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Towards the construction of Foundational Models at the LHC

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The emergence of models pre-trained on simple tasks and then fine-tuned to solve many downstream tasks has become a mainstay for the application of deep learning within a large variety of domains. The models, often referred to as foundation models, aim, through self-supervision, to simplify complex tasks by extracting the most salient features of the data through a careful choice of pre-training strategy. When done effectively, these models can lead to world-leading algorithm performance on a large number of tasks. We present a re-simulation strategy for a model pretraining (R3SL) and show that this strategy applied to quark and gluon jets at the Large Hadron Collider can be used to create a foundation model for hadronically decaying objects. We show R3SL creates a feature space insensitive to the parton shower model uncertainties while retaining the core features of quark and gluon jets. On downstream tasks utilizing the pre-trained feature space, we demonstrate our method achieves comparable, if not better, tagging performance to established benchmarks for jet tagging in Higgs to bottom quarks, but with greatly reduced uncertainties. The algorithm presents a crucial step towards more robust searches for new physics involving particle jets and paves the way for the development of foundation models at the Large Hadron Collider.

Significance

This study is one of the first examples of a foundation model for applications in high-energy physics.

References

Experiment context, if any

LHC

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