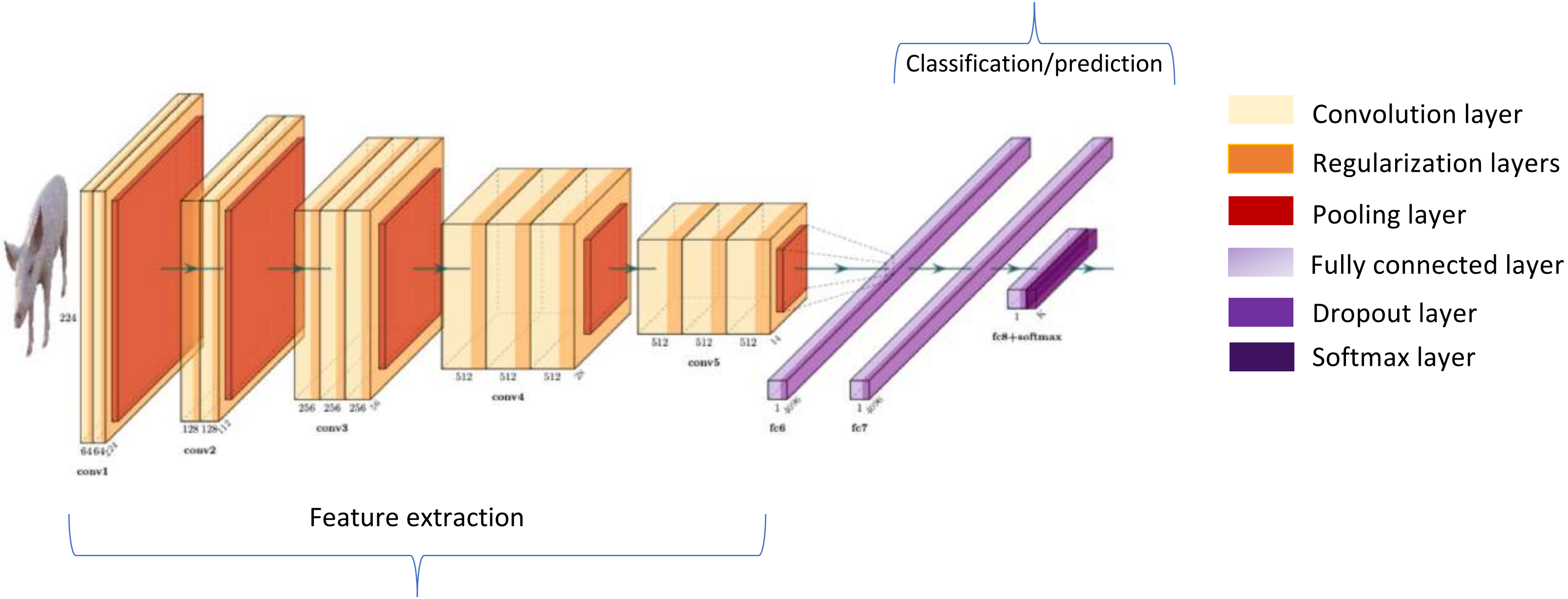


Image processing: body segmentation (deep learning)

Illustration of a corner case handled by deep learning

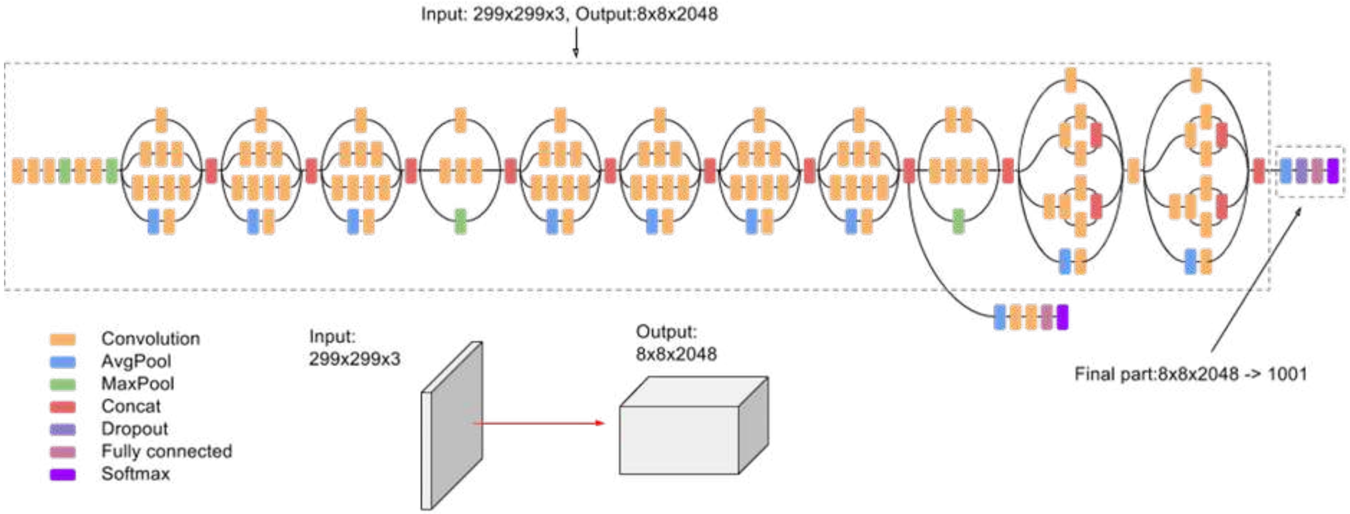
Feature extraction: VGG16



Feature extraction using pretrained VGG16

https://github.com/HarisIqbal88/PlotNeuralNet/tree/maste

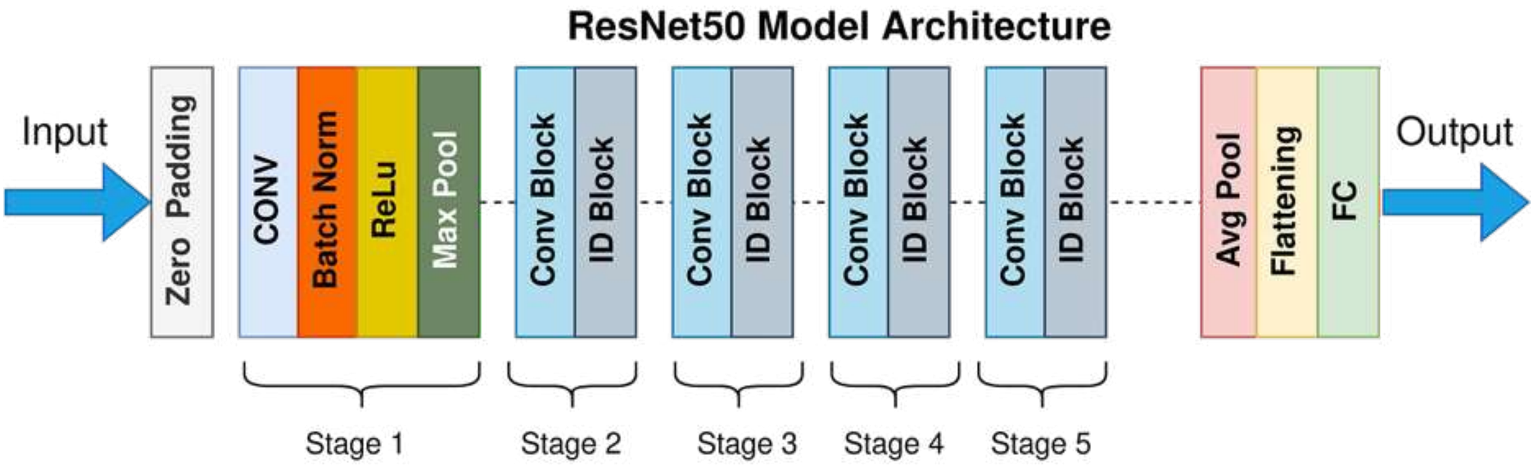
Feature extraction: InceptionV3



Feature extraction using pretrained InceptionV3

https://cloud.google.com/tpu/docs/inception-v3-advanced

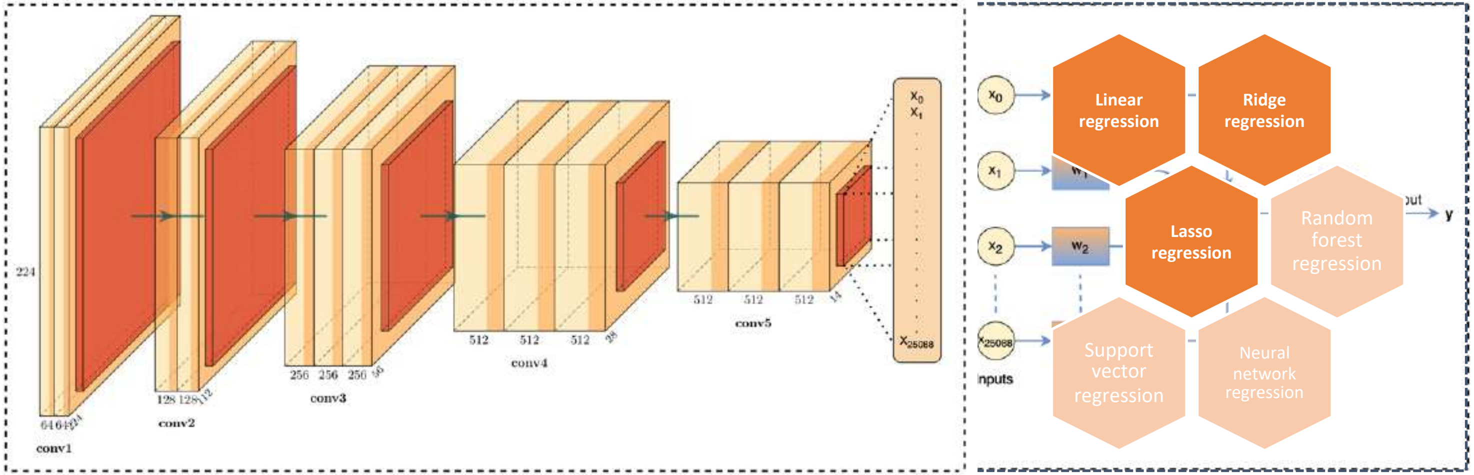
Feature extraction: ResNet50



Feature extraction using pretrained ResNet50

https://doi.org/10.3390/diagnostics12081853

Prediction: overview



Feature extraction

Prediction

Prediction: cost function

Linear regression

$$\sum_{i=1}^{M}(y_i - \hat{y}_i)^2 = \sum_{i=1}^{M}\left(y_i - \sum_{j=0}^{N}\beta_j * x_{ij}\right)^2$$

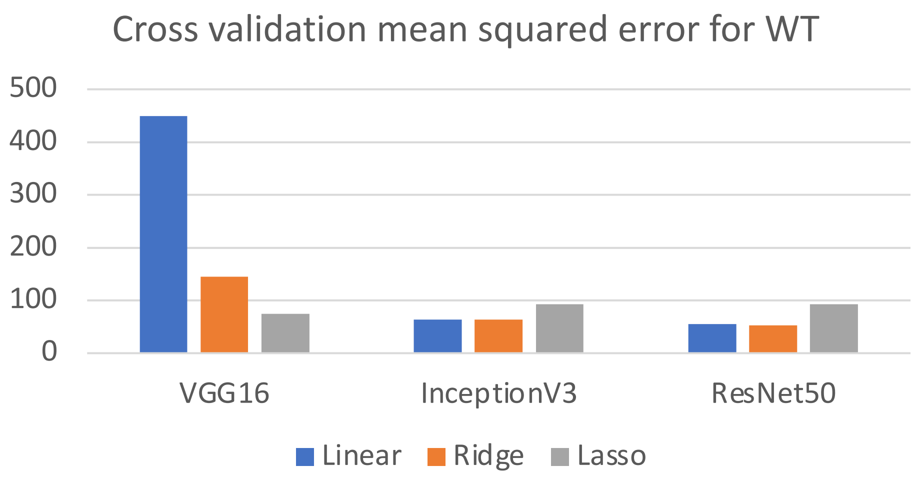
Lasso regression

$$\sum_{i=1}^{M}(y_i - \hat{y}_i)^2 = \sum_{i=1}^{M}\left(y_i - \sum_{j=0}^{N}\beta_j * x_{ij}\right)^2 + \lambda\sum_{j=0}^{N}|\beta_j|$$

Ridge regression

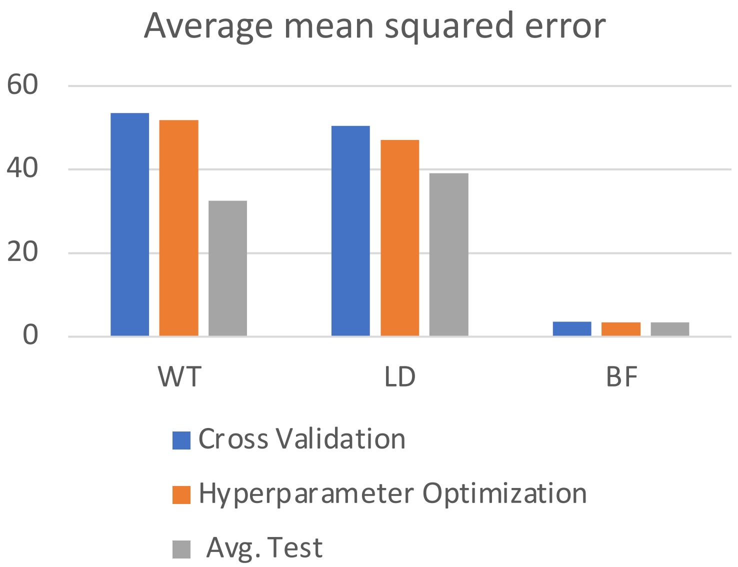
$$\sum_{i=1}^{M}(y_i - \hat{y}_i)^2 = \sum_{i=1}^{M}\left(y_i - \sum_{j=0}^{N}\beta_j * x_{ij}\right)^2 + \lambda\sum_{j=0}^{N}\beta_j^2$$

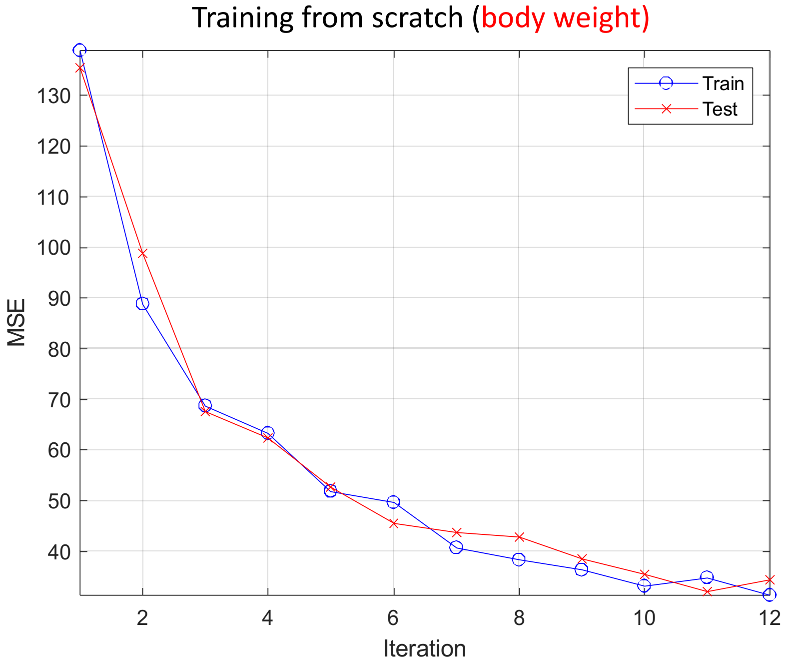
Results: model selection



- Body Weight -> ResNet50 + Ridge
- Loin Depth -> ResNet50 + Ridge
- Back Fat -> ResNet50 + Ridge

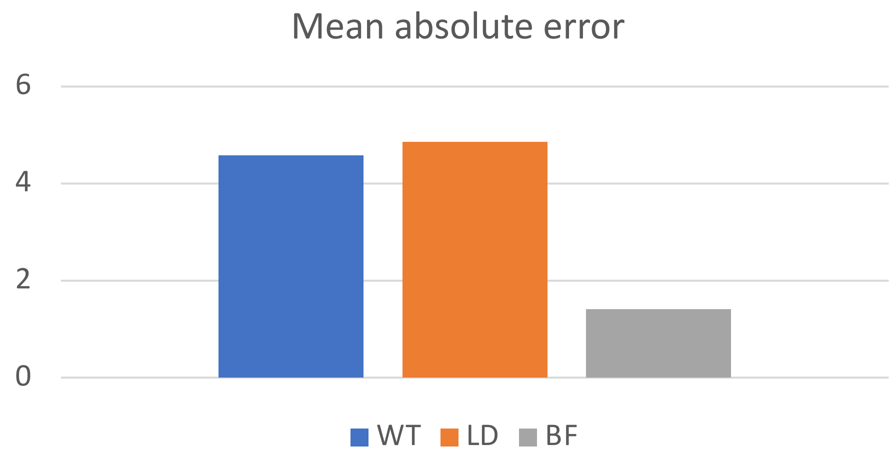
Results: prediction accuracy

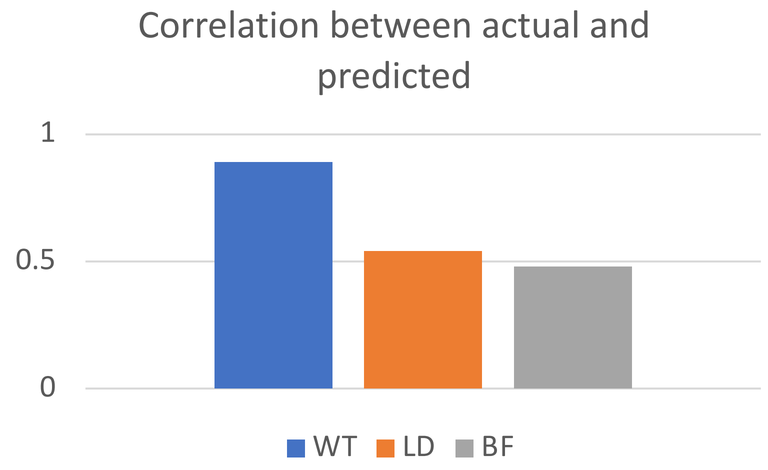




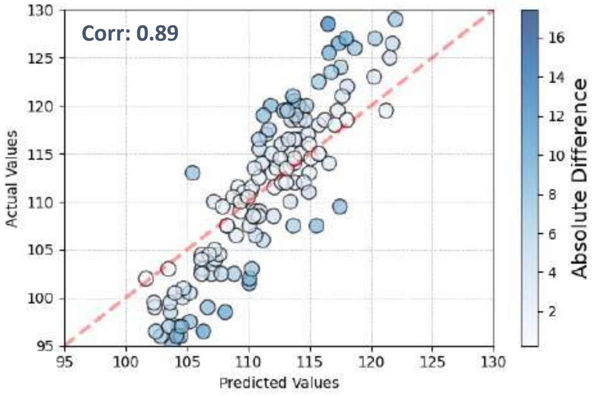
Source: Eric Psota, talk at AGBT-Ag 2024

Results: prediction accuracy

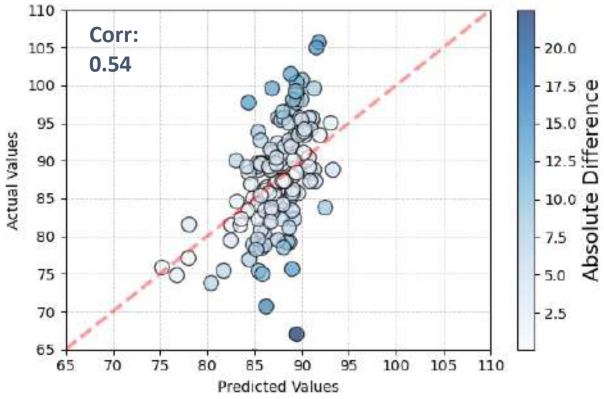




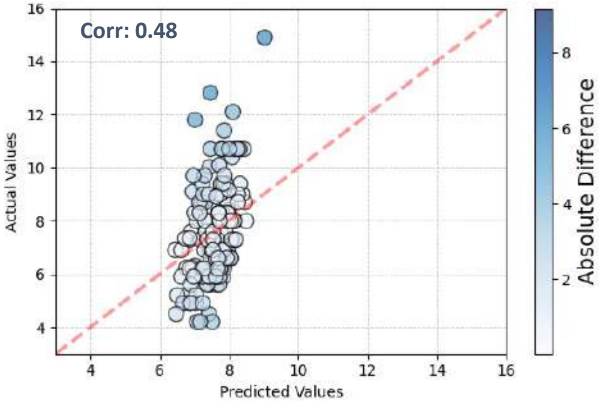
Results: actual vs predicted



Predicted average body weight
for each individual



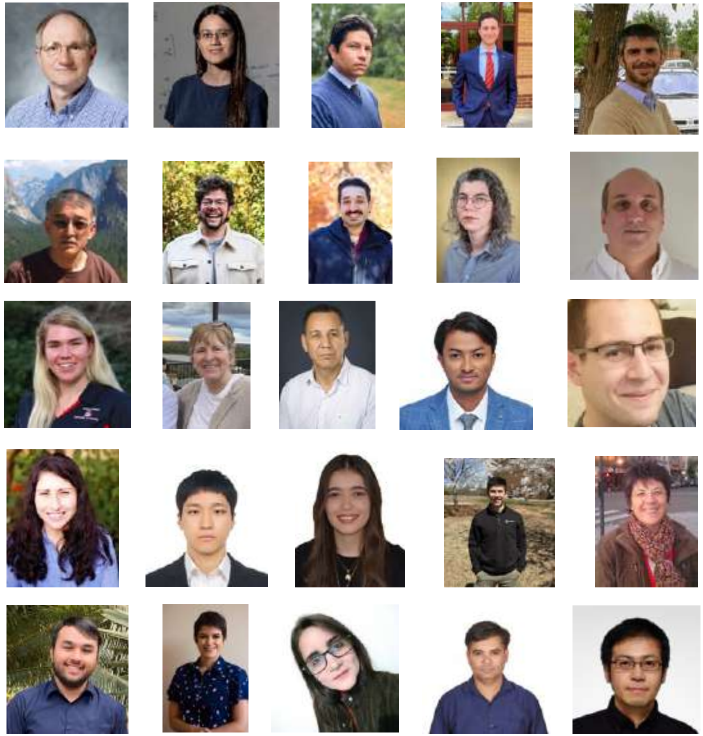
Predicted average loin depth
for each individual



Predicted average back fat
for each individual

Conclusions

- ❖ Many previous studies were limited in quality, variability, and dataset size
- ❖ Employed various deep learning approaches to extract features
- ❖ Applied different regression models to predict outcome
- ❖ Pre-trained deep learning model can efficiently extract meaningful features
- ❖ Enable large-scale digital phenotyping
- ❖ In our future work, we will use the extracted features for genomic predictions



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Thank you!

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