Lehrstuhl für Fahrzeugtechnik
Fakultät für Maschinenwesen
Technische Universität München

Master's Thesis

Making Autonomous Driving More Reliable: Localization Uncertainty Estimation in 3D Object Detectors – Implement a new AI Machine Learning MIMO Object Detector

Successfully mastering the task of autonomous driving relies on very accurate object detection algorithms. However, it is very unlikely that the quality of such algorithms can ever reach a perfect score. Therefore, we believe that the driving task will be better solved when tasks dependent on the perception's output (like trajectory planning) have access to detection uncertainties – either represented by class confidences or localization uncertainties. While we as humans use an intuitive understanding to handle uncertainties (imagine the feeling of driving in dense fog), AVs need to quantify their uncertainty mathematically.

State of the art that neural networks for LiDAR object detection only output the likeliest bounding box for each object as they learned it from training data. There are several strategies to enable the networks to estimate their own uncertainty. However, most strategies are sampling based and require multiple inference runs thereby making the object detector to slow for real world use.

The Multiple Input Multiple Output (MIMO) strategy is based on the discovery that a large proportion of a neural network's weights (up to 80%) can be pruned without significant loss in detection quality. A MIMO network uses the architecture of a proven network and trains it not on a single input and output pair, but on a tuple of different samples. In practice this trains several independent (!) sub-networks within the original architecture. During inference, the subnetworks are fed an identical input. Since they are independent, their different outputs to the same input can be used to infer the networks uncertainty. Because the subnetworks exist within the original architecture, the computational effort remains similar to the original.

The objective of this thesis is to apply the MIMO strategy to a well-proven 3D object detector and evaluate the detector's performance regarding detection quality and uncertainty estimation.

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The work packages include:

1. Literature review on state-of-the-art 3D object detectors and uncertainty estimation
2. Implementation of the MIMO strategy for a state-of-the-art 3D object detector
3. Training of the object detector
4. Evaluation of detection quality and uncertainty estimation

If you feel curious now, you fulfill the most important requirement 😉 But already knowing your way with python and some experience with a machine learning framework (preferably pytorch) will help you during this thesis.

If you are interested in this thesis project, please introduce yourself by sending your CV and a transcript of records to cornelius.schroeder@tum.de.

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