KI DELTA LEARNING
Scalable AI for Automated Driving

Robustness Against Noisy Labels Through Uncertainty Estimation for LiDAR-based Semantic Segmentation

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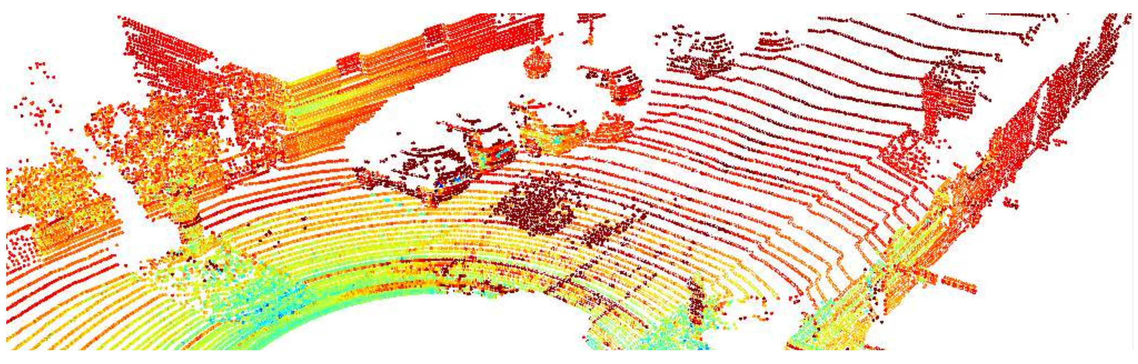

Abstract

The predictive performance of any deep learning-based environment perception model for autonomous driving is partially governed by the quality of the underlying dataset. Systematic problems with the dataset and the respective labels can have a huge impact on the internal representation of the feature landscape the model infers from the ingested data. We discovered that state-of-the-art uncertainty estimation methods provide a basis for identifying and dealing with problematic label definitions. We furthermore developed a lean method on robustness against noisy labels using an hierarchical abstraction loss. We suggest that it can be applied to different domain shifts present in the data.

Uncertainty Estimation in Deep Learning

- Softmax output tends to be overly confident [1] → Bayesian methods [2] to quantify uncertainty
  - Assign distributions to the network's weights instead of point estimates
  - → Sampling-based approaches simulate a non-deterministic behavior
- Data uncertainty with logit sampling [3]
- Model uncertainty with Monte Carlo Dropout [4]

Detection of Label Problems

- Filter incorrect classifications with low uncertainty to get hints about not well learned class representations
- Example *(Figure 1):* two bicyclists, which are partially predicted as "person", since the CNN learns local features the uncertainty is high on the borders but low for the person on the bicycle → Issues with the label hierarchy

Figure 1: Scene with two bicyclists (left: original label, mid: prediction, right: uncertainty), Setup: SalsaNext [6] with MCD on the SemanticKITTI dataset [5]

Label Hierarchy for Robustness against Label Noise

- Increase robustness against confusion of labels by introducing a label hierarchy
- → Allows the model to learn abstractions and implicitly express uncertainties about predictions

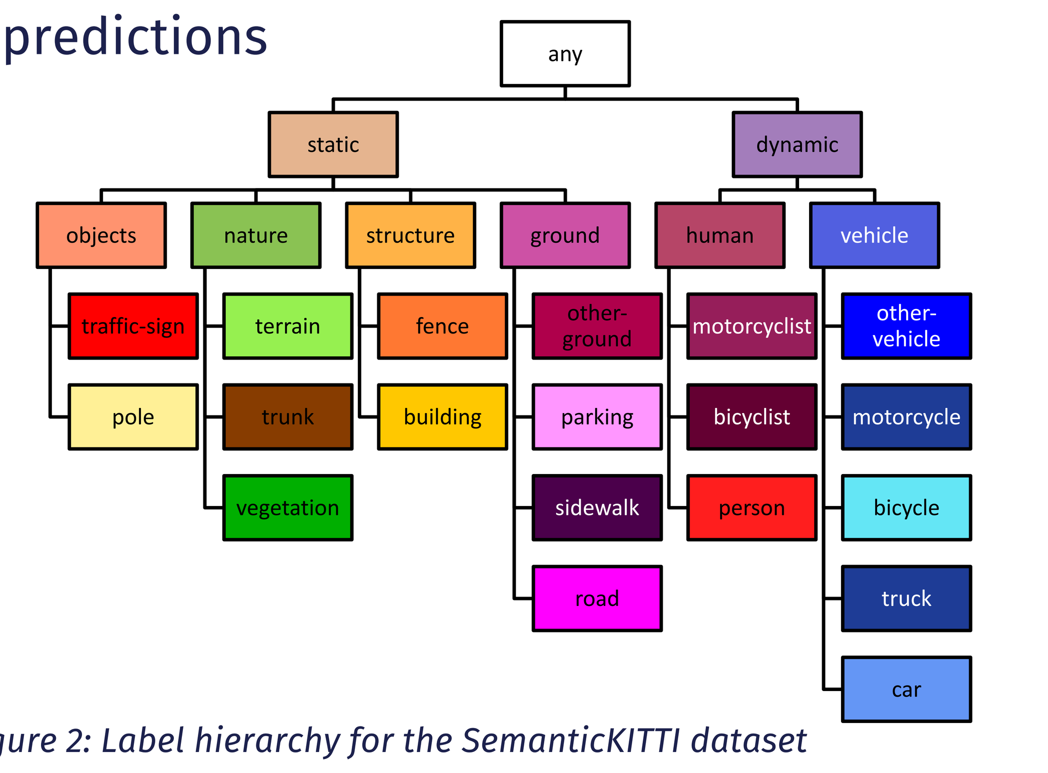

Figure 2: Label hierarchy for the SemanticKITTI dataset (original labels are leaf nodes, meta classes are added accordingly)

Approach:

- Add meta-classes to the model predictions (*Figure 2*)
- Alter ground truth labels: parent classes are partially correct (multi-class)

$$\Delta_{y,k} = \begin{cases} \frac{level(k)}{height}, & if\ k \in ancestor(y) \\ 0, & otherwise \end{cases}$$

Figure 3: Scene with two bicyclists (left: hierarchical prediction, right: uncertainty), Setup: SalsaNext [6] without MCD but with hierarchy on the SemanticKITTI dataset [5]

Results (*Figure 3*):

- Model predicts meta-class instead of leaf node for bicyclists, surrounding is still correctly predicted with leaf nodes
- Whole instance is predicted coherently
- Uncertainty lowers with higher hierarchy levels

Validation and Application to Other Scenarios

- Approach can be applied to other cases with noisy labels (e.g. adverse weather)
- Qualitative analysis required for further method refinement (boost performance and calibration through optimization of the loss function and the hierarchy)

Environment / Training Strategies

References
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KI Delta Learning 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.

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

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