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RNNs on Intel FPGAs for real time signal processing in the ATLAS LAr calorimeter

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Within the Phase-II upgrade of the LHC, the readout electronics of the ATLAS Liquid Argon (LAr) Calorimeters is prepared for high luminosity operation expecting a pile-up of up to 200 simultaneous pp interactions. The Liquid Argon calorimeters measure the energy of particles produced by LHC collisions, especially electrons and photons. The digitized signals from the LAr 182468 channels are analysed in real time, at 40 MHz, to provide a detailed map of energy deposits from up to 200 simultaneous collisions (pile-up). These measurements are to be performed by high-end Field Programmable Gate Array, each processing O(1TB/s) of data. In order to maintain high precision event reconstruction at HL-LHC in these challenging conditions, the LAr readout electronics and its embarked algorithms are to be improved.
The growing processing power of FPGAs and many advances in Artificial Intelligence systems provide cutting-edge opportunities to combine real-time data processing with high bandwidth, low latency and advanced algorithms. To cope with the signal pile-up, new machine learning approaches are explored: recurrent neural networks outperform the optimal signal filter currently used.
In this talk we present the first implementation of RNNs, especially those based on Long Short-Term Memory (LSTM), in the hls4ml software for generating firmware for Intel Stratix 10 FPGAs. Very good agreement between neural network implementations in FPGA and software based calculations is observed. The FPGA resource usage, the latency and the operation frequency are analysed. Latest performance results and experience with prototype implementations will be reported.

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