AKPIK 4: AKPIK III: Simulation & Application

Time: Thursday 16:00–18:15 Location: AKPIKa

AKPIK 4.1 Thu 16:00 AKPIKa

Deep Learning for Accelerating High Energy Physics Simulations — •Florian Rehm[1,2], Sofia Vallecorsa[1], Kerstin Borras[2,3], and Dirk Krücker[3] — [1]CERN (Switzerland) — [2]RWTH Aachen University (Germany) — [3]DESY (Germany)

In particle physics the simulation of particles transport through detectors require an enormous amount of computational resources. This motivated the investigation of different, faster approaches, to replace the standard Monte Carlo. We use Generative Adversarial Networks to simulate electromagnetic calorimeter responses and decrease the simulation time by orders of magnitudes while keeping the necessary level of accuracy. The standard approach for generating 3D images uses 3D convolutional layers, however, 3D convolutional networks are demanding in terms of computational resources and memory. We present a novel architecture using 2D convolutional layers for representing the 3D images which reaches a higher accuracy and reduces the computational time by a factor of 3. We further reduce the inference time by quantizing the neural network parameters to a lower precision using the novel Intel low precision optimization tool (iLoT). Performance benchmarks on Intel Xeon processors yield a 1.73x speed-up. Particle simulations follow the rules of quantum field theory. Therefore, it is reasonable to explore the potential of quantum computers for these simulations. However, today's quantum computers are by far not capable to solve such complicated tasks. Hence, the further planned initial investigations employ simplified models to study the performance of quantum computers.

AKPIK 4.2 Thu 16:15 AKPIKa

Fast simulation and validation of the Time of Propagation detector at Belle II — •Isabel Haide[1], James Kahn[1], Alex Hagen[2], Jan Strube[2], Shane Jackson[2], Connor Hainje[2], and Pablo Goldenzweig[1] — [1]Karlsruher Institut für Technologie — [2]Pacific Northwest National Laboratory

The Geant4 based simulation of Cherenkov photons in the time-of-propagation (TOP) detector at the Belle II experiment is currently the largest contributor to the total event simulation time. Replacing conventional simulations with neural network solutions, also called generative models, for a reduced simulation time is being actively researched in most fields of particle physics.

This work investigates the replacement of the current Geant4 based TOP simulation with a generative model. Such generative models have to be validated against the system in place in order to verify when a solution is ready for production use. The goal of this work is to design an evaluation framework that determines the agreement between a neural network and the conventionally simulated output with a target towards generalization for other detectors.

This talk shows the current status of this evaluation framework for generative models for the TOP detector at Belle II. In the context of this framework, a new high dimensional Kolmogorov-Smirnov metric for probability distributions is presented.

AKPIK 4.3 Thu 16:30 AKPIKa

GPU Accelerated IACT/Fluorescence Simulation in Atmosphere — •Dominik Baack for the CORSIKA 8-Collaboration — TU Dortmund, Dortmund, Germany

As several new or upgraded cosmic ray experiments are starting in the very near future, the need for high-quality simulation will increase equally. In addition, the CORSIKA 7 Fortran codebase is being completely rewritten to a "state of the art" C++ simulation framework, this will allow the use of new techniques and modifications that were not possible in previous versions.

One of the biggest runtime consumers in the classic simulation, over 80 percent, is the propagation of optical photons, chernekov and fluorescence, through the atmosphere. With the wider availability of GPUs and other parallel accelerators in computing clusters, the runtime of this specific workload can be reduced significantly. With the application of early cuts optimized by machine learning and specific hardware tailored for parallel execution, such as GPUs, the runtime can be greatly reduced.

AKPIK 4.4 Thu 16:45 AKPIKa

The Julia programming language in Particle Physics — •Tamas Gal for the KM3NeT-Collaboration — University of Erlangen-Nuremberg, Erlangen, Germany — Erlangen Centre for Astroparticle Physics, Erlangen, Germany

There has been a shift of programming languages in the scientific context over the past two decades: Fortran and C/C++ being less and less popular while high-level languages like Python, R and Matlab gaining great attraction. However, they all suffer under the two-language problem, meaning that performance critical code – especially in Python – needs to be implemented in low level languages. Julia is a modern, scientific programming language which provides Python-like syntax and C performance and is designed for parallelism and distributed computation. This talk is a short introduction to the language, shows how Julia is utilised in the KM3NeT detector monitoring and live event reconstruction and features a few packages related to particle physics and scientific workflows in general.

AKPIK 4.5 Thu 17:00 AKPIKa

How normalizing flows generalize the Gaussian distribution — •Thorsten Glüsenkamp — FAU Nürnberg, Erlangen, Germany

Normalizing-flows, flexible continuous probability distributions, are emerging in many machine-learning applications. We discuss how they can be described as generalizations of Multivariate Normal distributions and how this might guide us for the choice of which flow to use.

AKPIK 4.6 Thu 17:15 AKPIKa

Error Mitigation Methods in Quantum Computing — •Tom Weber[1], Matthias Riebisch[1], Kerstin Borras[2], Karl Jansen[2], and Dirk Krücker[2] — [1]University of Hamburg (Germany) — [2]DESY (Germany)

There is a variety of problems or applications in which we expect quantum computers to outperform their classical counterparts in the future. However, as of today quantum devices are prone to high error rates and we therefore need to be able to deal with noise. Due to the relatively small qubit numbers presently available we cannot use full correction procedures, but instead are rather left with minimising the effects of errors on computational results with other techniques, known as quantum error mitigation.

During the execution of a quantum circuit on a quantum device, noise can occur at every stage. The preparation of the initial state, its further manipulation as well as the final measurement are all affected by errors. We present possible ideas to model different types of noise and explain ways to mitigate them. Moreover, we test those ideas in the context of variational quantum eigensolvers, which form a typical algorithm for quantum computers. The different approaches differ in effectiveness, flexibility and computational effort. To make quantum computing usable in the near future, we are working to develop mitigation methods which combine all these benefits.

AKPIK 4.7 Thu 17:30 AKPIKa

Classification of spin qubit detection events with neural networks — •Tom Struck[1], Javed Lindner[1], Arne Hollmann[1], Lars R. Schreiber[1], Floyd Schauer[2], Andreas Schmidbauer[2], and Dominique Bougeard[2] — [1]JARA-Fit Institute for Quantum Information, Forschungszentrum Jülich GmbH and RWTH Aachen University, Aachen, Germany — [2]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, Regensburg Germany

Fast and accurate detection of a qubit state is essential for quantum information processing, in particular for quantum error correction. Here, we detect the state of a single electron spin, localized in a Si/SiGe quantum dot, in a single shot measurement using a single-electron transistor [1]. We investigate the capability of a neural network to classify the experimental signal traces into spin-up and -down events [2] and compare the network performance to a state-of-the-art Bayesian inference filter, which is theoretically optimal for signals with Gaussian noise. We find that the neural network can outperform the Bayesian filter on experimentally recorded data. The network can be made robust to setup-variations by training with proper synthetic traces.

[1] T. Struck et al., npj Quantum Inf. 6, 40 (2020).
[2] T. Struck et al., arXiv:2012.04686 (2020).

AKPIK 4.8 Thu 17:45 AKPIKa

Deep Continuum Suppression with Predictive Uncertainties

— •Lars Sowa, James Kahn, and Pablo Goldenzeig — Karlsruhe Institute of Technology (KIT)

The Belle II collaboration works on precision measurements using data collected from the SuperKEKB collider. This requires a high purity of signal candidates, therefore it is necessary to suppress $e^+e^- \to \bar{q}q$ $(q = u, d, c, s)$ continuum events effectively. To do so, the Belle II analysis framework uses traditional machine learning methods. In recent years, deep learning techniques have shown to be very powerful, outperforming these traditional methods in many fields of research. While deep learning techniques are promising for continuum suppression, an ongoing problem is that they traditionally don*t provide meaningful uncertainties to their predictions, a key requirement for physics analyses.

Recent work has shown that deep ensemble methods solve this problem by providing a measure of prediction uncertainty making them a promising candidate for use in continuum suppression. This talk presents the current status of a study into deep ensemble continuum suppression with predictive uncertainty estimation for the Belle II experiment. Additionally, a decorrelation mechanism to prevent biasing features of interest is presented.

AKPIK 4.9 Thu 18:00 AKPIKa

Identification of exotic highly ionising particles at the Belle II pixel detector using unsupervised autoencoders — Jens Sören Lange, Stephanie Käs, and •Katharina Dort — Justus Liebig University Giessen, Giessen, Germany

The Belle II experiment at the high luminosity SuperKEKB e+e- collider has started operation in 2018. The present setup features a 1-layer DEPFET pixel detector with 4 M pixels and trigger rates up to 5 kHz, installed in close proximity to the interaction region. It offers the unique opportunity of detecting highly ionising particles such as antideuterons, pions with small transverse momentum $<$ 100 MeV or exotic particle species like magnetic monopoles with a very short track length. Multivariate techniques are attractive tools to cope with the identification of these particles against the high beam background rates. In this contribution, we evaluate the performance of unsupervised autoencoders, in order to discriminate signal from beam background. In particular, we investigate the possibility of performing the training directly on background data, an unbiased approach to (a) avoid theoretical assumptions about the nature of signal and (b) avoid supervised training with Monte-Carlo data.