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Machine-Learning-Based Regression for Edge Data Reduction of Small Pixel, High-Bandwidth Silicon Detectors

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Based on deep-sub-micron CMOS processes, modern silicon pixel detectors exhibit large arrays of fine-pitch pixels. They are designed to provide
unprecedented precise information on particle detection, encoded in pixel addresses, energy, and Time-of-Arrival, and provide a large bandwidth for reading out this information. Information on the initiating particle interaction is determined from data analysis by clustering pixel hits in geometrical and temporal patterns to calculate the time and position of the interaction in the detector. Modern data analysis methods, based on machine learning and neural networks,can be exploited to perform data stream reduction in such detectors at a high rate, at the edge of the detector, contributing to the reduction in services in future detectors, the reduction of the bandwidth required for extraction of the data from the detector and to minimizing data storage need for experiments.
We propose the development of a Spiking Neural Network (SNN) for the
clustering and fitting of small-pixel, large-area, high-bandwidth silicon detector data stream. In this approach, an FPGA-based SNN is employed to perform the aggregation of pixels in a particle detection event, and the regression calculation necessary to reconstruct the timing and spatial information of the interaction. The SNN will be trained using Allpix2 simulation data and experimental data from test beams using a high-precision tracking telescope. We propose to use the Timepix4 technology or similar high bandwidth ASIC for experimental validation of the method.

Early Career

No

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