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Type: **Plenary**

Track Finding and Neural Network-Based Primary Vertex Reconstruction with FPGAs for the Upgrade of the CMS Level-1 Trigger System

Tuesday, 31 May 2022 11:00 (25 minutes)

The CMS experiment will be upgraded to take advantage of the rich and ambitious physics opportunities provided by the High Luminosity LHC. Part of this upgrade will see the first level (Level-1) trigger use charged particle tracks from the full outer silicon tracker as an input for the first time. The reconstruction of these tracks begins with on-detector hit suppression, identifying hits (stubs) from charged particles with transverse momentum (p_T) > 2 GeV within the tracker modules themselves. This reduces the hit rate by one order of magnitude with 15,000 stubs being produced per bunch crossing. Dedicated off-detector electronics using high performance FPGAs are used to find track candidates at 40 MHz using a road-search based pattern matching step. These are then passed to a combinatorial Kalman filter that performs the track fit for $\mathcal{O}(200)$ tracks. This overall track finding algorithm is described, as is the ongoing work developing the track fitting firmware and a boosted decision tree approach to track quality estimation.

The tracks are used in a variety of ways in downstream algorithms, in particular primary vertex finding in order to identify the hard scatter in an event and separate the primary interaction from an additional 200 simultaneous interactions. A novel approach to regress the primary vertex position and to reject tracks from additional soft interactions uses a lightweight 1000 parameter end-to-end neural network. This neural network possesses simultaneous knowledge of all stages in the reconstruction chain, which allows for end-to-end optimisation. The improved performance of this network versus a baseline approach in the primary vertex regression and track-to-vertex classification is shown. A quantised and pruned version of the neural network has been deployed on an FPGA to match the stringent timing and computing requirements of the Level-1 Trigger. Finally, integration tests between the track finder and vertexing firmware are shown using prototype hardware.

Consider for young scientist forum (Student or postdoc speaker)

Yes

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