KI DELTA LEARNING
Scalable AI for Automated Driving

Domain Shift Quantification using Activations

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Introduction and Motivation

- Domain adaptation is very popular many proposed approaches
- BUT: no little knowledge about what happens in the networks under shift
- AND: for evaluation often only mIoU is utilized which makes it difficult to assess complex methods

Approach

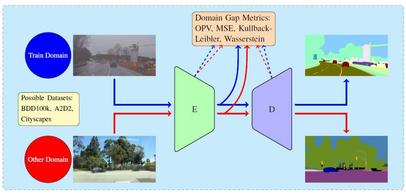


Figure 1: Domain Shift Quantification using Activations

Proposal: Quantify the domain shift between two domains in the activation space of a deep neural network using a distance metric.
Possible Applications:

- Active Learning
- Out-of-Distribution (OoD) Detection
- Performance Assessment (like mIoU)
- Domain Adaptation

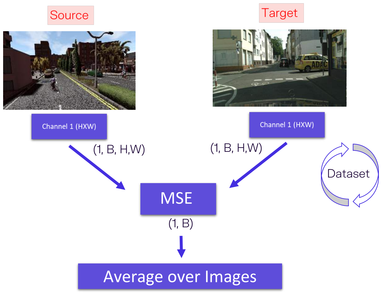


Figure 2: Element-wise Domain Shift Quantification

Activation Distribution

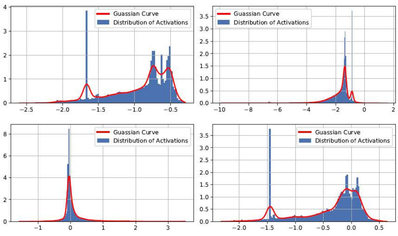


Figure 3: Activation Histogram for layer1.0.conv3 (© CARIAD SE)

Early Layers: many multi-modal Gaussians
Deep Layers: more uni-modal Gaussians

Results I:

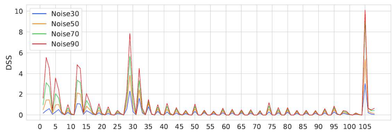
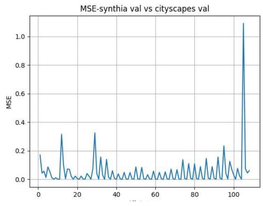


Figure 4: Domain Shift Score for noise augmentation (© CARIAD SE)

Measures	Noise30	Noise50	Noise70	Noise90
$M_{AVG-MSE}$	20.51	37.34	59.39	81.49
$M_{AVG-Wass}$	8.77	14.50	21.02	27.02
M_{FD}	4671.30	8199.21	12326.91	17015.25
M_{IMSE}	89.89	119.48	148.86	176.20
$M_{SVD-MSE}$	1.17E-07	1.26E-07	1.43E-07	1.53E-07
$M_{SVD-Wass}$	1.02E-04	1.24E-04	1.25E-04	1.26E-04

- Utilizing augmentations to generate controlled domain shifts to validate the domain shift measurement
- Layer-dependent domain shift is observed
- metrics perform as expected with increasing domain shift; dimensionality reduction using SVD does not perform well



- Layer-wise changing domain shift
- Zick-zack pattern
- Peaks in the early layers

Figure 5: Synthia->Cityscapes (© CARIAD SE)

Results II: Evaluation of adaptation methods

Approaches	mIOU	$M_{AVG-MSE}$	$M_{AVG-Wass}$	M_{FD}	M_{IMSE}
DPL_{DUAL}	54.2	0.03	0.03	3.33	0.62
DPL	53.9	0.04	0.04	5.12	0.68
$PCEDA$	53.6	0.09	0.07	14.06	1.18
FDA	52.5	0.04	0.05	7.03	1.42
BDL	51.4	0.06	0.05	8.66	0.88
LSR	48.1	0.02	0.03	3.07	0.48
$AdaptSegNet$	45.9	0.04	0.04	7.32	0.84

Figure 6: Domain Shift Score for UDA approaches (© CARIAD SE)

- High mIoU does not correspond to low domain shift score as expected
- Consistently missing correlation across all evaluted metrics; no clear pattern observable → more approaches for better insight into complex UDA approaches

Conclusions

- Complex, layer-dependent network bevahiour
- Domain shift results contradict the mIoU measurements
- Overall: foundational work for insights into network behaviour under domain shift → future work to explain

Environment

Partners

External partners

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