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Jets as sets or graphs: Fast jet classification on FPGAs for efficient triggering at the HL-LHC

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The upcoming high-luminosity upgrade of the LHC will lead to a factor of five increase in instantaneous luminosity during proton-proton collisions. Consequently, the experiments situated around the collider ring, such as the CMS experiment, will record approximately ten times more data. Furthermore, the luminosity increase will result in significantly higher data complexity, thus making more sophisticated and efficient real-time event selection algorithms an unavoidable necessity in the future of the LHC.

One particular facet of the looming increase in data complexity is the availability of information pertaining to the individual constituents of a jet at the first stage of the event filtering system, known as the level-1 trigger. Therefore, more intricate jet identification algorithms that utilise this additional constituent information can be designed if they meet the strict latency, throughput, and resource requirements. In this work, we construct, deploy, and compare fast machine-learning algorithms, including graph- and set-based models, that exploit jet constituent data on field-programmable gate arrays (FPGAs) to perform jet classification. The latencies and resource consumption of the studied models are reported. Through quantization-aware training and efficient FPGA implementations, we show that O(100) ns inference of complex models like graph neural networks and deep sets is feasible at low resource cost.

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