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Real-Time Detection of Low-Energy Events with 2DCNN on FPGA's for the DUNE Data Selection System

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Abstract: Large-scale physics experiments generating high data rates impose significant demands on the data acquisition system (DAQ). The Deep Underground Neutrino Experiment (DUNE) is a next-generation experiment for neutrino science at the Fermi National Accelerator Laboratory in Batavia, Illinois. It will consist of a massive detector operating continually for over a decade, resulting in several TB/s of data. This data must be processed in real time to detect rare events of interest and stored for further offline processing to prevent the need for otherwise extensive and expensive offline data processing. Accordingly, we designed convolutional neural networks (CNNs) capable of detecting these rare events with 90.69% efficiency and rejecting background noise with an efficiency of 99.80%; thereby demonstrating the viability of CNN-based algorithms for this use case. Deployment of such machine learning models on hardware has been made easy with modern tools like hl4ml and HLS. The deployment of this model on Xilinx alveo-u250 accelerator card has shown promising performance while meeting resource budget and latency targets by a large margin. This illustrates the practicality of deploying real-time AI on FPGAs for this application, with the potential for expanding the model to achieve classification of a broader set of event topologies with higher precision.

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