Deep learning in nano-optics - risks and opportunities

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Deep learning (DL) has emerged as a versatile numerical method in various fields of research, where large amounts of data are available and conventional techniques fail. DL is for example a promising method to solve ill posed inverse problems, such as design tasks [1,2].

In the first part of the seminar, I will critically review deep learning in general and discuss its main advantages for applications in physics like the differentiability of neural network models and the concept of the latent space, illustrated by examples from nano-optics [3,4].

In the second part of the presentation, I will discuss potentials and opportunities that arise as a side-effect from the huge global development efforts and monetary invest of Big Tech players in deep learning frameworks like tensorflow, jax or pytorch. Beyond deep artificial neural networks, these highly optimized and GPU-ready auto-diff tools enable various applications in physics.

[1] Wiecha, P. R. et al. Deep learning in nano-photonics: inverse design and beyond. Photonics Research 9, B182 (2021)

[2] Ren, S. et al. Inverse deep learning methods and benchmarks for artificial electromagnetic material design. Nanoscale 14, 3958–3969 (2022)

[3] Khaireh-Walieh, A. et al. A newcomer's guide to deep learning for inverse design in nano-photonics. Nanophotonics 12, 4387–4414 (2023).

[4] Wiecha, P. R. Deep learning for nano-photonic materials – The solution to everything!? Current Opinion in Solid State and Materials Science 28, 101129 (2024).