KU LEUVEN

Beyond More Data

-Transferable Computer Vision for Animal Digital Phenotyping

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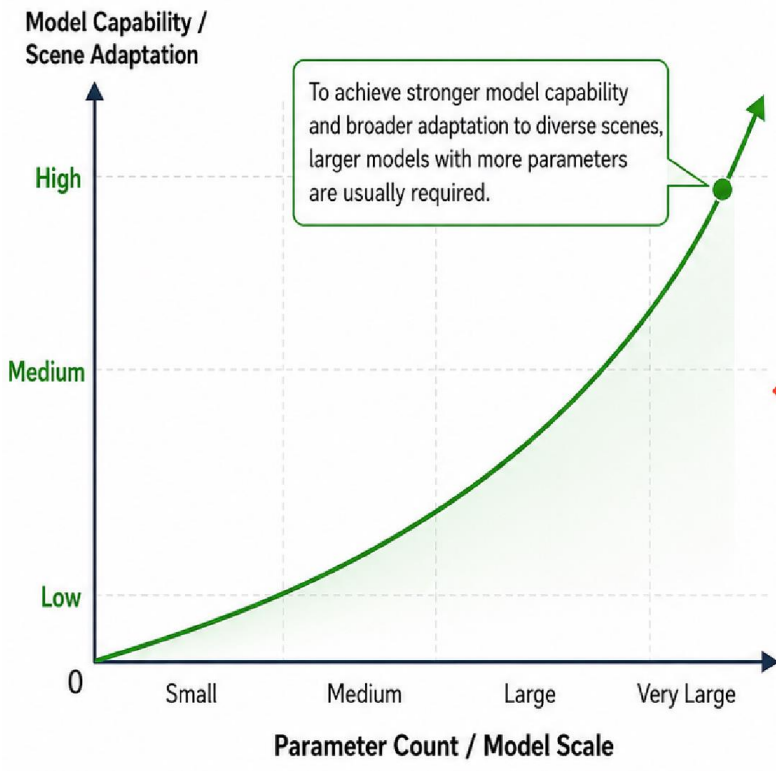
AI4AS Challenges

- Animal science requires large-scale, multi-site evidence
- Real-world farms introduce substantial scene variation
- AI models suffer from performance shifts across environments

AI4AS must move from **“high accuracy in one dataset”** to **“certified reliability across real-world scenarios.”**

Common Response: Collect and label more data until the dataset covers every possible case

Why larger datasets are not enough?



- More data helps, but full coverage is costly and impractical.
- More capability often comes with larger models, while real-world deployment requires lightweight, efficient, and resource-saving solutions.

AI4AS needs a stronger focus on transferable representations

Instead of asking neural networks to learn everything from raw data, we design representations that preserve what matters for phenotyping while reducing irrelevant environmental variation.

Global view

- Understanding the entire pig house
- Identifying pig presence
- De-coupling disturbances from downstream modules

- Skeleton
- Mask
- Posture
- Identity
- Motion
- Behaviors

Local view

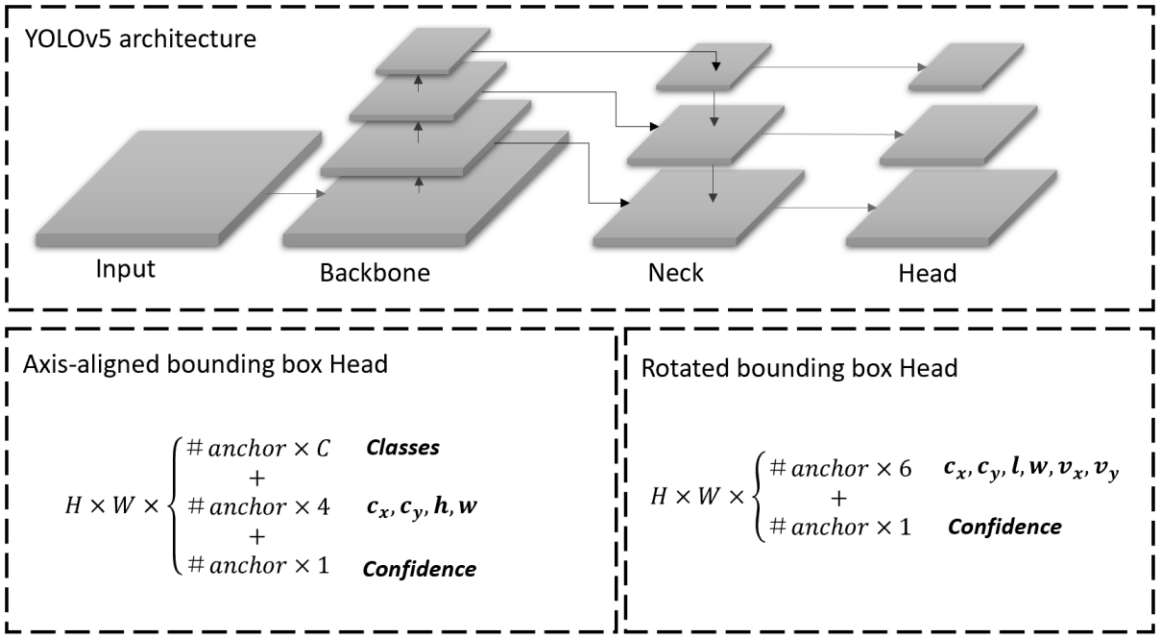
- Understanding individual pig
- Examining pig pixels to identify feature patterns crucial for sub-module tasks

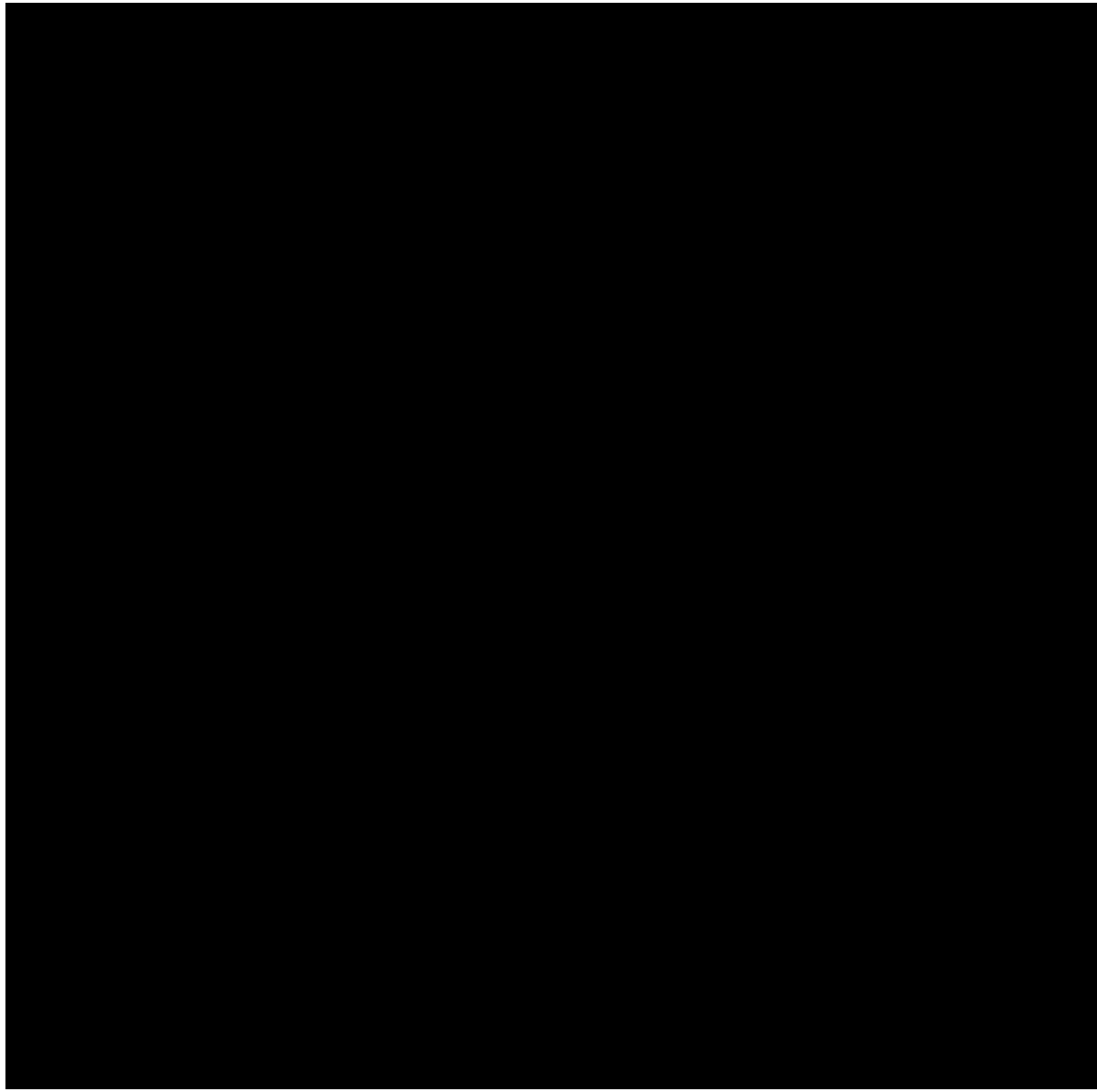
Learn from visual representation

- Lesion
- Body condition
- Weight estimation
- Body cleanness
- Standing
- Laying on belly
- Laying on side
- Sitting
- Feeding
- Drinking
- Tail biting
- Ear biting
- Fighting
- Replacement

Global View: Locate each animal by Rotated Bounding Box

- ✓ *Rotated bounding box → Performs well in dense scenario*
- ✓ *Direction vector → enable inferring the yaw angle*
- ✓ *Super lightweighted (1.7M) → edge device*

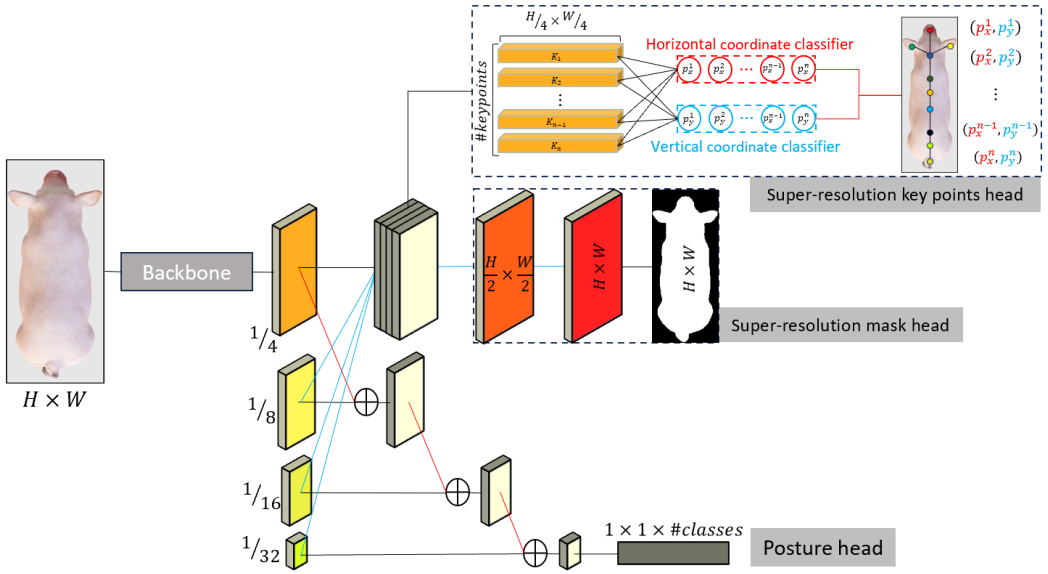


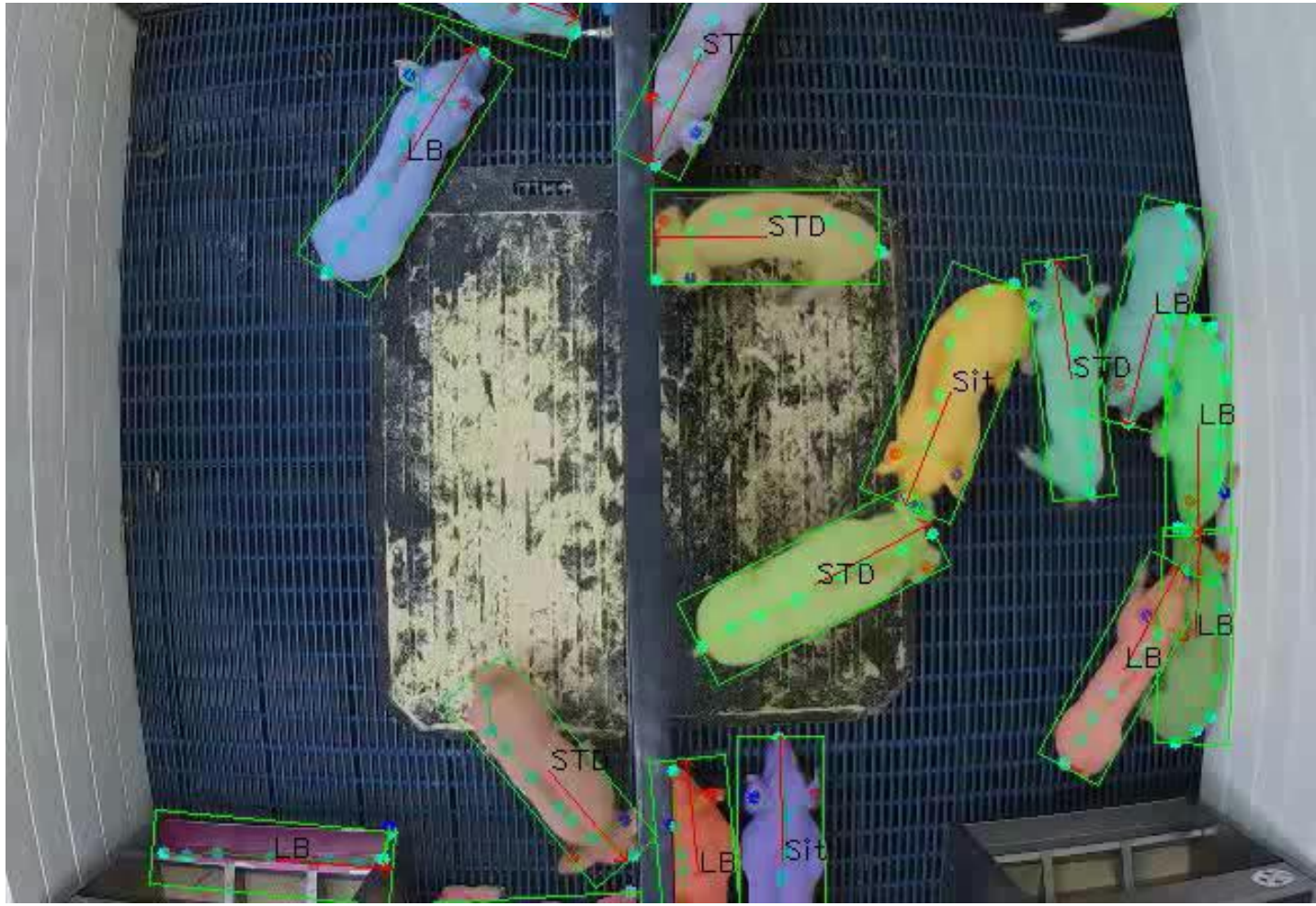


Liu, D., Parmiggiani, A., Psota, E., Fitzgerald, R. and Norton, T., 2023. Where's your head at? Detecting the orientation and position of pigs with rotated bounding boxes. *Computers and Electronics in Agriculture*, *212*, p.108099.

Local View: Encode animal representations

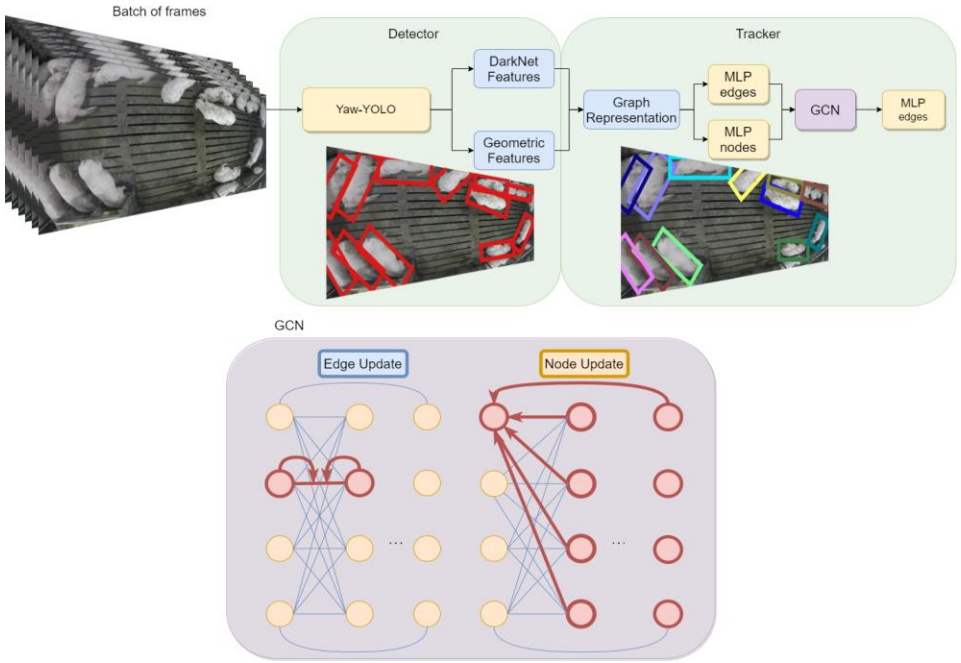
- ✓ *Multi-task learning* → *Low Latency*
- ✓ *Super precise* → *modalized design*
- ✓ *Cross-Scenario Generalization*
- ✓ *Super fast* → *14K FPS@3090GPU*
- ✓ *Super lightweighted (2M)* → *Edge device*





Temporal view – Associate identities cross frames

- ✓ *Track Rotated bounding box → Performs well in dense scenario*
- ✓ *Occlusion robust → Associate identities over 25 frames using Graph Neuro Network*



Parmiggiani, A., Liu, D., Psota, E., Fitzgerald, R. and Norton, T., 2023. Don't get lost in the crowd: graph convolutional network for online animal tracking in dense groups. *Computers and Electronics in Agriculture*, *212*, p.108038.

At any time point, each individual animal can be represented by...

$$Pig_i^t =< RBB, POSTURE, KEYPOINTS >$$

Applications using visual representation

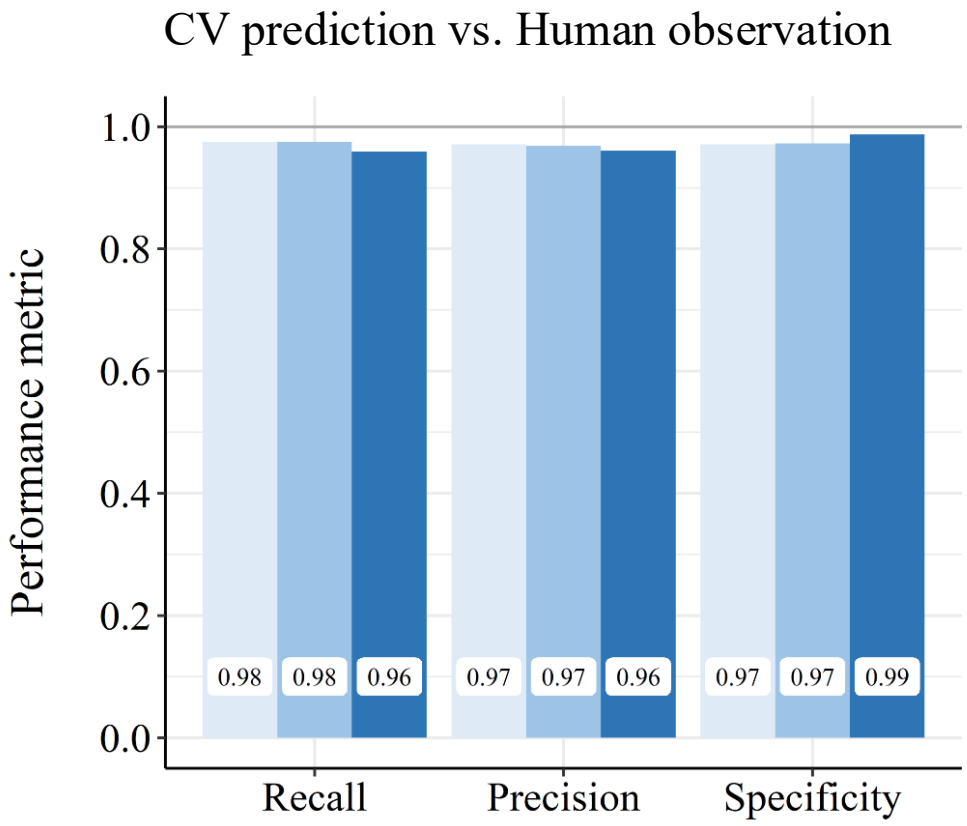
Targeted behaviors

- Feeding
- Drinking
- 1-to-1 fighting
- Tail biting
- Displacement

Why selected:

- Major impact on **welfare, health & productivity**
- Feeding/drinking = **early-warning signals** (stress, disease)
- Capture **diverse motion dynamics & duration** (rapid vs. subtle behaviors)
- Well-defined **ethogram** in literature
- Include both **social & environmental interactions**
- Build foundation for a **generalizable behavior model**

Feeding & Drinking



Larsen M L V, Liu D, Franchi G A, et al. Computer vision and ethological methods to produce large-scale data on feeding and drinking behaviour in finishing pigs[J]. Applied Animal Behaviour Science, 2026: 107101.

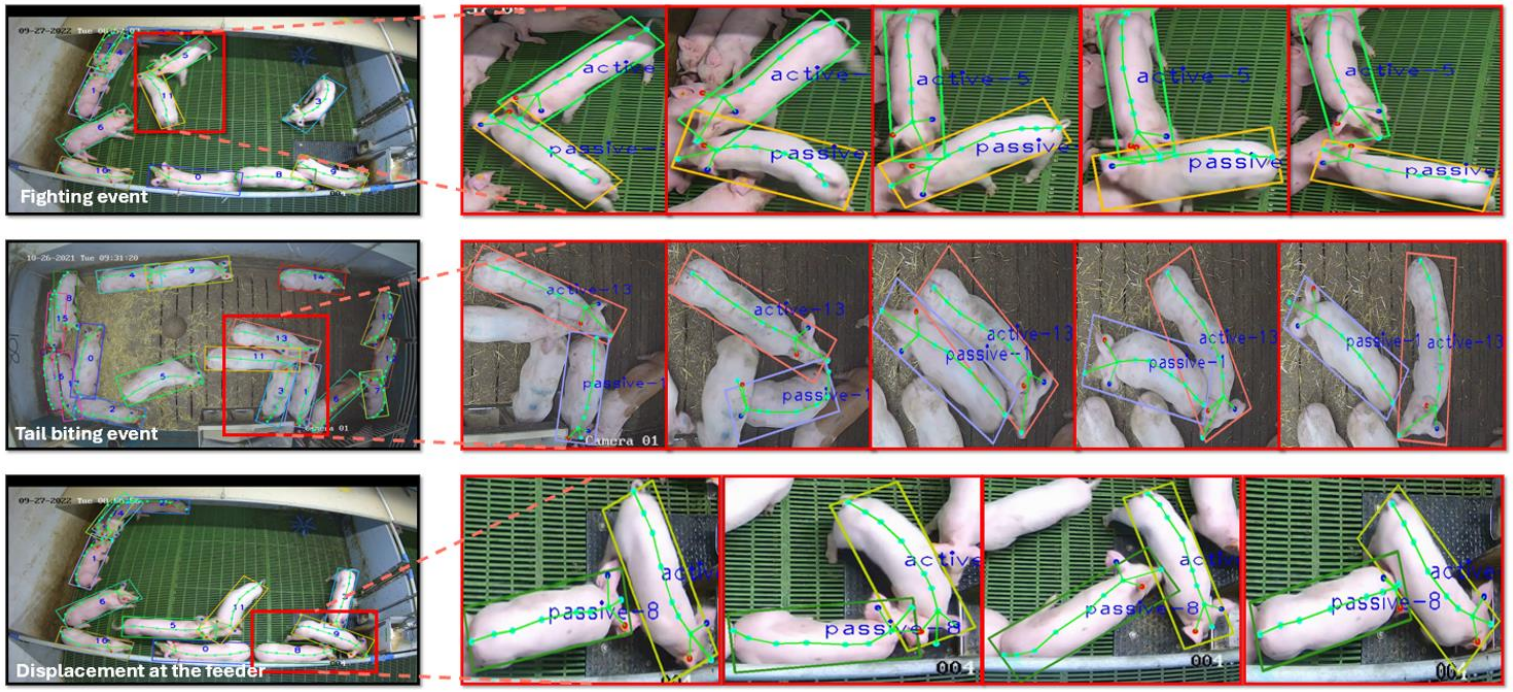
Animal-animal interactions

- **Stage one: Interaction Proposal Generation**
- Stage two: Proposals classification

Fighting proposals
- Snout-snout contact
- Headbutting
- Posture-aware constraints

Tail biting proposals
- Snout-tail contact
- Posture-aware constraints

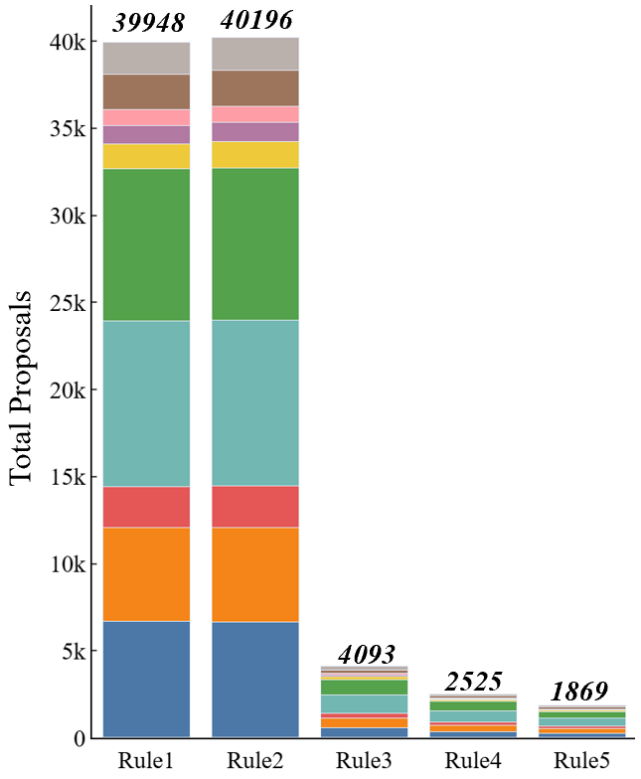
Displacement proposals
- Headbutting
- Posture-aware constraints



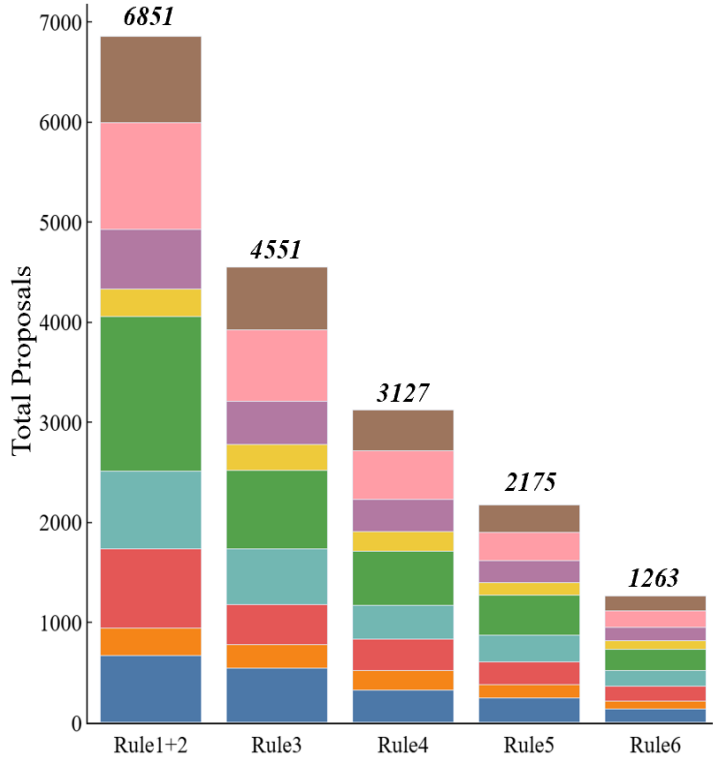
Objectives of Interaction Proposal Generation

- 100% recall
- Generating minimum suspected proposals as input to proposal classifier

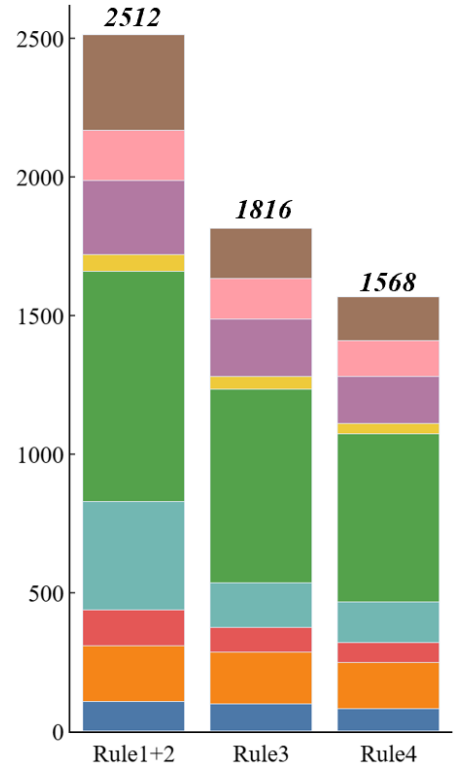
Counting of proposals as the rules progress



Tail biting



Fighting



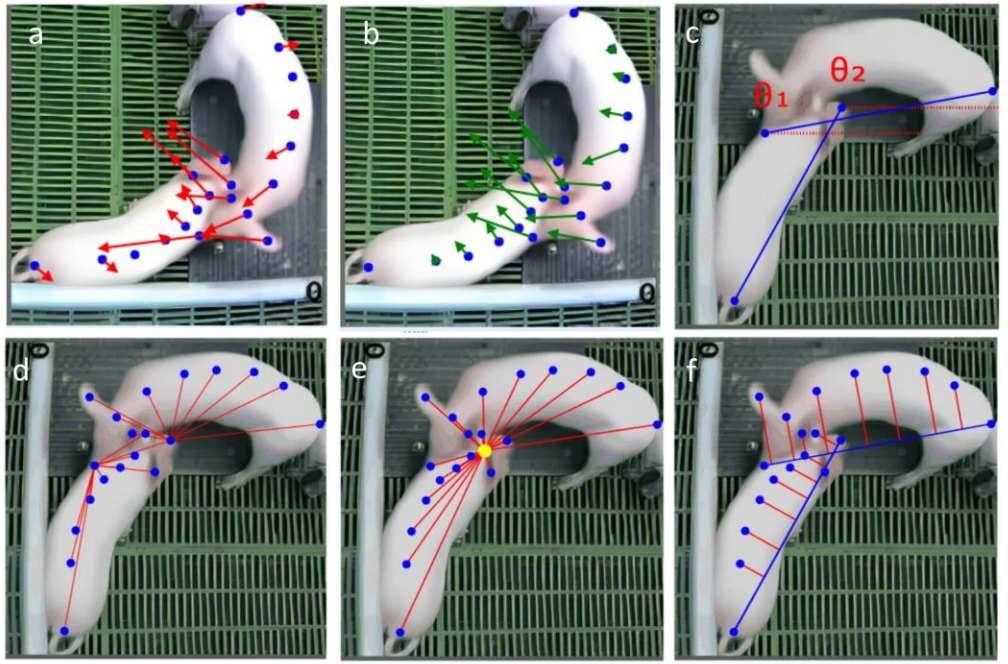
Displacement

Animal-animal interactions

- Stage one: Interaction Proposal Generation
- **Stage two: Proposals classification**

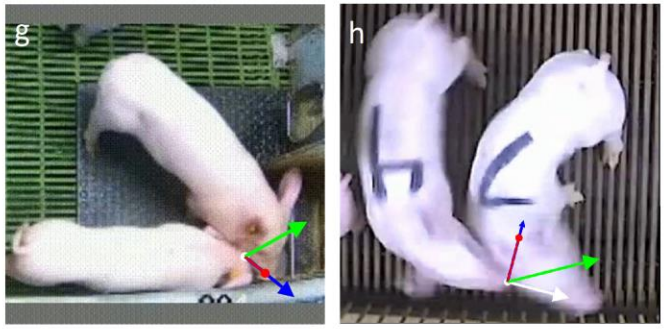
Motion features encoded into GNN classifier

- Key points velocities
- Key points accelerations
- Pigs' facing angles
- Distances between key points of one pig to the snout of the other pig
- Distances between key points and the centroid of all key points
- Spine deviations



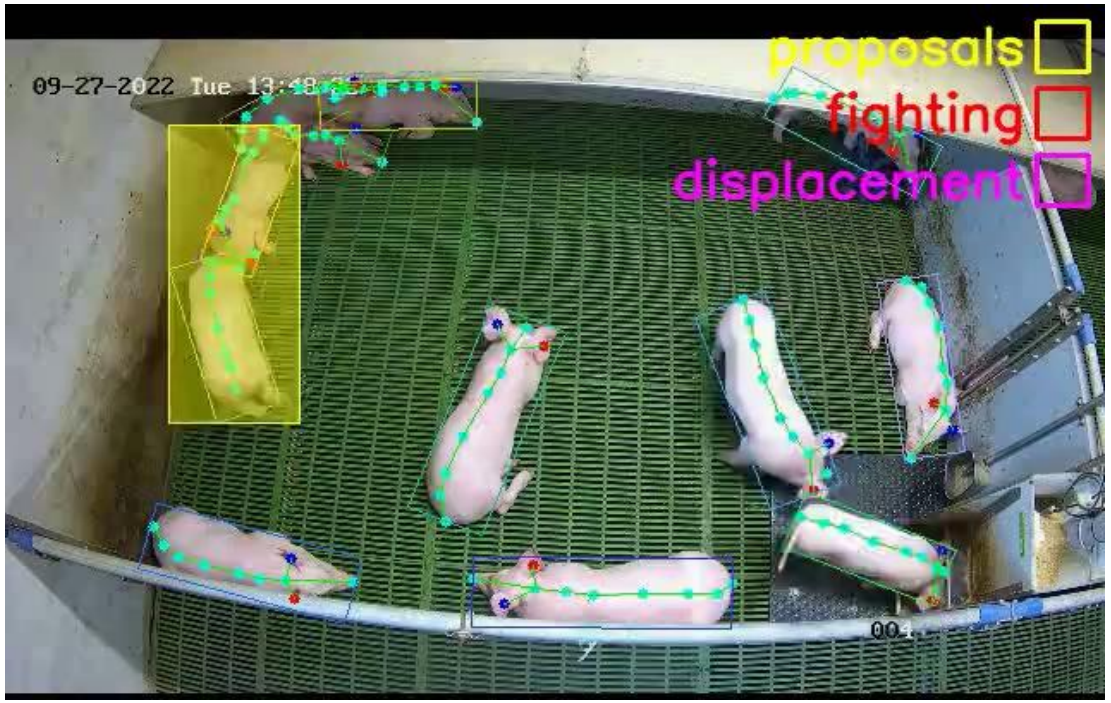
Only skeleton features (no appearance features)

- ✓ Generalization
- ✓ Computational efficient

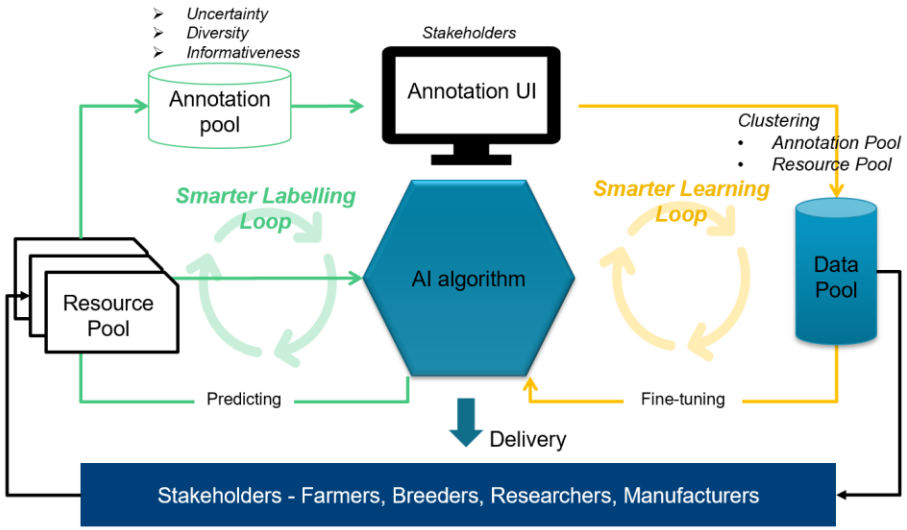


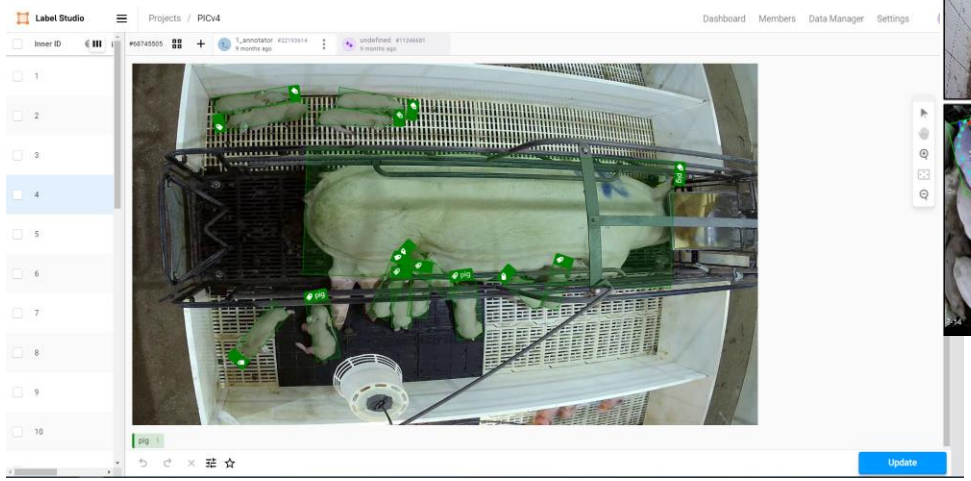
Who does what to whom, and when?

- Who? – pig identity (ear tag)
- When? – start/end time
- What? – Tail biting/Fighting/Ear biting/replacement



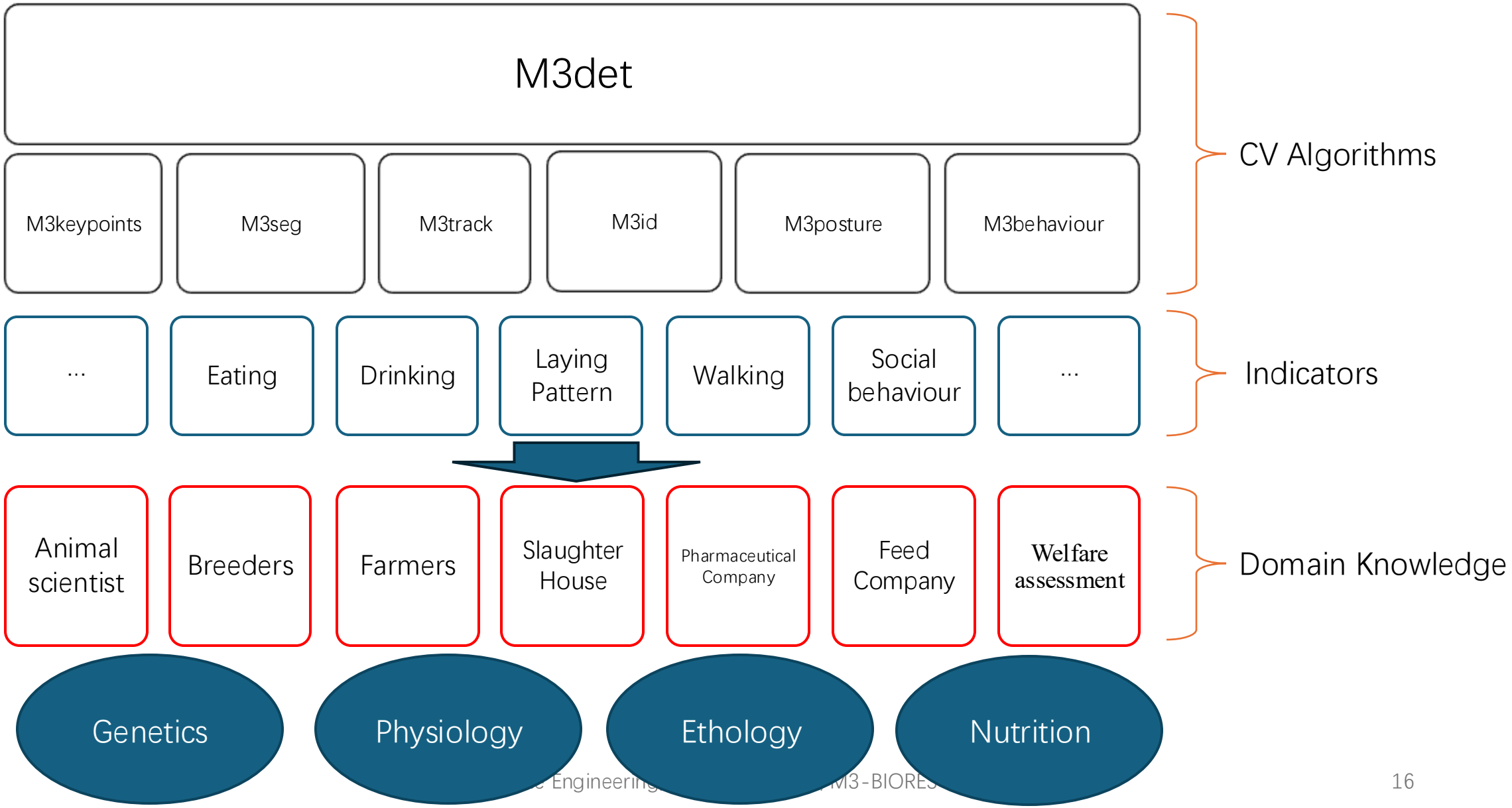
Remaining challenge and current solution

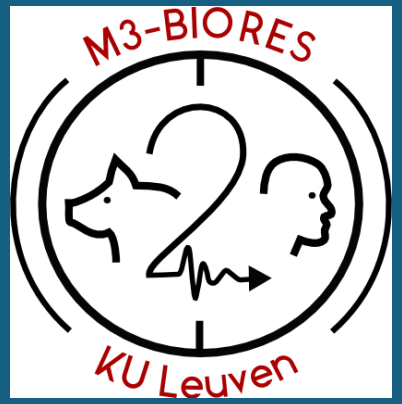




Fine-tune object detector by active learning

Future Vision





Thanks for your attention!

Project Page: https://gitlab.kuleuven.be/m3-biores/public/m3pig