T 63: ML Methods III

Time: Wednesday 15:50–17:20 Location: HSZ/0405

T 63.1 Wed 15:50 HSZ/0405

Automated Hyperparameter Optimization of Neural Networks for ATLAS analyses — •Erik Bachmann — Institute of Nuclear and Particle Physics, Technische Universität Dresden, Germany

In recent years, artificial neural networks have become a standard tool in many analyses to increase the sensitivity of measurements and largely replaced other multivariate techniques. The hyperparameters of the neural network, e. g. the number of hidden layers in a multilayer perceptron, are however usually chosen based on intuition and experience without any optimization. Additionally, the absence of overtraining is often only verified by visually inspecting the network's output distributions.

In this talk, a framework to perform automated hyperparameter optimization with a special focus on directly including objective overtraining conditions as part of the optimization is presented. Furthermore, its first application in the ATLAS vector boson polarization analysis of $W^{\pm}W^{\pm}$ scattering is discussed.

T 63.2 Wed 16:05 HSZ/0405

Optimising inference with binning — Phillip Keicher, Marcel Rieger, Peter Schleper, and •Jan Voss — Institut für Experimentalphysik Universität Hamburg, Hamburg, Deutschland

In order to increase the sensitivity of searches for rare processes, neural networks are nowadays a widely-spread tool to construct powerful discriminators. These discriminators are usually optimized to separate physics-motivated classes, but not necessarily on an optimal statistical inference. Consequently, the results can depend on auxiliary effects such as the exact binning choice for the distributions of the final discriminants.

This study aims to construct a setup for optimising the sensitivity with respect to the binning choice in the context of a Di-Higgs in the $b\bar{b}\tau^{+}\tau^{-}$ final state. This setup is based on the python packages pyhf and JAX, which are used for the statistical modeling and the derivation of the inference with respect to the bin edges. This talk presents the current status of this on-going project and will highlight the challenges and possible applications of this novel technique.

T 63.3 Wed 16:20 HSZ/0405

Uncertainty aware training — Markus Klute, •Artur Monsch, Günter Quast, Lars Sowa, and Roger Wolf — Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

As physics experiments continue their measurements, with the LHC Run-3 and the future High-Luminosity LHC as notable examples, the amount of data is steadily increasing. These continued measurements will lead to reduced statistical uncertianties of many analyses, emphasizing the importance of systematic uncertainties in analysis results. This talk presents a machine-learning (ML)-based data analysis strategy to obtain an optimal test statistic minimizing analysis-specific statistical and systematic uncertainties. To achieve this the training objective for the neural network is modified to take systematic variations into account, leading to an overall uncertainty reduction on the analysis objective. The method will be demonstrated on a simple example using pseudo data and on a reduced CMS dataset used for an ML-based analysis of the observed Higgs boson in the di-τ final state with the goal of differential measurements of Higgs boson production, with the CMS experiment.

T 63.4 Wed 16:35 HSZ/0405

Interpolating Antenna Calibration Data from Sparse Measurements with Information Field Theory — •Maximilian Straub, Martin Erdmann, and Alex Reuzki for the Pierre Auger-Collaboration — Physics Institute III A RWTH Aachen University

Extensive air showers are induced in the Earth's atmosphere by ultra-high-energy cosmic rays. These air showers are measured at the Pierre Auger Observatory using various detection techniques, including radio antennas. As part of the Pierre Auger Observatory's AugerPrime upgrade, so-called Short Aperiodic Loaded Loop Antennas (SALLAs) are currently being deployed. These antennas will be calibrated with a remotely-piloted aircraft that carries a known signal source to characterize the direction- and frequency dependent gain, the so-called antenna pattern. With this method, only a finite number of directions and frequencies is probed, limited by i.a. battery life of the aircraft. Information Field Theory (IFT) is a framework for reconstructing field-like structures using Bayesian statistics. With IFT it is possible to leverage local correlation structures to interpolate on the domain product $S^2 \times \mathbb{R}$, that is direction dependence and frequency dependence at the same time. The multidimensional interpolation is informed by physics and therefore performs better than e.g. a linear interpolation. Using Information Field Theory provides calibration uncertainties resulting from the calibration measurements. Furthermore, by operating directly on the sphere it avoids projection-related distortions and edge effects that stem from the angular periodicity.

T 63.5 Wed 16:50 HSZ/0405

Tau neutrino identification with Graph Neural Networks in KM3NeT/ORCA — •Lukas Hennig for the ANTARES-KM3NET-ERLANGEN-Collaboration — Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Erlangen Centre for Astroparticle Physics, Nikolaus-Fiebiger-Straße 2, 91058 Erlangen, Germany

One of the goals of the KM3NeT collaboration is to constrain the PMNS matrix elements associated with the tau neutrino flavour. The data needed to perform this task is taken with KM3NeT/ORCA, a neutrino detector currently under construction in the Mediterranean deep 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 tau neutrino interactions look very similar to the final states of muon or electron neutrino events. This classification problem was tackled in my Master's thesis using Graph Neural Networks (GNNs), a type of neural network architecture that showed promising results, e.g., on the related task of jet tagging. This talk will discuss the different methods used to optimise the GNN's performance on this classification task, including a computation-intensive automated hyperparameter search, and present the performance gains achieved by each of these steps and the final performance of the tau event classifier.

T 63.6 Wed 17:05 HSZ/0405

Negative event weights in Machine Learning and search for heavy Higgs bosons in top quark pair events at CMS — •Jörn Bach[1,2,3], Christian Schwanenberger[1,2], Peer Stelldinger[3], and Alexander Grohsjean[1] — [1]Deutsches Elektronen Synchrotron DESY, Hamburg — [2]Universität Hamburg, Hamburg — [3]Hochschule für angewandte Wissenschaften (HAW) Hamburg

Sophisticated Monte-Carlo event generators are key to the LHC research program. When involving higher order predictions or interference effects, simulated events can be negatively weighted. To achieve correct results with maximum sensitivity, negative weights cannot simply be ignored when working with Machine Learning methods. In this talk, I will discuss the issues that arise in trainings of Deep Neural Networks through negatively weighted events and propose a solution on how to efficiently handle them. Additionally, I will discuss the application of these techniques in a search for heavy Higgs bosons and its potential for LHC data analyses in general.