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Anatomy of Jet classification using deep learning

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State-of-the-art (SoTA) deep learning models have achieved tremendous improvements in jet classification performance while analyzing low-level inputs, but their decision-making processes have become increasingly opaque. We introduce an analysis model (AM) that combines several phenomenologically motivated neural networks to circumvent the interpretability issue while maintaining high classification performance. Our methodology incorporates networks that scrutinize two-point energy correlations, generalizations of particle multiplicities via Minkowski functionals, and subjet momenta. Regarding top jet tagging at the hadronic calorimeter angular resolution scale, this AM performs comparably to the SoTA models (such as the Particle-Transformer and ParticleNet) in top jet tagging, at the hadronic calorimeter angular resolution scale.

Subsequently, we explore the generator systematics of top versus QCD jet classification among event samples generated from different event generators (Pythia, Vincia, and Herwig) using both SoTA models and our AM. Both models can accurately discern differences between simulations, enabling us to adjust the systematic differences via reweighting using classifier outputs. Furthermore, AMs equipped with partial high-level inputs (AM-PIPs) can identify relevant high-level features; if critical features are omitted from the AM inputs, reweighting is affected adversely. We also visualize our correction method, focusing on important variables in top jet tagging identified by the DisCo method.

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