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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 propose an analysis model (AM) that amalgamates several phenomenologically inspired neural networks to address this interpretability issue without compromising 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, our AM's performance is on par with SoTA models, such as the Particle-Transformer and ParticleNet.

Subsequently, we explore the generator systematics of top versus QCD jet classification among Pythia (PY), Vincia (VIN), and Herwig (HW) samples using both SoTA models and our AM. Both models can accurately discern differences between simulations, enabling us to adjust the systematic differences via classifier output-based reweighting. Furthermore, AMs equipped with partial high-level inputs (AM-PHLIPs) can be utilized to 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, as identified by the DisCo method.

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