T 53: Data Analysis, Information Technology and Artificial Intelligence 3

Time: Tuesday 16:15–18:30 Location: T-H38

T 53.1 Tue 16:15 T-H38

Improved selective background Monte Carlo simulation at Belle II with graph attention networks and weighted events — •Boyang Yu, Nikolai Hartmann, and Thomas Kuhr — Ludwig-Maximilians-Universität München

When measuring rare processes at Belle II, a huge luminosity is required, which means a large number of simulations are necessary to determine signal efficiencies and background contributions. However, this process demands high computation costs while most of the simulated data, in particular in case of background, are discarded by the event selection. Thus filters using graph neural networks with attention mechanisms are introduced after the Monte Carlo event generation to save the resources for the detector simulation and reconstruction of events discarded at analysis level. Merely filtering out events will however inevitably introduce biases. Therefore statistical methods including sampling and reweighting are invested to deal with this side effect.

T 53.2 Tue 16:30 T-H38

Analysis Specific Filters for Selective Background Monte Carlo Simulations at Belle II — •Luca Schinnerl, Boyang Yu, Nikolai Hartmann, and Thomas Kuhr — Ludwig Maximilians University Munich, Munich, Germany

The Belle II experiment is expected to accumulate a data sample of 50 ab-1 in its lifetime. For rare processes, strong background suppression is needed to precisely measure these types of events. Because of this, an extremely large number of simulated background events is necessary for an effective analysis. However, a significant portion of the simulated data is discarded trivially in the first stage of analysis, demanding a better method of simulation to keep up with the amount of data. For this purpose a neural network is implemented to select the relevant data after the Monte Carlo event generation and then only run the costly detector simulation and reconstruction for selected events. Existing methods have shown good success with graph neural networks. However, the total speedup of simulations is limited when considering generic selections with a retention rate of 4.25%. Here a maximum speedup of 2.1 was reached. In this work we iteratively introduce analysis specific filters to the training of the neural networks, which can greatly increase efficiencies. For the rare process B -> K*vv this methodology has been successful in significantly improving simulation speed.

T 53.3 Tue 16:45 T-H38

Preparing transformer-based dose predictions: Performance of encoder/decoder structures for CT- and dose-sequence encoding — •Piet Hoffmann, Kevin Kröninger, Armin Lühr, Florian Mentzel, and Jens Weingarten — TU Dortmund

In radiotherapy, fast dose predictions based on CT images are useful as they reduce the need for computing-intensive Monte Carlo simulations and thus can speed up treatment planning. A new approach to these fast dose predictions consists of interpreting the CT to dose conversion as a sequence translation task and making use of a transformer machine learning model.

For this, the CT data is disected perpendicularly to the beam into a sequence of 2D slices, if not already aquired in this direction. Before these slices are fed into the translation architecture it is useful to first encode them to reduce their dimensionaltiy and concentrate the contained information. After translation the data then has to be decoded into a dose prediction slice.

For the whole model to work properly, the structure of such encoder and decoder is important and thus in this talk different approaches are compared with respect to their performance. Properties of the resulting encoded data space, like smooth transitioning between data points and the density distribution of data points, and their potential benefits are discussed.

T 53.4 Tue 17:00 T-H38

Progressive Generative Adversarial Networks for High Energy Physics Calorimeter Simulations — •Simon Schnake[1,2], Kerstin Borras[1,2], Dirk Krücker[1], Florian Rehm[2,3], and Sofia Vallecorsa[3] — [1]DESY, Hamburg, Germany — [2]RWTH Aachen, Germany — [3]CERN openlab, Geneva, Swiss

The simulation of particle showers in calorimeters is a computational demanding process. Deep generative models have been suggested to replace these computations. One of the complexities of this approach is the dimensionality of the data produced by high granularity calorimeters. One possible solution could be progressively growing the GAN to handle this dimensionality. In this study, electromagnetic showers of a (25x25x25) calorimeter in the energy range of 10 - 510 GeV are used to train generative adversarial networks. The resolution of the calorimeter data is increased while training. First results of this approach are shown.

T 53.5 Tue 17:15 T-H38

Generative Models For Hadron Shower Simulation — •Engin Eren — Deutsches Elektronen-Synchrotron, Notkestrasse 85, 22607 Hamburg, Germany

Simulations provide the crucial link between theoretical descriptions and experimental observations in particle physics. It describes fundamental processes or the interactions of particles with detectors. The high computational cost associated with producing precise simulations in sufficient quantities, e.g. for the upcoming data-taking phase of the Large Hadron Collider (LHC) or future colliders, motivates research into more computationally efficient solutions. However, the simulation of realistic showers in a highly granular detector remains a hard problem due to a large number of cells, values spanning many orders of magnitude, and the overall sparsity of data.

This contribution advances the state of the art in two key directions: Firstly, we present a precise generative model for the fast simulation of hadronic showers in a highly granular hadronic calorimeter. Secondly, we compare the achieved simulation quality before and after interfacing with a so-called particle-flow-based reconstruction algorithm. Together, these bring generative models one step closer to practical applications.

T 53.6 Tue 17:30 T-H38

Deep Set Generation of Collider Events — •Erik Buhmann — Institut für Experimentalphysik, Universität Hamburg

With current and future high-energy collider experiments' vast data collecting capabilities comes an increasing demand for computationally efficient simulations. Generative machine learning models allow fast event generation, yet are largely constrained to fixed data and detector geometries.

We introduce a novel autoencoder setup for generation of permutation invariant point clouds with variable cardinality - a flexible data structure optimal for collider events. Our model is simple, lightweight and purely set based without exploiting additional graph structures. We show that our model scales well to large particle multiplicities and achieves good performance on various data sets.

T 53.7 Tue 17:45 T-H38

Angular Conditioning of Generative Models for Fast Calorimeter Shower Simulation — •Peter McKeown — Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany

Modern high energy physics experiments fundamentally rely on accurate simulation- both to characterise detectors and to bridge observed signals and underlying theory. Traditional simulation tools are reliant upon Monte Carlo methods which, while powerful, require significant computational resources, and are projected to become a major bottleneck at the high luminosity stage of the LHC and for future colliders. Calorimeter showers are particularly computationally intensive to simulate, due to a large number of particle interactions with the detector material.

A potential solution based on deep generative models promises to provide drastic reductions in compute times. Previous work in our group has demonstrated the ability of various generative models to accurately reproduce key physical properties of showers in highly granular calorimeters. While this work has focused on the specific case of a particle incident perpendicular to the face of the calorimeter, a practical simulator must be able to correctly simulate arbitrary angles of incidence. In this talk, efforts to add conditioning on the incident angle of the particle will be addressed.

T 53.8 Tue 18:00 T-H38

Refinement of jet simulation with generative adversarial networks — •Shruthi Janardhan[1,2], Sven Harder[1], Patrick Connor[1], Peter Schleper[1], Daniel Ruprecht[2], and Sebastian Götschel[2] — [1]Universität Hamburg — [2]Technische Universität Hamburg

In High Energy Physics, the interaction of particles with matter at the detectors are best simulated with the GEANT4 software. Alternatively, less precise but faster simulations are sometimes preferred to reach higher statistical precision. We present recent progress of refinement of fast simulations with ML techniques to enhance the quality of such fast simulations. We demonstrate the use of generative adversarial networks in the context of jet simulation using a Wasserstein loss function. The architecture consists of two opposing networks, Refiner and Critic. The Refiner, refines the distribution of the energy of the jets obtained with the fast simulation. The Critic is used to effectively differentiate between the distributions of refined energy and the distribution obtained by the GEANT4 simulation. The Refiner can be used solely to obtain a fast but refined jet simulation.

T 53.9 Tue 18:15 T-H38

Using ML to analytically model the CMS detector response to jets — •Nils Gerber, Samuel Bein, and Peter Schleper — Universität Hamburg

Many applications in particle physics require an accurate modelling of the energy response of detectors to individual particles as well as jets. For example, unfolding, fast detector simulation, as well as certain background estimation techniques, all require some input related to the jet response. While typical models are constructed from established functional forms such as Crystal Ball functions fit to data distributions of the response, an alternative approach is explored where a DNN classifier is employed in order to arrive at a model which takes into account correlated dependencies in the response on the true jet energy, pseudorapidity, jet flavour, and other factors.