KI ABSICHERUNG
Safe AI for Automated Driving

Gradient-based Uncertainty Estimation for Deep Object Detection

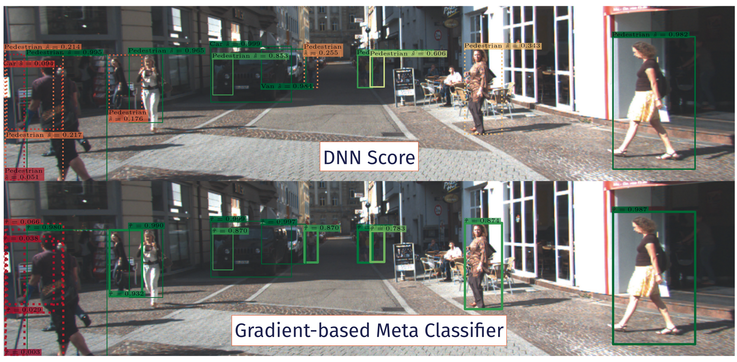
Tobias Riedlinger, Matthias Rottmann, Hanno Gottschalk

DNN specific Safety Concern: SC-1.1 Unreliable Confidence Information

Gradient-based Uncertainty Measures

Given an input to a DNN, self-learning gradients reflect the expected learning stress exerted on the model parameters. It is related to classification uncertainty metrics like softmax entropy and can be used to estimate prediction uncertainty. A generalization of this concept for object detectors has been developed in AP3.4 and further investigated in EWS1.

Safety Hypothesis:
This method addresses the safety concern of Unreliable Confidence Information. It allows for statistically improved and reliable (calibrated) confidence estimation without requiring architectural changes or re-training of the object detector.



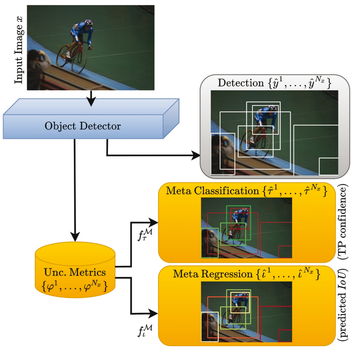
Instance-wise Learning Gradient

Estimating uncertainty for each predicted instance requires the adaptation of the learning gradient. We derive instance-wise self-learning gradients by restricting to proposed candidate boxes for an output box and regarding:

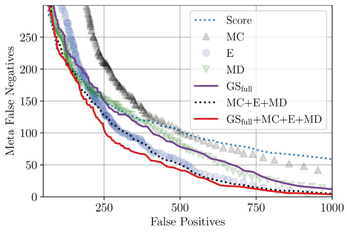
$$g^{\text{cand}}(\boldsymbol{x}, \boldsymbol{w}, \hat{y}^j) := \nabla_{\boldsymbol{w}} \mathcal{L}\left(\text{cand}[\hat{y}^j](\boldsymbol{x}, \boldsymbol{w}), \overline{y}^j\right)$$

This amounts to the learning stress on prior boxes responsible for predicting the regarded instance.

Meta Classification and Meta Regression

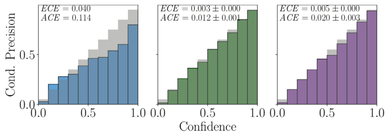


Decisions based on Meta Classification



Significant improvement in terms of False Positive error count for fixed False Negatives

Confidence Reliability



Calibrated confidences from meta classification (center and right) compared with the native DNN score (left).

References:

T. Riedlinger, et al. „Gradient-Based Quantification of Epistemic Uncertainty for Deep Object Detectors.“ arXiv preprint arXiv:2107.04517 (2021)

BERGISCHE UNIVERSITÄT WUPPERTAL

For more information contact:
riedlinger@math.uni-wuppertal.de

KI Absicherung is a project of the KI Familie. It was initiated and developed by the VDA Leitinitiative autonomous and connected driving and is funded by the Federal Ministry for Economic Affairs and Climate Action.

KI FAMILIE

Supported by:
Federal Ministry for Economic Affairs and Climate Action
on the basis of a decision by the German Bundestag

https://www.ki-absicherung-projekt.de @KI_Familie KI Familie

Image Sources:
Traffic Scene: (KITTI): KIT & Toyota Technological Institute Chicago (TTIC)
Bicycle Scene: Pascal VOC dataset): Pascal VOC / Flickr
Others: Bergische Universität Wuppertal