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Event Generation with Lorentz-Equivariant Geometric Algebra Transformers

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Extracting scientific understanding from particle-physics experiments requires solving diverse learning problems with high precision and good data efficiency. We propose the Lorentz Geometric Algebra Transformer (L-GATr), a new multi-purpose architecture for high-energy physics. L-GATr represents high-energy data in a geometric algebra over four-dimensional space-time and is equivariant under Lorentz transformations, the symmetry group of relativistic kinematics. At the same time, the architecture is a Transformer, which makes it versatile and scalable to large systems. We use L-GATr to construct the first Lorentz-equivariant generative network for LHC events. The continuous normalizing flow is trained with Riemannian flow matching, where we incorporate knowledge about challenging phase space features into the construction of the target velocity field. We discuss the role of symmetry breaking in the construction of the L-GATr generator. Across all performance metrics, the L-GATr generator surpasses equivariant and non-equivariant baselines, positioning it as a robust and innovative framework for pushing the boundaries of machine learning in particle physics.

Track

Detector simulation & event generation

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