Scatterometry Applications: Addressing Model Inaccuracies

EUV metrology

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Scatterometry provides a fast and indirect method for nano-optical shape reconstruction from measured light intensities. The shape parameters are determined by solving an inverse problem, that is based on the forward model. Bayesian inversion is a powerful tool for solving inverse problems but limited by the complexity of the forward model. As nanotechnology advances and structures become smaller, a higher resolution of the forward model becomes necessary. For such computationally expensive problems, the forward model usually has to be simplified. The inaccuracy of the forward model, the so-called model error, is often ignored in the Bayesian setting and thus causes an additional error in the posterior distribution approximation. Including the model error in the Bayesian setting allows us to use a simplified forward model for faster computation while still obtaining a posterior distribution close to the exact one.

In the presented approach, an arbitrary (e.g. Gaussian) reference density is transported to the desired Bayesian posterior distribution, which is then in turn given as the push-forward under the transport. In the presented approach, the model error is included as a stochastic variable distributed according to the push forward of the reference density under the model error function. Hence, samples from the reference density are transported to the posterior approximation and from there under the model error function to the model error distribution. This approach provides a more flexible description of the model error and allows us to generate posterior samples efficiently. Furthermore, our approach is based on the theory of invertible maps, which allows us to employ arbitrary machine learning architectures as the invertibility of the transport is guaranteed through an analytical construction. For the applications presented here, we focus on simply connected feed-forward networks, which in this context is commonly known as invertible neural networks. We demonstrate the effectiveness of our approach by providing an example of a nano-optical shape reconstruction task that is typically encountered in EUV scatterometry.