FM 82: Quantum & Information Science: Neural Networks, Machine Learning, and Artificial Intelligence III

Time: Thursday 14:00–15:45 Location: 3044

Invited Talk FM 82.1 Thu 14:00 3044

Deep Learning Advances in Particle Physics — •Yannik Rath[1], Martin Erdmann[1], Benjamin Fischer[1], Erik Geiser[1], Jonas Glombitza[1], Dennis Noll[1], Thorben Quast[1,2], and Marcel Rieger[1] — [1]III. Physikalisches Institut A, RWTH Aachen University — [2]EP-LCD, CERN

Machine learning methods have found widespread use in high-energy particle physics, their most common application being the identification of particles and the separation of signal and background processes in collision events. Deep learning in particular has seen many recent developments, for example the creation of dedicated neural network architectures incorporating physics knowledge (e.g. JINST 14 (2019) P06006). In addition, increasing attention has been directed towards unsupervised learning methods. Most notably, generative adversarial networks are extensively studied for their potential to speed up event simulations by several orders of magnitude (e.g. T. Comput Softw Big Sci 3 (2019) 4). Further unsupervised approaches based on reinforcement learning are also starting to be investigated. In this talk we present an overview of deep learning applications in high-energy particle physics focusing on most recent advancements.

FM 82.2 Thu 14:30 3044

Mining for Particles from Space – Project C3 of the Collaborative Research Center 876 — •Tim Ruhe, Wolfgang Rhode, Katharina Morik, and Mirko Bunse — TU Dortmund

Project C3 of the Collaborative Research Center SFB 876 aims at answering fundamental questions in neutrino- and Cherenkov-astronomy by developing and applying state-of-the-art algorithms from the field Artificial Intelligence. For the past eight years the project has contributed to a variety of analyses in astroparticle physics. This includes the reconstruction of particle properties and energy spectra, searches for point sources and tau-neutrinos as well as the development of algorithms. This report will provide an overview over the project's activities and discuss the latest results.

FM 82.3 Thu 14:45 3044

 # aict-tools – ML-based Event Reconstruction for Imaging Air Cherenkov Telescopes — •Maximilian Nöthe[1], Kai Arno Brügge[1], and Sabrina Einecke[2] — [1]Astroparticle Physics, TU Dortmund, Germany — [2]Faculty of Sciences, University of Adelaide, Australia

Imaging Air Cherenkov Telescopes (IACTs) cover the highest energy ranges in the electromagnetic spectrum of astronomy.

These telescopes record the faint, nano-second scale flashes of Cherenkov radiation emitted by extensive air showers.

All IACTs face the same three reconstruction tasks, for each event, the primary particle's energy, direction and particle type have to be estimated. The particle type classification is necessary, as most extensive air showers are induced by charged cosmic rays.

Most commonly, IACTs record multiple time slices for each pixel in the camera for each shower, which is subsequently reduced to a few parameters describing each event.

The aict-tools use classical machine learning approaches as implemented by scikit-learn to reconstruct the gamma-ray properties from these image parameters.

Originally developed for the FACT Telescope, the library was extended to also work with data of the upcoming Cherenkov Telescope Array, e.g. the CHEC camera prototype.

The package provides executables to train, validate and apply models. It uses the yaml standard for defining configuration files and can store the resulting models in the pickle, pmml and onnx formats.

FM 82.4 Thu 15:00 3044

Analyzing VLBI Data Using Neural Networks — •Kevin Schmidt — TU Dortmund

Very long baseline interferometry (VLBI) allows the observation of distant astronomical objects with the highest resolution. In this technique, the data of several radio telescopes are combined to achieve an effective diameter equal to the greatest distance between the telescopes.

Radio interferometers measure visibilities depending on the baseline between the individual telescopes. Since they are distributed only sparsely, much visibility space remains uncovered. This lack of information causes noise artifacts in the recorded data. In recent decades, various implementations of the CLEAN algorithm (Clark, 1980) have been used to remove these artifacts from radio images. With the increasing data rates of modern radio telescopes, faster solutions have to be found to analyze the observations in a reasonable time.

A new and faster approach is using neural networks. This presentation gives an overview of the first results.

FM 82.5 Thu 15:15 3044

DSEA+: Deconvolution by Machine Learning — •Tim Ruhe[1], Mirko Bunse[2], Kai Brügge[1], and Tobias Hoinka[1] — [1]Lehrstuhl Experimentelle Physik 5, TU Dortmund — [2]LS8, Fakultät Informatik, TU Dortmund

The reconstruction of an experimentally inaccessible quantity, e.g. a particle's energy, is a common challenge in particle- and astroparticle physics, where correlated observables are measured instead. The transfer from the variable of interest into an experimentally observable quantity is, however, usually governed by stochastical processes, leading to the Fredholm integral equation of the first kind. Additional smearing, stemming from particle propagation and the detector itself, complicate the problem even further. We present a novel machine learning-based approach, DSEA+, which sidesteps certain limitations of existing algorithms by interpreting deconvolution as a multinominal classification task. We discuss the algorithm and show results obtained from simulations provided by the FACT Open Data Project.

FM 82.6 Thu 15:30 3044

Reconstructing Nanoclusters from Single Wide-Angle Scattering Images with Neural Networks — •Thomas Stielow, Robin Schmidt, Thomas Fennel, and Stefan Scheel — Institut fürPhysik, Universität Rostock, Albert-Einstein-Straße 23, 18059 Rostock

Single-shot diffraction imaging by soft X-ray laser pulses is a valuable tool for structural analyses of unsupported and short-lived nanosystems, although inversion of the scattering patterns still prove challenging [1]. Deep learning, on the other hand, is widely used in data sciences for the extraction of information from images and sees more and more application in various sciences. We demonstrate how neural networks can be utilized in the reconstruction of objects from single-shot wide angle scattering patterns in the case of silver nanoclusters [2]. Our network is trained solely on data obtained by existing physical theories and can be applied to real-world experimental data with little to no prior knowledge of the specific experimental setup. With high quality real-time evaluation results, deep learning may hold the key for a fully automated analysis of scattering data and real-time reconstruction of ultrafast nanoscale dynamics probed at the next generation of X-ray light sources with high repetition rate.

[1] I. Barke et al., Nat. Comm. **6**, 6187 (2015).
[2] T. Stielow et al., arXiv:1906.06883 (2019).