Quantum generative adversarial learning

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Generative adversarial networks (GANs) represent a powerful tool for classical machine learning: a generator tries to create statistics for data that mimics those of a true data set, while a discriminator tries to discriminate between the true and fake data. The learning process for generator and discriminator can be thought of as an adversarial game, and under reasonable assumptions, the game converges to the point where the generator generates the same statistics as the true data and the discriminator is unable to discriminate between the true and the generated data. We introduce the notion of quantum generative adversarial networks (QuGANs), where the data consists either of quantum states, or of classical data, and the generator and discriminator are equipped with quantum information processors [1, 2]. We show that the unique fixed point of the quantum adversarial game also occurs when the generator produces the same statistics as the data. Since quantum systems are intrinsically probabilistic the proof of the quantum case is different from - and simpler than - the classical case. We show that when the data consists of samples of measurements made on high-dimensional spaces, quantum adversarial networks may exhibit an exponential advantage over classical adversarial networks. In addition, we show how to construct generative adversarial networks using quantum circuits and we also show how to compute gradients – a key element in generative adversarial network training – using another quantum circuit. We give an example of a simple practical circuit ansatz to parametrize quantum machine learning models and perform a simple numerical experiment to demonstrate that quantum generative adversarial networks can be trained successfully.

References

[1] Pierre-Luc Dallaire-Demers and Nathan Killoran. Quantum generative adversarial networks. *arXiv:1804.08641*. 2018.

[2] Seth Lloyd and Christian Weedbrook. Quantum generative adversarial learning. *arXiv:1804.09139*. 2018.