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Intelligent experiments through real-time AI: GNN-based trigger pipeline for sPHENIX

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This R&D project, initiated by the DOE Nuclear Physics AI-Machine Learning initiative in 2022, explores advanced AI technologies to address data processing challenges at RHIC and future EIC experiments. The main objective is to develop a demonstrator capable of efficient online identification of heavy-flavor events in proton-proton collisions (~1 MHz) based on their decay topologies, while optimizing the use of a limited DAQ bandwidth (~15 kHz). This showcases the transformative potential of AI and FPGA technologies in real-time data processing for high-energy nuclear and particle experiments. We deploy an attention-GNN-based trigger algorithm with the target latency of 10 μs, trained on sPHENIX p+p collision simulated data. The target device is a FELIX-712 board equipped with Xilinx Kintex Ultrascale FPGA. Hls4ml and FlowGNN was used to create two IP cores of the AI inference.
In this talk we would like to report the latest progress of the project. Firstly, showcase the attention-based model used for the trigger pipeline comparing it to other state-of-the-art GNN algorithms. Secondly, report the utilization of the FPGA infrastructure, data decoder, clusteriser, and a simplified trigger detection pipeline based on GARNET translated with both hls4ml and FlowGNN.

Focus areas

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