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Graph neural networks for track reconstruction in space experiments

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For tracking reconstruction purposes, various models inspired by computer vision applications have been studied, operating on an image-like representation of tracking detector data. Image-based methods encounter challenges in scaling up to realistic space experiment data due to high dimensionality and sparsity. Conversely, geometric deep learning methods such as graph neural networks (GNNs) are well-suited to address reconstruction problems in astroparticle physics. GNNs leverage the inherent graph structure of particle tracking data, where tracker hits are naturally represented as nodes and connections between hits as edges or links. By exploiting this graph representation, GNNs can effectively capture complex patterns and dependencies in the data, making them particularly suitable for tasks such as noise versus signal identification in particle tracking applications.

We will present a novel GNN approach for particle reconstruction in space experiments. Specifically, by using the Geant4 toolkit, we simulated the response of 4 scintillating fiber tracking layers, aiming to mimic the setup employed during a beam test at CERN, which utilized a 10 GeV negative pion beam. Our approach involves training and evaluating different node-classifying GNN algorithms to distinguish between noise and signal hits in the simulated detector data. These GNN algorithms utilize techniques such as message passing and graph convolution to iteratively aggregate information from neighboring hits and learn discriminative features for classification tasks. We compare the performances of these GNN algorithms with those of traditional analytical tracking approaches, highlighting the advantages of leveraging deep learning techniques for particle reconstruction in space experiments.

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