T 34: ML Methods II

Time: Tuesday 17:00–18:30 Location: HSZ/0405

T 34.1 Tue 17:00 HSZ/0405

Equivariant Normalising Flows for Particle Jets — •Cedric Ewen — Institut für Experimentalphysik, Universität Hamburg

In high energy physics, current Monte Carlo simulations are time-consuming and the demand for fast computationally efficient simulations is rising. Therefore, generative machine learning models have become a major research interest due to their ability to speed up data generation. A data structure capable of describing collider events such as jets are variable-size point clouds. However, due to complex correlations between the points, a powerful architecture is needed for high generative fidelity. Continuously normalising flows (CNFs) can model these complex point processes while having traceable likelihood and straightforward sampling. We show an implementation of an architecture using CNFs with equivariant functions and compare its performance to multiple GAN approaches on benchmark datasets.

T 34.2 Tue 17:15 HSZ/0405

Identification of bb-Jets Using a Deep-Sets-Based Flavour-Tagging Algorithm with the ATLAS Experiment — •Joschka Birk[1,2], A. Froch[1], M. Guth[3], and A. Knue[1] — [1]University of Freiburg — [2]University of Hamburg — [3]University of Geneva

Jets that contain two b-hadrons (bb-jets) are usually not considered as an individual target class in flavour-tagging algorithms. Instead, these jets are included in an inclusive b-jet category which consists of single-b jets and bb-jets, making these two types of jets indistinguishable when they are processed with such an algorithm.

While this is sufficient for most physics analyses, an explicit identification of bb-jets could be promising for analyses like the search for the $t\bar{t}H(\to b\bar{b})$ signal, which suffers from the large irreducible $t\bar{t}+b\bar{b}$ background. This irreducible background contains the same final-state particles as the signal, including four b-quarks. In the background process, a radiated gluon can split into a b-quark pair, which might be contained in one single jet. In order to improve the rejection of these particular background events, the ATLAS DL1d algorithm, which is the b-tagging algorithm designed for ATLAS Run 3 analyses, is extended with an additional output class dedicated to bb-jets (bb-DL1d).

By applying a cut in a two-dimensional discriminant plane, bb-DL1d provides a proof-of-concept for a flavour-tagging algorithm that is capable of both inclusive b-tagging and bb-jet identification. The design of the bb-DL1d algorithm and its most important, Deep-Sets-based, low-level tagger bb-DIPS are discussed in this talk. Futhermore, performance studies for both algorithms are shown.

T 34.3 Tue 17:30 HSZ/0405

Improving the robustness of jet tagging algorithms with adversarial training — •Hendrik Schönen[1], Annika Stein[1], Judith Bennertz[1], Xavier Coubez[1,2], Alexander Jung[1], Summer Kassem[1], Ming-Yan Lee[1], Spandan Mondal[1], Alexandre de Moor[3], Andrzej Novak[1], and Alexander Schmidt[1] — [1]III. Physikalisches Institut A, RWTH Aachen University, Germany — [2]Brown University, USA — [3]Vrije Universiteit Brussel, Belgium

Neural network architectures have advanced over the last decade and are an important part of current jet flavour tagging algorithms. Since these algorithms rely on training the network with simulated events as input, they might have a worse performance on detector data due to data/MC deviations. A possible approach to address this issue is adversarial training, which uses distorted inputs for training. One possibility to distort the inputs is applying a FGSM attack, which shifts the inputs in a way that maximizes the loss with a fixed magnitude. This talk is about the impact of adversarial training on the model performance and robustness.

T 34.4 Tue 17:45 HSZ/0405

Binning high-dimensional classifier output for HEP analyses through a clustering algorithm — •Svenja Diekmann, Niclas Eich, and Martin Erdmann — III. Physikalisches Institut A, RWTH Aachen University

The usage of Deep Neural Networks (DNNs) as multi-classifiers is widespread in modern HEP analyses. In standard categorisation methods, the high-dimensional output of the DNN is often reduced to a one-dimensional distribution by exclusively passing the information about the highest class score to the statistical inference method. Correlations to other classes are hereby omitted. Moreover, in common statistical inference tools, the classification values need to be binned, which relies on the researcher's expertise and is often non-trivial. To overcome the challenge of binning multiple dimensions and preserving the correlations of the event-related classification information, we perform K-means clustering on the high-dimensional DNN output to create bins without marginalising any axes. We evaluate our method in the context of a simulated cross section measurement at the CMS experiment, showing an increased expected sensitivity over the standard binning approach.

T 34.5 Tue 18:00 HSZ/0405

Resonant anomaly detection without background sculpting — •Manuel Sommerhalder[1], Gregor Kasieczka[1,2], Tobias Quadfasel[1], Anna Hallin[3], and David Shih[3] — [1]Institut für Experimentalphysik, Universität Hamburg, 22761 Hamburg, Germany — [2]Center for Data and Computing in Natural Sciences (CDCS), 22607 Hamburg, Germany — [3]NHETC, Dept. of Physics and Astronomy, Rutgers University, Piscataway, NJ 08854, USA

Anomaly searches are a class of machine learning–based methods to search for new phenomena without relying on specific signal and background models. They provide a promising complement to the typically model-dependent searches for physics beyond the standard model at the LHC. Resonant anomaly detection methods, such as CATHODE, make use of the assumptions of a signal being localized in one feature and have demonstrated great performance in terms of classifying new physics signals on simulation-based studies. However, they are prone to background sculpting in the case of input features being correlated with the resonant one and thus can ultimately impair a background estimation via the bump hunt. We thus propose Latent CATHODE (LaCATHODE), a new technique for resonant anomaly detection, which moves the features into a decorrelated latent space. Using the LHC Olympics R&D dataset, we observe that LaCATHODE leaves the background unsculpted while retaining much of the signal extraction performance of the original CATHODE approach.

T 34.6 Tue 18:15 HSZ/0405

ANN for Pulse Shape Analysis in GERDA — •Vikas Bothe for the GERDA-Collaboration — Max-Planck-Institute for Nuclear physics, Heidelberg

The GERDA experiment searches for the neutrinoless double-beta decay of 76Ge using enriched high-purity Germanium diodes as a source as well as a detector. For such a rare event search, the sensitivity of the experiment can be improved by employing active background suppression techniques. The time-profile analysis of the signals, called pulse shape analysis (PSA), generated by energy deposits within the detectors is employed to discriminate signal and background events. An effective PSA with artificial neural networks can reject the background events like alpha particles and Compton scattered photons while preserving a high signal efficiency for double beta decay-like events.

Coaxial detectors due to their geometry have significantly homogenous weighting potential adding a spatial dependence to pulse shapes. This makes the signal-background differentiation difficult with the use of simple mono-parametric cuts and to overcome this, we employ a multi-variate analysis with artificial neural networks which are capable of modeling complex relationships.

I will give a review of the methodology in building these ANN and their performance for PSA in GERDA.