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Machine learning-enhanced beam trajectory stabilization at Canadian Light Source

Thursday 5 June 2025 15:30 (2 hours)

This study presents a Neural Network (NN)-based feedback system to improve orbit correction precision at the Canadian Light Source (CLS), replacing the traditional Response Matrix (RM) algorithm. Implemented with TensorFlow-Keras, the NN model features three hidden layers with 96 nodes, processing high-frequency beam position monitor (BPM) data at 1 kHz from 48 vertical and 48 horizontal sensors. The model was trained on a dataset of BPM and orbit corrector (OC) values under varying beam currents, with alignment tolerances set at ±1000 µm and ±500 µm horizontally and vertically. Tests over 11 minutes at 8.0 mA beam current showed the NN model's superior performance, reducing root-mean-square (RMS) horizontal beam position fluctuations by 56.4% in section 11 and 20.3% in section 1. RMS values dropped from 1.28×10^{-4} (RM) to 1.02×10^{-4} (NN) in section 11. The NN consistently stabilized beam trajectory without manual intervention, demonstrating the potential of machine learning to revolutionize particle accelerator control systems with adaptive, precise real-time management.

Footnotes

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