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The Calorimeter Pyramid: Rethinking the design of generative calorimeter shower models

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The simulation of calorimeter showers is computationally intensive, leading to the development of generative models as substitutes. We propose a framework for designing generative models for calorimeter showers that combines the strengths of voxel and point cloud approaches to improve both accuracy and computational efficiency. Our approach employs a pyramid-shaped design, where the base of the pyramid encompasses all calorimeter cells. Each subsequent level corresponds to a pre-defined clustering of cells from the previous level, which aggregates their energy. The pyramid culminates in a single cell that contains the total energy of the shower. Within this hierarchical framework, each model learns to calculate the energy of the hit cells at the current level and determines which cells are hit on the lower level. Importantly, each model only focuses on the 'hit' cells at its level. The final models solely determine the energy of individual hit cells. To accommodate differences in the hit cell cardinality across levels, we introduce two new Set Normalizing Flows which utilize Set Transformers and Deep Sets. Moreover, we propose a newly designed dequantization technique tailored for learning boolean values. We validate the framework on multiple datasets, including CaloChallenge.

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