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Latent evolution model for time-inversion of spatiotemporal beam dynamics

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Charged particle dynamics under the influence of electromagnetic fields is a challenging spatiotemporal problem. Current physics-based simulators for beam diagnostics are computationally expensive, limiting their utility for solving inverse problems in real time. The problem of estimating upstream six-dimensional phase space given downstream measurements of charged particles is an inverse problem of growing interest. In this work, we propose a latent evolution model to invert the forward spatiotemporal beam dynamics. In this two-step unsupervised deep learning framework, we first use a variational autoencoder (VAE) to transform 6D phase space projections of a charged particle beam into a lower-dimensional latent distribution. We then autoregressively learn the inverse temporal dynamics in the latent space using a long-short-term memory (LSTM) network. The coupled VAE-LSTM framework can predict 6D phase space projections in upstream accelerating sections given downstream phase space projections as inputs.

Footnotes

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Primary author: RAUTELA, Mahindra (Los Alamos National Laboratory)

Co-authors: WILLIAMS, Alan (Los Alamos National Laboratory); SCHEINKER, Alexander (Los Alamos National Laboratory)

Presenter: RAUTELA, Mahindra (Los Alamos National Laboratory)

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