T 23: Experimentelle Techniken der Astroteilchenphysik 2

Zeit: Montag 16:45–19:00 Raum: S 055

T 23.1 Mo 16:45 S 055

Deep Learning für Neutrinoteleskope — •Stefan Geisselsöder für die ANTARES-KM3NeT-Erlangen-Kollaboration — Friedrich-Alexander-Universität Erlangen-Nürnberg — ECAP

Neutrinoteleskope erlauben uns Erkenntnisse sowohl über die Flüsse hochenergetischer kosmischer Neutrinos als auch über deren teilchenphysikalische Eigenschaften zu gewinnen. Die benötigte Datenanalyse, speziell die Identifikation und Rekonstruktion von Neutrinointeraktionen, ist jedoch bei allen existierenden und geplanten Neutrinoteleskopen eine herausfordernde Aufgabe, die signifikanten Einfluss auf den Erfolg späterer Analysen hat.

Deep Learning bezeichnet eine gegenwärtig in vielen Anwendungsbereichen sehr erfolgreiche und flexibel einsetzbare Gruppe von Algorithmen, die einen hohen Grad an automatisch erzielter Abstraktion gemeinsam haben. Der Vortrag zeigt Methoden und Ideen, wie mittels Deep Learning Frameworks (hier Tensorflow und CNTK) verschiedene Ansätze (Convolutional Neural Networks und Recurrent Neural Networks) genutzt werden können, um die Genauigkeit der Datenanalyse für Neutrinoteleskope zu verbessern. Dabei ist insbesondere die Art der betrachteten Daten interessant, da sie bei Neutrinoteleskopen, im Gegensatz zu im Rahmen von Deep Learning häufig betrachten zweidimensionalen Bilddaten, drei Raum- und eine Zeitdimension aufweisen. Die Entwicklungen werden am Beispiel des KM3NeT Neutrinoteleskops gezeigt, das gegenwärtig am Grund des Mittelmeeres im Aufbau ist, sind jedoch größtenteils allgemein anwendbar.

T 23.2 Mo 17:00 S 055

Deep Learning für KM3NeT — •Christoph Biernoth für die ANTARES-KM3NeT-Erlangen-Kollaboration — Friedrich-Alexander-Universität Erlangen-Nürnberg — ECAP

Der Wasser-Cherenkov-Detektor KM3NeT/ARCA wird aktuell auf dem Grund des Mittelmeeres vor der sizilischen Küste in einer Wassertiefe von 3500m errichtet. Das Hauptaugenmerk ist die Untersuchung der Quellen des Flusses hochenergetischer kosmischer Neutrinos, dessen Existenz inzwischen von IceCube nachgewiesen wurde. Das Neutrinoteleskop besteht aus einen dreidimensionalen Aufbau von optischen Senormodulen, die unter anderem die Ankunftszeit des Cherenkovlichtes aus Neutrinoreaktionen registrieren.

Ein (künstliches) neuronales Netz ist durch Nervenzellvernetzungen im Gehirn motiviert. Es besteht aus in Ebenen angeordneten Neuronen, welche miteinander verknüpft sind und kann mittels Beispieldaten darauf trainiert werden, Korrelationen in den Daten zu erkennen und damit die Daten in Klassen einzuordnen. Der Vortrag zeigt, wie verschiedene Ansätze von tiefen neuronalen Netzen genutzt werden können, um bestimmte Merkmale wie die Teilchenart, aus Roh- oder bereits vorverarbeiteten Daten zu abstrahieren. Dabei werden die zwei verwendeten Frameworks Tensorflow und CNTK sowie verschiedene Netzwerkstrukturen wie Convolutional Neural Networks und Recurrent Neural Networks vorgestellt. Eine Besonderheit im Vergleich zu gängigen Anwendungsfällen ist hierbei der vierdimensionale Parameterraum bestehend aus Ort und Zeit der registrierten Photonen.

T 23.3 Mo 17:15 S 055

Deep Learning in Physics exemplified by the reconstruction of muon-neutrino events in IceCube — •Mirco Hünnefeld for the IceCube-Collaboration — TU Dortmund, Dortmund, Germany

Recent advances, especially in image recognition, have shown the capabilities of deep learning. Deep neural networks can be extremely powerful and their usage is computationally cheap once the networks are trained. While the main bottleneck for deep neural networks in the traditional domain of image classification is the lack of sufficient labeled data, this usually does not apply to physics where millions of Monte Carlo simulations exist.

At the IceCube Neutrino Observatory, the reconstruction of muon-neutrino events is one of the key challenges. Due to limited computational resources and the high data rate, only very basic and simplified reconstructions limited to a small subset of data can be run on-site at the South Pole. However, in order to perform online analysis and to issue real-time alerts, a fast and powerful reconstruction is necessary.

In this talk I will present how deep learning techniques such as those used in image recognition can be applied to IceCube waveforms in order to reconstruct muon-neutrino events. These methods can be generalized to other physics experiments.

T 23.4 Mo 17:30 S 055

Mining for Spectra - The Dortmund Spectrum Estimation Algorithm — •Tim Ruhe — Technische Universität Dortmund, Dortmund, Deutschland

Obtaining energy spectra of incident particles such as neutrinos or gamma-rays is a common challenge in neutrino- and Air-Cherenkov astronomy, as the particle's energy cannot be observed directly but has to be inferred from other observables e.g. energy losses of secondary particles utilized for detection. The task is further made difficult by the fact that the production of secondaries, e.g. in a neutrino-nucleon interaction is governed by stochastical processes. Mathematically this corresponds to an inverse problem, which is described by the Fredholm integral equation of the first kind. Several algorithms for solving inverse problems exist, which are, however, somewhat limited, for example in the number of input variables or in the sense that only the unfolded distribution is returned and information on individual events is lost. We present the Dortmund Spectrum Estimation Algorithm (DSEA), which aims at overcoming the afore mentioned obstacles by treating the inverse problem as a multinominal classification task. This results in a modular and highly flexible algorithm that can easily be tailored to a problem at hand. To avoid a potential bias on the class distribution used for the training of the learner, DSEA can be used iteratively using a uniform class-distribution as input.

T 23.5 Mo 17:45 S 055

Online Classification of IceCube Events using Neural Networks — •Joshua Luckey for the IceCube-Collaboration — Technische Universität Dortmund, Deutschland

The IceCube neutrino detector is located at the geographic South Pole and consists of 5160 digital optical modules, each containing a photomultiplier tube, deployed into the ice. With an instrumented volume of $1\,\mathrm{km}^2$ IceCube detects events at a rate of about 3000 Hz. The first data processing steps are done by a system of online filters, which are applying reconstruction algorithms to the data. An analysis on the data at this early stage bears the advantage of being independent of time- and CPU-intensive data preprocessing. In this talk a classification of online data of the IceCube detector is presented. The classification is based on the topology of the events in the detector. At first the events can be separated into the two classes of track-like and cascade-like events and from there further classifications can be carried out. With the recent advancements in other fields of research in mind, Deep Learning algorithms in conjunction with neural networks are used to conduct the afore-mentioned classification as early in the data acquisition process as possible. A classification at this early stage could be beneficial to analyses focusing on just one type of event. Furthermore an optimization of the used neural net, with the aim of minimizing the classification time, could be performed to classify every detected event.

T 23.6 Mo 18:00 S 055

Improvement of energy reconstruction by using machine learning algorithms in MAGIC — •Kazuma Ishio[1], Galina Maneva[2], Abelardo Moralejo[3], David Paneque[1], Julian Sitarek[4], and Petar Temnikov[2] for the MAGIC-Collaboration — [1]Max-Planck-Institut für Physik, München, Germany — [2]Institute for Nuclear Research and Nuclear Energy, Sofia, Bulgaria — [3]Institut de Fisica d'Altes Energies (IFAE), Barcelona, Spain — [4]University of Lodz, Lodz, Poland

The MAGIC telescopes perform gamma-ray astronomy at energies above 50 GeV and extending to about 50 TeV. The energy of the detected gamma ray is estimated with a set of parameters extracted from the shower image on the cameras and using Look-Up-Tables (LUTs) derived from Monte Carlo simulations. The current strategy yields an energy bias smaller than 5% with a resolution of approximately 20%, depending on energy range. The talk focuses on the usage of machine learning strategies, namely artificial neural network (ANN) and random forest (RF), for the determination of the gamma-ray energy. I will show that these strategies provide independent ways of reconstructing the energy, which are very helpful for cross-checks, and they also yield an improvement in the performance for energies above 1 TeV with respect to LUTs.

T 23.7 Mo 18:15 S 055

Neural Networks for Energy Reconstruction in the IceCube Neutrino Observatory — •Martin Brenzke, Jan Auffenberg, Christian Haack, René Reimann, and Christopher Wiebusch for the IceCube-Collaboration — III. Physikalisches Institut, RWTH Aachen University, D-52056 Aachen, Germany

Energy reconstruction of track-like events induced by muons is an essential part of the data analysis of the IceCube Neutrino Observatory. There already are sophisticated methods to reconstruct the energy of those events. However, the progress achieved in the recent decade in deep learning techniques makes them an interesting candidate for an alternative method for energy reconstruction, which might perform as well as or even better than the established algorithms. We focus on supervised learning techniques using recurrent neural networks and present first results of performance studies as well as comparisons to commonly used reconstruction methods.

T 23.8 Mo 18:30 S 055

Event Identification for KM3NeT/ARCA — •Thomas Heid for the ANTARES-KM3NeT-Erlangen-Collaboration — Friedrich-Alexander-Universität Erlangen-Nürnberg, ECAP

KM3NeT is a distributed neutrino research infrastructure in the Mediterranean sea. KM3NeT/ARCA is the high energy part of it, which is dedicated for the search of extraterrestrial neutrino sources in the TeV-PeV range. One major goal is to study the source of the recently discovered neutrino flux by IceCube. Furthermore KM3NeT/ARCA is optimised to study galactical neutrino point sources. More insight into neutrino sources can be achieved by distinguishing between neutrino flavours. Neutrinos can have different interactions inside or near the detector which lead to various event topologies. These topologies can be differentiated with machine learning algorithms. Here neural nets were trained on selected event features, for example based on time-residual distributions. Five target topologies are differentiated: double bang events, cascades and three different track-like topologies. Based on the topologies, the neutrino flavour composition can be inferred on a statistical basis. In addition, computationally complex, tailored reconstruction algorithms can be employed based on the event topology.

T 23.9 Mo 18:45 S 055

Dealing with Data/Simulation Mismatches in Machine Learning based Analyses — •Mathis Börner, Jens Buss, and Thorben Menne for the IceCube-Collaboration — Technische Universität Dortmund, Dortmund, Deutschland

The widespread use of machine learning algorithms in physical analyses require an intensive check for the compatibility between measured data and simulations. Since all frequently used algorithms use us more than one observable as the input. Therefore, the typical univariate comparison might not be sufficient. Furthermore, simulations always have finite mismatches, so it is necessary to decide whether they can be neglected or not. In this talk an approach utilizing machine learning algorithms to tackle both challenges is presented. The approach can be used exploratory to discover observables and areas in the observable space with significant mismatches. In a different application the approach is applicable to select observables with the lowest mismatch from a large set. Moreover, a way to show that no significant mismatches are presented in the simulation is shown. All presented methods are illustrated with results based on IceCube data.