T 47: Neural networks and systematic uncertainties

Time: Wednesday 16:30–19:00 Location: H-HS IV

T 47.1 Wed 16:30 H-HS IV

VISPA: Platform as a Service (PaaS) for Scientific Data Analysis — Max Beer, Friederike Butt, Niclas Eich, Martin Erdmann, Peter Fackeldey, Benjamin Fischer, •Katharina Hafner, Dennis Noll, Yannik Rath, Erwin Rudi, Alexander Temme, and Maximilian Vieweg — Physikalisches Institut 3A, RWTH Aachen University

The VISPA project delivers a cloud platform that enables scientific data analysis with the convenience of using a web browser. Our goal is to explore how scientific work with data might look like in the future. Through the VISPA web platform, each user is provided with a working environment consisting of pre-installed tools and software. The working environment can be largely customized and expanded according to the users preferences. To enable a jump start into the infrastructure, a large collection of examples, including classical data analysis and deep learning, can be tried out directly. Computing resources like disk space, processors and GPUs are either assigned to individual users or groups of users, such as research teams. As the emerging JupyterLab is an ideal choice for a comprehensive, browser-based, and extensible work environment, it is currently being integrated into the VISPA frontend. Beside the new frontend, users can now have individual access rights to experimental data (public data, experiment data), use Jupyter Notebooks and state-of-the-art visualization tools for data analysis.

T 47.2 Wed 16:45 H-HS IV

New methods for the application of neural networks in the presence of systematic uncertainties — Simon Jörger[1], Günter Quast[1], Roger Wolf[1], and •Stefan Wunsch[1,2] — [1]KIT — [2]CERN

In this talk, we introduce new methods for the application of neural networks in the presence of systematic uncertainties, common in HEP analysis. We discuss a new technique to identify those features of the multi-dimensional input space, which the response of the network is most sensitive to, as a crucial input to the discussion of the propagation of systematic uncertainties onto the neural network output and therefore the measurement. A second method is presented to penalize such propagations of systematic variations controlling the impact of systematic uncertainties on the measurement.

T 47.3 Wed 17:00 H-HS IV

Treating Uncertainties with Bayesian Neural Networks in a $t\bar{t}$H Measurement — Ulrich Husemann, Philip Keicher, Matthias Schröder, and •Nikita Shadskiy — Institut für Experimentelle Teilchenphysik (ETP), Karlsruher Institut für Technologie (KIT)

In the Standard Model, fermions couple to the Higgs boson via a Yukawa coupling with a strength proportional to their mass. The top quark is the heaviest known fermion and, therefore, has the strongest coupling to the Higgs boson.
One of the processes to investigate this coupling is the associated $t\bar{t}$+H production where the Higgs boson decays into a $b\bar{b}$ pair. This signal process has a much smaller cross section than the challenging background processes like $t\bar{t}$+jets production. Especially $t\bar{t}+b\bar{b}$ events are very signal-like. A common approach to separate this signal from the backgrounds is to use artificial neural networks.
Neural networks normally do not take into account uncertainties of the processes. Bayesian neural networks, however, use whole weight distributions instead of single weight values. In this talk it is investigated how this feature of Bayesian neural networks can be used to treat uncertainties in a $t\bar{t}$H measurement.

T 47.4 Wed 17:15 H-HS IV

Reduction of systematic uncertainties with adversarial neural networks in scope of the $t\bar{t}$H($b\bar{b}$) analysis at CMS — •Simon Ehnle, Ulrich Husemann, Philip Keicher, Matthias Schröder, and Sebastian Wieland — Institut für Experimentelle Teilchenphysik (ETP), Karlsruher Institut für Technologie (KIT)

The production of top quark-antiquark pairs in association with the Higgs boson allows a direct measurement of the top-Higgs Yukawa coupling. To compensate the small cross section, the Higgs boson decay into a bottom quark-antiquark pair ($t\bar{t}$H($b\bar{b}$)), which has the largest branching ratio, is investigated. Multivariate analysis methods are used to separate signal from background.

A major background in this channel is the top quark-antiquark pair production in association with a bottom quark-antiquark pair. This process is hard to model and different simulation approaches with different uncertainties exist. The classifying neural networks have the potential to get robust against these differences by using adversarial neural networks, whereby two neural networks compete against each other in a zero-sum game.

In this presentation, the approach of reducing systematic uncertainties with adversarial neural networks is studied in scope of the $t\bar{t}$H($b\bar{b}$) analysis in the semileptonic channel at CMS.

T 47.5 Wed 17:30 H-HS IV

Runtime optimisation of Adversarial Neural Networks in the *tW* dilepton channel using the ATLAS detector — •Nicolas Boeing, Ian C. Brock, and Christian Kirfel — Physikalisches Institut, Bonn, Deutschland

Neural networks have proven effective for signal to background separation in high energy physics. These classifier networks can be highly sensitive to systematic uncertainties. A possible solution is the use of an adversarial neural network, a technique that pits two networks against each other. The first network has the classic task of separating signal and background, while a second adversarial network attempts to separate nominal from systematic samples, based on the output of the first network. By minimising the separation of the adversarial network, the classifier can be made more robust with respect to systematic uncertainties. This type of network structure has been shown to work for training on Monte Carlo simulated tW dilepton signal events and $t\bar{t}$ background events using the ATLAS detector, but a significant downside of training in this channel has been computation time. In this talk, we introduce methods to reduce training time using GPUs. Based on this improved performance, further improvements to the network are presented.

T 47.6 Wed 17:45 H-HS IV

Evaluation of performance gains in the training of neural networks for HEP analysis applications using GPUs — •Michael Holzbock, Günter Duckeck, and Klaus Dolag — Ludwig-Maximilians-Universität München

It has become more and more popular to tackle typical analysis task in high-energy physics (HEP) with approaches based on machine learning (ML) techniques. The training of such algorithms is computationally demanding but can be accelerated by the usage of GPUs, which architectures are better suited to perform the underlying calculations.

Studies are presented which evaluate the speed-up in case the training of ML algorithms is accelerated by GPUs. Several test cases are considered, that involve ML techniques commonly used in HEP data analysis such as deep and convolutional neural networks. To study whether benefits of GPUs depend on a network's layout, several of its hyperparameters such as the number of neurons were systematically varied. Finally, the results of these to some extend artificial test cases are compared with the acceleration observed for a neural network configuration used in a search for physics beyond the Standard Model.

T 47.7 Wed 18:00 H-HS IV

Use of Deep Learning techniques in the search for the Higgs boson decay to pair of charm quarks at CMS — Andrey Pozdnyakov[1], Xavier Coubez[1,2], Luca Mastrolorenzo[1], Spandal Mondal[1], Andrzej Novak[1], Alexander Schmidt[1], and •Guillermo Rocamora Pérez[1] — [1]RWTH Aachen, Germany — [2]Brown University, Providence, USA

With the increasing amount of data expected from the Large Hadron Collider, the Higgs boson coupling to second generation fermions is becoming accessible to the experiments. Already now machine learning techniques such as Deep Neural Networks (DNNs) are playing a crucial role in many physics analyses. This presentation shows how a DNN is used in improving the sensitivity of the search for the H->cc decay.

T 47.8 Wed 18:15 H-HS IV

Reinforcement learning for sorting jets in top pair associated

Higgs boson production — •Dennis Noll, Martin Erdmann, and Benjamin Fischer — III. Physikalisches Institut A, RWTH Aachen University

For physics analyses with identical final state objects, e.g. jets, the correct sorting of input objects often leads to a sizeable performance increase.

We present a new approach in which a sorting network is placed in front of a classification network. The sorting network provides a two-dimensional likelihood that is used to guide the rearrangement of particle four-momenta.

Because the optimal order is generally not known, a reinforcement learning approach is chosen, in which the sorting network is trained with end-to-end feedback from the analysis. In this way, we enable the system to autonomously find an optimal solution to the sorting problem.

Using the example of top-quark pair associated Higgs boson production, we show an improvement of the signal and background separation in comparison to conventional sorting of jets with respect to their transverse momenta.

T 47.9 Wed 18:30 H-HS IV

Multivariate analysis methods in the analysis of single top-quark production in association with a heavy boson at ATLAS — •Christian Kirfel, Ian Brock, Richard Baumann, and Piet Nogga — Physikalisches Institut Bonn

Single top-quark production in association with a heavy boson gives rise to a multitude of interesting analyses including the production of a top quark and a Higgs boson. To separate the signal from background events, multivariate analysis methods are a common choice.

Previous analyses of a top quark associated with a Z boson featured a shallow neural network provided by the NeuroBayes package. Since the long-term support for this program is unclear, efforts are being made to create an algorithm using the open source software Keras to replace NeuroBayes.

A summary of approaches is presented, ranging from a performance comparison between the formerly used NeuroBayes algorithm and a deep neural network built in Keras, to the use of Lorentz-invariant variables. The different approaches are introduced and the results are discussed not only in the context of replacing the NeuroBayes network but also focusing on the general usability of the methods in particle physics analyses.

T 47.10 Wed 18:45 H-HS IV

Confronting EFT with artificial neural networks in the quest for physics beyond the Standard Model — Alexander Grohsjean and •Jonas Rübenach — DESY, Hamburg, Germany

As no sign of physics beyond the Standard Model has emerged at the Large Hadron Collider so far, high precision measurements of particle properties and couplings become increasingly interesting. A commonly used language to interpret these measurements is effective field theory, in which higher-dimensional operators are added to the Standard Model. Traditional approaches most commonly set constraints on anomalous couplings by employing and combining unfolded measurements.

This talk introduces novel neural-network driven analysis methods to be used in conjunction with effective field theory. The neural networks learn from truth information of Monte Carlo simulation in order to directly perform hypothesis testing on measured data. These new methods outperform traditional approaches by providing stronger constraints of at least a factor of 5.