T 9: DAQ NN/ML – HW

Time: Monday 16:30–18:00 Location: HSZ/0301

T 9.1 Mon 16:30 HSZ/0301

Implementation of an improved Neural Network for identification of hadronically decaying τ leptons in the ATLAS trigger system for the LHC Run 3 — •Naman Kumar Bhalla, Ö. Oğul Öncel, and Markus Schumacher — Albert-Ludwigs-Universität Freiburg

The ATLAS detector employs a trigger system to reduce the large event rate by saving only interesting events on mass storage for further analyses. This is done via dedicated triggers for each observable physics object. Being the heaviest lepton in the Standard Model of particle physics, the τ lepton is highly unstable, allowing only its decay products to be directly observed. While the electron and muon triggers can be used for the leptonic decays of the τ lepton, separate triggers are necessary to differentiate between hadronically decaying τ leptons (τ_{had}) and jets, which are produced with significantly higher abundance. ATLAS uses a recurrent neural network (RNN) for τ_{had} identification, which exploits various track, cluster and high-level variables as inputs, and returns a single classifier as output. However, it needed to be retuned for operations in the ongoing Run 3 phase of the Large Hadron Collider (LHC) due to upgrades in the detector and the accelerator. Furthermore, new input variables were added to improve the performance of the RNN. An alternative architecture based on Deep Sets was tested in order to have a more efficient usage of computing resources. This talk presents the results of performance studies of the retuned RNN, and a comparison between the two network architectures in terms of efficacy and resource consumption.

T 9.2 Mon 16:45 HSZ/0301

Machine learning based triggers for VBF H $\rightarrow$ inv at the Level-1 trigger system of CMS — •Shahin Sepanlou, Johannes Haller, Gregor Kasieczka, Finn Labe, Artur Lobanov, and Matthias Schröder — Institut für Experimentalphysik, Universität Hamburg

At the CMS experiment, a two-level trigger system is used to decide which collision events to store for later analysis. The Level-1 trigger is subject to strict latency, resource and rate constraints. To handle the even more challenging High Luminosity-LHC environment, novel strategies in the trigger system are necessary. Therefore, in this talk studies towards a topological trigger algorithm using fast machine learning on FPGAs are presented. The vector boson fusion production of a Higgs boson decaying to invisible particles is used as an example process that is difficult to select with classical trigger strategies and would benefit from machine learning based approaches.

T 9.3 Mon 17:00 HSZ/0301

FPGA-based fast Machine Learning Triggers for Neutrino Telescopes — •Francesca Capel[1,3], Christian Haack[2,3], Lukas Heinrich[2,3], and Christian Spannfellner[2,3] — [1]Max-Planck-Institut für Physik — [2]Technische Universität München — [3]ORIGINS Excellence Cluster

Neutrinos provide valuable insight into the origin and acceleration mechanisms of cosmic particles. They are able to traverse vast distances and dense environments on their way to Earth unimpeded, but are also challenging to detect due to their weakly interacting nature. Earth itself is used as detector, where large volumes are equipped with photosensors to detect the Cherenkov light induced by astrophysical neutrino interactions. Neutrino telescopes are located deep underwater or in the Antarctic ice to reduce the background rate, inducing often strict limits on power and bandwidth available for the detector. Trigger algorithms are inevitable to reject background signals and reduce the data stream to manageable rates. In this contribution we will present the potential of fast, intelligent machine learning triggers implemented on low power FPGAs for the usage as online trigger in neutrino telescopes. Our main objectives are an improved signal to background discrimination and improved sensitivity for low energy events.

T 9.4 Mon 17:15 HSZ/0301

The MDT Trigger Processor for the ATLAS HL-LHC Upgrade of the Level-0 Muon Trigger — •Davide Cieri, Markus Fras, Oliver Kortner, and Sandra Kortner — Max-Planck-Institut für Physik, Munich, Germany

The novel MDT Trigger Processor (MDTTP) system is a fundamental part of the upgrade of the first-level (L0) muon trigger of the ATLAS experiment at the HL-LHC. The new system will be responsible for improving the muon momentum resolution and thus refining the muon selectivity, using for the first time at L0 the precision tracking information from Monitored Drift Tube (MDT) chambers in addition to the trigger chamber information. The system will also transmit the MDT hit data to the data acquisition (DAQ) system in the event of a trigger accept. Sixty-four MDTTP boards will be installed in ATLAS, one for each MDT trigger sector. The design of the MDTTP is highly challenging, requiring a high number of optical links and high-performance processing units.

We present here the recently fabricated MDTTP prototype and its testing plans. Based on an ATCA design, it is composed by two modules: the Service Module responsible for the powering and the infrastructure; and the Command Module, performing the trigger and DAQ processing and communicating with the other components of the ATLAS muon trigger. The Command Module mounts a powerful Xilinx Virtex Ultrascale+ FPGA XCVU13P, and ten 12-channel bidirectional optical transceiver modules with a link speed of up to 14 Gbps.

T 9.5 Mon 17:30 HSZ/0301

The ATLAS Forward Feature Extractor for the HL-LHC — •Adrian Alvarez Fernandez, Stefan Tapprogge, Ulrich Schaefer, Bruno Bauss, Julian Blumenthal, Marcel Weirich, and Dennis Layh — Johannes Gutenberg University (Mainz)

The ATLAS detector will undergo many upgrades to account for the more challenging running conditions of the High Luminosity LHC (HL-LHC). Some of these Phase-II upgrades will be focused on improving the trigger system, a crucial part to deal with the higher data rates and increased pile-up. Phase-I upgrades for Run 3 introduced the Feature EXtractors for a more refined processing of the calorimeter information and to better discriminate between jets, photons, electrons and taus. A Forward Feature EXtractor (fFEX) is being developed for the HL-LHC that will provide more flexible algorithms for the objects in the forward region (|eta|>2.5 for electrons/photons and |eta|>3.2 for jets). In contrast to the first level calorimeter trigger before HL-LHC, this system will have access to the full detailed calorimeter granularity in that region. The preliminary design of the fFEX has been recently reviewed and will be discussed in this presentation.

T 9.6 Mon 17:45 HSZ/0301

High-Speed Link Tests for the fFEX L1Trigger Module — •Dennis Layh, Stefan Tapprogge, Ulrich Schäfer, and Bruno Bauss — Johannes Gutenberg Universität

For the planned High Luminosity LHC upgrade the forward Feature EXtractor (fFEX), which will be a new component of the ATLAS first level trigger, will have an estimated input data rate of 2.2Tb/s. To achieve a data rate of this magnitude it is necessary to move to a higher line rate than previous modules, which were running at about 12Gb/s per link. The planned line rate of 25.7Gb/s per link will require thorough testing to make sure that signal integrity and quality needs are met. One part along the path from the LAr calorimeters to the fFEX FPGAs are opto-electrical modules, which translate the data from incoming optical fibers to electrical signals and vice versa. For this purpose a PCB was designed, produced and utilized to test a new 12-channel unidirectional firefly module from Samtec which runs at line rates of up to 28Gb/s.