T 33: Data, AI, Computing, Electronics III (ML in Jet Tagging, Misc.)

Time: Tuesday 16:15–17:45 Location: VG 2.101

T 33.1 Tue 16:15 VG 2.101

Representation Learning — •Niklas Meier — TUM, Munich, Germany

Large neutrino telescopes, such as IceCube or KM3NeT, are experiments that try to measure incident neutrinos in order to learn about their properties and origins. For the detection, these experiments employ large volumes of transparent media, along with photo-sensors, to measure the light produced by secondary processes of neutrino events.

In the pursuit of analyzing data from these large neutrino telescopes, one often runs into the problem of a high memory footprint, due to the length of representations of neutrino events. Approaches that try to circumvent this issue, e.g. by subsampling, were in the past shown to perform poorly on these long representations. Hence it is worth putting in the effort to develop a method to generate low memory representations of neutrino events.

The approach, that is presented here, regards each event as a graph, where each node corresponds to a detector response, and aims to learn assignments that map the graphs to ones with fewer nodes. Such an encoding network can be trained, e.g. in the context of an autoencoder, where a similar second network decodes back to the original graph size. Alternatively, in so called contrastive methods, the encoding network is applied twice, but with different augmentations to the data, and the learned representations are compared. In this presentation, I will show the principles of dense pooling methods in encoding networks and their performance in both frameworks.

T 33.2 Tue 16:30 VG 2.101

Aspen Open Jets: Unlocking LHC Data for Foundation Models in Particle Physics — Oz Amram[1], Luca Anzalone[2], •Joschka Birk[3], Darius A. Faroughy[4], Anna Hallin[3], Gregor Kasieczka[3], Michael Krämer[5], Ian Pang[4], Humberto Reyes-Gonzalez[5], and David Shih[4] — [1]Fermi National Accelerator Laboratory — [2]University of Bologna — [3]University of Hamburg — [4]Rutgers University — [5]RWTH Aachen University

A foundation model is a type of deep learning model that is pre-trained on a large dataset, enabling it to serve as a versatile base for being fine-tuned to various downstream tasks or other datasets. This study illustrates the utility of data gathered from the CMS experiment at the Large Hadron Collider in pre-training foundation models for High Energy Physics (HEP). We present the AspenOpenJets dataset, which comprises approximately 180 million high-p_{T} jets extracted from the CMS 2016 Open Data. Our findings include new studies conducted with the OmniJet-α foundation model, highlighting how pre-training on AspenOpenJets enhances performance on generative tasks that involve significant domain shifts, such as generating boosted top and QCD jets from the simulated JetClass dataset. Beyond showcasing the effectiveness of pre-training a jet-based foundation model using actual proton-proton collision data, we also offer the ML-ready AspenOpenJets dataset for public access and further research.

T 33.3 Tue 16:45 VG 2.101

LHCb's neural network-based beauty trigger: Insights from Run 3 — •Nicole Schulte[1], Johannes Albrecht[1], Gregory Max Ciezarek[2], Blaise Delaney[3], and Niklas Nolte[4] — [1]TU Dortmund University, Dortmund, Germany — [2]CERN, Geneva, Switzerland — [3]Massachusetts Institute of Technology, Cambridge, USA — [4]META AI (FAIR)

The quality of the LHCb beauty physics programme relies upon b-hadron selection algorithms, particularly topological b-hadron triggers. These triggers are optimized to identify b-hadron candidates by exploiting the distinctive decay topologies of b-hadrons and their characteristic kinematic properties. As the dominant contributor to the trigger selection bandwidth, topological triggers are essential for enabling a wide range of physics analyses at LHCb.

In Run 3, LHCb introduced a novel inclusive beauty trigger which incorporates Lipschitz monotonic neural networks to enhance robustness against fluctuating detector conditions and improve sensitivity to long-lived particle candidates.

This contribution presents the performance of the inclusive topological beauty trigger across diverse conditions during the 2024 data-taking period. We demonstrate the effectiveness of these topological triggers in maintaining stable performance under varying conditions and discuss the selection efficiency using well-understood decay modes. Additionally, we examine the advantages provided by the monotonicity constraints in the trigger design.

T 33.4 Tue 17:00 VG 2.101

Domain adaptation in the context of flavour tagging at the LHCb experiment — Johannes Albrecht[1,2], Mirko Bunse[2], and •Quentin Führing[1,2] — [1]TU Dortmund University, Dortmund, Germany — [2]Lamarr Institute for Machine Learning and Artificial Intelligence, Dortmund, Germany

Decay-time-dependent measurements of oscillating neutral B mesons at LHCb require information of the B-meson flavour at the time of its production. This information cannot be inferred from the decay products used for the reconstruction of signal candidates. Instead, multivariate algorithms are used to estimate the production flavour of B mesons, which exploit a variety of particles produced in association with the signal in the proton-proton interaction.

Simulation is often used to provide a labelled data sample for the training of these algorithms. However, known differences between simulation and recorded data are present, particularly in quantities significantly impacting the flavour tagging performance, such as the track multiplicity in fragmentation processes. As a consequence, the algorithms do not reach the same level of performance in data as in simulation.

We approach this mismatch between data and simulation with machine-learning techniques from the realm of domain adaptation. These methods prevent the multivariate algorithms from learning an implicit and undesired distinction between data and simulations. As a result, we expect improved performance on data. In this presentation, the idea and the status of the ongoing project is presented.

T 33.5 Tue 17:15 VG 2.101

Adversarial Studies on Jet-Flavor Tagging Machine Learning Algorithms using PAIReD Jets within the CMS Experiment — Alexander Jung[1], Spandan Mondal[2], Alexander Schmidt[1], Jan Schulz[1], and •Ulrich Willemsen[1] — [1]III. Physikalisches Institut A, RWTH Aachen — [2]Brown University

The PAIReD tagger is a novel jet flavor tagging algorithm in CMS that employs unconventional large-radius jets to identify Higgs boson decays to pairs of heavy-flavor quarks. In this talk, the vulnerability of machine learning-based jet flavor taggers to adversarial attacks is investigated, with a focus on the ParticleTransformer architecture used in the PAIReD tagger. It is shown that this architecture is more susceptible to adversarial perturbations than other established models. To mitigate this vulnerability, adversarial training is applied, incorporating adversarial examples into the training process. It is demonstrated that adversarial training enhances the robustness of the PAIReD tagger, recovering almost the nominal performance on both undisturbed and attacked inputs. These findings provide valuable insights into the behavior of the PAIReD tagger and the ParticleTransformer architecture for future applications in the CMS experiment.

T 33.6 Tue 17:30 VG 2.101

Gravity Gradient Noise Mitigation using Deep Learning at the Einstein Telescope — Markus Bachlechner[1], David Bertram[1], Johannes Erdmann[2], •Jan Kelleter[2], Patrick Schillings[2], and Achim Stahl[1] — [1]III. Physikalisches Institut B, RWTH Aachen — [2]III. Physikalisches Institut A, RWTH Aachen

The Einstein Telescope is a proposed gravitational wave detector of the third generation. It aims to improve sensitivity by at least an order of magnitude compared to current detectors. The dominant noise source in the region of 1 to 10 Hz is expected to be gravity gradient noise (GGN) from seismic activity in the surrounding rock. In order to reach the desired sensitivity, GGN must be actively mitigated. Seismometers will be installed in boreholes around the mirrors to measure the seismic activity. The current gold standard to predict the mirror response from seismometer measurements is the application of linear filters. In this talk, we present an approach to using neural networks in order to predict the mirror response to GGN from simulated seismometer measurements.