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GNN based noise filtering algorithm for tracking on STCF experiment

Track reconstruction is one of the most important and challenging tasks in the offline data processing of collider experiments. The Super Tau-Charm Facility (STCF) is a next-generation electron-positron collider running in the tau-charm energy region proposed in China, where conventional track reconstruction methods face enormous challenges from the higher background environment introduced by the higher collision luminosity.
In this contribution, we demonstrate a novel hybrid tracking algorithm based on Graph Neural Network (GNN) method and traditional methods for the STCF drift chamber. In the GNN method, a hit pattern map representing the connectivity between drift cells is constructed considering the geometrical layout of the sense wires, based on which we design an optimal graph construction method, then an edge-classifying graph neural network is trained to distinguish the hit-on-track from noise hits. Finally, the result after the noise filtering is integrated into the traditional tracking software where a track-finding algorithm based on the Hough transform is performed and a track-fitting algorithm based on GENFIT is used to obtain the track parameters.
Preliminary results based on the STCF MC sample, considering different background conditions, show promising performance with increased tracking efficiency, especially for the tracks with the low momentum (< 600 MeV/c), and reduced track fake rate compared to the traditional tracking method. Furthermore, the GNN based noise filtering algorithm can also be potentially applied to other collider experiments with similar drift chamber based trackers.

Significance

In this contribution, we demonstrate a novel hybrid tracking algorithm based on Graph Neural Network (GNN) method and traditional methods for the drift chamber of the Super Tau-Charm Facility (STCF) to cope with high background level induced by high collision luminosity. This noise filtering algorithm uses low level information such as sense wire positions and time information of hits in the drift chamber and takes advantage of large statistics of training samples to achieve effective signal-noise discrimination. Sophisticated graph construction and optimized layer-dependent signal requirements ensure effective noise suppression without compromising signal integrity. Detailed performance study shows this noise filtering algorithm enable an improvement in tracking efficiency especially in the low momentum region and reduction of fake track rate compared to the traditional method. This implementation on STCF drift chamber has not been reported before.

References

Xiaoqian Jia et al. BESIII track reconstruction algorithm based on machine learning. EPJ Web Conf. 295 (2024) 09006, Contribution to: CHEP 2023
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Experiment context, if any

Super Tau-Charm Facility (STCF) proposed in China. The CDR is available: STCF conceptual design report (Volume 1): Physics & detector Front.Phys.(Beijing) 19 (2024) 1, 14701 https://link.springer.com/article/10.1007/s11467-023-1333-z

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