Abstract:

Pipeline for performance evaluation of flavour tagging dedicated Graph Neural Network algorithms

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In the High Energy Physics (HEP) research at colliders, the identification of jets originating from b- and c-quarks (flavour tagging) is crucial for many analyses, including searches beyond the Standard Model (SM) signatures and measurements of the properties of SM particles. Suitable candidates for the optimization of flavour tagging efficiency are Graph Neural Networks-based algorithms (GNNs), which are already successfully applied in different scientific fields. In this contribution, a pipeline for training and optimization of flavour tagging dedicated GNNs is presented. Each jet is portrayed by a graph-structure, wherein the associated charged particle tracks correspond to nodes totally connected. By analyzing the topology of the graph, a wide range of information can be extracted which are exploited from the network to identify the partonic species of the jets. To evaluate the performance of this approach, we simulated a next-to-leading order (NLO) $t\bar{t}$ dataset by integrating multiple frameworks. The MadGraph_aMC@NLO [1] framework generates the necessary matrix elements, accounting for virtual and real radiation contributions. The events are then hadronized with PYTHIA-8.3 [2], following the ATLAS A15 configuration [3]. Finally, to model the response of particle detectors to the final-state particles, the DELPHES-3.5.0 fast simulation [4] of the ATLAS detector is used. To extend the accessible transverse momentum range, an additional high-p_T $Z'H$ dataset at LO precision has been simulated using the same configuration. The evaluation of the pipeline performance has been executed by comparison of the results obtained with those from the ATLAS experiment and CMS experiment. Moreover, has been evaluated the comparability of our pipeline with traditional jet tagging methods and other state-of-the-art GNN-based algorithms. This work contributes to the growing body of research on GNNs in HEP and demonstrates the potential of GNNs for jet tagging. Additionally, the pipeline architecture provides the possibility to explore the input feature ranking and the application of attention mechanism methods to GNNs.

References

[1] J. Alwall et al. “The automated computation of tree-level and next-to-leading order differential cross sections, and their matching to parton shower simulations”. In: *Journal of High Energy Physics* 2014.7 (July 2014). DOI: 10.1007/jhep07(2014)079. URL: https://doi.org/10.1007%2Fjhep07%282014%29079.

[2] Christian Bierlich et al. “”A comprehensive guide to the physics and usage of PYTHIA 8.3””. In: (2022). DOI: 10.48550/ARXIV.2203.11601. URL: https://arxiv.org/abs/2203.11601.

[3] ATLAS collaboration. “MC Tuning ATLAS”. In: (). URL: https://cds.cern.ch/record/2129370/files/ATL-PHYS-SLIDE-2016-051.pdf.

[4] J. de Favereau et al. “DELPHES 3: a modular framework for fast simulation of a generic collider experiment”. In: (2014). DOI: 10.1007/jhep02(2014)057. URL: https://doi.org/10.1007%5C%2Fjhep02%5C%282014%5C%29057.