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Reinforcement Learning Algorithms for Charged Particle Tracking with Applications in Proton Computed Tomography

Tuesday, 30 January 2024 11:50 (20 minutes)

Deep learning, especially graph neural networks, significantly improved tracking performances in modern particle detectors while reducing runtimes compared to previous state of the art approaches. However, training neural networks requires significant amount of labeled data, usually acquired by performing complex particle simulations. We present first studies of leveraging deep reinforcement learning (RL) and constrained multi-agent reinforcement learning (MARL) as ground-truth free alternatives to supervised learning.
Instead of minimizing a loss function based on ground-truth, we optimize by trial-and-error behavior policies, acting as approximations to the full combinatorial optimization problem, maximizing the physical plausibility of sampled track candidates. Our approaches works on graph-structured data, capturing track hypotheses through edge connections between particles in the detector layers.
We demonstrate, on simulated data for a particle detector used for proton computed tomography, the high potential as well as the competitiveness of RL for both single-agent as well as multi-agent settings.

Partially based on: T. Kortus, R. Keidel, N. R. Gauger, on behalf of the Bergen pCT collaboration, "Towards Neural Charged Particle Tracking in Digital Tracking Calorimeters with Reinforcement Learning," in IEEE Transactions on Pattern Analysis and Machine Intelligence, doi: 10.1109/TPAMI.2023.3305027.

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