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Graph Neural Networks for Pattern Recognition & Fast Track Finding

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Particle track reconstruction is a challenging problem in modern high-energy physics detectors where existing algorithms do not scale well with a growing data stream. The development of novel methods incorporating machine learning techniques is a vibrant and ongoing area of research. In the past two years, algorithms for track pattern recognition based on graph neural networks (GNNs) have emerged as a particularly promising technique. Previous research has included edge & node classification via training multi-layered perceptrons. Here we present a novel and unique approach to track finding utilising a GNN-based architecture in an unsupervised manner, allowing the network to learn patterns as it evolves.

The development of the GNN-based framework leverages information aggregation to iteratively improve the precision of track parameters and extract compatible track candidates. To efficiently exploit a priori knowledge about charged particle dynamics, Gaussian mixture techniques and Kalman filters are embedded within the track following network. Gaussian mixtures are used to approximate the densities of track states and Kalman filtering is used as a mechanism for information propagation across the neighbourhood, as well as track extraction. The excitation/inhibition rules of individual edge connections are designed to facilitate the "simple-to-complex"approach for "hits-to-tracks"association, such that the network starts with low hit density regions of an event and gradually progresses towards more complex areas.

We discuss preliminary results from the application of the GNN-based architecture on the TrackML dataset; a simulation of a LHC-inspired tracking detector. Track reconstruction efficiency and track purity metrics are also presented. This work aims at implementing a realistic GNN-based algorithm for fast track finding that can be deployed in the ATLAS detector at the LHC experiment.

Consider for young scientist forum (Student or postdoc speaker)

No

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