T 107: Data Analysis, Information Technology and Artificial Intelligence 5

Time: Thursday 16:15–18:15 Location: T-H39

T 107.1 Thu 16:15 T-H39

Introducing novel order statistic tests based on spacings and their applications — •Lolian Shtembari — Max Planck Institute for Physics, Munich, Germany

The use of spacings between ordered real-valued numbers is very useful in many areas of science. In particular, either unnaturally small or large spacings can be a signal of an interesting effect. We introduce new statistical tests based on the observed spacings of ordered data. These statistics are sensitive to detect non-uniformity in random samples, or short-lived features in event time series. Under some conditions, these new test can outperform existing ones, such as the well known Kolmogorov-Smirnov or Anderson-Darling tests, in particular when the number of samples is small and differences occur over a small quantile of the null hypothesis distribution. A detailed description of the test statistics is provided including examples and proposed applications for the analysis of neutrino experiments.

T 107.2 Thu 16:30 T-H39

Cosmic ray composition measurement with Graph Neural Networks in KM3NeT/ORCA — •Stefan Reck for the ANTARES-KM3NET-ERLANGEN-Collaboration — Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), ECAP

KM3NeT/ORCA is a water-Cherenkov neutrino detector, currently under construction in the Mediterranean Sea at a depth of 2450 meters. The project's 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. Additionally, the detector observes atmospheric muons, which can be used to study the properties of extensive air showers and cosmic ray particles.

This contribution will present a deep-learning based approach to analyse the signatures of muon bundles traversing the detector using graph convolutional networks. Even though the detector is still in an early stage of construction, this reconstruction can already be used to measure the composition of cosmic ray primary particles.

T 107.3 Thu 16:45 T-H39

Tau neutrino selection with Graph Neural Networks for KM3NeT/ORCA — •Lukas Hennig for the ANTARES-KM3NET-ERLANGEN-Collaboration — Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Erlangen Centre for Astroparticle Physics, Erwin-Rommel-Straße 1, 91058 Erlangen, Germany

One of the goals of the KM3NeT collaboration is to constrain the PMNS matrix elements associated with the tau neutrino flavor. The data needed to perform this task is taken by KM3NeT's ORCA detector, a water Cherenkov neutrino detector currently under construction in the deep Mediterranean Sea. To constrain the matrix elements, one needs to measure the tau neutrino flux produced by atmospheric muon and electron neutrinos oscillating into tau neutrinos. Selecting the tau neutrino events from the full neutrino event dataset is a notoriously difficult task because the final states of a tau neutrino interaction on a nucleon or nucleus look very similar to those produced in other CC and NC neutrino interactions. This classification problem is addressed by using Graph Neural Networks, a type of neural network architecture that has shown promising results, e.g., in the related task of jet tagging. This presentation will explain how GNNs are applied to neutrino telescope data and report the first results concerning the classification performance.

T 107.4 Thu 17:00 T-H39

Conditional Invertible Neural Network for the inference of properties of ultra-high-energy cosmic ray sources — Teresa Bister, Martin Erdmann, Natalie Nast, Johanna Schafmeister, and •Josina Schulte — III. Physikalisches Institut A, RWTH Aachen

A core challenge in physics data analyses is to estimate model parameters from corresponding measurements, often without the possibility to formulate an explicit inverse function. In a Bayesian framework, parameters are usually estimated using posterior distributions providing not only point estimates but also enabling the determination of uncertainties and correlations. To assess the posterior distributions, we use a so-called conditional Invertible Neural Network (cINN) which is based on the concept of normalizing flows. We apply this new method to a simulated scenario from astroparticle physics to gain information on the parameters of a source model of ultra-high-energy cosmic rays. The corresponding simulated measurements are the energy spectrum, depth of shower maximum distributions and the arrival directions as measured on Earth with similar statistics as data from the Pierre Auger Observatory. We present and evaluate the performance of the cINN on this scenario.

T 107.5 Thu 17:15 T-H39

Deep-Learning-Based Reconstruction of Cosmic-Ray Masses from Extensive Air Shower Measurements with AugerPrime — Martin Erdmann, Jonas Glombitza, Berenika Idaszek, •Niklas Langner, and Dominik Steinberg — III. Physikalisches Institut A, RWTH Aachen University

Ultra-high-energy cosmic rays (UHECRs) that penetrate the Earth's atmosphere induce extensive air showers. At the Pierre Auger Observatory, showers are measured from the ground using the fluorescence detector (FD) and the surface detector (SD) consisting of water Cherenkov detectors (WCDs). Currently, the SD is extended with scintillators (SSDs) as part of the AugerPrime upgrade.

Actual measurements of the UHECR mass composition are based on FD observations of the depth of shower maximum $X_{\max}$. Using deep learning, $X_{\max}$ was successfully extracted using only the SD, exploiting the full statistics of the observatory. However, the precision of $X_{\max}$ as a mass estimator at the event level is limited. The new SD upgrade offers the possibility to measure individual components of the shower, potentially improving the reconstruction of the mass composition.

We introduce our network to extract the properties of air showers by analyzing the signals of water Cherenkov detectors as well as the SSDs. We show that the mass-separation power when using only the observable $X_{\max}$ is already fully exploited using only WCDs. Thus, we investigate additional observables, novel network architectures and new reconstruction strategies to increase the mass sensitivity with the combination of WCDs and SSD measurements.

T 107.6 Thu 17:30 T-H39

PID with Recurrent Neural Networks in the ATLAS Transition Radiation Tracker for Run 3 — •Lena Herrmann, Christian Grefe, Philip Bechtle, and Klaus Desch — Physikalisches Institut, University of Bonn

The measurement of transition radiation effects by the ATLAS transition radiation tracker (TRT) is a key ingredient to the electron identification, especially at low momenta. A recurrent neural network (NN) was developed to combine hit- and track-level information into a single classifier, which significantly improves the particle identification capabilities provided by the TRT.

Since the gas configuration in the TRT will change for the upcoming Run 3 data taking period, separate RNNs have to be trained. The optimisation and training of the RNN will be presented and differences between the Run 2 and Run 3 networks will be discussed. Furthermore, the RNN response on real data taken during Run 2 will be compared to its performance in simulation.

T 107.7 Thu 17:45 T-H39

Usage of neural networks in photon identification in ATLAS — •Florian Kirfel — Physikalisches Institut der Universität Bonn

Precise photon identification is crucial for many ATLAS analyses. Currently, photons are selected using a set of cuts on calorimeter variables which characterise the shape of electromagnetic showers. These cuts were optimized using Monte Carlo simulations of photons and jets. Due to the simulations not being ideal, the selection efficiency must be corrected to match data. However, the measurement technique used to determine the identification efficiency in the data requires the hadronic activity around the photon candidate and the photon identification efficiency to be independent. In this work, neural networks are employed to improve over cut-based photon identification. In addition, they are constrained to keep the classification independent of the isolation using the distance correlation. This allows a simplified setup comparing to alternatives such as the adversarial neural network.

T 107.8 Thu 18:00 T-H39

A super-resolution GAN for photon identification at collider experiments — Johannes Erdmann, Florian Mentzel, Olaf Nackenhorst, and •Aaron van der Graaf — TU Dortmund University, Department of Physics

Many processes in proton-proton collisions contain prompt photons in the final state, ranging from Standard Model (SM) measurements, such as $H \to \gamma\gamma$, to searches for physics beyond the SM. In order to measure these processes with a high precision, a good photon identification efficiency while retaining a high background rejection rate is important. Most misidentified photons arise from hadron decays, such as $\pi^0 \to \gamma\gamma$, which could possibly be rejected better with a higher calorimeter granularity. This motivates the idea of artificially increasing the calorimeter granularity by training a super-resolution Generative Adversarial Network (SRGAN) with simulated low and high resolution calorimeter images. As a proof of concept, mono-energetic photons and neutral pions are simulated in an electromagnetic calorimeter and only the second calorimeter layer is used for the SRGAN training. In this presentation, the used SRGAN model, the results of the SRGAN training and the predicted super-resolution images are presented. It is shown that the predicted super-resolution images contain additional information that increases the pion rejection rate compared to the low resolution images.