T 91: Machine Learning: Event and jet reconstruction

Time: Friday 11:00–13:00 Location: H-HS I

T 91.1 Fri 11:00 H-HS I

Event reconstruction for ANTARES using Convolutional Neural Networks — •Nicole Geisselbrecht for the ANTARES-KM3NeT-Erlangen-Collaboration — FAU Erlangen-Nürnberg, ECAP

ANTARES is the largest undersea neutrino detector, installed in the Mediterranean Sea, and is primarily sensitive to neutrinos in the TeV-PeV energy range. Data taking with the telescope has been continous since 2008. One of the central goals of ANTARES, next to searches for neutrino signals from point, transient, and extended sources, is an independent detection and investigation of the diffuse cosmic neutrino flux discovered by IceCube. The suppression of backgrounds, in particular of atmospheric muons, is essential to further increase the sensitivity of the data analysis. The contribution reports on the design and application of deep Convolutional Neural Networks to ANTARES telescope data. Data preprocessing concepts, image generation, and first performance investigations of an event-topology classificator will be presented.

T 91.2 Fri 11:15 H-HS I

Adversarial Neural Network-based shape calibrations of observables for jet-tagging at CMS — Martin Erdmann[1], •Benjamin Fischer[1], Dennis Noll[1], Yannik Alexander Rath[1], Marcel Rieger[2], and David Josef Schmidt[1] — [1]III. Physikalisches Institut A, RWTH Aachen University — [2]CERN

Scale factors are commonly used in HEP to improve shape agreement between distributions of data and simulation. The choice of the underlying model for such corrections is of great importance, but often requires a lot of manual tuning e.g. of bin sizes or fitted functions. This can be alleviated through the use of neural networks and their inherent powerful data modeling capabilities.

We present a novel and generalized method for producing shape changing scale factors using adversarial neural networks. This method is investigated in the context of the bottom-quark jet-tagging algorithms within the CMS experiment. The scale factor of each jet is produced by the primary network using the jet's variables. The second network, the adversary, aims to differentiate between data and rescaled simulation events and facilitates the training of the former. An additional third network is used for normalization preservation with respect to correlated variables.

We present the conceptual design and resulting scale factors in comparison to the previously applied methods.

T 91.3 Fri 11:30 H-HS I

Study on the use of convolutional neural networks for strange-tagging based on jet images from calorimeters — •Nils J. Abicht, Johannes Erdmann, Olaf Nackenhorst, and Sonja Zeissner — TU Dortmund, Lehrstuhl für Experimentelle Physik IV

In addition to already existing algorithms for bottom- and charm-tagging, a technique that identifies jets originating from the hadronisation of strange quarks (strange-tagging) would be useful for various analyses at the LHC. This study focuses on making use of calorimeter information for this identification in the form of *jet images*, i.e. a representation of energy depositions in η and ϕ. Such jet images are built from simulations of jets from strange and down quarks. Convolutional neural networks (CNNs), which are especially geared towards extracting possible patterns in images, are used to learn the distinctive features of the strange and down jet images. During the optimization of the performance of the final CNN, different preprocessing steps as well as CNN layouts are explored in order to create a new method for strange-tagging.

T 91.4 Fri 11:45 H-HS I

Di-tau mass reconstruction in ATLAS using regression-based deep neural networks — •Lena Herrmann, Philip Bechtle, Klaus Desch, Michael Hübner, and Peter Wagner — Physical Institute, University Bonn, Germany

The di-tau decay channel of resonances is important and challenging at the same time. On the one hand, it is essential for the H-analysis, but on the other hand, the unmeasured neutrinos of the tau decays complicate the mass reconstruction. As a consequence, it is hard to distinguish H-events from Z-background.

Common techniques like collinear approximations [1] or the maximum likelihood method of the Missing Mass Calculator (MMC) [2] are applied in order to estimate the invisible components and thus the invariant mass of the resonance. Alternatively, regression-based deep neural networks can be trained for this specific task. By now, the accuracy of the MMC can be approached [3] but there are still important areas of studies. Hence, edge effects, the optimum usage of the true tau-mass in the training process or the effect of tau-spin-correlations on the learning results are investigated. In the following, the optimization of a regression-based deep neural network for the di-tau mass reconstruction in ATLAS regarding the mentioned aspects, will be presented.

[1] ATLAS Collaboration: G. Aad et al., arXiv:0901.0512v4 [hep-ex]
[2] A. Elagin et al., arXiv:1012.4686, Dec 2010
[3] M. Werres, Apr 2019, *Estimating the Mass of Di-Tau Systems in the ATLAS Experiment Using Neural Network Regression*

T 91.5 Fri 12:00 H-HS I

Primary Vertex Reconstruction with ML in ACTS — •Bastian Schlag — CERN / JGU Mainz

The reconstruction of particle trajectories and their associated vertices is an essential task in the event reconstruction of most high energy physics experiments. In order to maintain or even improve upon the current performance of tracking and vertexing algorithms under the upcoming challenges of increasing energies and ever increasing luminosities in the future, major software upgrades are required. Based on the well-tested ATLAS tracking and vertexing software, ACTS (A Common Tracking Software) provides a modern, experiment-independent set of track- and vertex reconstruction software, specifically designed for parallel execution. In addition to thread-safe reimplementations of classical primary vertexing algorithms, ACTS provides a solid code base for evaluating new approaches to primary vertex finding, such as applications of sophisticated deep learning methods. Associating tracks to the correct vertex candidate is a crucial step in vertexing and will become even more important in the high-pileup environments expected for HL-LHC or FCC-hh. Learning a track representation in an embedding space in such a way that tracks emerging from a common vertex are close together while tracks from neighboring vertices are further separated from one another allows for the determination of a similarity score between a pair of tracks. Constructing undirected, edge-weighted graphs from these results allows the subsequent usage of classical graph algorithms or graph neural networks for clustering tracks to vertex candidates.

T 91.6 Fri 12:15 H-HS I

Track finding algorithm for the BelleII detector — •Thomas Lück and Thomas Kuhr for the Belle II-Collaboration — Ludwig-Maximilians-Universität München, München, Germany

BelleII is a multi-purpose detector which will collect data produced at the asymmetric e+e- collider SuperKEKB located in Japan. The goal of BelleII is to test the standard model (SM) of particle physics with measurements of unprecedented high precision. Possible contributions from physics beyond the SM can manifest theirselves as significant discrepancies among the SM predictions and the actual measurements. While BelleII already took data with a partially completed detector in 2018, and started data taking with the full detector in 2019. It is foreseen to collect a data sample corresponding to 50 ab-1 by 2027. To achieve these physics goals it is required to have an efficient and precise track finding which has to cope with the higher background level at BelleII compared to its predecessors. The tracking devices of the BelleII detector consist of, from inner to outer, two layers of pixelated detectors, 4 layers of double sided strip detectors, and a drift chamber. In this contribution I will present the functionality and the performance of the BelleII track finding algorithms which reconstruct the tracks of charged particles in the tracking devices. These are direct input for the physics analyses.

T 91.7 Fri 12:30 H-HS I

Particle identification with the Belle II Calorimeter using Machine Learning — •Abtin Narimani Charan and Torben Ferber — Deutsches Elektronen-Synchrotron (DESY)

The Belle II experiment, located at the asymmetric SuperKEKB $e^+ e^-$

collider in Tsukuba, Japan, plans to perform studies of B-physics and searches for new physics at the luminosity frontier. The Belle II electromagnetic calorimeter is designed to measure the energy deposited by charged and neutral particles. The electromagnetic calorimeter also provides important contributions to the Belle II particle identification system. In particular for lower momentum muons and pions which do not reach the outer muon detector, the electromagnetic calorimeter can be critical for muon vs. pion separation. This is crucial for the study of semi-tauonic and semi-leptonic B decays.

This talk presents an application of a convolutional neural network in order to tackle this challenge. Such a network uses the granularity of the calorimeter crystals to provide 5×5 and 7×7 images of calorimeter clusters that contain information of the spatial location of the crystals' energy deposits from extrapolated tracks. The cluster images of muons and pions are distinguishable since pions undergo hadronic shower in addition to ionization, making the deposited energy more dispersed. In this talk, the performance of the network is investigated with MC samples of muons and pions selected from the Belle II simulation together with data samples which were collected in 2019. Moreover, comparisons will be presented benchmarking against independent approaches to calorimeter-based particle identification.

T 91.8 Fri 12:45 H-HS I

Muon bundle reconstruction with KM3NeT/ORCA using Deep Learning techniques — •Stefan Reck for the ANTARES-KM3NeT-Erlangen-Collaboration — Friedrich-Alexander-Universität Erlangen-Nürnberg, ECAP

KM3NeT/ORCA is a water-Cherenkov neutrino detector, currently under construction in the Mediterranean Sea at a sea depth of 2450 meters. The projects main goal is the determination of the neutrino mass hierarchy by measuring the energy- and zenith-angle-resolved oscillation probabilities of atmospheric neutrinos traversing the Earth.

Deep Learning techniques provide promising methods to analyse the signatures induced by the particles traversing the detector. Despite being in an early stage of construction, the data taken so far already provide large statistics to investigate the signatures from atmospheric muons. This talk will cover a deep-learning based approach using convolutional networks to reconstruct atmospheric muon bundles, and results on both simulations and data will be presented. Furthermore, the performances are compared to the ones of classical approaches, showing good agreement.