KI DATA TOOLING
The Data Kit for Automotive AI

Relevance Estimation of Corner Cases for Semantic Segmentation

Jasmin Breitenstein, Tim Fingscheidt | TU BS
Maria Lyssenko, Maarten Bieshaar | Bosch
Daniel Bogdoll, J. Marius Zöllner | FZI
Florian Heidecker, Bernhard Sick | Uni Kassel

ML Function Development

Motivation

We know definitions for knowledge-driven corner cases [1,2,3].
Problem:

- We don't know which type of corner case affects a perception method in which way
- Typical metrics are task-agnostic

Solution

- Corner-case-weighted mIoU based on pixel-wise weightings to measure the effect of corner cases on the performance

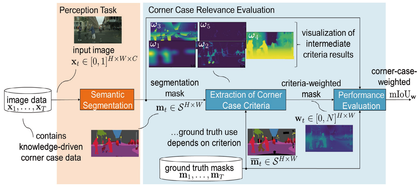

Figure 1: Pipeline for Corner Case Relevance Estimation (©TUBS)

Corner Case Criteria

The investigated corner case are based on visual and safety arguments: crowdedness, confidence, spatial diversity, time-to-collision (TTC), misclassification. The misclassification weights are derived from insurance costs related to different accident types.

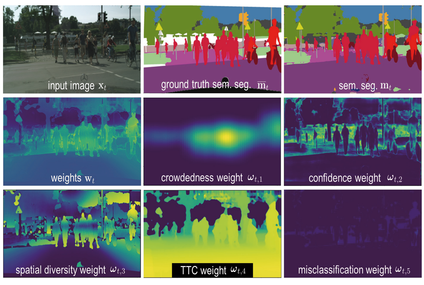

Figure 2: Input image with corresponding aggregated weights and the separate corner case criteria weights (©TUBS)

Corner-case-weighted mIoU

Typically, intersection over union (IoU) is used to measure the quality of semantic segmentation per semantic class. We modify IoU as we are interested in the segmentation quality for corner cases. We propose a weighted IoU to better account for the segmentation quality of corner cases:

$$\mathrm{IoU}_{\mathbf{w}}(s) = \frac{\sum_{i \in \mathcal{I}} \mathrm{TP}(i,s)}{\sum_{i \in \mathcal{I}} \mathrm{TP}(i,s) + (\mathrm{FP}(i,s) + \mathrm{FN}(i,s)) \cdot w(i)}$$

We use aggregated pixel-wise weights:

$$w(i) = \frac{1}{N} \sum_{n \in \mathcal{N}} \lambda_n \omega_n(i)$$

The pixel-wise weights form the criteria-weighted mask $\mathbf{w}_t$ when regarded for all pixels.

Corner Case Results

Semantic segmentation method: OCRNet

	$\mathcal{D}_{\mathrm{CS}}^{\mathrm{val}}$	$\mathcal{D}_{\mathrm{CS}}^{\mathrm{CC}}$
mIoU	80.23%	74.12%
$\mathrm{mIoU}_{\mathbf{w}}$	80.35%	72.33%

Table 1: Results on Cityscapes $\mathcal{D}_{\mathrm{CS}}^{\mathrm{val}}$ and corner case dataset $\mathcal{D}_{\mathrm{CS}}^{\mathrm{CC}}$: Similar corner-case-weighted mIoU values on Cityscapes but decrease on the corner case dataset

Conclusions:

The novel relevance-adapted mIoU is adapted to the task of corner case identification. It establishes a link between knowledge-driven corner case types and perception methods. For the OCRNet, collective anomalies are the most relevant corner case type. We can use $\mathrm{mIoU}_{\mathbf{w}}$ to estimate the relevance of corner cases for a semantic segmentation method.

References:

[1]: J.-A. Termöhlen, A. Bär, D. Lipinski, T. Fingscheidt "Towards Corner Case Detection for Autonomous Driving", Proc. of IV, 2019
[2]: J. Breitenstein, J.-A. Termöhlen, D. Lipinski, T. Fingscheidt, "Systematization of Corner Cases for Visual Perception in Automated Driving", Proc. of IV 2020
[3]: F. Heidecker, J. Breitenstein, K. Rösch, J. Löhdefink, M. Bieshaar, C. Stiller, T. Fingscheidt, B. Sick: "An Application-Driven Conceptualization of Corner Cases for Perception in Highly Automated Driving", Proc. of IV 2021
[4]: J. Breitenstein, F. Heidecker, M. Lyssenko, D. Bogdoll, M. Bieshaar, J. M. Zöllner, B. Sick, T. Fingscheidt: „What Does Really Count? Estimating Relevance of Corner Cases for Semantic Segmentation in Automated Driving", Proc. of ICCV-Workshops 2023

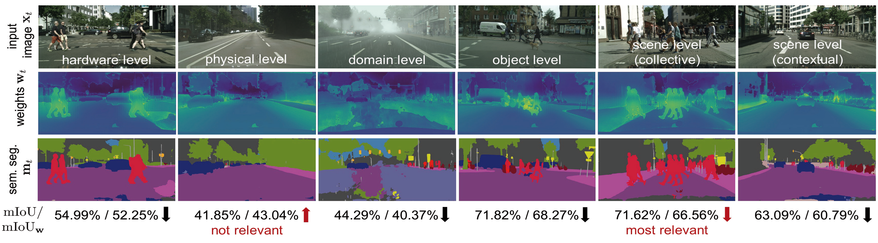

Figure 3: mIoU and $\mathrm{mIoU}_{\mathbf{w}}$ for example images of corner case types with the corresponding weights. Corner cases have a high relevance when the negative impact on the $\mathrm{mIoU}_{\mathbf{w}}$ is high compared to mIoU. Collective anomalies have the highest relevance for OCRNet, physical-level corner cases have no relevance for OCRNet.

Corner cases on...	Hardware	Physical	Domain	Object	Collective	Contextual
mIoU	79.48%	78.34%	54.06%	80.12%	78.01%	76.21%
$\mathrm{mIoU}_{\mathbf{w}}$	78.98%	79.14%	48.98%	80.46%	75.71%	74.92%

Table 2: Results in mIoU and mIoU$_w$ for each corner case level of the corner case dataset.

Partners

External partners

For more information contact:
j.breitenstein@tu-bs.de

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