AKPIK 2: Data Analytics & Machine Learning

Time: Wednesday 16:15–18:30 Location: AKPIK-H13

AKPIK 2.1 Wed 16:15 AKPIK-H13

Interpolation of Instrument Response Functions for the Cherenkov Telescope Array — •Rune Michael Dominik and Maximilian Nöthe for the CTA-Collaboration — Astroparticle Physics WG Elsässer, TU Dortmund University, Germany

In very-high-energy gamma-ray astronomy, the Instrument Response Function (IRF) relates the observed and reconstructed properties to the original properties of the primary particles. The IRFs are usually factored into multiple components, namely the Effective Area, the Energy Dispersion and the Point Spread Function that are needed for the proper reconstruction of spectral and spacial information. These quantities are derived from Monte Carlo Simulations but depend on observation conditions like telescope pointing direction or atmospheric transparency. Producing a complete IRF for every observation taken is a time consuming task and not feasible on the short timescales needed to release e.g. an alert for a transient event. In consequence, IRFs are typically produced at fixed combinations of observation conditions. To derive the optimal IRFs for a given observation, interpolation techniques are investigated. This talk will summarize interpolation strategies that are being tested for the Cherenkov Telescope Array IRFs.

AKPIK 2.2 Wed 16:30 AKPIK-H13

Investigating the Potential Application of Neural Networks for Data Denoising at the Einstein Telescope — •David Bertram, Markus Bachlechner, and Achim Stahl — III. Physikalisches Institut B, RWTH Aachen

The Einstein Telescope is a proposed third-generation gravitational wave detector aiming to improve the sensitivity over the whole frequency band compared to the previous generation. For this purpose solely hardware improvements could turn out to be insufficient and novel data processing techniques are crucial. A promising idea for the latter is the implementation of neural networks that can operate on potential irregularly structured additional inputs like seismic sensors. This talk investigates the potential of such techniques in terms of data denoising.

AKPIK 2.3 Wed 16:45 AKPIK-H13

Anomaly detection for Belle II PXD cluster data — •Stephanie Käs, Jens Sören Lange, Johannes Bilk, and Timo Schellhaas — Justus-Liebig-Universität Gießen

The Belle II pixeldetector (PXD) has a trigger rate of up to 30 kHz for 8 M pixels. Highly ionizing particles such as antideuterons, pions with small transverse momenta <100 MeV ("slow pions"), magnetic monopoles or stable tetraquarks generate characteristic clusters in the PXD. A large fraction of those does not reach outer detectors and therefore does not generate reconstructable tracks. We study their identification based exclusively on the PXD data, by means of anomaly detection algorithms. In this presentation, we show results from multivariate statistics analysis and tree-based multiclassifiers. In a first step, principal component analysis, linear discriminant analysis, t-distributed stochastic neighbor embedding and random forests are used for each anomaly to investigate the separability of signal and background. In a second step, a multiclassifier system shall be used. The design and output of this approach will be presented, including results on accuracy and sensitivity as well as a comparison to other methods such as Convolutional Neural Networks and Support Vector Machines.

AKPIK 2.4 Wed 17:00 AKPIK-H13

Fast simulation of the HGCAL using generative models — soham bhattacharya[1], samuel bein[2], engin eren[1], frank gaede[1], gregor kasieczka[2], •william korcari[2], dirk kruecker[1], peter mckeown[1], and moritz scham[1] — [1]DESY — [2]Universität Hamburg

Accurate simulation of the interaction of particles with the detector materials is of utmost importance for the success of modern particle physics. Software libraries like GEANT4 are tools that already allow the modeling of physical processes inside detectors with high precision. The downside of this method is its computational cost in terms of time. Recent developments in generative machine learning models seem to provide a promising alternative for faster and accurate simulations to accelerate this process. For the challenges of the High Luminosity phase of the LHC, CMS will deploy the High Granularity Calorimeter (HGCal), an imaging calorimeter for the endcap region with a high cell density, and irregular geometry. In this talk, we will show the taken steps in the development of a GraphGAN for the simulation of particle showers in the HGCal and the first achieved results.

AKPIK 2.5 Wed 17:15 AKPIK-H13

Ephemeral Learning - Augmenting Triggers with online-trained normalizing flows — •Sascha Diefenbacher — Institut für Experimentalphysik, Universität Hamburg, Germany

The high collision rates at the Large Hadron Collider (LHC) make it impossible to store every single observed interaction. For this reason, only a small subset that passes so-called triggers – which select potentially interesting events – are saved while the remainder is discarded. This makes it difficult to perform searches in regions that are usually ignored by trigger setups, for example at low energies. However a sufficiently efficient data compression method could help these searches by storing information about more events than can be saved offline. We investigate the use of a generative machine learning model (specifically a normalizing flow) for the purpose of this compression. The model is trained to learn the underlying data structure of collisions events in an online setting, meaning we can never have a repeated look at past data. After the training the underlying distribution encoded into the network parameters can be analyzed and, for example, probed for anomalies. We initially demonstrate this method for a simple bump hunt, showing that the online trained flow model can recover sensitivity compared to a classical trigger setup. We then extend this demonstration to more complex examples using the LHC Olympics Anomaly Detection Challenge dataset.

AKPIK 2.6 Wed 17:30 AKPIK-H13

Simulation of High-Granularity Calorimeter Showers for the ILD Using Normalizing Flows — •Imahn Shekhzadeh — Universität Hamburg, Hamburg, Deutschland

The large computational cost of Monte Carlo simulations together with recent advances in deep learning motivate using deep generative models to speed up simulations. This talk explores the use of normalizing flows (NFs) for high-granularity calorimeter simulations, such as the ones planned for the International Large Detector (ILD). We show that NFs are able to generate high-fidelity showers of simulated photons in the electromagnetic calorimeter of the ILD. Strictly monotonic rational quadratic spline flows are used to enhance the fidelity in comparison to the generally used affine-linear transformations. Finally, we compare the generative performance of the NFs to other state-of-the-art generative network architectures

AKPIK 2.7 Wed 17:45 AKPIK-H13

Identifying Slow Pions using Support Vector Machines — •Timo Schellhaas[1], Jens Sören Lange[2], and Stephanie Käs[3] — [1]II. Physikalisches Institut, JLU Gießen, Germany — [2]II. Physikalisches Institut, JLU Gießen, Germany — [3]II. Physikalisches Institut, JLU Gießen, Germany

Finding new physics beyond the standard model is of highest interest. Pions with a low transversal momentum (slow pions) are linked to interesting decay scenarios and are therefore studied at the Belle II experiment. However, it is dificult to detect slow pions due to their low momenta: a large amount of them does only reach the Belle II pixeldetector (PXD), but not the outer detectors (e.g. the drift chamber). In order to improve the detection rate it is suggested to use a machine learning model. One possible model is the support vector machine (SVM) algorithm. Therefore a simulated data set is used to train the SVM model with different parameters, including a modified kernel, with the goal of reaching better results than other models.

AKPIK 2.8 Wed 18:00 AKPIK-H13

Deep Learning Accelerated Maximum Likelihood Reconstruction of IACT Events — •Noah Biederbeck and Maximilian Nöthe for the CTA Consortium — Astroparticle Physics WG Elsässer, TU Dortmund University, Germany

The Cherenkov Telescope Array will be the next generation ground-based gamma-ray observatory, consisting of tens of Imaging Atmospheric Cherenkov Telescopes (IACTs) at two sites once its construction is finished.

In this talk we present a deep learning accelerated maximum likelihood reconstruction of gamma-ray events. A generative neural network predicts IACT camera images from a set of physical event parameters. These generated images are then compared to Monte Carlo simulated event images using a Poissonian likelihood loss in order to reconstruct the event properties, e.g. the energy of the primary particle and its direction.

First results on simulated single-telescope events will be presented and extensions to predictions of array events will be outlined.

AKPIK 2.9 Wed 18:15 AKPIK-H13

Adding Errors to the Quantum Circuit Model — •Tom Weber[1], Matthias Riebisch[1], Kerstin Borras[2,4], Karl Jansen[3], and Dirk Krücker[2] — [1]Universität Hamburg, Hamburg, Germany — [2]Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany — [3]Deutsches Elektronen-Synchrotron DESY, Zeuthen, Germany — [4]RWTH Aachen University, Aachen, Germany

The full potential of quantum computers cannot yet be realised because existing quantum hardware is still error-prone. It is essential to understand the impact of these errors on calculations to counteract them with methods like quantum error mitigation. Models can provide this understanding of the complexity of quantum noise. In addition, they can be a tool for communication between different quantum computing stakeholders who do not necessarily have an education in physics. While the quantum circuit model is commonly used to model gate-based quantum computation, errors are modelled mathematically by quantum operations on density operators. However, the quantum circuit model is restricted to the description of error-free processes. On the other hand, mathematical models are difficult to understand without a background in theoretical physics. Therefore, we present a way to couple both models, combining the comprehensibility of the quantum circuit model with the mathematical models' ability to represent quantum noise accurately.