T 21: Data analysis, Information technology I

Time: Monday 16:00–18:15 Location: Tu

T 21.1 Mon 16:00 Tu

Anomaly searches for new physics based on generative classifiers — •Sven Bollweg and Gregor Kasieczka — Universität Hamburg, Germany

There exist strong hints for the existence of physics beyond the standard model (BSM). Many models for BSM physics have been investigated but none of these could be observed in data so far. Another strategy are model-independent searches. The idea is that events originating from BSM processes differ from events originating from SM processes. Without applying any knowledge of possible BSM processes, it can be used to search for anomalous events.

To search for anomalies, we use a generative classifier (GC) based on invertible neural networks. A GC learns the likelihood of the input data. The likelihood can be used either for classification or anomaly detection. In the ideal case, anomalous events are less likely than all the other events if we train the GC on SM events. We show a first attempt to apply this method in the context of searching for new physics with the CMS experiment in the dijet final state. We investigate different input representations and anomaly scores based on the likelihood.

T 21.2 Mon 16:15 Tu

Searching for new physics with anomaly detection — •Manuel Sommerhalder[1], Tobias Lösche[1], Gregor Kasieczka[1], David Shih[2], and Anna Hallin[2] — [1]Universität Hamburg — [2]Rutgers University

Most analyses looking for new physics, such as beyond Standard Model searches at the LHC, rely on a specific signal hypothesis for selecting relevant data points. However, recently there is an increased interest in developing model-independent selection criteria with the aim of generically gaining sensitivity to unthought-of phenomena. A potential solution to this problem lies in anomaly detection, which consists of various techniques that quantify how anomalous each data point (or group of data points) is with respect to the entire data set, thus yielding an additional measure to identify signal candidates.

We present our recent developments in using anomaly detection to search for new physics via the concrete example of resonance searches at the LHC. The primary focus is our application of Anomaly Detection with Density Estimation (ANODE) using normalizing flows. Building up on the previous state-of-the-art performance achieved by ANODE, we highlight further advancements to improve its performance and useability.

T 21.3 Mon 16:30 Tu

Utilization of GPUs in the training of neural networks — Günter Quast, Roger Wolf, Janek Bechtel, Sebastian Brommer, Rene Caspart, Ralf Schmieder, Felix Heyen, Gessi Risto, Andrew Issac, and •Tim Voigtländer — Karlsruher Institut für Technologie, Karlsruhe, Deutschland

Machine learning has become a commonly used technique in recent particle physics analyses. As machine learning algorithms become more refined and the neural networks used in recent analyses have become more complex, the usage of specialized computing resources needs to be explored, in order to ensure a reasonable turnaround cycle, especially for the training of the networks. In this talk the utilization of a cluster of GPUs used to accelerate the training process is shown by the example of the multilayer neural networks used in the CMS Higgs $\to \tau\tau$ analysis.

T 21.4 Mon 16:45 Tu

Improved energy resolution via super-resolution — Johannes Erdmann, Florian Mentzel, Olaf Nackenhorst, and •Aaron van der Graaf — TU Dortmund, Experimentelle Physik IV

In high energy particle physics, detectors with a good energy resolution are essential for the precision of measurements. One possibility to improve the energy resolution are detector upgrades. Another approach is to artificially enhance the energy resolution by using super-resolution (SR) algorithms. SR algorithms learn to upscale low resolution data to high resolution data. The SR algorithms that are used in this work are based on generative adversarial networks (GANs). By training GANs with simulation-based high resolution and low resolution data, they have been shown to learn the complex correlations between low and high resolution data. After the training, GANs can then upscale the low resolution data. In this presentation, preliminary results are presented.

T 21.5 Mon 17:00 Tu

Decoding γ-showers: Physics in the Latent Space of a BIB-AE Generative Network — •Erik Buhmann — Institut für Experimentalphysik, Universität Hamburg

With future collider experiments' vast data collection capabilities and limited computing resources, interest in using generative neural networks for fast simulation of collider events is growing. In our previous study the Bounded Information Bottleneck Autoencoder (BIB-AE) showed state-of-the-art generation accuracy for photon showers in a high-granularity calorimeter, precisely modelling various global differential shower distributions. In this work we investigate how the BIB-AE encodes these physics information in the latent space for different model configurations. Our understanding of this latent space encoding allows us to propose methods to further optimize the generation performance of the BIB-AE model, namely specific hyperparameter optimization and an altered latent space sampling. In particular we were able to improve the modelling of the shower shape along the particle incident axis.

T 21.6 Mon 17:15 Tu

Hadronic Shower Separation in Five Dimensions using Machine Learning Methods — •Jack Rolph, Gregor Kasieczka, and Erika Garutti — Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Deutschland

Accurate clustering of hadronic energy depositions plays a critical role in the particle flow approach proposed for future linear colliders. The highly-granular CALICE Analogue Hadronic Calorimeter prototype (AHCAL), designed with this task in mind, is distinguishable due to its ability to measure the development of a hadron shower in time as well as space. The benefit of time as an additional observable to the clustering of the simulated energy depositions of a charged and 'faked' neutral hadron observed with the AHCAL was studied using several state-of-the-art neural network architectures. These neural networks were optimised using simulations of perfect and expected operating time resolutions. As a control, networks with the same architectures were also trained without time. The clustering performance of each network relative to the control was then assessed over a range of possible operating time resolutions. For all studied networks and resolutions, the improvement in energy resolution due to time was found to be minor to negligible using these existing methods.

T 21.7 Mon 17:30 Tu

Applications of Graph Neural Networks in Liquid Scintillator Neutrino Detectors — •Alexandros Tsagkarakis, Markus Bachlechner, Thilo Birkenfeld, Philipp Soldin, Achim Stahl, and Christopher Wiebusch — III. Physikalisches Institut B, RWTH Aachen University

In neutrino physics, liquid scintillator detectors like Double Chooz and JUNO are utilized to measure the elements of the Pontecorvo-Maki-Nakagawa-Sakata matrix or to determine the sign of the mass difference Δm^2_{31} of the neutrino mass hierarchy. The main channel for the detection of neutrinos is the Inverse Beta Decay with protons in the detector medium, resulting in a positron and a neutron. Those initiate a prompt signal from the positron and a delayed signal from the neutron. On the other hand electrons from various sources, such as the decay of 9Li and 8He atoms, produce similar signatures, which cause a significant amount of background and hence challenges to achieve the above goals. Therefore, we apply machine learning algorithms for energy and vertex reconstruction or direct electron-positron discrimination to reduce this background. The geometry of the experiments can be well mapped in a Graph Neural Network. In this talk, we present the implementation and the first results of the aforementioned tasks.

T 21.8 Mon 17:45 Tu

Online Event Selection using GPUs for the Mu3e experiment — •Valentin Henkys for the Mu3e-Collaboration — Johannes Gutenberg University Mainz

The Mu3e experiment searches for physics beyond the Standard Model using the lepton flavour violating decay $\mu^+ \rightarrow e^+e^-e^+$. Observing the decay products of $1 \cdot 10^8 \mu/s$ results in a data rate of 80Gbps. An online algorithm for graphics processing units (GPU) is presented, reducing the data rate with the Mu3e filter farm by a factor of over 100, to bring it below 100MBps. The filter farm consists of 12 PCs running this algorithm on one GPU each.

The algorithm is divided into three parts. The first step selects possible event candidates using simple and fast geometric selection criteria, reducing the candidates to under 2.5% of the initial set. These are then used in the second step, reconstructing the helical tracks of the electrons and positrons. Finally these tracks are used to reconstruct the event vertex. To fulfill the high performance requirements, fast geometric considerations are used instead of a full vertex fit.

The algorithm is able to reduce the data rate by a factor of over 100 while keeping 98% of the events found by the offline algorithm.

T 21.9 Mon 18:00 Tu

Muon Track Reconstruction in Liquid Scintillators with Graph Neural Networks — •Rosmarie Wirth — Hamburg University, Hamburg, Germany

Large liquid scintillation detectors are successfully used to observe the neutrino oscillation parameters by detecting reactor neutrinos. A main, hard to identify background are cosmogenics. These are ^{9}Li and ^{8}He atoms, which are produced in showers along cosmic muon tracks. While decaying the cosmogenics mimic the inverse β-decay, which is the detection process to identify reactor neutrinos. While muon vetos are a straight forward method to reduce this background, they create a lot of dead time. With the JUNO experiment 15.7 % reactor neutrino events are predicted to be missed, due to the muon veto. A superior muon track and shower reconstruction method, could improve the data taking of JUNO and comparable experiments tremendously. Classical and machine learning approaches are being developed for JUNO.

The here presented work studies the use of Graph Neural Networks to reconstruct muon tracks and corresponding showers. Graph Neural Networks provide the option to include the geometrical detector setup to improve the reconstruction. On TOY Monte Carlo Data showers in the detector volume could be located with an accuracy of $\pm 0.22 \pm 0.14$ m. Additionally results on a voxelwise photon emission distribution are presented.