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Hierarchical Graph Neural Networks for Particle Track Reconstruction

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Graph Neural Networks (GNN) have recently attained competitive particle track reconstruction performance compared to traditional approaches such as combinatorial Kalman filters. In this work, we implement a version of Hierarchical Graph Neural Networks (HGNN) for track reconstruction, which creates the hierarchy dynamically. The HGNN creates "supernodes"by pooling nodes into clusters, and builds a "supergraph"which enables message passing among supernodes. A new differentiable pooling algorithm that can maintain the sparsity and produce variable number of supernodes is proposed to facilitate the hierarchy construction. We perform an apples-to-apples comparison between the Interaction Network (IN) and HGNN on track finding performance using node embedding metric learning, which shows that in general HGNNs are more robust against imperfectly constructed input graphs, and more powerful in recognizing long-distance patterns. Equipped with soft assignment, HGNN also allows assigning a given hit to multiple track candidates. The HGNN model can be used as a node-supernode pair classifier, where supernodes are considered to be track candidates. Under this regime, the pair-classifying HGNN is even more powerful than the node embedding HGNN. We show that the HGNN can not only improve upon the performance of common GNN architectures on embedding and clustering problems but also opens up other approaches for GNNs in high energy physics.

Significance

We explore the behavior of hierarchical GNNs in the context of high energy physics, proposing HEP-specific ways they can be applied, and demonstrating superior performance to traditional GNNs

References

Experiment context, if any

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