Environmental adaptation and self-attention in the context of unsupervised domain adaptation

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KI DELTA LEARNING
Scalable AI for Automated Driving

Environment / Semi- and Unsupervised Learning

Use-Case in Delta Learning

The overall goal of our work is to investigate Unsupervised Domain Adaptation (UDA) for both cross-domain and cross-sensor domain adaptation scenarios.

We address the following use cases for human pose estimation and object detection tasks.

- **Time**: adapt the network for novel mobility classes in the dataset such as E-Scooters and hoverboard
- **Environment**: adapt the network to different lighting and weather conditions
- **Network**: adapt the network using partially supervised and unsupervised signals to increase the performance of task models

Environmental Adaptation

To address time and environment use cases, we developed a driving simulation to generate data containing novel mobility classes such as E-scooters and hoverboards, as well as a variety of weather conditions (sunny, foggy, rainy, snowy), for the environmental adaptation task. A FasterRCNN Object detection model was trained using data from the sunny condition and adapted to other weather conditions using the UDA model.

Figure 1: Simulated environmental conditions(©Reutlingen University)

For unsupervised domain adaptation, a cycleGAN-based model developed was used [1].

Weather adaptation setting	Source accuracy (mAP)	Target with UDA accuracy (mAP)	Target accuracy no UDA (mAP)
Sunny to foggy	69.38	**55.24**	22.48
Sunny to rainy	73.95	**60.19**	58.71
Sunny to snowy	77.26	**61.78**	61.26

Table 1: Comparison of object detection model performance for different weather adaptation settings

Based on the results in Table 1, it can be concluded that UDA is effective for adapting object detection models to different weather conditions, but the effectiveness may vary depending on the domain gap and occlusion.

Transferability evaluation of attention-based pose estimation models

For the network adaptation, we evaluated pose estimation models with attention layers using the UDA network. The goal of these evaluations was to determine whether improving the performance of a human pose estimation model on the source domain using attention methods can be transferred to the model's performance on the target (real) domain through the use of the UDA network. We identified and integrated External Attention Network (EANET), and Convolutional Block Attention Module (CBAM) layers to our pose estimation model and evaluated the performance on simulated to real setting.

	Reutlingen University Dataset Sim to Real			SURREAL to LSP		
Measured metric/Attention	No Attention	EANET	CBAM	No Attention	EANET	CBAM
Source Accuracy PCKh@0.5	99.34	99.40	99.24	49.70	48.31	56.35
Source Accuracy PCKh@0.1	61.15	60.10	57.81	0.10	0.08	0.13
UDA Target Accuracy PCKh@0.5	**94.25**	**95.22**	**95.20**	**31.85**	**34.75**	**39.90**
UDA Target Accuracy PCKh@0.1	**27.08**	**28.37**	**27.75**	**3.29**	**3.90**	**4.83**
No DA Target Accuracy PCKh@0.5	11.12	15.04	9.89	31.83	31.47	36.11
No DA Target Accuracy PCKh@0.1	1.19	0.83	0.71	3.98	3.89	5.0

Table 2: Validation accuracy comparison of pose estimation models with attention when adapting from synthetic to real image

Using attention improves model performance by focusing on the relevant parts of the image as shown in figure 2. By combining UDA with attention based models, the improved source performance can be transferred to the target domain as shown by the results on table 2. However, the relative effectiveness varies depending on the dataset used.

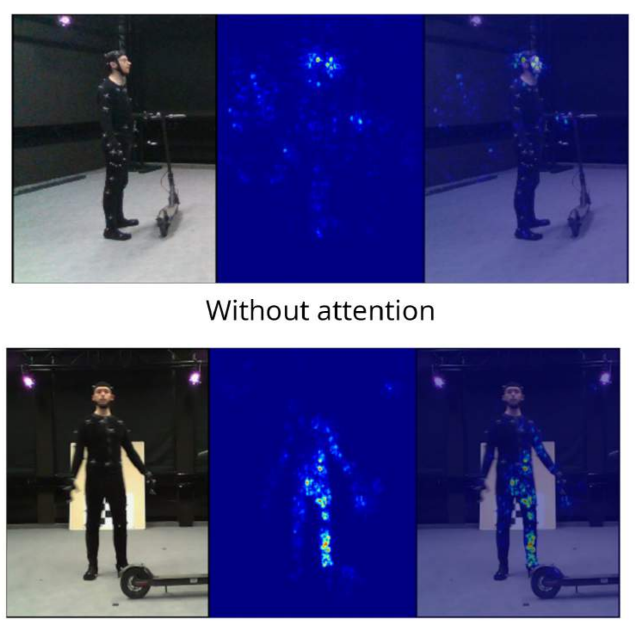

Figure 2: Network saliency comparison of pose estimation model with attention (© Reutlingen University)

References:

1. M. Essich, M. Rehmann, and C. Curio, “Auxiliary task-guided CycleGAN for black-box model domain adaptation,” in Proc. of the IEEE/CVF winter conference on applications of computer vision (WACV), 2023

Partners

External partners

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