AKPIK 10: AI Topical Day – Computing II (joint session HK/AKPIK)

Time: Thursday 14:00–15:30 Location: HSZ/0103

AKPIK 10.1 Thu 14:00 HSZ/0103

Exploiting Differentiable Programming for the End-to-end Optimization of Detectors — The MODE Collaboration[1] and •Anastasios Belias[2] — [1]mode-collaboration.github.io — [2]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany

Machine-learning Optimized Design of Experiments, the MODE Collaboration, targets the end-to-end optimization of experimental apparatus, by using techniques developed in modern computer science to fully explore the multi-dimensional space of experiment design solutions. Differentiable Programming is employed to create models of detectors that include stochastic data-generation processes, the full modeling of the reconstruction and inference procedures, and a suitably defined objective function, along with the cost of any given detector configuration, geometry and materials.

The MODE Collaboration considers the end-to-end optimization challenges in its generality, providing software architectures for machine learning to explore experiment design strategies, information on the relative merit of different configurations, with the potential to identify and investigate novel, possibly revolutionary solutions. In this contribution we present use cases, and highlight the potential for on-going and future experiment design studies in fundamental physics research.

AKPIK 10.2 Thu 14:15 HSZ/0103

Klassifikation von Pulsdaten mit neuronalen Netzwerken auf einer FPGA Accelerator Card — •Robert Ufer, Bastian Auer, Helene Hoffmann, Oliver Knodel, Mani Lokamani und Stefan Müller — Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany

Zur Analyse der entstehenden Detektordaten bei dem Mu2e Experiment am Fermilab soll die Datenauswertung mit Field Programmable Gate Array (FPGA) erfolgen. Diese übernehmen die notwendige Vorverarbeitung und Reduktion der Messdaten, noch während der Durchführung der Messung. Die dabei ausgeführten Anwendungen werden standardmäßig durch Algorithmen realisiert. Eine dieser Anwendungen führt die Klassifikation der ermittelten Pulsdaten durch. Mit den Testläufen an der gELBE Bremstrahlungs-Beamline am Helmholtz-Zentrum Dresden-Rossendorf (HZDR) konnte für das zukünftige Experiment eine große Menge dieser Datensätze erfasst werden. Diese dienen zur Charakterisierung des Detektorsystems und wurden mit einem Lanthanbromid (LaBr) Detektor gemessen. Für die Pulsdatenklassifikation wird auf der Basis des Algorithmus und der erfassten Datensätze, ein neuronales Netzwerk erstellt, trainiert und validiert. Um bei diesen Schritten etablierte Machine Learning Frameworks zu verwenden, wird für die Portierung des Netzwerks in eine High-Level Synthese (HLS) Sprache die Software hls4ml verwendet. Dabei werden verschiedene Konfigurationen genutzt, um unterschiedlich optimierte Implementierungen zu generieren. Zum Evaluieren erfolgt die Ausführung der Implementierungen auf einer Xilinx Alveo Accelerator Card.

AKPIK 10.3 Thu 14:30 HSZ/0103

Pattern recognition using machine learning for the mCBM mRICH detector — •Martin Beyer for the CBM-Collaboration — Justus-Liebig-Universität Gießen

The Compressed Baryonic Matter experiment (CBM) is designed to explore the QCD phase diagram at high baryon densities using high-energy heavy ion collisions at high interaction rates. The Ring Imaging Cherenkov detector (RICH) contributes to the overall particle identification by reconstruction of rings from electrons with their respective radius, position and time. The miniCBM (mCBM) detector is the test setup for the CBM experiment, with the purpose of testing both hardware and software including the triggerless free-streaming data acquisition and data reconstruction algorithms. The miniRICH (mRICH) detector in the mCBM setup is a proximity focussing RICH detector with a photon detection plane consisting of 36 MultiAnode Photo Multipliers (MAPMTs). This setup results in charged particles passing directly through the MAPMTs resulting in quite some additional signals typically inside ring structures and reducing the overall ring finding efficiency based on the Hough Transformation.

In this talk a machine learning approach is presented to classify those signals in ring centers and thus improving the overall ring finding efficiency and precision.

AKPIK 10.4 Thu 14:45 HSZ/0103

Machine Learning Algorithms for Pattern Recognition with the PANDA Barrel DIRC — •Yannic Wolf[1,2], Roman Dzhygadlo[1], Klaus Peters[1,2], Georg Schepers[1], Carsten Schwarz[1], and Jochen Schwiening[1] — [1]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt — [2]Goethe-Universität Frankfurt

Precise and fast hadronic particle identification (PID) is crucial to reach the physics goals of the PANDA detector at FAIR. The Barrel DIRC (Detection of Internally Reflected Cherenkov light) is a key detector for the identification of charged hadrons in PANDA. Several reconstruction algorithms have been developed to extract the PID information from the measured location and arrival time of the Cherenkov photons. In comparison to other Ring Imaging Cherenkov detectors, the hit patterns observed with DIRC counters do not appear as rings on the photosensor plane but as complex, disjoint 3D-patterns.

Using the recent advances in machine learning (ML) algorithms, especially in the area of image recognition, we plan to develop new ML PID algorithms for the PANDA Barrel DIRC and compare the results to conventional reconstruction methods. In search for the best performance, different network architectures are currently under investigation.

AKPIK 10.5 Thu 15:00 HSZ/0103

Optimization of the specific energy loss measurement for the upgraded ALICE TPC using machine learning — •Tuba Gündem for the ALICE Germany-Collaboration — Institut fuer Kernphysik, Frankfurt, Germany

The Time Projection Chamber (TPC) is the primary detector used in the ALICE experiment for tracking and particle identification (PID). PID is accomplished by reconstructing the momentum and the specific energy loss ($\mathrm{d}E/\mathrm{d}x$) of a particle. The $\mathrm{d}E/\mathrm{d}x$ for a given track is calculated using a truncated mean on the charge signals associated to the track. The readout plane, on which the signals are measured, is radially subdivided into four regions with different pad sizes. Since the measured signals depend on the pad size, an optimization of the $\mathrm{d}E/\mathrm{d}x$ calculation based on the pad size can be performed.

In this talk, a method for optimizing the $\mathrm{d}E/\mathrm{d}x$ calculation using machine learning (ML) algorithms will be presented. By performing realistic simulations of the generated signals on the pads, various effects such as the different pad sizes and track geometry are modeled. These simulations are used as inputs for the training of the ML model and are investigated using RootInteractive.

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AKPIK 10.6 Thu 15:15 HSZ/0103

Deep Leaning Based PID with the HADES detector — •Waleed Esmail[1] and James Ritman[1,2,3] for the HADES-Collaboration — [1]GSI Helmholtzzentrum für Schwerionenforschung GmbH, 64291 Darmstadt, Germany — [2]Forschungszentrum Jülich, 52428 Jülich, Germany — [3]Ruhr-Universität Bochum, 44801 Bochum, Germany

The main purpose of a particle identification (PID) algorithm is to provide a clean sample of particle species needed to conduct a physics analysis. The conventional approach used in the HADES experiment is to apply the so-called "graphical cuts" around the theoretical Bethe-Bloch curves of the energy loss as a function of the particle momentum. However, this approach is not optimal, since the distributions resulting from the different particle species overlap. A better approach is based on deep learning algorithms. In our preliminary studies done with the p(4.5 GeV)+p data recently collected by HADES, we were able to improve the separation power of the particle species. The algorithm is based on Domain Adversarial Neural Networks (DANN) trained in a semi-supervised way to simultaneously look at simulated and real data to learn the discrepancies between the two data domains. In this talk we will present our preliminary results, which show that this technique significantly improves the classification of particle species in the experimental data.