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Generative Modeling for Fast Shower Simulation

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Here, we present deep generative models for the fast simulation of calorimeter shower events. Using a three-dimensional, cylindrical scoring mesh, a shower event is parameterized by the total energy deposited on each cell of the scoring mesh. Due to the three-dimensional geometry, to simulate a shower event, it is required to learn a complex probability distribution of $O(10^3) \sim O(10^4)$ dimensional random variable. It should be noted that, on top of the high dimensionality, the sparse nature of a shower event, where energy is randomly deposited only on less than than 20\% of the cells, and the intermittency, which requires to capture large magnitudes but low probability events, make the development of a fast shower simulator challenging. To overcome these challenges, we develop a deep-learning framework, which can facilitate a model development by combining different neural network architectures with a range of generative models, e.g., variational auto-encoder, generative adversarial network, Wasserstein generative adversarial network, and denoising diffusion probabilistic model. In this study, we compare various generative models for the shower simulation. Also, the effects of the data scaling and regularizations are discussed. A distributed computing strategy for the deep generative model is discussed to develop a foundation model for the fast shower simulation.

Significance

In this study, we aim to build a foundation model for the fast shower simulation. To achieve the goal, we first develop a deep learning framework to build a range of deep generative models to learn the high-dimensional probability density function and compare their strengths and weaknesses for the fast shower simulation. We also discuss a parallel computing strategy to digest the large data set to build a foundation model.

References

Experiment context, if any

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