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Longitudinal Phase Space Reconstruction from Beam Current Projections Using Deep Convolutional Neural Networks

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We propose an end-to-end deep learning method for reconstruction of proton synchrotron longitudinal phase space distributions from 1D beam current projections. Unlike iterative tomographic approaches, our model bypasses complex physics computations by establishing a direct sequence-to-image mapping. The architecture integrates sinusoidal positional encoding to capture multi-turn temporal dependencies and attention pooling to weight critical frames. Spatial reconstruction uses convolutional upsampling. Trained on 10,000 simulated datasets generated with XiPAF parameters, the model achieves high-fidelity results with average KL divergence <0.1 and SSIM >0.7 on validation data. Compared to Algebraic Reconstruction Technique (ART), our method maintains equivalent projection discrepancy (<0.04) while reducing reconstruction time from ˜3 minutes to ˜100 ms per image –a 3-order-of-magnitude acceleration. Current 128×128 pixel resolution limitations will be addressed in future work. This framework enables real-time beam diagnostics for high-intensity hadron accelerators.

Footnotes

*Simulation parameters: E_s=10 MeV, L=30.9 m, V_rf=100 V, h=1, γ_T=1.64468

Funding Agency

I have read and accept the Privacy Policy Statement

Yes

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