Contribution ID: **26** Type: **not specified**

Refining Fast Calorimeter Simulations with a Schrödinger Bridge

Monday 6 November 2023 14:15 (15 minutes)

Machine learning-based simulations, especially calorimeter simulations, are promising tools for approximating the precision of classical high energy physics simulations with a fraction of the generation time. Nearly all methods proposed so far learn neural networks that map a random variable with a known probability density, like a Gaussian, to realistic-looking events. In many cases, physics events are not close to Gaussian and so these neural networks have to learn a highly complex function. We study an alternative approach: Schrödinger bridge Quality Improvement via Refinement of Existing Lightweight Simulations (SQuIRELS). SQuIRELS leverages the power of diffusion-based neural networks and Schrödinger bridges to map between samples where the probability density is not known explicitly. We apply SQuIRELS to the task of refining a classical fast simulation to approximate a full classical simulation. On simulated calorimeter events, we find that SQuIRELS is able to reproduce highly non-trivial features of the full simulation with a fraction of the generation time.

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Session Classification: Super Resolution, Reweighting, and Refinement