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Attention to the strengths of physics interactions: Enhanced Deep Learning Event Classification for Particle Physics Experiments

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A major task in particle physics is the measurement of rare signal processes. These measurements are highly dependent on the classification accuracy of these events in relation to the huge background of other Standard Model processes. Reducing the background by a few tens of percent with the same signal efficiency can already increase the sensitivity considerably.

This study demonstrates the importance of adding physical information (and inductive biases) to these architectures. In addition to the information previously proposed for jet tagging, we add particle measures for energy-dependent particle-particle interaction strengths as predicted by the Feynman rules of the Standard Model (SM). Our work includes this information into different methods for classifying events, in particular Boosted Decision Trees, Transformer Architectures (Particle Transformer) and Graph Neural Networks (Particle Net). We find that the integration of physical information into the attention matrix (transformers) or edges (graphs) notably improves background rejection by 10% to 30% over baseline models (Particle Net), with about 10% of this improvement directly attributable to what we call the SM interaction matrix.

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