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sPHENIX Novel Jet Background Subtraction and Full Detector Simulation Using Self-Supervised Generative AI Models

Machine learning models have previously been utilized to address the challenge of subtracting combinatorial backgrounds from jets in heavy-ion collisions, with most earlier efforts focusing on supervised regression models. In this talk, we introduce the first self-supervised application of a generative AI model for jet background subtraction. We utilize UVCGAN [1], a Cycle Consistent Generative Adversarial Network (CycleGAN), to perform unpaired translations of full detector calorimeter data between heavy-ion and proton-proton collisions. This approach effectively isolates jets from combinatorial backgrounds in heavy-ion collisions while preserving both global jet kinematics and jet substructure.
Additionally, we present the effectiveness of denoising diffusion probabilistic models (DDPMs) as AI-based generative surrogate models for full-detector, whole-event, and high-fidelity simulations in high-energy heavy-ion experiments [2]. Trained on HIJING minimum-bias data simulated with Geant4 in the sPHENIX geometry, DDPMs achieve speedups of approximately 100 times over Geant4 simulations. This allows for the rapid generation of large datasets for applications requiring high statistics heavy ion simulation, such as the background events for jet embedding. Both methods were trained and benchmarked with simulated sPHENIX data, which will be discussed in this talk.

[1] D. Torbunov et al, UVCGAN v2: An Improved Cycle-Consistent GAN for Unpaired Image-to-Image Translation, https://arxiv.org/abs/2303.16280
[2] Y. Go and D. Torbunov et al, Effectiveness of denoising diffusion probabilistic models for fast and high-fidelity whole-event simulation in high-energy heavy-ion experiments, https://link.aps.org/doi/10.1103/PhysRevC.110.034912, https://arxiv.org/abs/2406.01602

Category

Experiment

Collaboration (if applicable)

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