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Fitting a deep generative hadronization model

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Hadronization is a critical step in the simulation of high-energy particle and nuclear physics experiments. As there is no first principles understanding of this process, physically-inspired hadronization models have a large number of parameters that are fit to data. Deep generative models are a natural replacement for classical techniques, since they are more flexible and may be able to improve the overall precision. Proof of principle studies have shown how to use neural networks to emulate specific hadronization when trained using the inputs and outputs of classical methods. However, these approaches will not work with data, where we do not have a matching between observed hadrons and partons. In this paper, we develop a protocol for fitting a deep generative hadronization model in a realistic setting, where we only have access to a set of hadrons in data. Our approach uses a variation of a Generative Adversarial Network with a permutation invariant discriminator. We find that this setup is able to match the hadronization model in Herwig with multiple sets of parameters. This work represents a significant step forward in a longer term program to develop, train, and integrate machine learning-based hadronization models into parton shower Monte Carlo programs.

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