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ADVANCING MONTE CARLO SIMULATION WITH GANs, DIFFUSION MODELS, AND NORMALIZING FLOWS

Dr. Renato Assunção

Departamento de Ciência da Computação

Universidade Federal de Minas Gerais

Belo Horizonte, Brasil

Contacto: assuncaoest@gmail.com

Abstract

In recent years, Monte Carlo simulation methods have undergone significant advancements through the integration of cutting-edge machine learning techniques, particularly Generative Adversarial Networks (GANs), diffusion models, and normalizing flows. GANs provide a novel approach to generating complex, high-dimensional data by training two networks in a competitive setting, which leads to highly realistic sample generation from distributions that are often challenging to simulate using traditional methods. Diffusion models, on the other hand, leverage iterative refinement to generate samples by reversing a noise-adding process, offering a powerful alternative to Monte Carlo sampling in cases where smooth transitions between data points are critical. Normalizing flows introduces a new class of methods that map simple, tractable distributions (like Gaussians) to more complex target distributions via a sequence of invertible transformations, providing both efficient density estimation and sample generation. These innovations are expanding the scope of Monte Carlo simulations, and are allowing statisticians to explore more complex and non-standard distributions with higher accuracy and computational efficiency.

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