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Tackling Multimodal Device Distributions in Inverse Photonic Design: Lessons learned from Invertible Neural Networks

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Inverse design problems in photonics typically operate in very high dimensional parameter spaces which are notoriously difficult to navigate to find local or global optima. Even worse, from practice it is known that different devices can have comparable performance leading to multimodal device distributions. This often confuses optimization routines causing oscillations and failure to converge. Bayesian inference provides a framework to obtain complete device distributions and has been applied with great success to problems in astrophysics and particle physics. However, traditional Bayesian methods typically also suffer from the curse of dimensionality which makes them unsuitable to apply to problems in photonics with large parameter spaces. However, recent developments in machine learning and specifically generative modeling have enabled the exploration of high-dimensional problems with Bayesian inference.
In this talk I will show how we apply this framework to two problems in nanophotonic design with multimodal device distributions. We investigate a slit flanked by periodic corrugations and a stack of alternating layers of different dielectric materials. Using invertible neural networks allows us to identify symmetric solutions in these devices and generate the complete distribution of devices with a certain behavior. This approach significantly outperforms other traditional generative models like variational autoencoders. From this discussion we motivate a general procedure to benchmark new models for photonic inverse design and how to choose an appropriate architecture in face of an unknown dataset.
References:
1. Frising M, Bravo-Abad J, Prins F, "Tackling Multimodal Device Distributions in Inverse Photonic Design using Invertible Neural Networks" (to be submitted)

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