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Noise removal of the events at main drift chamber of BESIII with deep learning techniques

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There are established classical methods to reconstruct particle tracks from recorded hits on the particle detectors. Current algorithms do this either by cut in some features, like recorded time of the hits, or by the fitting process. This is potentially error prone and resource consuming. For high noise events, these issues are more critical and this method might even fail. We have been developing artificial neural networks which can learn to separate noise from signal in the simulated data. The data sample we use for this purpose is Monte-Carlo simulated Bhabha events generated by BESIII offline software system. We study different types of deep neural networks and their effectiveness to remove the noise which happens in the main drift chamber of BESIII from various origins.

The fully connected networks that we first try find sophisticated cuts in hit features of each cell of the detector. These features include raw time of a hit and the recorded charge associated to it. This leads to about 85 percent efficiency and purity of the signal separation. This sets up a lower limit for us since such a network judges every hit only by its own features. Next, we develop a CNN network and show that with information of only four neighboring cells, the noise removal happens with 99 percent purity and efficiency at the same time. We discuss the effectiveness of the network for events with different noise levels.

The main drift chamber is consisted of 6796 sense wires arranged in 43 layers. The structure of the wire system is known and therefore we also examine the idea of looking at the main drift chamber structure as a graph. We make a model based on graph convolutional layers and chose node classification approach. We include a message passing process in three of the hidden layers and get 95 percent efficiency and purity for the noise removal. We then describe the results of our network for other events such as j/psi to p+ p_ pi+ pi-. In the end, we compare all of this with the classical methods.

Experiment context, if any

References

Significance

As a proof of concept, we show how different machine learning techniques can be applied to remove noise from events (FNN, CNN, GCN) and find tracks of particles at the same time. Also, compared to classical algorithms, our neural networks can be used to much more efficiently remove noise, especially for events with a high level of it.
For the graph approach, two aspects of our work are different from the literature. Firstly, we model the real structure of the main drift chamber as a graph and secondly, we have a node classification approach to find tracks of the particles and remove noise hits.

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