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Reconstruction of SAXS Data using Neural Networks

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The understanding of laser-solid interactions is important to the development of future laser-driven particle and photon sources, e.g., for tumor therapy, astrophysics or fusion. Currently, these interactions can only be modeled by simulations which need verification in the real world. Consequently, in 2016, a pump-probe experiment was conducted by Thomas Kluge to examine the laser-plasma interaction that occurs when an ultrahigh-intensity laser hits a solid density target. To handle the nanometer spatial and femtosecond temporal resolution of the laser-plasma interactions, Small-Angle X-Ray Scattering (SAXS) was used as a diagnostic to reconstruct the laser-driven target. However, the reconstruction of the target from the SAXS diffraction pattern is an inverse problem which are often ambiguous, due to the phase problem, and has no closed-form solution. We aim to simplify the process of reconstructing the target from SAXS images by employing Neural Networks, due to their speed and generalization capabilities. To be more specific, we use a conditional Invertible Neural Network (cINN), a type of Normalizing Flows, to resolve the ambiguities of the target with a probability density distribution. The target in this case is modelled by a simple grating function with three parameters. We chose this analytically well-defined and relatively simple target as a trial run for Neural Networks in this field to pave the way for more sophisticated targets and methods. Unfortunately, we don't have enough and reliable experimental data that could be used as training. So, in consequence, the network is trained only on simulated diffraction patterns and their respective ground truth parameters. The cINN is able to accurately reconstruct simulated- as well as preshot data. The performance on main-shot data remains unclear due to the fact that the simulation might not be able to explain the governing processes.

Physical Presentation

I would be willing present physically.

Primary author: THIESSENHUSEN, Erik (HZDR)

Co-authors: HOFFMANN, Nico (HZDR); KLUGE, Thomas (HZDR); Prof. COWAN, Tom (HZDR); RÖDEL, Melanie (HZDR); BUSSMANN, Michael (CASUS)

Presenter: THIESSENHUSEN, Erik (HZDR)

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