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Harnessing computer vision to phenotype problematic behavior and stress resilience in pigs

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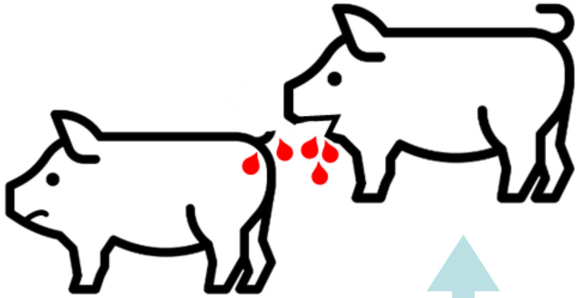
SABRE-TP "Phänotypisierung im digitalen Zeitalter", Schluechthof Cham

Motivation

- **Tail biting** in pigs
  - reduced welfare
  - economic losses
- Indication that **behavioural needs** are **unmet**
  - biter's welfare reduced
- **Multifactorial** origin
  - accumulating stressors (boredom, stable climate, sanitary conditions, diet, health)
- **Outbreaks** *(brewing beneath the surface)*



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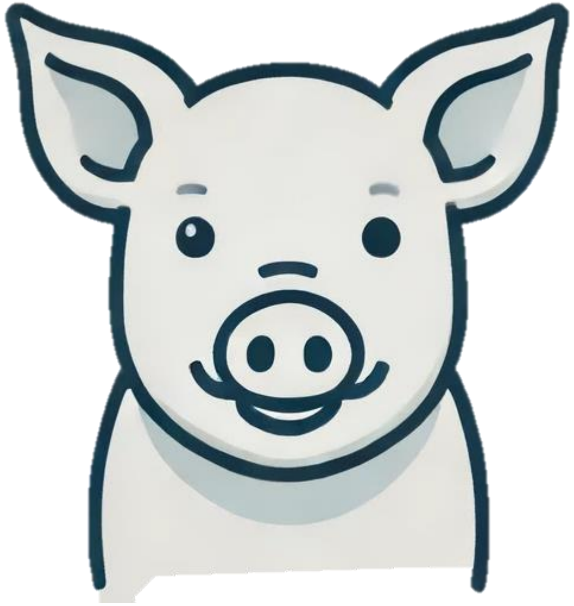
Breeding pigs with higher stress resilience



- in *addition* to improved management!
- coping with stress has genetic basis Kadarmideen & Janss 2007; Kasper et al., 2020
- tail biting is heritable Breuer et al., 2005

Phenotype: behavioural changes long before outbreak – **'precursors'**

- feeding patterns change (pen) Ollagnier et al., 2023
- tail posture (individual) Statham et al., 2009; Zonderland et al., 2009; Drexl et al., 2023
- activity increases (biter) Statham et al., 2009; Zonderland et al., 2011
- tail-in-mouth events increase Schrøder-Petersen & Simonsen, 2001

Developing high-throughput phenotyping

- **Goal:** identify pigs with higher stress resilience
  → 'measure' stress resilience at ***individual level***

- record behaviour live with 'pen and paper' or from videos

- > 1'000 individuals with phenotypes
- **high throughput needed!**

- **video surveillance**
  - gather data on individuals to select stress-resilient pigs
  - monitoring pig behaviour real-time, alarm system for farmers

Computer vision for phenotyping

Ongoing project @Agroscope


Hassan Nasser – Computer Vision expert (Agroscope)

Ana Margarida Gomes Farinha – Master's student (Agroscope & Polytechnic Institute of Viseu, Portugal)

Vladimir Zivkovic – Animal Scientist (Institute for animal husbandry, Belgrade, Serbia)

Kirill Ivanov – PhD student (Dept of Comparative Biomedicine and Food Science, Padova, Italy)

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A Roadmap for assessing pigs behavior from video surveillance

Goal

Compare methods for detecting behaviours of ***individual*** pigs

- 2 pens with 12 castrated male pigs each
- 100 – 140 kg live weight
- 5 surveillance cameras

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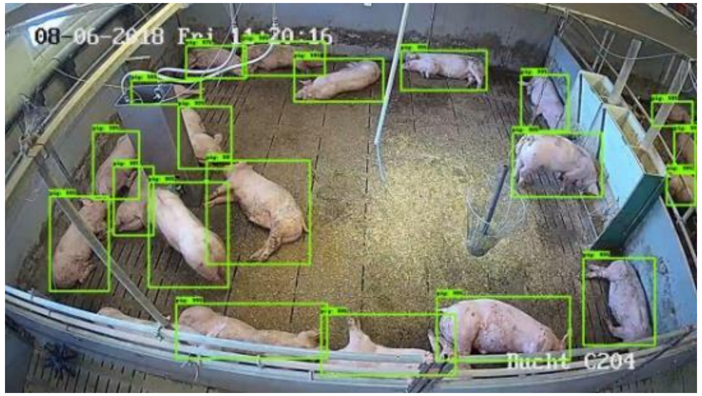
Steps and challenges

1. Establishing ethogram & installing cameras
2. Selecting images with highest information content
3. Annotating images
4. Choosing and training the model
5. Evaluating model performance



Establishing ethogram & installing cameras

36 days x 13h (7:00 – 20:00) x 5 cameras = **3’055 hours of video**
after preselection: **1’850 h of video** = 231.25 work days

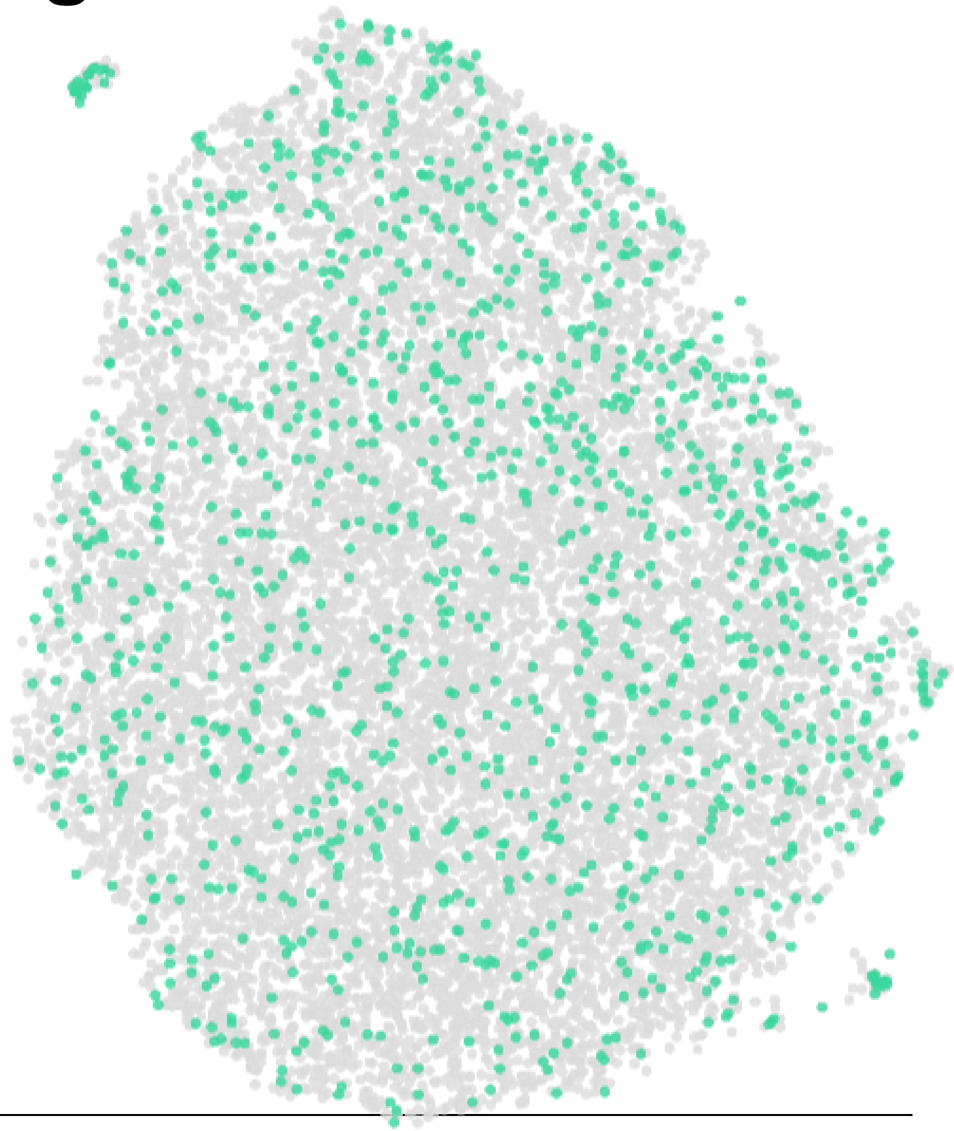
Ethogram: catalogue of behaviours

Selecting information-rich images

- Software *Lightly*

Select subset of images (frames) with the biggest impact on model accuracy – reduce redundancy

Embeddings: reduce dimensionality and cluster similar frames together



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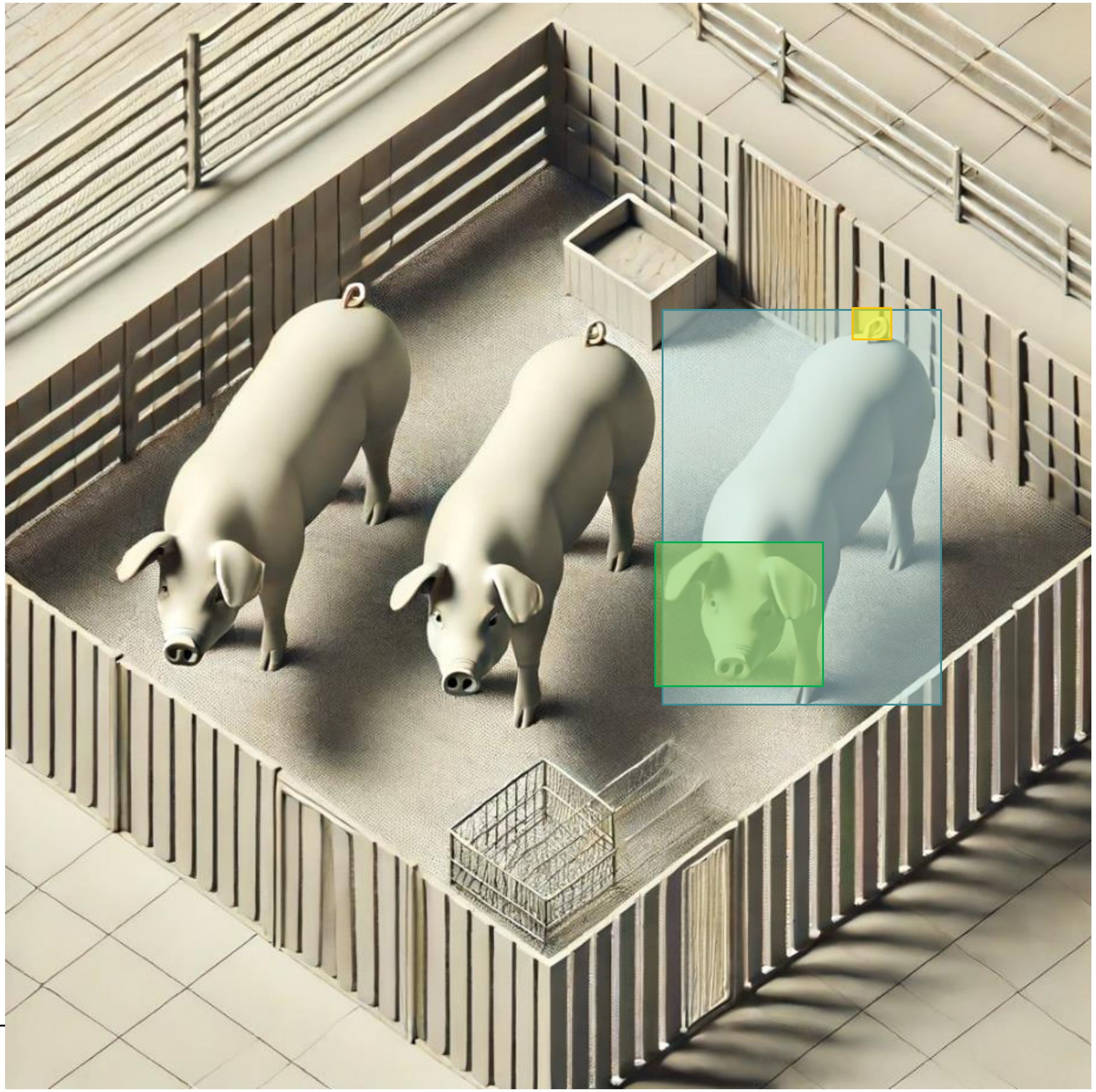
Annotating the images

- Software *CVAT*

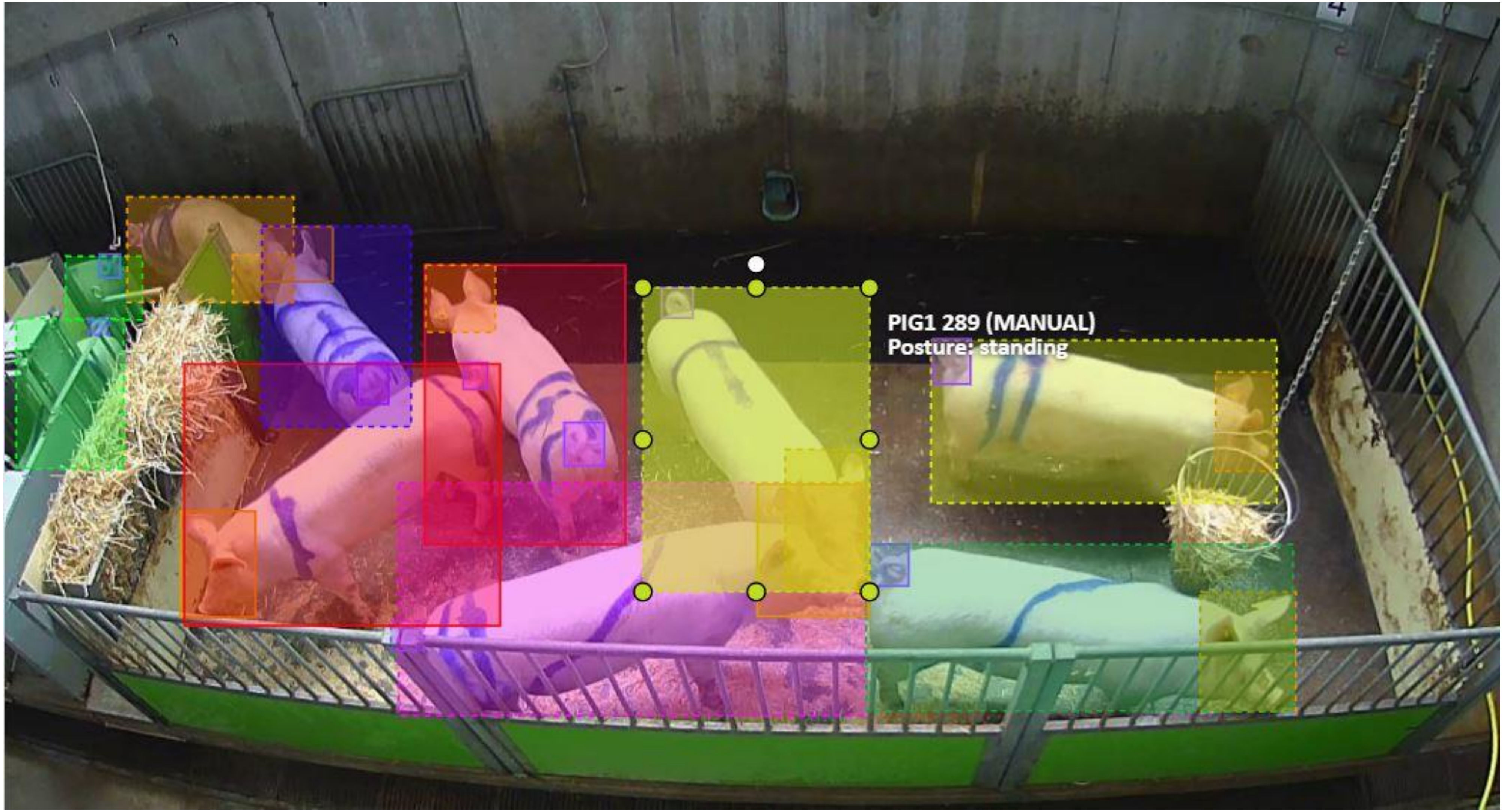
Label images with relevant information to be used in training models

- Posture of pig (*standing/sitting/lying*)
- Bounding boxes (BB) around pig, head, tail → 286 frames
- Segmentation + BB head & tail → 516 frames

1 camera –
800 frames
15’645 objects



Annotating the images



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Annotating the images

- Individual pigs
- Head
- Tail

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Annotating the images

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Annotating the images

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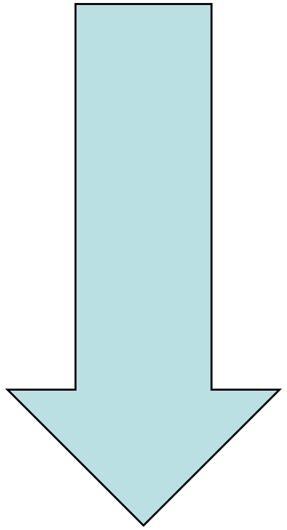
Which model fits best to solve our problem?

Object detection?

Key Points?

Action recognition?



Complexity

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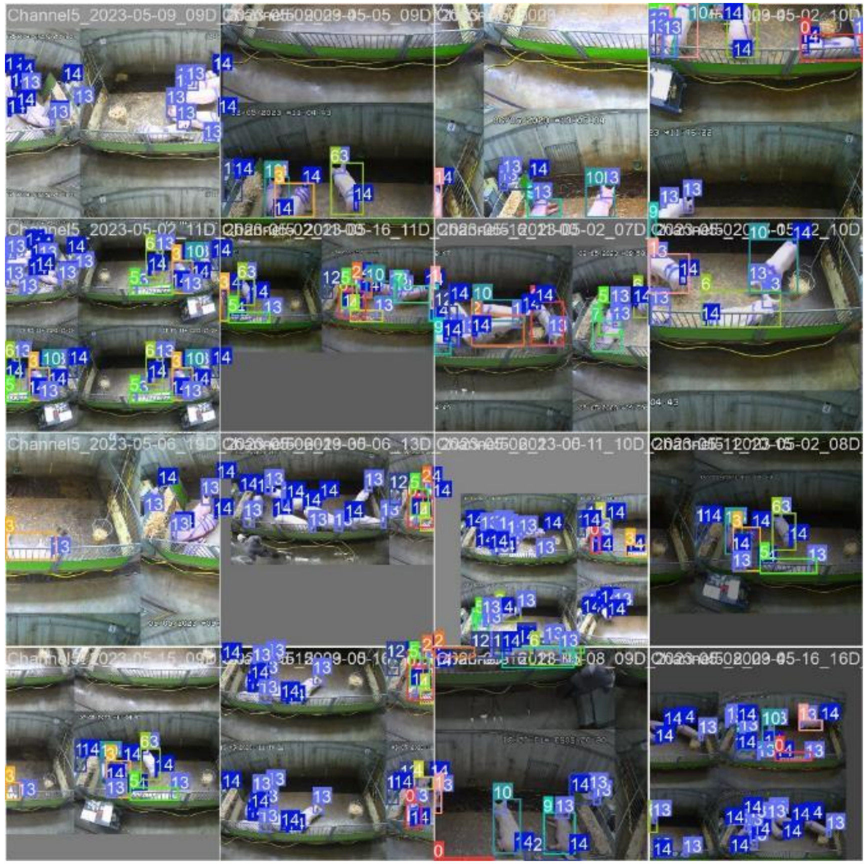
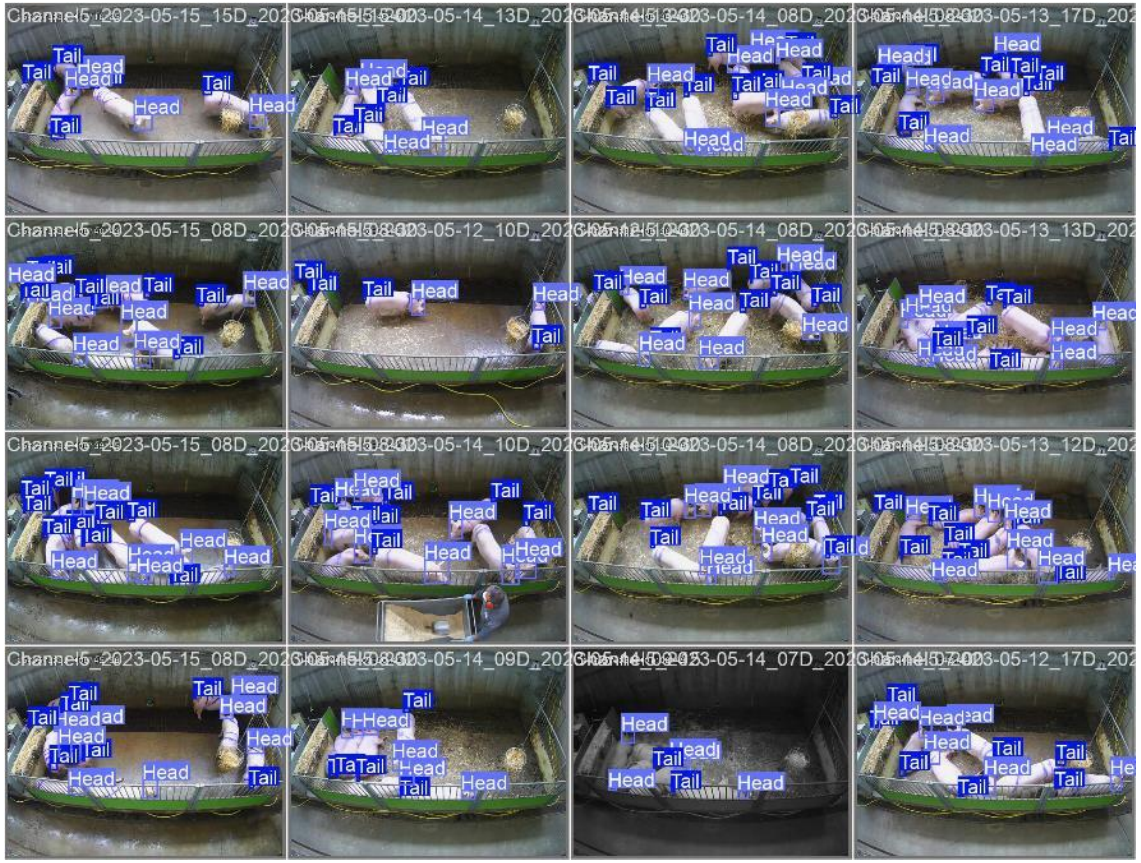
Training the model

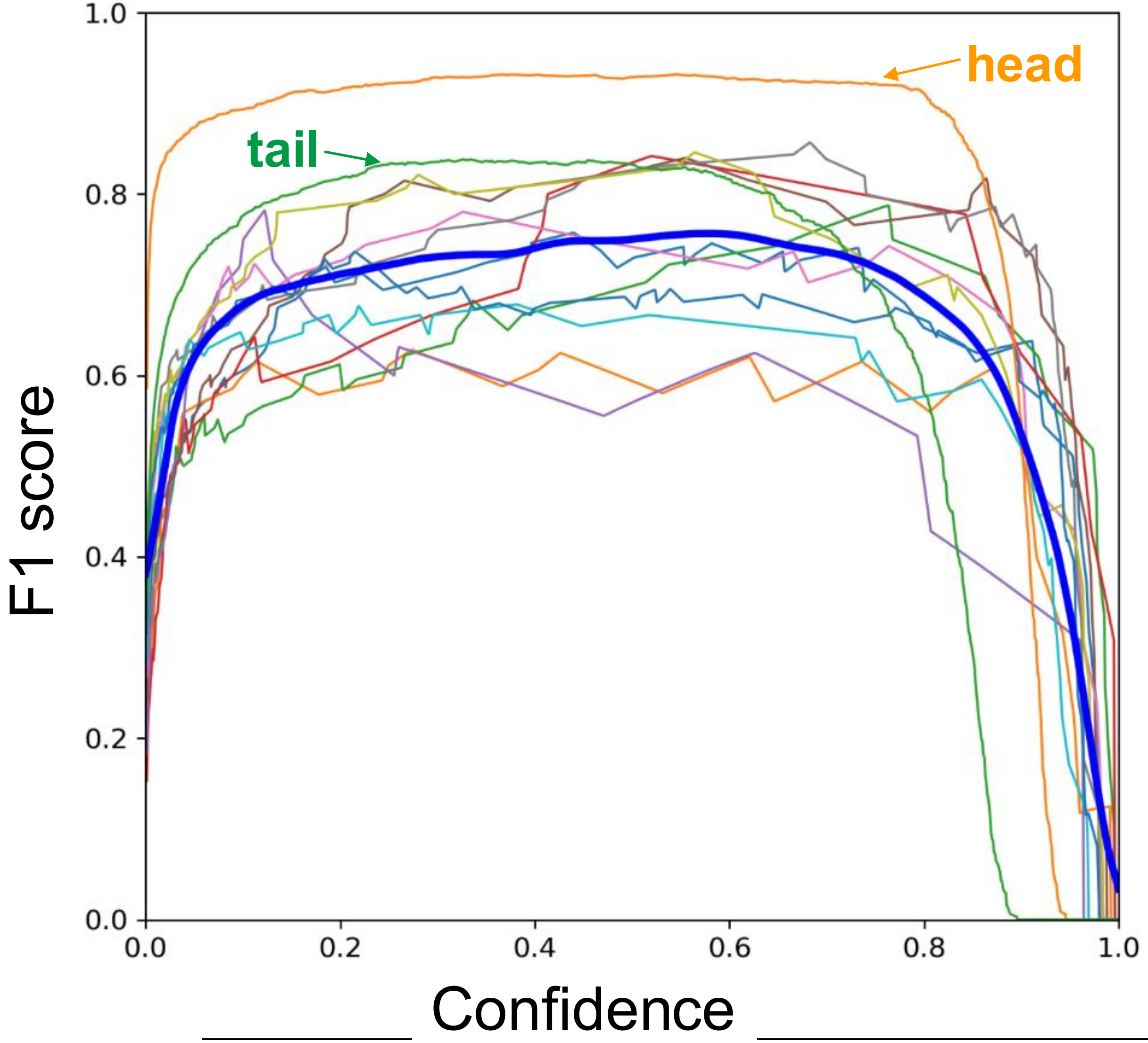
Baseline model!

- *YOLO v8 medium – 286 frames, 4’872 objects (BB pig, head & tail only)*





Evaluating model performance



F1 confidence curve:

false positive and false negative
(average of precision and recall)

against different confidence thresholds

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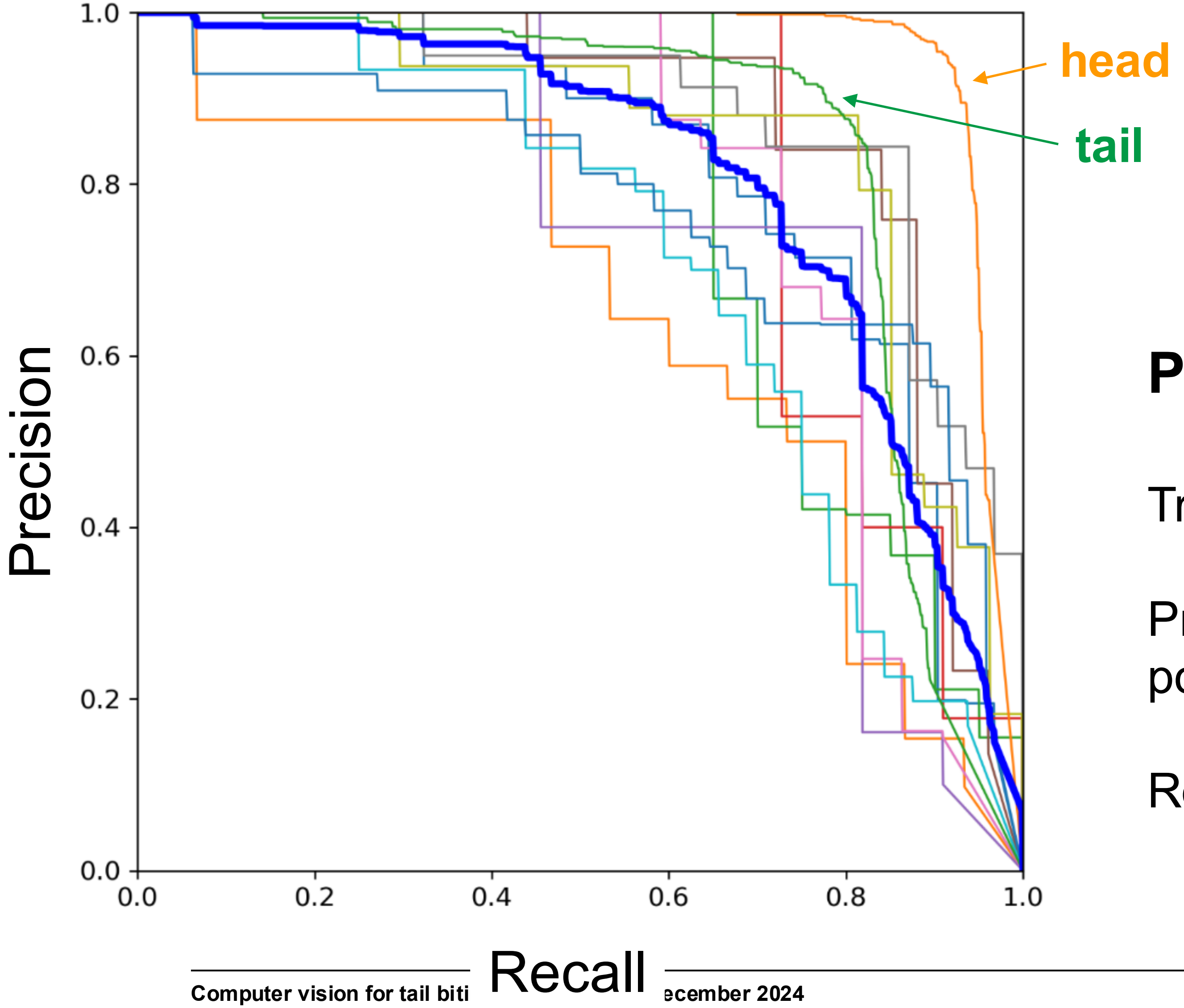
Evaluating model performance



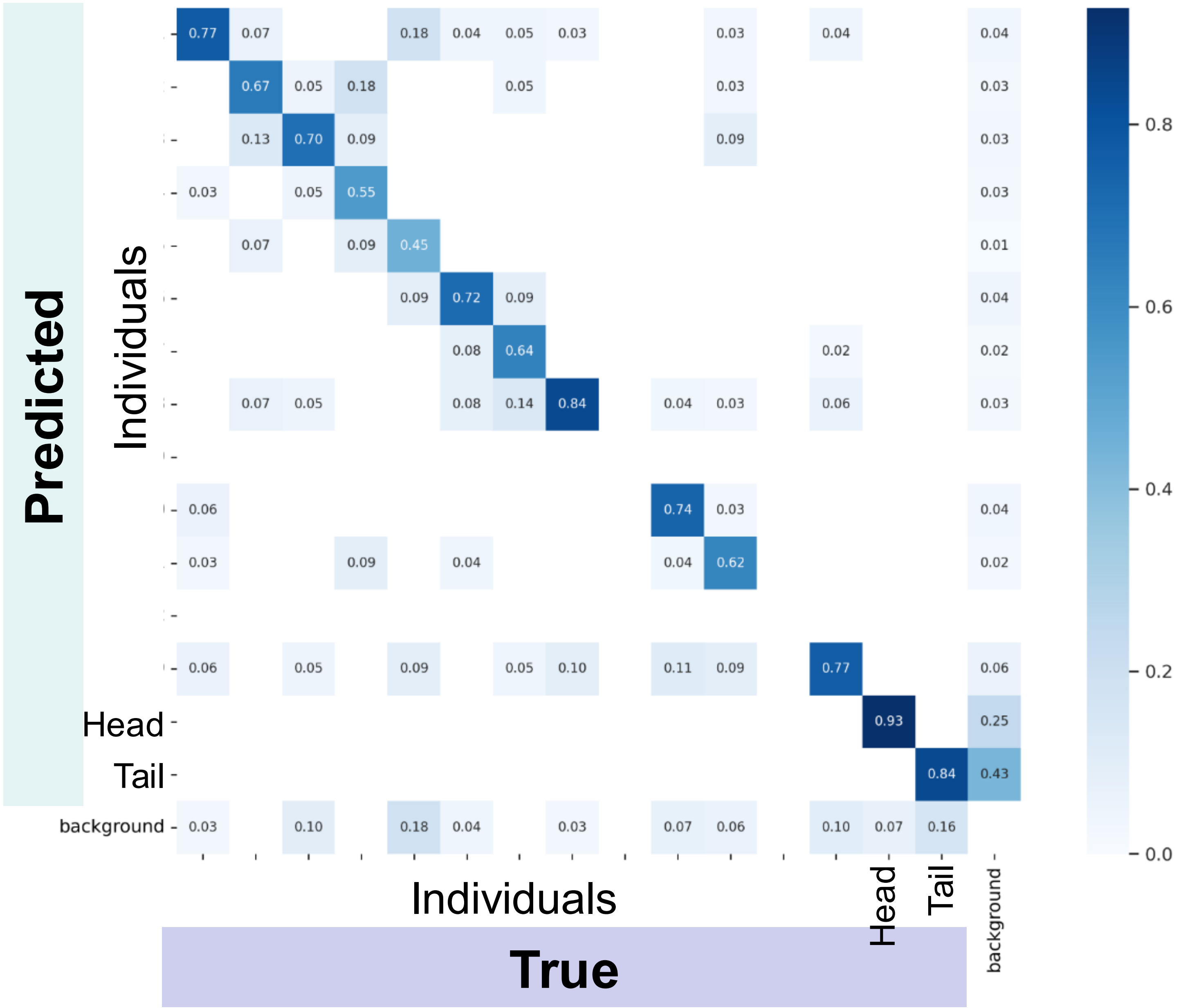
Precision-recall curve:

Trade-off between precision and recall

Precision: ability to not categorize negative as positive

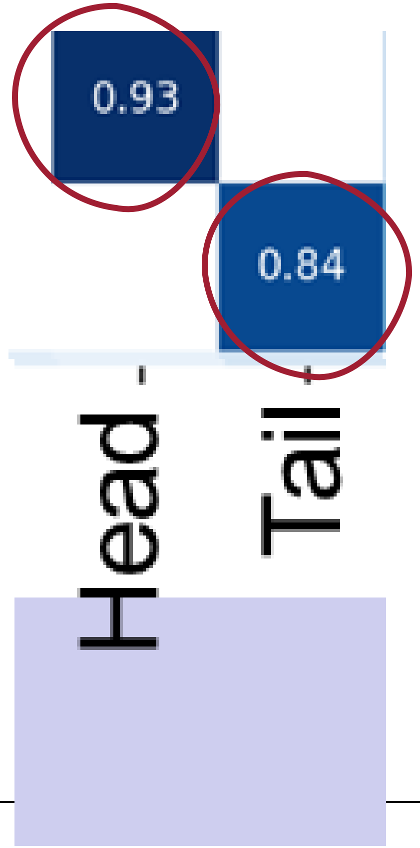
Recall: ability to detect positive

Evaluating model performance



Confusion matrix:

True vs predicted



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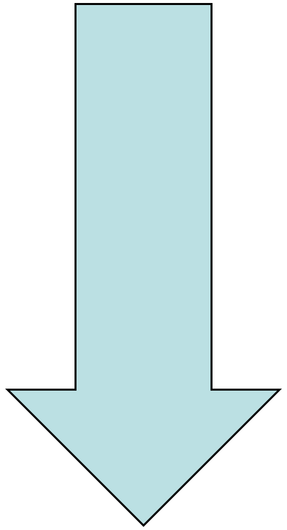
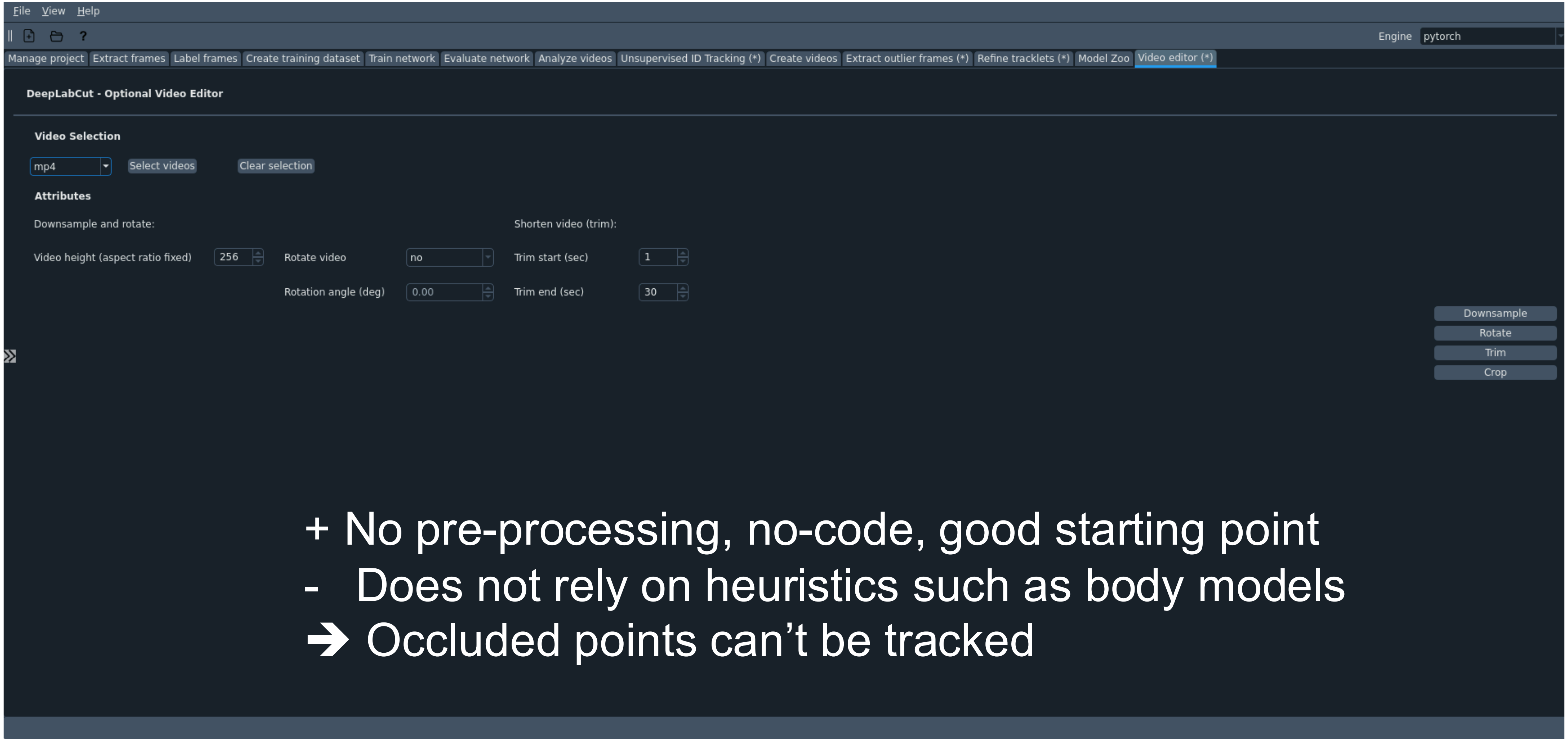


Complexity

Data Labeling with keypoints

DeepLabCut (developed at EPFL)

GitHub



\+ No pre-processing, no-code, good starting point

\- Does not rely on heuristics such as body models

➔ Occluded points can't be tracked

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Comparing models (deep neural networks)

- with a minimum baseline keypoint configuration
- Resnet50 performs best

Param	HRNet W32 ImN	HRNet W32 AniQ	Resnet50 ImN	Resnet101 ImN
Train rmse_pcutoff	1.96	1.65	2.04	2.17
Train mAP	99.23	97.31	97.67	99.77
Train mAR	99.8	100	99.85	99.95
Train rmse_detections	1.97	1.61	1.99	2.19
Train rmse_detections_pcutoff	1.95	1.6	1.96	2.17
Test rmse	9.84	9.63	6.29	6.56
Test rmse_pcutoff	8.88	9.17	5.72	6.34
Test mAP	74.24	66.85	82.9	93.68
Test mAR	80	77	93.33	94.17
Test rmse_detections	9.68	22.47	6.2	6.56
Test rmse_detections_pcutoff	8.76	21.22	5.63	6.34

Key point selection

- How many key points?

Keypoints	Minimum requirements (Baseline model)	Unitary test (with everything else fixed)
Ears	1	3 (EAR3P)
Eyes	0	2 (EYES2P)
Tail	1	-
Nose	1	2 (SNOUT2P)
Back	3	5 (BODY5P)

Which model fits best to solve our problem?

Object detection?

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Action recognition?

Complexity

Conclusion & next steps

- Obtained ok results with just 286 frames
- Training on the full set of available annotated frames promising

Next steps

- Transfer model to other cameras (different angles)
- Extract relative positions of heads and tails
- Infer behaviours using specialized software and define rules
- Compare the three methods (object detection – key points – action recognition)

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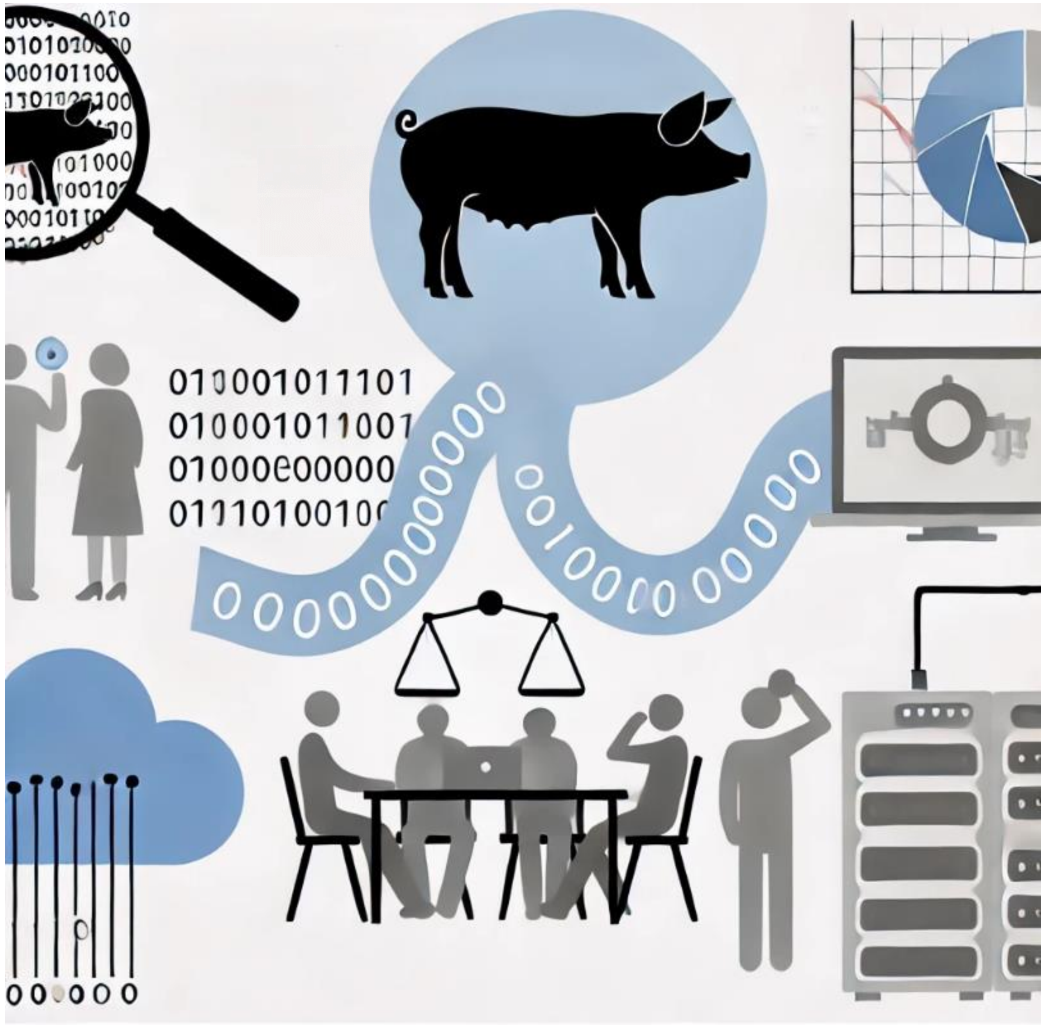
Challenges

- The right **phenotype**
  - **Validity** (welfare specialists needed)
- Translate **ethogram** to computer language
- Camera positioning
- **Communication** in interdisciplinary team
- Setting up cloud/server
- Getting DeepLabCut to work
- **Individual** tracking



Thank you!

Experimental Farm:

- Guy Maïkoff
- Bertrand Egger
- Fabrice Sansonnens

COST Action CA22112
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multidisciplinary, interconnected and inclusive community of experts in Livestock Phenomics

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Thank you for your attention

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