KI DELTA LEARNING
Scalable AI for Automated Driving

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Auxiliary Task-Guided CycleGAN for Black-Box Model Domain Adaptation

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Neural network training needs a lot of data

- Task specific annotations are required for supervised learning
- Annotating data is a very time-consuming and therefore expensive task
- Very limited or even no data for dangerous and rare scenarios (corner cases)

https://cocodataset.org/#keypoints-2020
https://cocodataset.org/#panoptic-2020

Simulation

- These issues can be tackled with simulation
  - Fully observable environment
  - Ground truth available for free
  - Source of (almost) unlimited data
  - Corner cases can be explicitly addressed
- Sim vs real: Domain shift
- Domain adaptation to compensate the domain shift

Image source: J. Hoffman et al., "CyCADA: Cycle-Consistent Adversarial Domain Adaptation," in Proceedings of the 35th International Conference on Machine Learning, 2018.

Our contribution

- Usually, existing domain adaptation (DA) methods
  - are targeted at specific tasks
  - require access to source model's parameters

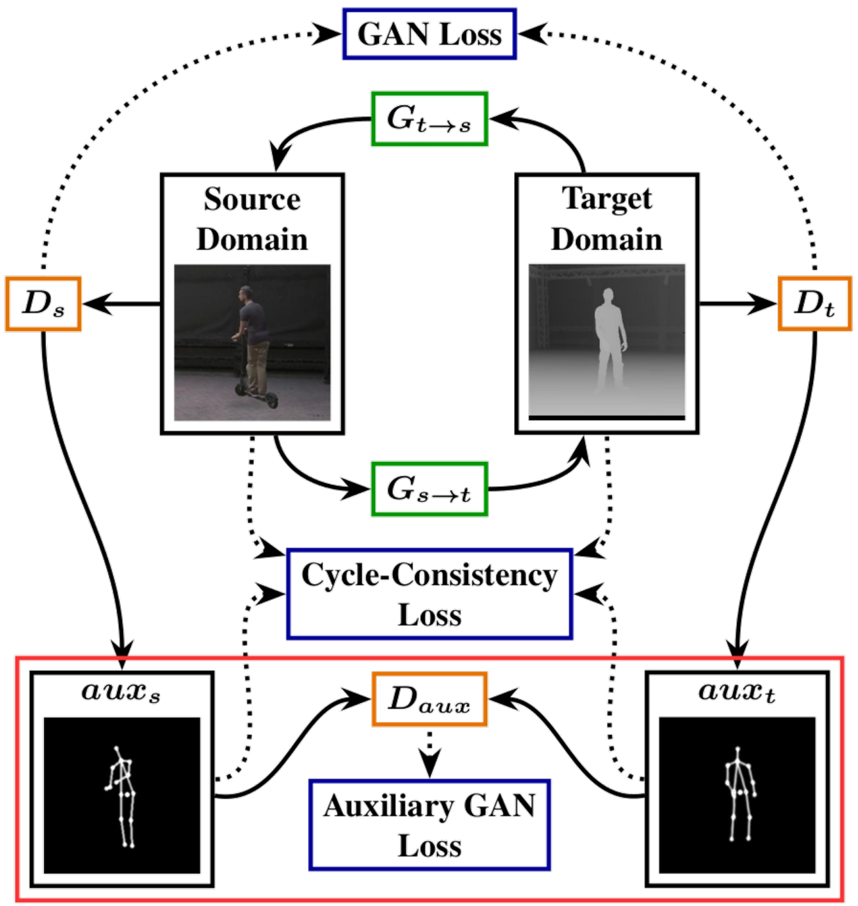
    → Major drawback when only a black-box model is available

- We perform unsupervised domain adaptation (UDA) for black-box models
  - Regression, i.e., human pose estimation, instead of classification as done in [1, 2]
  - Sim-to-real and cross-sensor transfer
  - Comparison with CycleGAN [3] and RegDA [4] under varying domain shifts

[1] H. Zhang et al., "Unsupervised domain adaptation of black-box source models," in 32nd British Machine Vision Conference (BMVC), 2021.
[2] J. Liang et al., "DINE: Domain adaptation from single and multiple black-box predictors," in 2022 IEEE/CVF Conference on Computer Vison and Pattern Recognition (CVPR), 2022.
[3] J.-Y. Zhu et al., "Unpaired image-to-image translation using cycle-consistent adversarial networks," in 2017 IEEE International Conference on Computer Vision (ICCV), 2017.
[4] J. Jiang et al., "Regressive domain adaptation for unsupervised keypoint detection," in 2021 IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR), 2021.

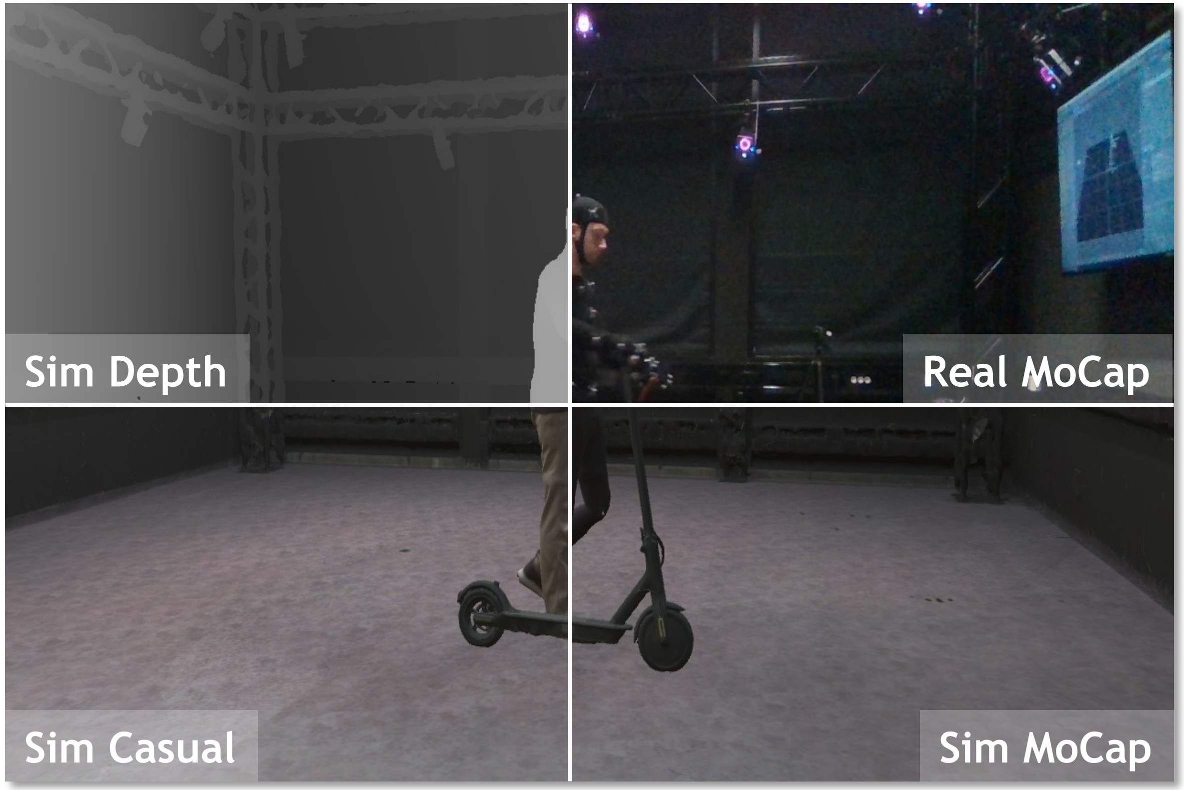
Our Method [1]

- Based on CycleGAN → unpaired data
- Auxiliary task to support transfer across domains
- No target domain labels → unsupervised DA
- Auxiliary task is learned by the discriminators
- D_{aux} to support transfer of auxiliary task from source to target domain



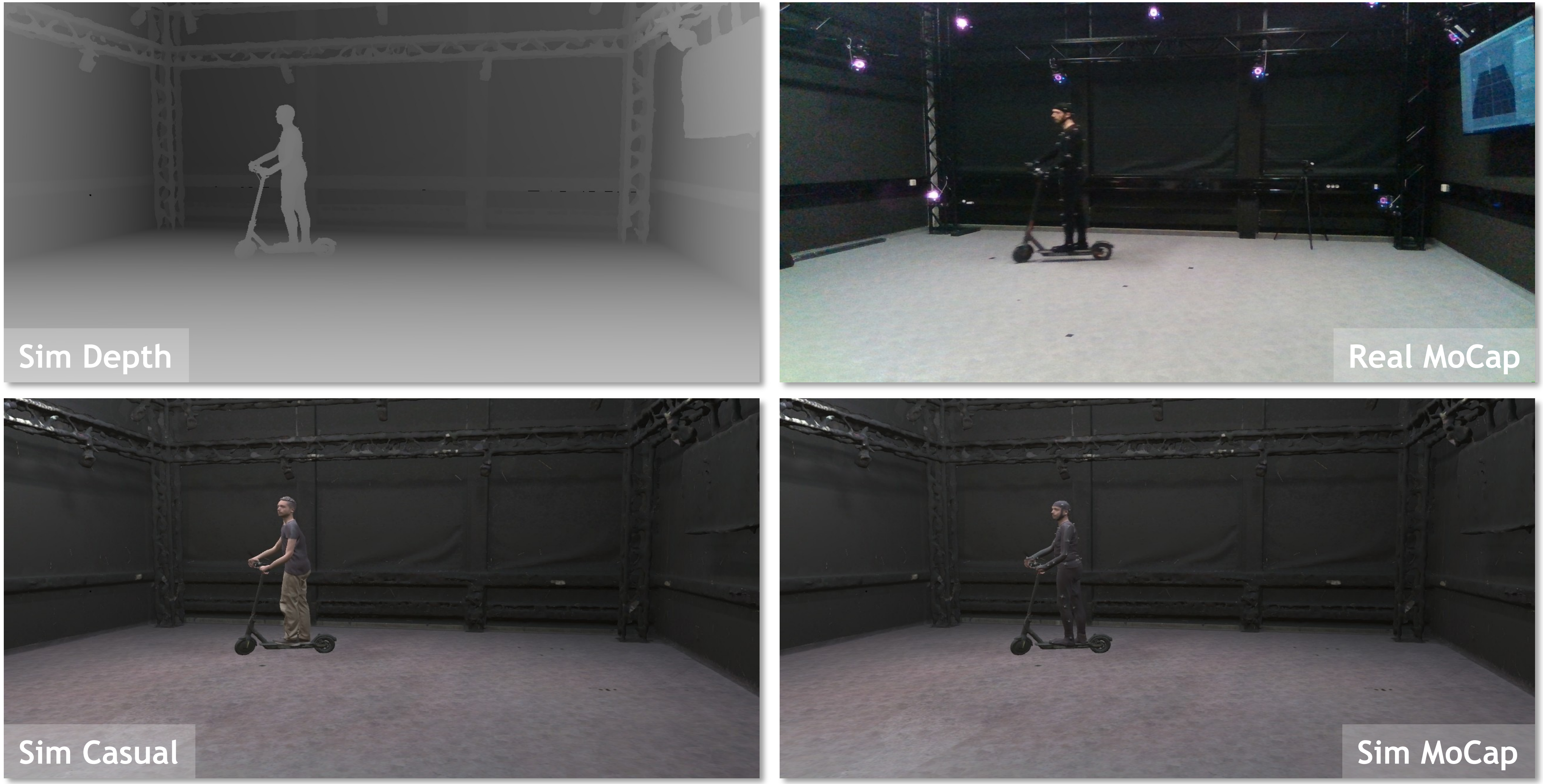
[1] M. Essich, M. Rehmann, and C. Curio, "Auxiliary Task-Guided CycleGAN for Black-Box Model Domain Adaptation," in Proceedings of the IEEE/CVF Winter Conference on Applications of Computer Vision (WACV), 2023.

Synchronized and paired sim-to-real and cross-sensor dataset



- Targeted at sim-to-real and cross-sensor DA
- Synchronized and paired data was recorded with our motion capture system
- Pose distributions are kept the same across domains
- Paired data is only used for validation

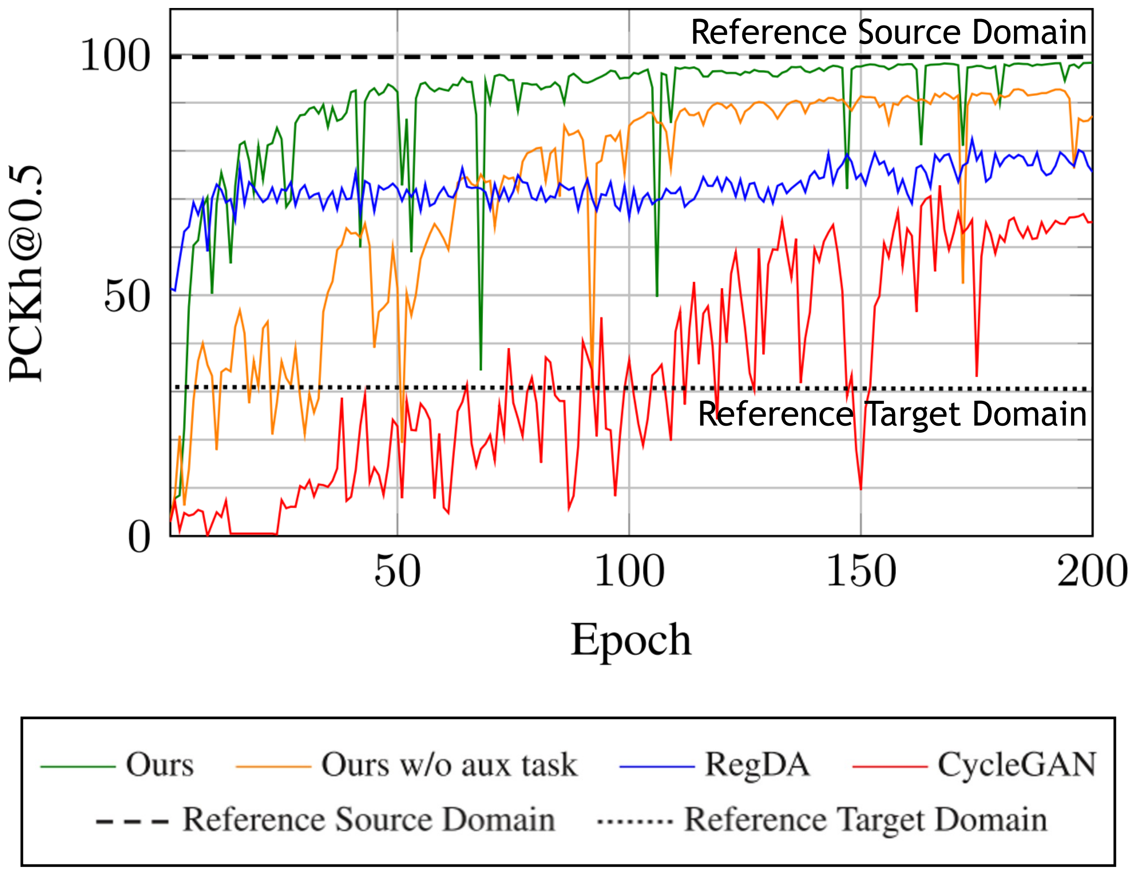
Synchronized Real and Simulated Data



Experiment Setting 1

Small variation in avatar appearance

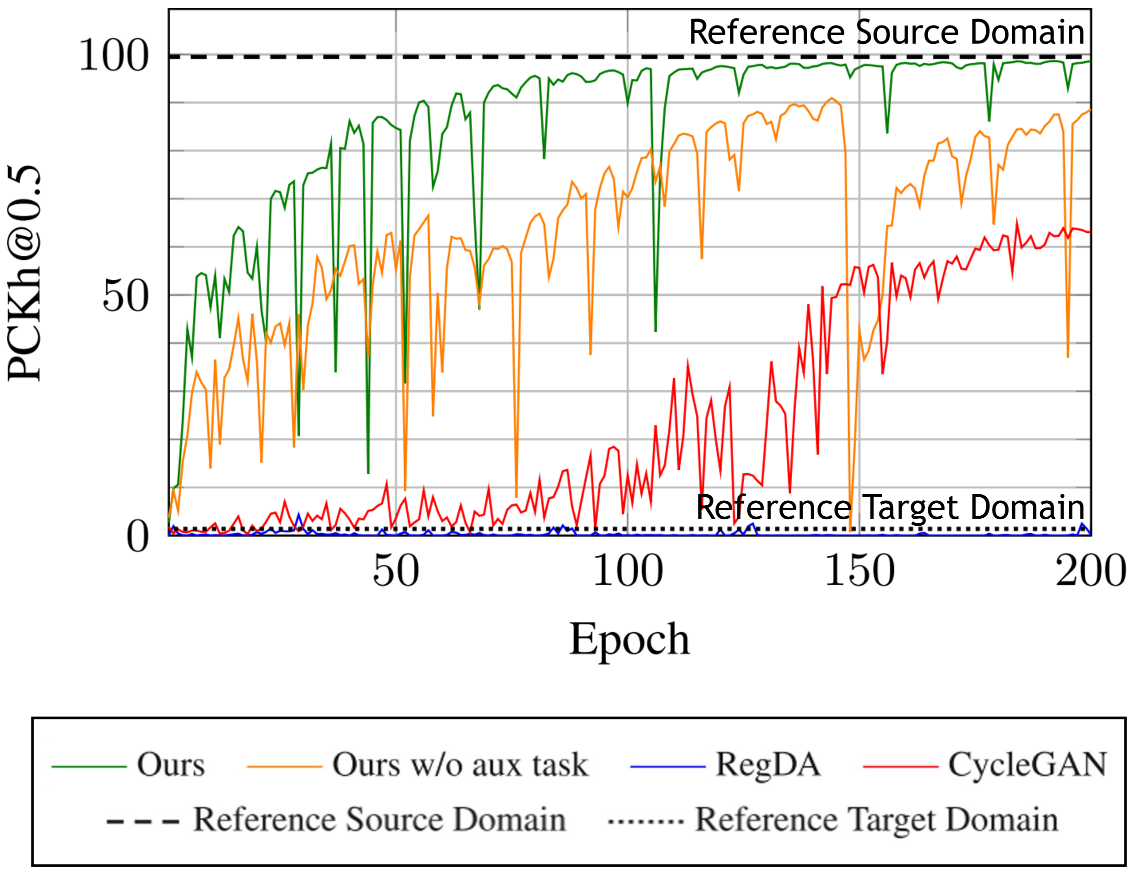
- A cyclical learning rate increases DA performance with CycleGAN (orange)
- Our (green) auxiliary task
  - further increases DA performance
  - leads to a more stable training process



Experiment Setting 2

Different sensors

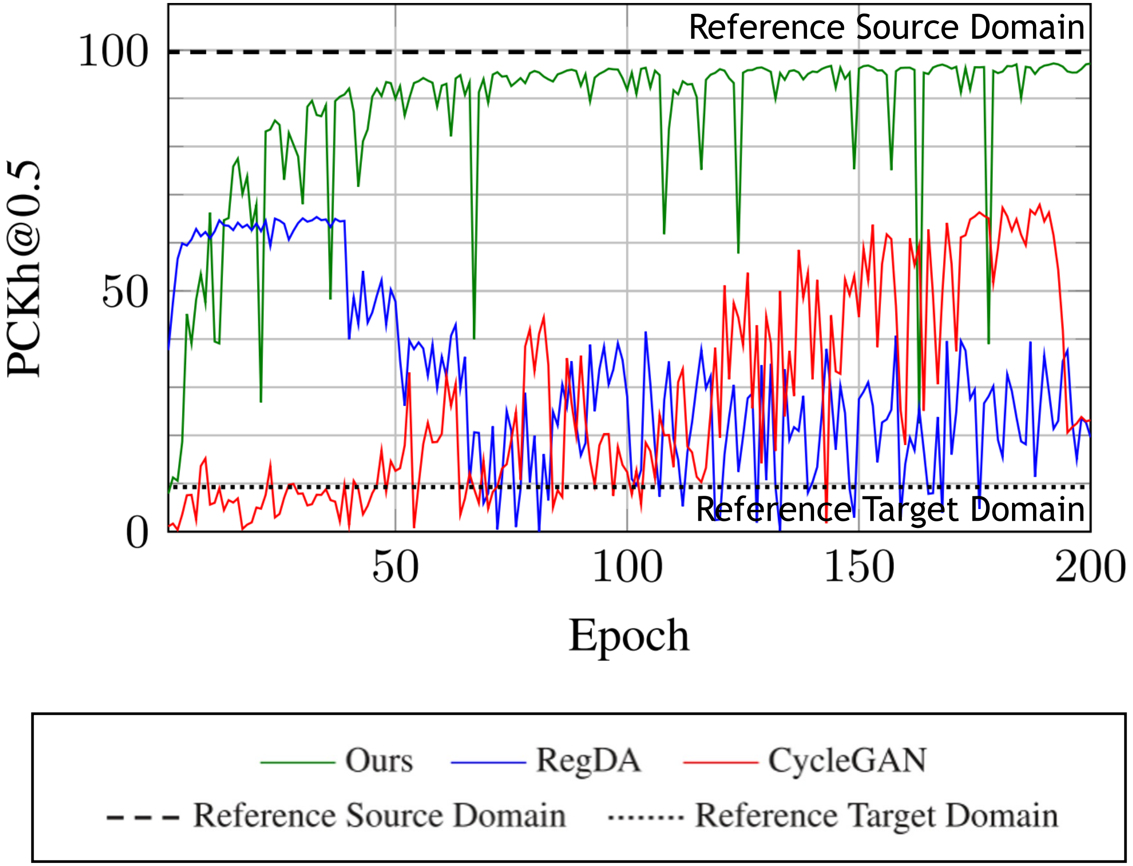
- RegDA (blue) requires the pose estimation's predictions on target domain
- RegDA (blue) struggles with the large sensor domain shift



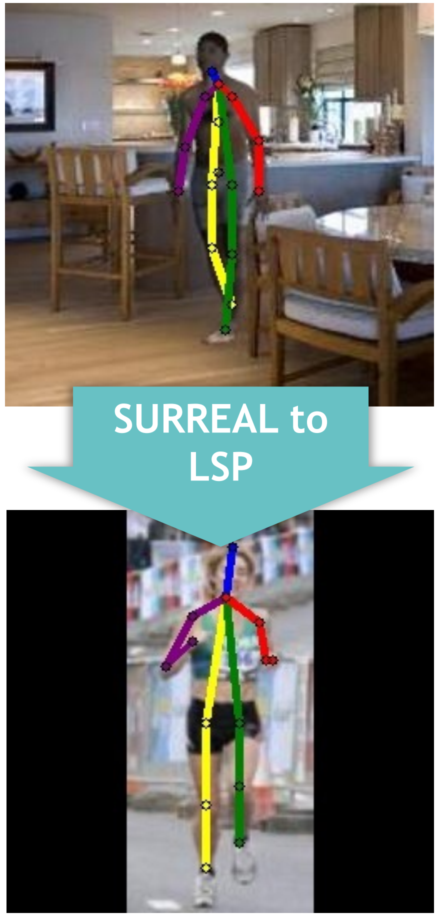
Experiment Setting 3
Sim-to-real

- RegDA's performance (blue) depends on the pose estimation's predictions on target domain

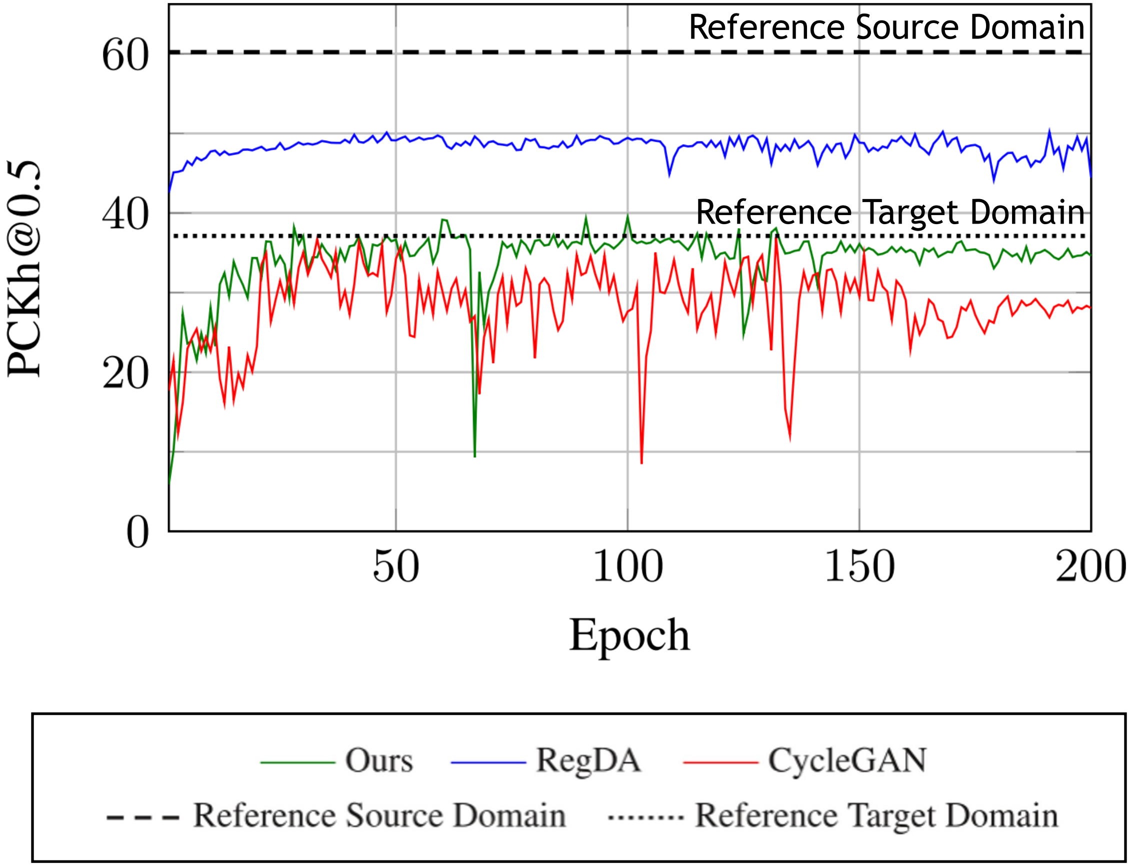
- Sim-to-real adaptation successfully handled with our approach (green)



Experiment Setting 4
Different datasets



- Source model already achieves a high performance on target domain
  → RegDA (blue) performs well
- One/many-to-many mappings occur in this setting
  → Limitation of our approach (green) and CycleGAN (red)



Conclusion

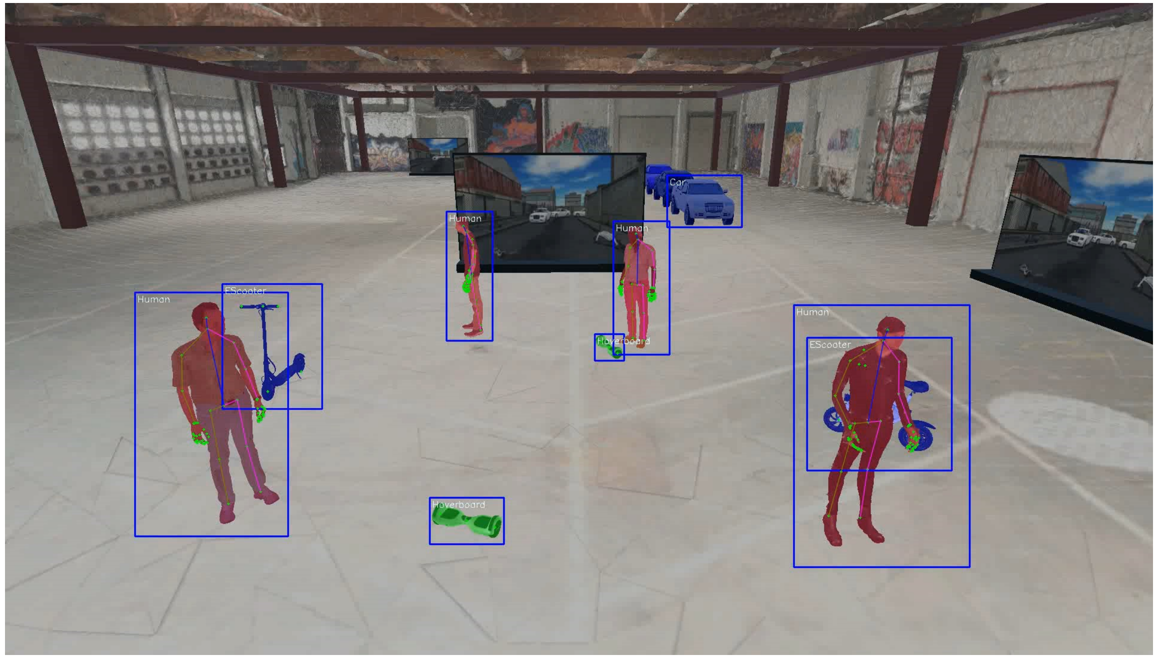
- We compared our approach with RegDA and CycleGAN
- Four settings with varying domain shift
- We emphasize the necessity for explicitly addressing sensor domain shift

Outlook

- One/many-to-many mappings are a current limitation of our approach
  → Addressable by, e.g., disentangling style and content [1]
- Follow-up work: Sim-to-real research in large-scale motion capture space

[1] X. Huang, M.-Y. Liu, S. Belongie, and J. Kautz, “Multimodal Unsupervised Image-to-Image Translation,” in Computer Vision – ECCV 2018, Cham, 2018, pp. 179–196.

Human-centered Interactive
Artificial Intelligence Data-Incubation Center (AIDA)



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