T 71: Data analysis, Information technology III

Time: Wednesday 16:00–18:15 Location: Tu

T 71.1 Wed 16:00 Tu

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

Optimal photon identification in ATLAS analyses plays an important role in precise measurements of Higgs boson properties and in the search for new particles.

Currently photons are selected using a set of cuts on calorimeter variables which describe 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 efficiencies must be corrected to match data. The efficiency measurement in data is not simple and requires assumptions about some shower shape variables, i.e. that they are independent of the isolation of the photon candidate.

Artificial neural networks are employed to improve the current photon identification. Decorrelation of the neural network output from the isolation variable results in an improvement of the efficiency measurement in data.

T 71.2 Wed 16:15 Tu

Studies of modern machine learning methods for tau lepton identification with the CMS detector — •Andrew Issac[1], Günter Quast[1], Roger Wolf[1], Stefan Wunsch[1,2], and Sebastian Brommer[1] — [1]Karlsruhe Institute of Technology, Institute of Experimental Particle Physics, Karlsruhe, Germany — [2]CERN, Geneva, Switzerland

High-energy physics particle reconstruction algorithms are a perfect playground for modern machine learning methods due to the vast amount of data and complex learning tasks. The tau lepton identification is an interesting field to explore new neural network models such as graph-based networks and benchmark them against existing approaches, e.g., a deep convolutional model currently used by CMS.

T 71.3 Wed 16:30 Tu

Adversarial Neural Network-based shape calibrations of observables for jet-tagging at CMS — Martin Erdmann[1], •Benjamin Fischer[1], Jan Middendorf[1], Dennis Noll[1], Yannik Alexander Rath[1], Marcel Rieger[2], Erwin Rudi[1], and David Josef Schmidt[1] — [1]III. Physikalisches Institut A, RWTH Aachen University — [2]CERN

Scale factors are commonly used in HEP to improve shape agreement between distributions of data and simulation. The choice of the underlying model for such corrections is of great importance, but often requires a lot of manual tuning e.g. of bin sizes or fitted functions. This can be alleviated through the use of neural networks and their inherent powerful data modeling capabilities.

We present a novel and generalized method for producing shape changing scale factors using adversarial neural networks. This method is investigated in the context of the bottom-quark jet-tagging algorithms within the CMS experiment. The scale factor of each jet is produced by the primary network using the jet's variables. The second network, the adversary, aims to differentiate between data and rescaled simulation events and facilitates the training of the former. An additional third network is used for normalization preservation with respect to correlated variables.

We present the conceptual design and resulting scale factors in comparison to the previously applied methods.

T 71.4 Wed 16:45 Tu

AI-safety for jet flavour tagging at the CMS experiment — Xavier Coubez[1,2], Nikolas Frediani[1], Spandan Mondal[1], Andrzej Novak[1], Alexander Schmidt[1], and •Annika Stein[1] — [1]RWTH Aachen University, Germany — [2]Brown University, USA

Besides traditional Machine Learning techniques, Deep Learning has gained popularity in High Energy Physics in general. At the CMS experiment in particular, jet identification algorithms use Deep Neural Networks to classify the quark flavour from which the jet originates. The tagger learns to discriminate between heavy flavour quarks and light quarks.

The aim of AI safety studies is to test how susceptible neural networks are when mismodeling occurs in the simulation or when adversarial attacks are applied to the input data. Subtle mismodelings could be invisible to typical validation methods. In this talk, several methods to manipulate the input data and the impact on the performance of the tagging algorithm will be shown.

T 71.5 Wed 17:00 Tu

Charm jet identification and discriminator calibration with the CMS experiment — •Spandan Mondal[1], Xavier Coubez[1,2], Alena Dodonova[1], Luca Mastrolorenzo[1], Andrzej Novak[1], Andrey Pozdnyakov[1], and Alexander Schmidt[1] — [1]RWTH Aachen University, Germany — [2]Brown University, USA

Identification of charm-quark-initiated jets at the LHC is especially challenging. Over the past few years, usage of advanced deep learning based algorithms has enabled several CMS analyses to efficiently discriminate charm jets simultaneously from bottom and light jets. The charm probability scores yielded by such charm tagging algorithms can play a powerful role when used as inputs to a machine learning based signal-background discriminating algorithm. However, as jet identification algorithms are trained strictly on simulated jets, a direct usage of charm tagger output values requires calibrating the entire output probability distributions using real jets reconstructed from CMS data. This talk focuses on charm jet identification algorithms in CMS as well as the calibration of their output discriminator values using flavour-enriched selections of jets in data.

T 71.6 Wed 17:15 Tu

Performance Studies of the Integration of a Deep-Impact-Parameter-Setsbased Tagger for the ATLAS Experiment *b*-Tagging Algorithm — •Alexander Froch, Manuel Guth, and Andrea Knue — Albert-Ludwigs Universität Freiburg, Experimentelle Teilchenphysik AG Herten

The identification of the origin of a jet produced in a high-energy collision is an important task and is crucial for most analyses performed at the ATLAS experiment. Different multivariate techniques are used and combined to determine the jet origin. One of these techniques is the Deep Impact Parameter Sets (DIPS) tagger.
The DIPS tagger is a deep neural network based on the Deep Sets architecture. It uses track information of the particles inside the clustered jets for classification. It is part of a new tagging algorithm currently developed in ATLAS. The algorithm itself can distinguish between different jet origins, like light, charm or bottom jets. A good performance was already observed for a training using $t\bar{t}$ events. For further improvement in the high p_T region, jets from Z' decays are included in the training.

The performance of this training will be shown along with the impact of the hyper-parameter optimization studies.

T 71.7 Wed 17:30 Tu

Training of an extended *b*-tagging algorithm with deep neural networks. — •Thea Engler, Manuel Guth, Gregor Herten, and Andrea Knue — Uni Freiburg, Deutschland

The search for the $t\bar{t}H(H \to b\bar{b})$ signal provides direct access to the top-Higgs Yukawa coupling. This channel has four b-jets in the final state and is suffering from large physics background, which makes b-tagging a crucial tool for this analysis. The irreducible $t\bar{t} + b\bar{b}$ background has the same final-state particles as the signal process. In this background process, a radiated gluon splits into a b-quark pair. If these b-hadrons are close to each other, they can be reconstructed as one single jet (bb-jet). The irreducible background $t\bar{t} + b\bar{b}$ can be better rejected if these bb-jets can be classified. Accordingly, an extended b-tagging algorithm is prepared, based on the ATLAS recommended b-tagger, with an additional classification category for bb-jets. To prepare the extended b-tagging algorithm, the importance of balanced input classes in the training of deep neural networks is studied. The studied approaches are implemented in the extended bb-tagger and a first training is presented.

T 71.8 Wed 17:45 Tu

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

In the Standard Model of particle physics, fermions couple to the Higgs boson via a Yukawa-type 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 $\mathrm{t\bar{t}H}$ production in which the Higgs boson decays into a $\mathrm{b\bar{b}}$ pair. This signal process has a much smaller cross section than the challenging background processes like $\mathrm{t\bar{t}}$+jets production. Especially $\mathrm{t\bar{t}+b\bar{b}}$ events are very signal-like. A common approach to separating this signal from the backgrounds is to use artificial neural networks.
Neural networks usually do not take into account uncertainties. In contrast, Bayesian neural networks use weight distributions instead of single weight values. This not only prevents overfitting but also allows to obtain an uncertainty estimate on the predictions of the neural network. In this talk it is investigated how this feature of Bayesian neural networks can be used in a $\mathrm{t\bar{t}H(b\bar{b})}$ measurement.

T 71.9 Wed 18:00 Tu

Improvement of the jet-parton assignment in $t\bar{t}H(b\bar{b})$ events using machine-learning techniques — •Daniel Bahner, Andrea Knue, and Gregor Herten — Albert-Ludwigs-University, Freiburg, Germany

The associated production of a Higgs boson and a top quark pair allows to directly measure the Higgs-top Yukawa coupling, which can be sensitive to Beyond Standard Model physics. In the studies presented, the process of interest is the semileptonic decay of the $t\bar{t}$ pair accompanied by a $b\bar{b}$ pair resulting from the most prominent Higgs decay. In this topology, four b-jets and two light jets are expected. This Higgs decay channel suffers from irreducible background due to $t\bar{t}+b\bar{b}$ production. Furthermore, the full reconstruction of this final state proves difficult because of the ambiguities in assigning the jets to their original parton.

In the latest publication, a Boosted Decision Tree was used for the jet-parton assignment. In the studies presented, a Deep Neural Network is used that has been previously trained in the scope of a master thesis. Optimization studies of the network architecture and the impact of using the new ATLAS b-tagging algorithm DL1r will be shown.