ID de Contribution: **141** Type: **Non spécifié**

Optimization of embedded neural networks for the energy reconstruction of the liquid argon calorimeter cells of ATLAS

jeudi 27 novembre 2025 16:45 (20 minutes)

The Large Hadron Collider (LHC) collides protons at nearly the speed of light, producing new particles observed by the ATLAS detector. In 2026, the LHC will undergo a major upgrade to the High-Luminosity LHC (HL-LHC), increasing luminosity by a factor of 5–7 and delivering up to 200 simultaneous collisions. To cope with the resulting data rates, ATLAS will replace the readout electronics of the Liquid Argon Calorimeter (LAr) as part of its Phase-II upgrade. The new LASP board, equipped with two FPGAs, will perform real-time energy reconstruction for 384 channels each, covering about 180,000 calorimeter cells in total.
At high pileup, overlapping electronic pulses challenge the current Optimal Filtering (OF) algorithm used to compute the energy. Neural network (NN)–based alternatives are being explored to surpass OF while respecting FPGA constraints: <125 ns latency and limited resource usage. After earlier studies of recurrent and convolutional architectures, a dense-layer design is proposed, reducing both latency and resource consumption.
Bayesian hyperparameter optimization is used to adapt the network size, balancing energy resolution with FPGA feasibility. The results show how to achieve optimal performance within hardware limits. In addition, deep evidential regression is employed to estimate uncertainties by fitting predicted energies to probability distributions, enabling quantification of both data noise and model imprecision with minimal overhead.
The talk will compare network architectures and present the Bayesian optimization results, as well as demonstrate uncertainty estimation with evidential regression.

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Classification de Session: AI at the edge

Classification de thématique: Fast ML : DAQ/Trigger/Real Time Analysis