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Machine Learning Templates for QCD Factorization in the Search for Physics Beyond the Standard Model

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High-multiplicity all-hadronic final states are an important, but difficult final state for searching for physics beyond the Standard Model. A powerful search method is to look for large jets with accidental substructure due to multiple hard partons falling within a single jet. One way for estimating the background in this search is to exploit an approximate factorization in quantum chromodynamics whereby the jet mass distribution is determined only by its kinematic properties. Traditionally, this approach has been executed using histograms constructed in a background-rich region. We propose a new approach based on Generative Adversarial Networks (GANs). These neural network approaches are naturally unbinned and can be readily conditioned on multiple jet properties. In addition to using vanilla GANs for this purpose, a modification to the traditional WGAN approach has been investigated where weight clipping is replaced with a naturally compact set (in this case, the circle). Both the vanilla and modified WGAN approaches significantly outperform the histogram method, especially when modeling the dependence on features not used in the histogram construction. These results can be useful for enhancing the sensitivity of LHC searches to high-multiplicity final states involving many quarks and gluons and serve as a useful benchmark where GANs may have immediate benefit to the HEP community.

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