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Towards the differentiable design of a neutron tomography system.

Designing optimal experiments in nuclear and particle physics is often a challenging and computationally expensive task. In this context, machine learning and differentiable programming are rapidly emerging as powerful tools for the end-to-end optimization of detector parameters.

In this work, we present the machine learning optimization of a neutron tomography system based on a stack of Parallel-Plate Avalanche Counters with Optical Readout (O-PPACs). Building on previous work that optimized the design of a single O-PPAC, we aim to extend this framework to the complete detector stack. The core challenge lies in writing the entire pipeline, from the detector response to particle reconstruction, in a differentiable manner. To achieve this, we employ conditional generative models as differentiable surrogates for the Geant4 detector simulation, while position reconstruction is performed by a convolutional neural network-based model that outperforms traditional methods. With this framework, we aim to jointly optimize detector configuration, cost, efficiency, and spatial resolution, demonstrating the potential of differentiable programming for designing imaging systems in neutron tomography.

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