# Uncertainty Estimation for Semantic Segmentation via Bayesian Deep Learning

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## Abstract

In recent years, deep learning-based methods have demonstrated convincing results for semantic segmentation. However, such results are commonly not free of errors, a measure of the uncertainty associated to a prediction is needed. To address this need, investigations in the literature mainly focus on stochastic network-based methods, such as ensemble learning and Monte Carlo dropout, while often neglecting Bayesian approaches due to their higher complexity. But Bayesian deep learning in general and Bayesian neural networks in particular, allow to explicitly consider prior information on the observations as well as on the model parameters in form of particular types of probability distributions. Thus, Bayesian approaches have the potential to lead to uncertainty estimates of higher quality compared to non-Bayesian ones, it is necessary to consider how to estimate uncertainty based on it.

The approach to estimate epistemic uncertainty in the context of semantic segmentation is addressed in this thesis. For the purpose of epistemic uncertainty estimation, a Bayesian Neural Network is trained with variational inference. Semantic segmentation is performed using a modified U-Net architecture, which is meanwhile used as baseline for the approach. Then the baseline would be transformed into a Bayesian one that could estimate the epistemic uncertainty.

To evaluate the performance of the proposed method and to investigate strengths and limitations, experiments are carried out using Cityscapes dataset, which is popular in the field of computer vision. The results of these experiments demonstrate that the usage of a Bayesian Neural Network instead of a deterministic variant not only allows for epistemic uncertainty estimation, but also supports the semantic segmentation itself, reducing the errors contained in the prediction maps.

**Keywords** Semantic Segmentation, Uncertainty Estimation, Deep Learning, Bayesian Neural Network