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Real-Time Charged Track Reconstruction with AI in CLAS12

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Charged track reconstruction is a pivotal task in nuclear physics experiments, enabling the detection and analysis of particles generated in high-energy collisions. Machine learning (ML) has proven to be a transformative tool in this domain, overcoming challenges such as intricate detector geometries, high event multiplicities, and noisy data. While traditional methods like the Kalman filter have been widely used for pattern recognition, ML approaches—including neural networks, graph neural networks (GNNs), and recurrent neural networks (RNNs)—offer enhanced accuracy and scalability.

In this presentation, we share our findings on leveraging AI to aid data reconstruction for identifying charged tracks in the Drift Chambers of the CLAS12 detector. A Convolutional Autoencoder (CNN) is employed to de-noise the drift chamber data, while a Multi-Layer Perceptron (MLP) network identifies track candidates from the segments reconstructed in each layer. This AI-driven track identification results in approximately a 60% increase in statistics for multiparticle inclusive states. Additionally, we developed a neural network to predict particle parameters directly from raw Drift Chamber hits, enabling full event reconstruction at a rate of approximately 20 kHz, surpassing the experimental data acquisition speed. These advancements are redefining the application of AI in experimental physics and transforming the methodologies of nuclear physics experiments.

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