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Quantum Generative Models in High Energy Physics

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Theoretical and algorithmic advances, availability of data, and computing power have opened the door to exceptional perspectives for application of classical Deep Learning in the most diverse fields of science, business and society at large, and notably in High Energy Physics (HEP). Generative models, in particular, are among the most promising approaches to analyse and understand the amount of information the next generation HEP detectors will produce.

Generative modeling is also a promising task for near-term quantum devices that can leverage compressed high dimensional representations and use the stochastic nature of quantum measurements as random source. Several architectures are being investigated. Quantum implementations of Generative Adversarial Networks (GAN) and Auto-Encoders, among the most popular classical approaches, are being proposed for different applications. Born machines are purely quantum models that can generate probability distributions in a unique way, inaccessible to classical computers.

This talk will give an overview of the current state of the art in terms of generative modeling on quantum computers with focus on their application to HEP. Examples will include the application of Born machines and quantum GAN to the problem of joint and conditional distributions learning.

Furthermore, experiments on the effect of intrinsic quantum noise on model convergence will be discussed and framed in the broader context of quantum machine learning.

Indeed, while a number of studies have proven that noise plays a crucial role in the training of classical neural networks, near-term quantum hardware encounters the challenge to overcome the noise due to the gate errors, readout errors, and interactions with the environment. The presence of these intrinsic quantum noises suggests the possibility to replace the artificial noise in the context of classical machine learning with the noise of the quantum hardware.

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