Engineering Risk Analysis Group
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Master's Thesis – Environmental Engineering

Modeling the effect of precipitation on automotive LIDAR detection capability

Michael Dura, October 2017

Background

With increasing driving automation, the automotive environment perception provided by sensors such as lidars becomes more and more safety relevant. Therefore, it is crucial to assess their reliability (sensor performance) and limits (maximum sensor range). As the detection capability of a lidar sensor is sensitive to adverse weather phenomena like rain, fog or spray, it is the objective to gain information about the maximum range and the detection capabilities of a sensor with regard to these adverse conditions. To this end, a generic sensor model based on a probabilistic extension of the lidar equation, considering the effect of uncertain rainfall is established. Key parameters of the lidar equation, which previously have been implemented deterministically are with this extension represented stochastically.

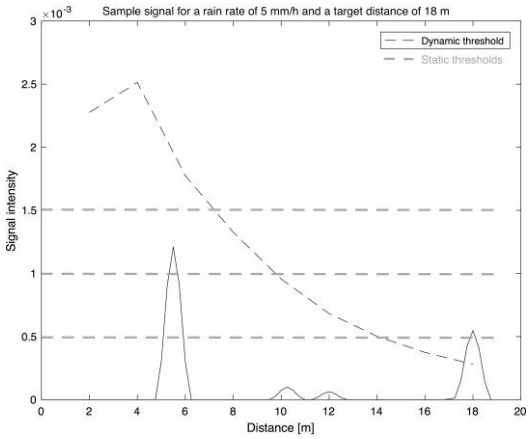

Figure 1: Received sample signal with static and dynamic detection thresholds for a target distance of 18 m and a rain rate for 5 mm/h;

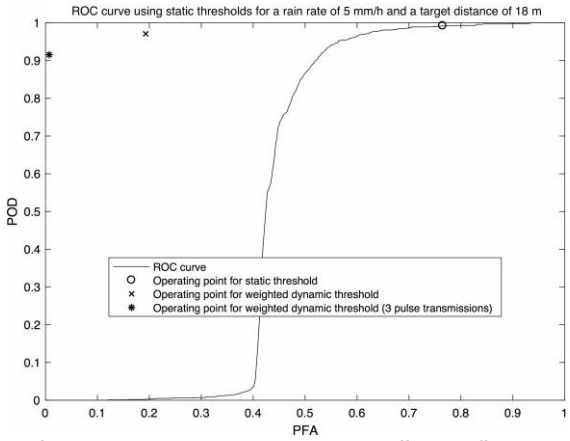

Figure 2: ROC curve corresponding to figure 1 (determined with static thresholds) and three "optimal" operating points applying static and dynamic detection thresholds.

Methodology

To solve the convolution integral of the probabilistically extended lidar equation, a spatial discretization is applied. The results are evaluated utilizing the signal detection theory, to describe a sensor's detection capability with a probability of detection (POD), a probability of false alarm (PFA) and receiver operating characteristics (ROC). These metrics are evaluated based on the proposed sensor model by means of a Monte Carlo simulation (MCS).

Conclusion

With the proposed sensor model, the limitations of lidar sensors caused by adverse weather conditions can be quantified in detail and implemented early in the development process. Therefore, extensive real world tests can be reduced and it helps to improve the performance of lidars by optimizing detection thresholds.

Supervised by M.Sc. Mario Berk; Prof. Dr. Daniel Straub