

Event Generation and Statistical Sampling with Deep Generative Models

Wednesday, 17 April 2019 11:45 (20 minutes)

We present a study for the generation of events from a physical process with generative deep learning. To simulate physical processes it is not only important to produce physical events, but also to produce the events with the right frequency of occurrence (density). We investigate the feasibility to learn the event generation and the frequency of occurrence with Generative Adversarial Networks (GANs) and Variational Autoencoders (VAEs) to produce events like Monte Carlo generators. We study three toy models from high energy physics, i.e. a simple two-body decay, the processes $e^+e^- \rightarrow Z \rightarrow l^+l^-$ and $pp \rightarrow t\bar{t}$ including the decay of the top quarks and a simulation of the detector response. We show that GANs and the standard VAE do not produce the right distributions. By buffering density information of Monte Carlo events in latent space given the encoder of a VAE we are able to construct a prior for the sampling of new events from the decoder that yields distributions that are in very good agreement with real Monte Carlo events and are generated $\mathcal{O}(10^8)$ times faster. Applications of this work include generic density estimation and sampling, targeted event generation via a principal component analysis of encoded events in the latent space and the possibility to generate better random numbers for importance sampling, e.g. for the phase space integration of matrix elements in quantum perturbation theories. The method also allows to build event generators directly from real data events.

Preferred contribution length

20 minutes

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Session Classification: Submitted contributions