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Online track reconstruction with graph neural networks on FPGAs for the ATLAS experiment

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The next phase of high energy particle physics research at CERN will involve the High-Luminosity Large Hadron Collider (HL-LHC). In preparation for this phase, the ATLAS Trigger and Data AcQuisition (TDAQ) system will undergo upgrades to the online software tracking capabilities. Studies are underway to assess a heterogeneous computing farm deploying GPUs and/or FPGAs, together with the use of modern machine learning algorithms such as Graph Neural Networks (GNNs). We present a study on the reconstruction of tracks in the new all-silicon ATLAS Inner Tracker using GNNs on FPGAs for the Event Filter system. We explore each of the steps in a GNN-based tracking pipeline: graph construction, edge classification using an interaction network, and segmentation of the graph into track candidates. We investigate optimizations of the GNN approach that aim to minimize FPGA resources utilization and maximize throughput while retaining high track reconstruction efficiency and low fake rates required for the ATLAS Event Filter tracking system. These studies include model hyperparameter tuning, model pruning and quantization-aware training, and sequential processing of regions of the detector as graphs.

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