AKPIK 3: Machine-learning methods and computing in astroparticle physics

Zeit: Mittwoch 16:00–17:50 Raum: H06

AKPIK 3.1 Mi 16:00 H06

Exploring Optical Properties of Antarctic Ice with IceCube Using Gradient Descent — •Alexander Harnisch for the IceCube-Collaboration — TU Dortmund

The IceCube Neutrino Observatory detects Cherenkov photons emitted by charged particles passing through the antarctic ice. The properties of light propagation in and around the detector must be well understood to be able to learn about the interacting particles and their sources. This talk gives an overview of how to use in-situ light sources to derive ice model parameters by performing gradient descent optimization instead of grid searches. To be able to do so, it is necessary to differentiate the photon propagation simulation. Here we present a working method to differentiate the simulation with respect to absorption coefficients. The derived gradient is fed to an optimizer which performs gradient descent optimization to find the best fitting coefficients.

AKPIK 3.2 Mi 16:10 H06

Possible ways to improve the DeepCore NMO analysis — •Jan Weldert and Sebastian Böser for the IceCube-Collaboration — JGU, Mainz, Germany

The neutrino mass ordering (NMO) is one of the driving questions in the field of neutrino physics. The NMO sensitivity potential of atmospheric neutrino detectors like the IceCube low energy extension DeepCore is limited by the achievable resolutions.
Two of the most promising ways to increase the DeepCore NMO sensitivity are:

1) Relaxing the background cuts to increase the number of events considered in the analysis

2) A better classification of the different event types (current track-like and cascade-like events).

While improvements in both of these are likely computationally expensive, the analysis of future detectors/detector upgrades will also benefit from advances made for current detectors.
This talk will discuss the potential of these improvements and possible ways to realize them, especially focusing on the application of neural networks to classify low energetic DeepCore events.

AKPIK 3.3 Mi 16:20 H06

Using ANNs to Find Anomalies in Waveforms Detected by IceCube — •Max Pernklau for the IceCube-Collaboration — Lehrstuhl für Experimentelle Physik Vb, TU Dortmund, Germany

Modern particle detectors such as the IceCube Neutrino Observatory produce large amounts of data. Almost all events detected are background events, so stringent cuts are made to ensure a usable signal-to-noise ratio. That means only phenomena which are actively searched for can be discovered, since events that cannot be properly reconstructed are removed from the analysis.

This talk deals with the viability of using artificial neural networks to search for anomalies in low-level waveform data produced by photomultiplier tubes. Unsupervised learners like Autoencoders are employed to detect unusual waveforms caused by e.g. double pulses or hardware artifacts. This approach seems promising as prior knowledge about the shape of the outlier waveforms is not required. Results might lead to a better understanding of possible detector artifacts.

AKPIK 3.4 Mi 16:30 H06

Determination of Antarctic Ice Parameters Using a Neural Network — •Sebastian Bange, Mirco Hünnefeld, and Alexander Harnisch for the IceCube-Collaboration — TU Dortmund, Dortmund, Deutschland

The IceCube Neutrino Observatory uses digital optical modules to detect Cherenkov photons emitted by particles on their way through the detector. They use the available antarctic ice as a medium for the particles to react in. It naturally shows depth dependent und a priori unknown effects on how it changes the path of the photons. This talk gives an overview on how to use a neural network to obtain the scattering coefficients for the currently used ice model. This works approach is to approximate the waveform of the detected photons by inputting the scattering coefficients. The network can then be reversed to obtain the scattering coefficients belonging to one specific waveform.

AKPIK 3.5 Mi 16:40 H06

Search for new Source Populations with Autoencoding Neural Networks — •Simone Mender, Tobias Hoinka, and Kevin Schmidt — TU Dortmund

Active Galactic Nuclei (AGN) are astrophysical objects, whose emission range covers the entire electromagnetic spectrum. Based on the observations in different wavelengths, various source catalogs were published. In these catalogs, lots of unclassified sources are included. For example, the Fermi-LAT third source catalog (3FGL) contains 1010 unassociated sources.

In order to classify these sources, machine learning methods can be applied. With the use of supervised learning, it is possible to enlarge well-known source populations. To find new populations, unsupervised learning is a promising approach. Unknown source populations are expected to feature different characteristics compared to well-known populations. For outlier detection, an autoencoding neural network is a useful unsupervised machine learning technique. In this talk, we present our results of the application of autoencoding neural networks to gamma-ray and radio datasets.

AKPIK 3.6 Mi 16:50 H06

Cascade Reconstruction in IceCube using Generative Neural Networks — •Mirco Huennefeld, Tobias Hoinka, Jan Soedingrekso, Sebastian Bange, and Alexander Harnisch for the IceCube-Collaboration — TU Dortmund, Dortmund, Deutschland

Reliable and accurate reconstruction methods are vital to the success of high-energy physics experiments such as IceCube. Machine learning based techniques, in particular deep neural networks, can provide a viable alternative to maximum-likelihood methods. Most common neural network architectures originate from non-physical domains such as image recognition. While these methods can enhance the reconstruction performance in IceCube, there is much potential for tailored techniques. In the typical physics use-case, many symmetries, invariances and prior knowledge exist in the data, which are yet to be exploited by current network architectures. Novel and specialized deep learning-based reconstruction techniques are desired which can leverage the physics potential of experiments like IceCube. A new approach using generative neural networks for the reconstruction of cascade-like events in IceCube is presented.

AKPIK 3.7 Mi 17:00 H06

Towards online triggering for the radio detection of air showers using deep neural networks — •Florian Führer[1,2] and Anne Zilles[1] — [1]Institut d'Astrophysique de Paris — [2]Institut Lagrange de Paris

The future Giant Radio Array for Neutrino Detection (GRAND) is designed as a huge standalone radio array to detect UHE neutrinos.

The detection of air-shower events induced by high-energetic particles via the emitted radio signals only requires the development of a trigger algorithm for a clean discrimination between signal and background events.

In this contribution we will describe an approach to trigger air-shower events on a single-antenna level as well as performing an online reconstruction of the shower parameters using neural networks. If time permits we will outline strategies to compress and hence speed-up the evaluation of neural networks, hence allowing to apply neural network based triggers in real-time.

AKPIK 3.8 Mi 17:10 H06

German-Russian Astroparticle Data Life Cycle Initiative — •Victoria Tokareva for the KRAD/APPDS-Collaboration — Institut für Kernphysik, Karlsruher Institut für Technologie, DE-76021 Karlsruhe, Germany

Data life cycle (DLC) is a high-level data processing pipeline that involves data acquisition, event reconstruction, data analysis, publication, archiving, and sharing. While such approach to data management is widespread in HEP experiments, such as CMS, ALICE, COMPASS, Belle-2, LHCb, etc., it is still not the case for the astroparticle physics community, and no conventional approach has been developed for that purpose yet.

According to Astroparticle Physics European Consortium, the joint data rate for modern astroparticle experiments is comparable to the one for the LHC, and tends to grow significantly in the nearest future. Meanwhile, the studies of rare phenomena in the approach of multi-messenger astronomy make it crucial to develop field-specific solutions for the joint analysis of data.

The German-Russian Astroparticle Data Life Cycle Initiative is a joint project aiming at the development of a concept and creation of a DLC prototype that takes into account the data processing features specific for the astroparticle physics.

The work was financially supported by Russian Science Foundation Grant 18-41-06003 (Sections 2 and 3) and Helmholtz Society Grant HRSF-0027.

AKPIK 3.9 Mi 17:20 H06

Benchmarking of compute resources — •Benoit Roland, Felix Buehrer, Anton Gamel, and Markus Schumacher — Albert Ludwigs Universitaet Freiburg, Freiburg, Germany

The high luminosity phase of the LHC will be accompanied by a considerable increase in the need of compute resources and storage. In addition to dedicated GRID-sites, opportunistic resources can be used to fulfill the increasing requirements. These resources are heteroge- neous and their rapid classification is useful for an efficient utilization. The use of fast benchmarks as representative of CPU workload for GRID activity is presented within this context, with the aim to provide site monitoring and prompt matching between workload and available compute resources. The performance of several fast benchmarks have been studied and compared to the one of the legacy HEP-SPEC06 suite. The results have been obtained for different system configura- tions, with a particular focus on the behavior of the benchmarks when hyperthreading is active and their performance loss when virtualiza- tion is used.

AKPIK 3.10 Mi 17:30 H06

Highly parallel CORSIKA processing — •Dominik Baack — TU Dortmund, Dortmund, Germany

The increasing amount of simulation necessary for an effective analysis in the high energy regime requires new approaches for the optimization of the existing simulation software like CORSIKA.

The dominating factor for the simulations including Cherenkov photons is the creation and propagation of those. With more than half of the overall runtime and billions of executions for each shower this part benefits heavily from any possible optimization. The approach taken for the acceleration of this part is the parallel implementation in OpenCL. This can be used on CPU or even faster on specialized hardware like GPUs.

The second approach focuses on the distribution of a single simulation over multiple independent nodes over the network with the ZeroMQ library. This allows the parallel work of multiple nodes of different architecture on a single shower or the control of multiple independent showers via a single control instance. Optimization focusing on low power usage allows the distribution over hundreds of low power ARM cores via a central computing node.

The methods used and first results of different experiments done will be shown.

AKPIK 3.11 Mi 17:40 H06

Resistive Plate Chamber (RPC) tests as muon detector — •Victor Barbosa Martins[1], Vitor de Souza[2], Luis Lopes[3], and Sofia Andringa[4] — [1]IFSC- USP, São Carlos, Brasilien, now at DESY, Zeuthen, Deutschland — [2]IFSC - USP, São Carlos, Brasilien — [3]LIP, Coimbra, Portugal — [4]LIP, Lissabon, Portugal

Cosmic rays are the most energetic particles in the universe. Their production, propagation, and detection are objects of numerous studies. Surface detectors aim to identify particles from extensive air showers (EAS), which are the result of cosmic rays interacting with the atmosphere. Resistive Plate Chambers (RPCs) have shown to be a suitable muon detector to be integrated into the Pierre Auger Observatory. Data from RPCs by the Pierre Auger Collaboration in Coimbra (POR) were analyzed. The detector efficiency to muons was calculated and is approximately 88%, which is in good agreement with the values quoted in the literature. Direction maps were built to investigate the muon incoming direction and the quantity of matter traversed by the muons. The dependence of the muon flux on the zenith angle was calculated and compared with results from simulations. A square cosine dependence is expected, though it is seen that the building structure has enough matter to block some of the incident muons and alter the dependence curve. The total muon flux was estimated based on the detector efficiencies and solid angle and then compared with the literature. The results show an absorption by the building of approximately 77% of the incident muons.