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Behaviour and welfare monitoring of cattle using computer vision and machine learning

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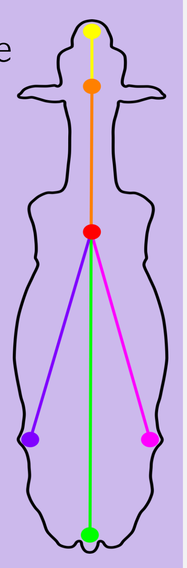
Introduction

Holstein-Friesian dairy cattle have distinct, unique coat patterns, offering opportunities to identify animals in video captures obtained during experiments requiring behavioural analysis. Past research focused on standardized frontal, lateral or top-down views and often uses classification-based models. However, for applications in practice, algorithms have to deal with images of freely moving animals, a complex task due to the high asymmetry of cattle coat patterns. Therefore, we introduce algorithms that combine pose-estimation with primary behaviour classification, tracking and spatial pose projection. The objective is to obtain the coordinates of keypoints in a 3D space barn.

Material & Methods

Pose estimation

- Animal segmentation Mask R-CNN network finetuned for cattle
- Bottom-up pose estimation based on part-affinity fields
- Viewpoint estimation based on spine-angle ∈[0°, 360°]
- Pose classification using a random forest classifier



Primary behaviour classification

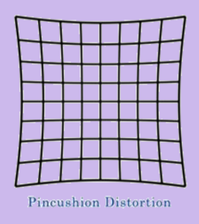
- 3 behaviours: standing, lying left side, lying right side
- Essential for re-identification
- Essential for spatial pose-projection:
  - Projection of keypoints from 2D to 3D coordinates
  - Primary behaviour defines projection height of keypoints

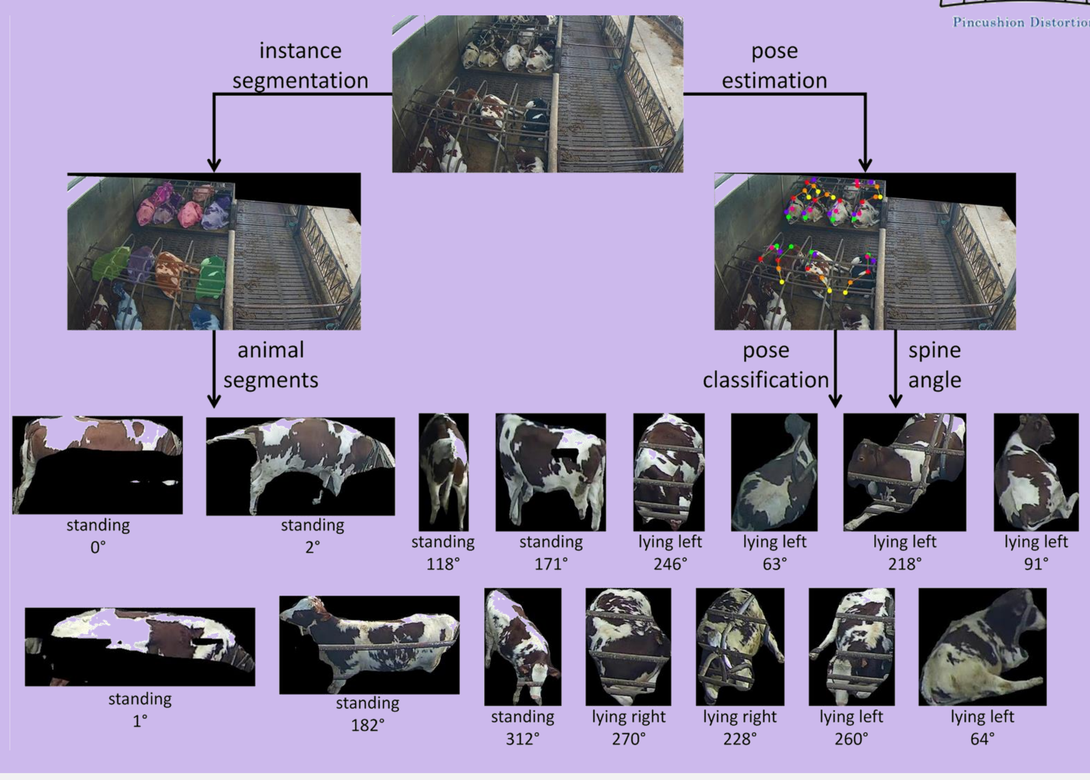
Tracking

- KeySORT: bounding box independent tracking
- Optimal use of advantages of bottom-up pose-estimation
- Adaptive Kalman filter
- Increased consistency of pose estimation
- No difference in accuracy

Spatial pose projection

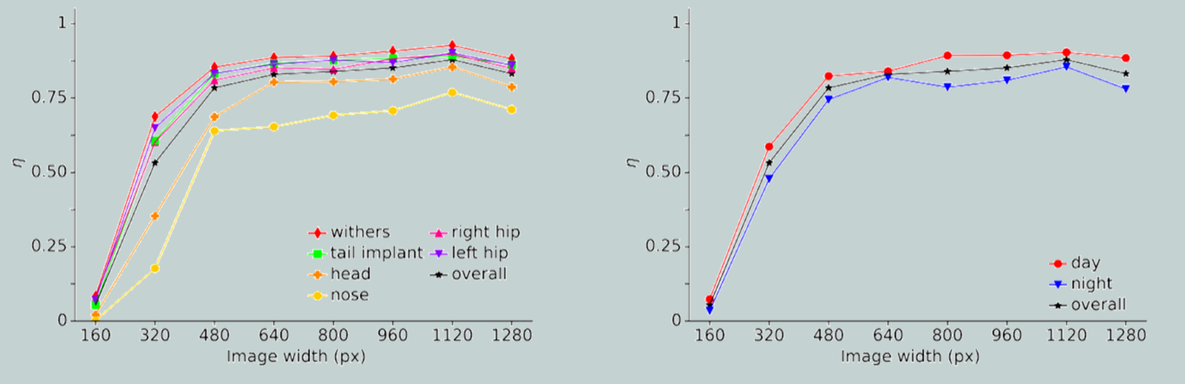
- Projection of keypoints from image to 3D space barn
  - 2D image coordinates + approximate height keypoints
- Lens distortion: straight lines become curved





Results & Discussion

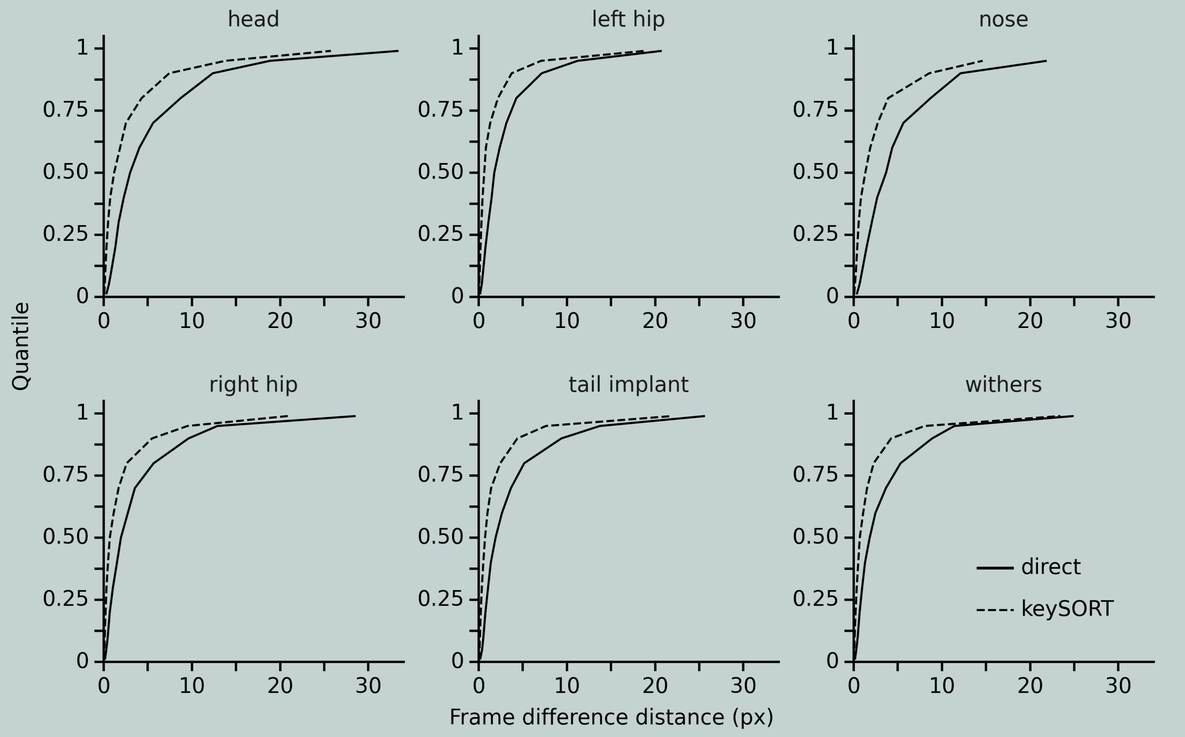
Pose estimation



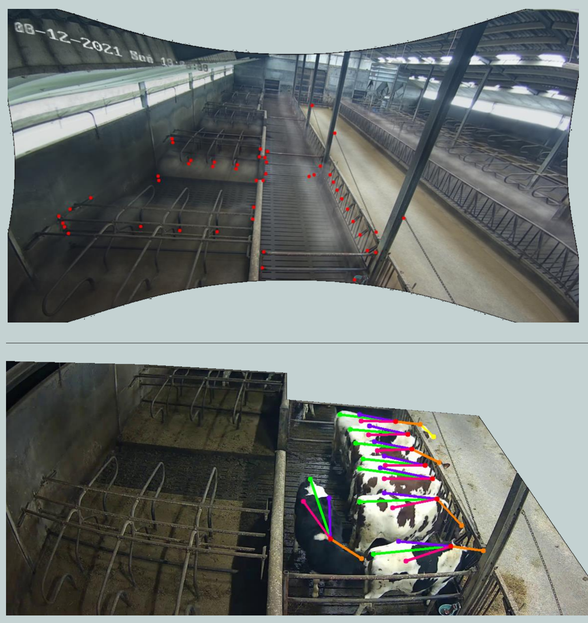
Primary behaviour classification

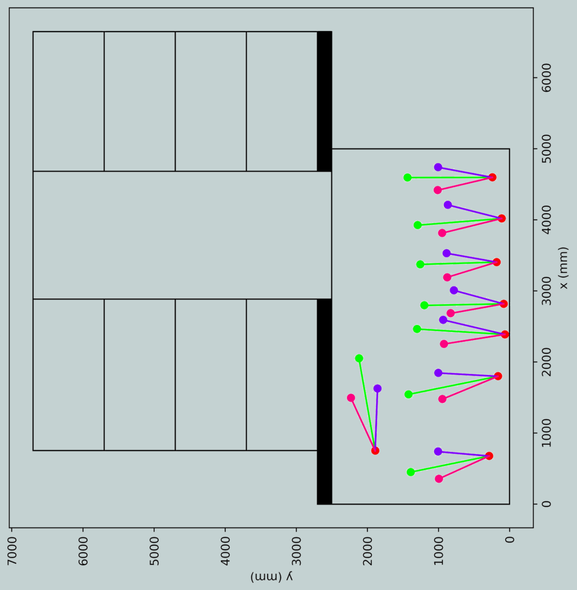
		Predicted behaviour		
		Standing	Lying left	Lying right
True beh.	Standing	0.99	0.004	0.005
	Lying left	0	0.94	0.007
	Lying right	0.007	0.03	0.96

Tracking



Spatial pose projection





Conclusions & Application and future research

Conclusions

- Able to detect up to 80% of the ground truth keypoints with high accuracy.
- Method can cope with complex scenes of multiple animals close to each other, without computational overload.
- Kalman filter based tracking handles both stable and dynamic system behaviour and results in consistent keypoint detection.

Livestock Technology

Application and future research

- Identification and re-identification to link keypoint coordinates and tracking to animal id. The tracking and instance segmentation can support the (re-)identification and limit the computational efforts.
- Integrated pipeline will facilitate automated behaviour monitoring of animals, study animal interactions and support the detection of oestrus, lameness and influence of environment on behaviour.