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FastPointNet: Fast Event Reconstruction for the KamLAND-Zen Experiment using FPGA-Deployed Machine Learning

Monolithic liquid scintillator detector technology has been at the center for exploring new neutrino physics. The KamLAND-Zen experiment exemplifies this detector technology and has yielded top results in the quest for neutrinoless double-beta ($0\nu\beta\beta$) decay. Experimenters must reconstruct each event's position and energy from the raw data produced to understand the physical events that occur in the detector. Traditionally, this event position and energy information would only be available days after data collection, as this information is obtained through a time-consuming offline process. This work introduces a new pipeline to acquire this information quickly by implementing a machine learning model, PointNet, onto an AMD RFSoC4x2 Development Board, a type of Field Programmable Gate Array (FPGA). This work outlines a successful demonstration of the entire pipeline, showing that event position and energy information can be reliably and quickly obtained as physics events occur in the detector. This marks one of the first instances of applying hardware-AI co-design in the context of $0\nu\beta\beta$ decay experiments.

Focus areas

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