Contribution ID: **194** Type: **Oral**

Testing a Neural Network for Anomaly Detection in the CMS Global Trigger test crate during Run 3

Monday 2 October 2023 16:15 (20 minutes)

We present the deployment and testing of an autoencoder trained for unbiased detection of new physics signatures in the CMS Global Trigger test crate during LHC Run 3. The GT test crate is a copy of the main GT system, receiving the same input data, but whose output is not used to trigger the readout of CMS, providing a platform for thorough testing of new trigger algorithms on live data, but without interrupting data taking. We describe the integration of the DNN into the GT test crate, and the monitoring, testing, and validation of the algorithm during proton collisions.

Summary (500 words)

In the CMS Level-1 hardware trigger, the Global Trigger (μGT) component is responsible for selecting which collisions are recorded and which are discarded, based on the signals from the different sub-detectors.

The μGT comprises several custom MP7 processing boards equipped with Xilinx Virtex-7 FPGAs with high-speed 10 Gb/s optical connections. For Run 3, a test crate comprising the same hardware as the μGT has been added. Consisting of 7 MP7 boards with the same Virtex-7 FPGAs and high-speed optical fibers, the GT test crate is a copy of the main μGT system, receiving the same input data, but whose output is not used to trigger the readout of CMS. This provides a platform for thorough testing and validation of new trigger selection on live data, without interrupting data taking.

ML-based anomaly detection methods have been gaining popularity in particle physics as a way of extracting potential new physics signals in a model-agnostic way, by rephrasing the problem as an out-of-distribution detection task. One promising technique is self-supervised variational autoencoders, which have the added benefit of enabling algorithms to be trained on unlabeled data rather than simulations.

In this project, we present the deployment and testing of a variational autoencoder trained for unbiased detection of new physics signatures in the test crate of the CMS Global Trigger during LHC Run 3. The DNN is integrated into the μGT test crate using hls4ml, a software package that allows the conversion of machine learning models into hardware descriptions that can be implemented on FPGAs. This allows the DNN to be run in real-time, with low latency and high throughput, making it suitable for deployment in the μGT system.

We describe the monitoring, testing, and validation of the algorithm during proton collisions in 2023. From the μGT test crate trigger bit counters are read out and logged, enabling validation of the rate of the algorithm in data against the emulation of the algorithm on Zero Bias data. Through the central Prometheus monitoring database, the performance of the algorithm can be evaluated in real time.

Since the test crate is not able to trigger the readout of the CMS experiment, it is also possible to deploy trigger menus not intended for data taking but enabling full characterisation and probing of the behavior of an algorithm during LHC collisions. This includes, for example, applying different thresholds than the eventual online target, or using different NN trainings simultaneously.

The deployment and testing of this DNN in the GT test crate is a crucial step towards the development of new trigger algorithms for the CMS detector. By providing an unbiased platform for testing and validation, we can ensure that new algorithms are effective, while maintaining the efficiency and reliability of the overall μGT system.

Primary authors: NGADIUBA, Jennifer (FNAL); SUMMERS, Sioni Paris (CERN); AARRESTAD, Thea (ETH Zurich (CH))

Presenter: ZIPPER, Noah Alexander (University of Colorado Boulder (US))

Session Classification: Trigger and Timing Distribution

Track Classification: Trigger and Timing Distribution