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CENTER FOR QUANTITATIVE GENETICS AND GENOMICS QGG

Ensemble Learner Enhances Prediction Accuracies for Extreme Body Condition Classes in Jersey Dairy Cattle in a 3D Image High-Throughput System

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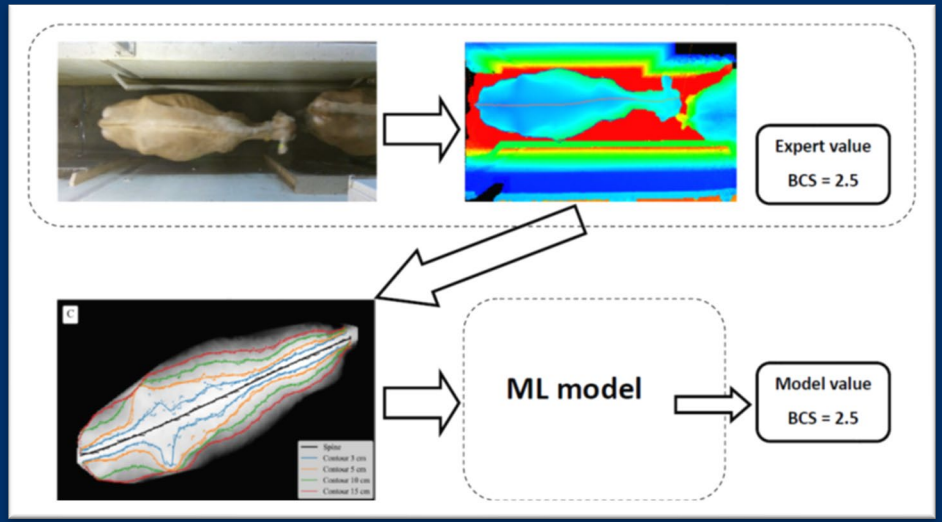


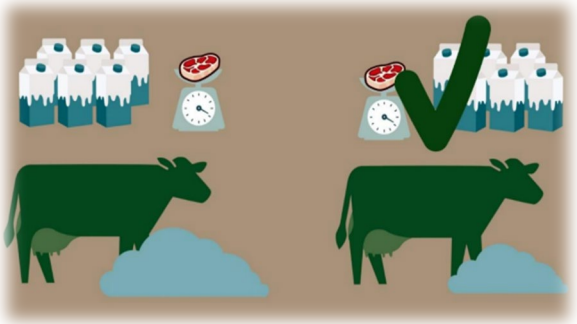
Why measure body condition?

Welfare indicator

- High management level of body condition gives
  - More functional cows (fertility, health, etc.)
  - Higher production

Important for **Metabolic Efficiency**

- Gives ability to model changes in energy
  - Distinguish between fat & protein



Previous lessons

Algorithm developed earlier

Regression analysis showed best predictive performance

Challenged in predicting **obese** classes (low frequency)

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Prediction of body condition in Jersey dairy cattle from 3D-images using machine learning techniques

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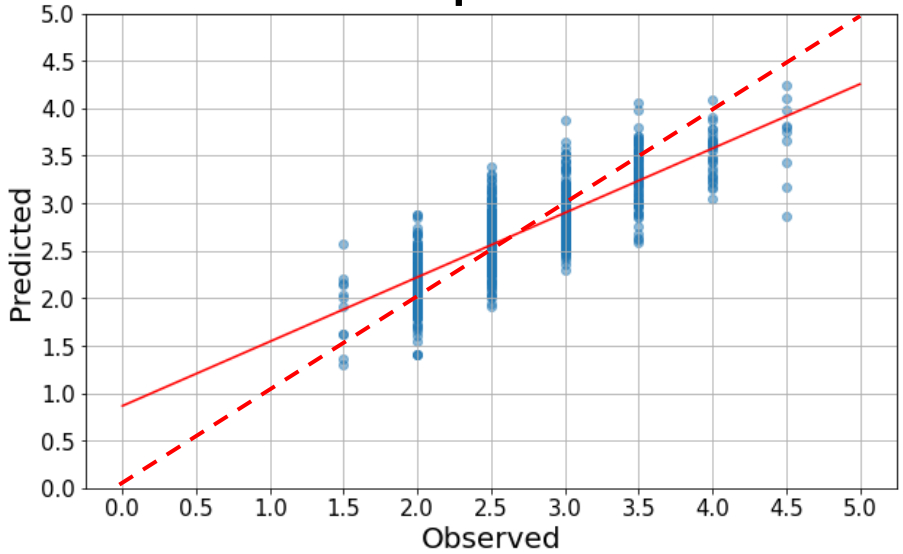
This project

Improve predictions in obese classes

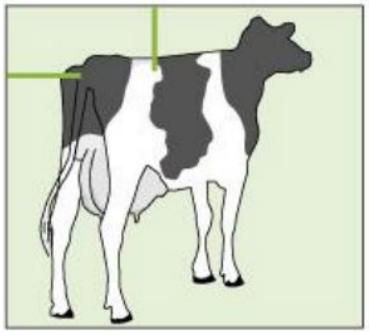
Reduce challenges with **bias** and **dispersion**



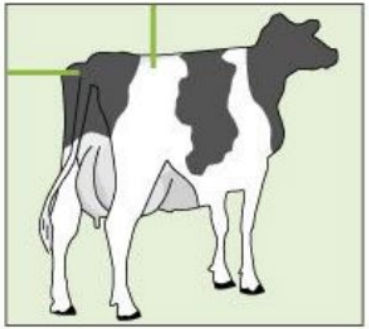
Aim - establish a more reliable BCS prediction

Data collection

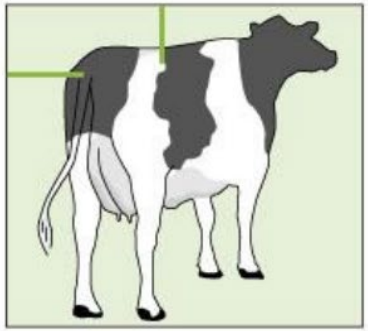
- 3 Jersey herds had all cows **classified** (cows: 794; n: 2167)



1
Lean



5
Intermediate



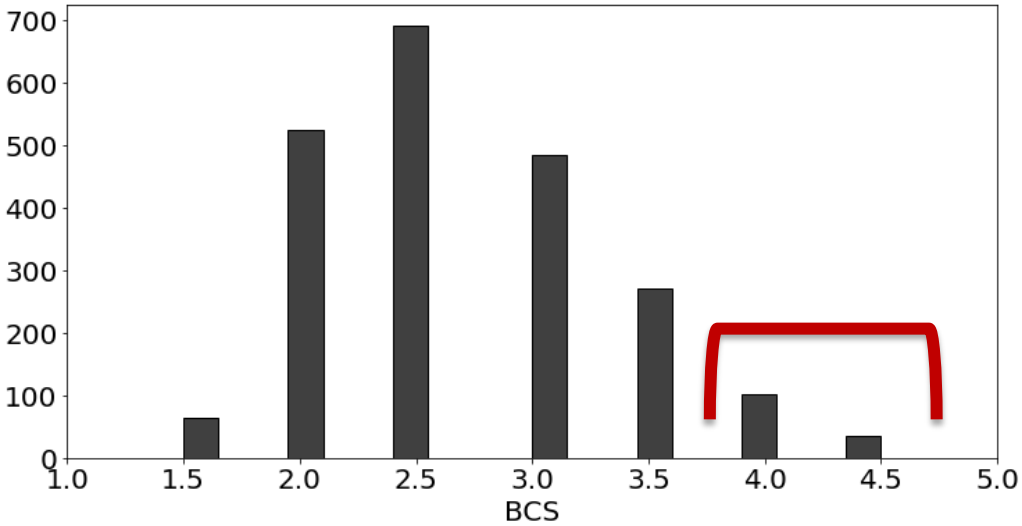
9
Fat

ICAR, 2023

Data collection

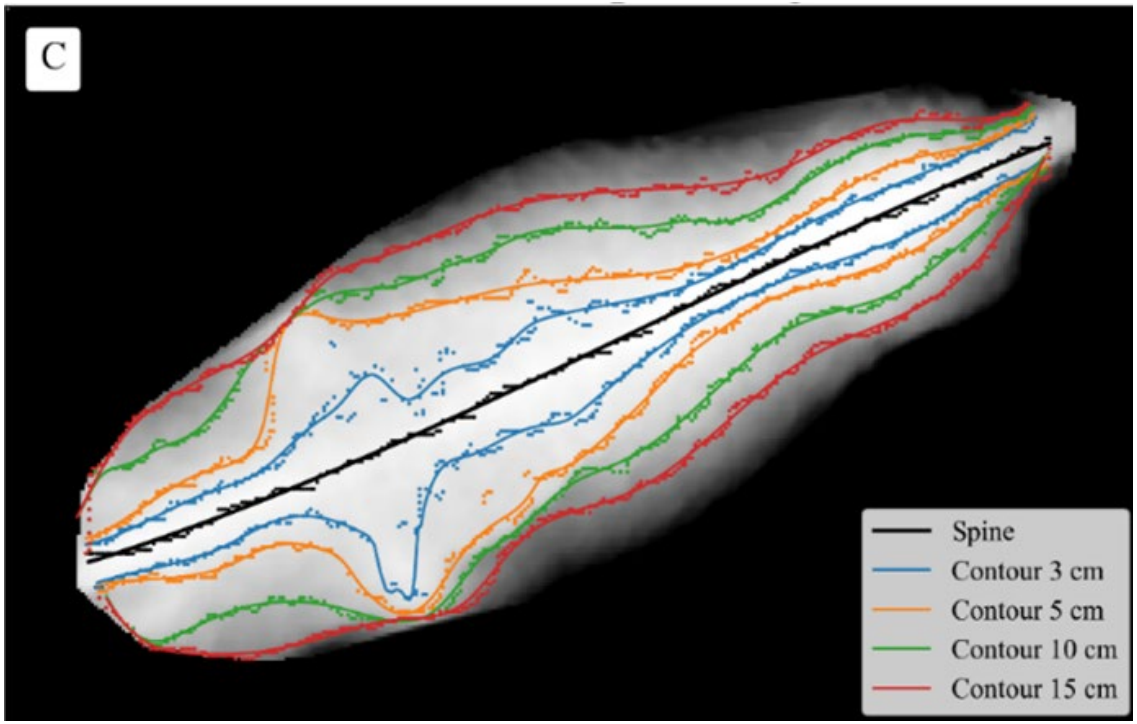
- 3 Jersey herds had all cows **classified** (cows: 794; n: 2167)

$$BCS = 0.5 \times score + 0.5,$$ Garnsworthy (2006)



Features for prediction

- 691 Features used from 3D **CFIT** system (VikingGenetics)



Machine Learning algorithms

Machine Learning **algorithms** determination

Identified with *LazyRegressor* in Python

- *BayesianRidge* from scikit.learn
- *LassoCV* from scikit.learn

Predictors

CFIT features (n = 691)

Fixed effect of evaluator + round x herd

Sub-model development

Non weighted models

BayesianRidge NoW

LassoCV NoW

Weighted models by class **frequency**: $\frac{N}{k \times f_c}$

N number of samples, k number of classes, f_c frequency of cth class

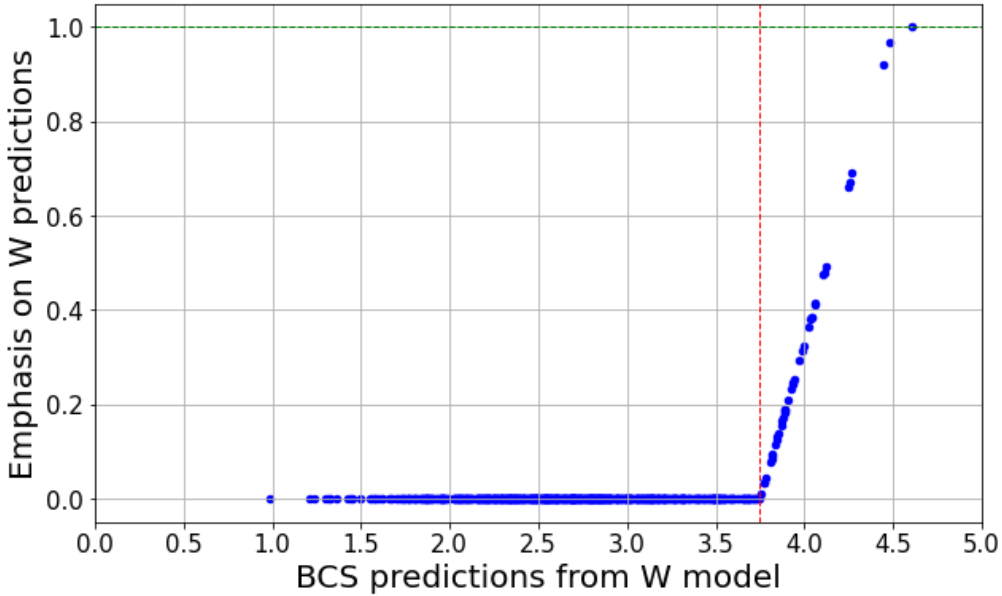
BayesianRidge W

LassoCVW

Ensemble model

Ensemble Model

1. Combine predictions equally within NoW and W models
2. Combine predictions of NoW and W by:



Training and validation

Defining Training and Validation data

Random **7:3** split, clustered by cows

Herd cross-validation

2 herds for training & 1 for validation

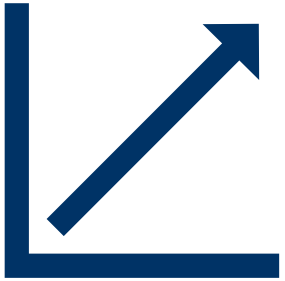
Evaluation parameters

Approximate **classification** using rounded predictions

Accuracy, %
F1-Score, %
Both assessed on **Exact** & **0.5-unit** deviation

Regression

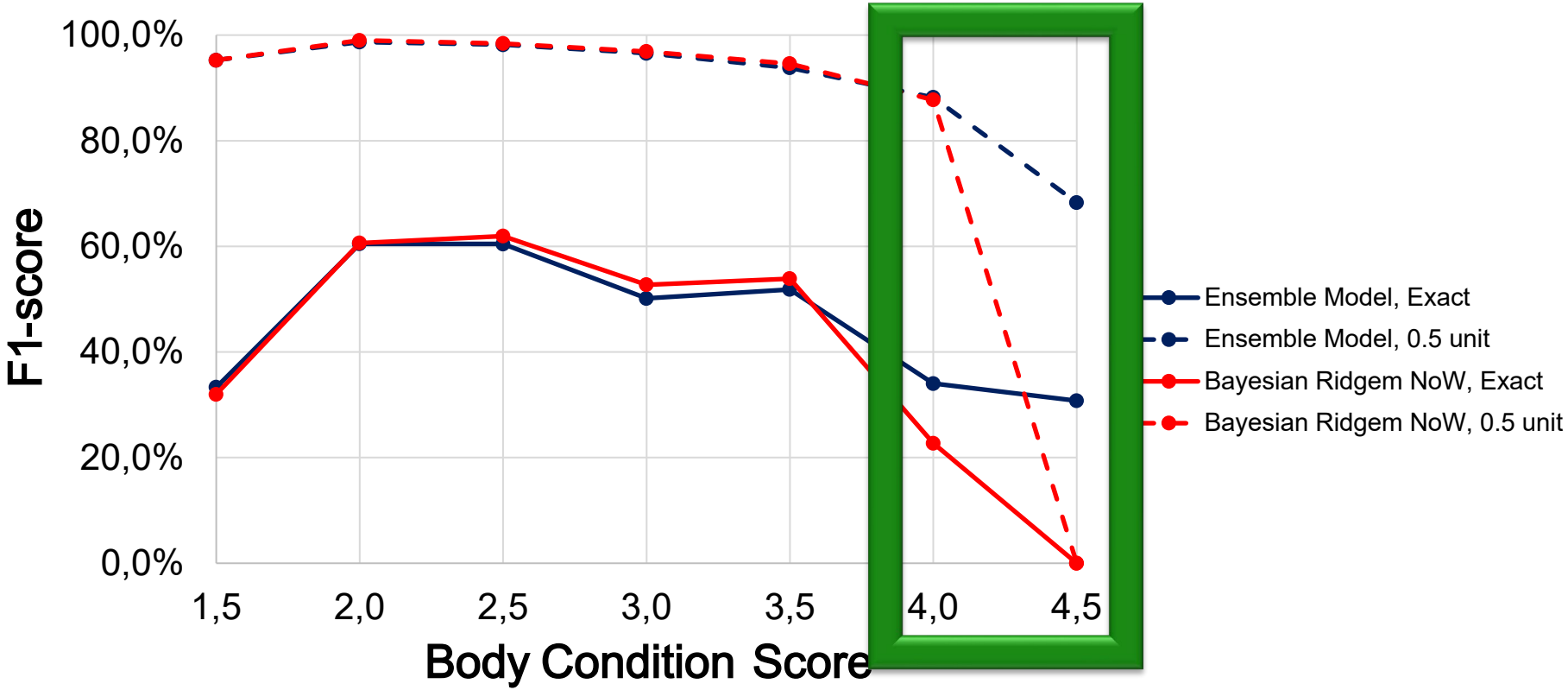
R^2, coefficient of determination
μ, bias (ideally 0)
ß, dispersion (ideally 1.0)



Validation results 7:3 split

	BayesianRidge NoW		Ensemble Model	
	Exact	0.5 unit	Exact	0.5 unit
Accuracy, %	56.0	96.8	55.1	96.5

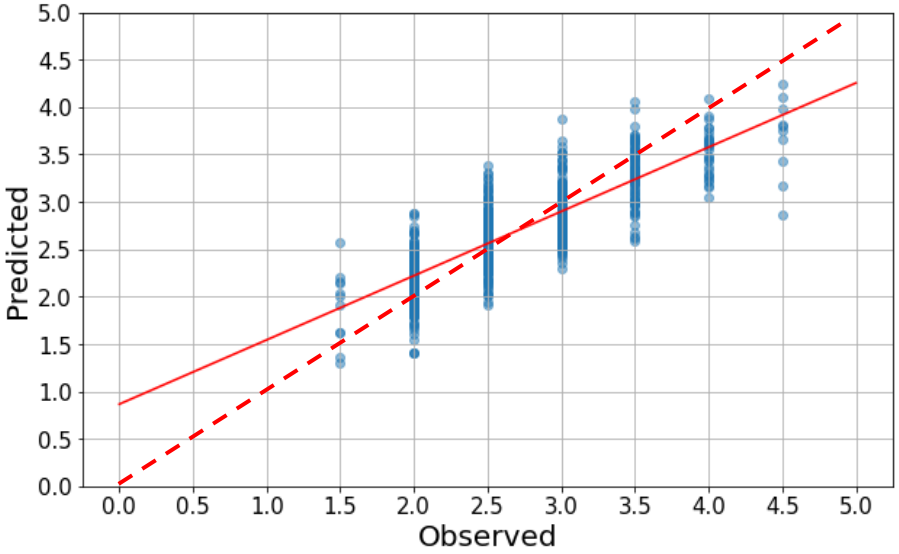
Validation results 7:3 split



Validation results 7:3 split

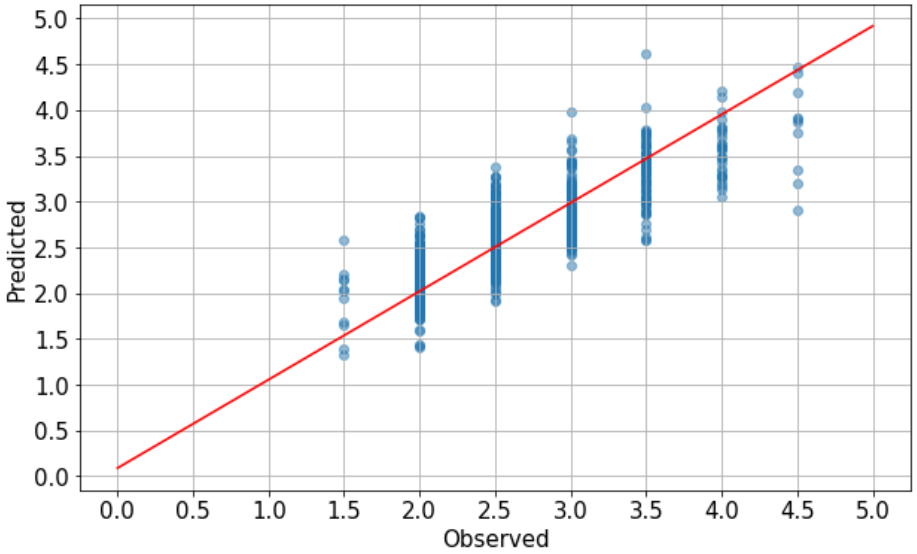
Bayesian Ridge, NoW

μ: 0.86 ß:0.68 R^2:0.67



Ensemble Model

μ: 0.09 ß:0.97 R^2:0.67



Validation results Herd CV

BayesianRidge NoW	Herd 1	Herd 2	Herd 3
Accuracy, %	Exact: 50.7 0.5 unit: 93.5	Exact: 44.9 0.5 unit: 90.5	Exact: 50.0 0.5 unit: 92.7

Ensemble Model	Herd 1	Herd 2	Herd 3
Accuracy, %	Exact: 52.2 0.5 unit: 93.0	Exact: 43.9 0.5 unit: 88.2	Exact: 50.2 0.5 unit: 92.9

Validation results Herd CV

BayesianRidge NoW	Herd 1	Herd 2	Herd 3
Accuracy, %	Exact: 50.7 0.5 unit: 93.5	Exact: 44.9 0.5 unit: 90.5	Exact: 50.0 0.5 unit: 92.7
μ, bias	0.74	1.29	1.00

Ensemble Model	Herd 1	Herd 2	Herd 3
Accuracy, %	Exact: 52.2 0.5 unit: 93.0	Exact: 43.9 0.5 unit: 88.2	Exact: 50.2 0.5 unit: 92.9
μ, bias	0.40	0.05	0.57

Validation results Herd CV

BayesianRidge NoW	Herd 1	Herd 2	Herd 3
Accuracy, %	Exact: 50.7 0.5 unit: 93.5	Exact: 44.9 0.5 unit: 90.5	Exact: 50.0 0.5 unit: 92.7
μ, bias	0.74	1.29	1.00
ß, dispersion	0.70	0.58	0.62

Ensemble Model	Herd 1	Herd 2	Herd 3
Accuracy, %	Exact: 52.2 0.5 unit: 93.0	Exact: 43.9 0.5 unit: 88.2	Exact: 50.2 0.5 unit: 92.9
μ, bias	0.40	0.05	0.57
ß, dispersion	0.87	0.94	0.76

Take-home messages

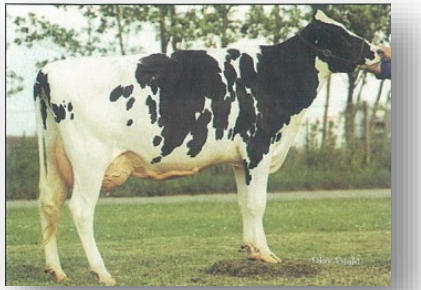
Ensemble model reduce **bias** and **dispersion** problems

Did **not** improve prediction accuracy

We could test Stacking Ensemble learning models

We can predict BCS in **Jersey** from 3D-images

Next step is to build a model for **Holstein**



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Thank you for your attention