Machine Learning with Noisy Intermediate-Scale Quantum Devices

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Machine learning techniques are remarkably useful for finding atypical patterns in data. It is known quantum computers perform exponentially faster than their classical counterparts for various computational tasks, in particular, for machine learning. In this contribution, we review potential applications of near-term noisy intermediate-scale quantum (NISQ) devices for applications in machine learning tasks [1].

The combination of quantum physics, quantum information theory, and machine learning represent a relatively new research filed – quantum machine learning. There are several important directions in this scope: (i) research on quantum algorithms for universal quantum computers that could act as the building blocks of machine learning programs; (ii) development of programmable special-purpose machines that are not universal quantum computers yet possess some quantum properties that enhance training classical neural networks; (iii) using classical neural networks in order to obtain variational solutions for many-body quantum-mechanical problems.

Recently explored research avenue for implementation of machine learning methods in the quantum area is quantum state tomography [2]. As it is well-known, exact brute-force approaches to quantum state tomography place a high demand on computational resources, making them unfeasible for anything except small systems. Here we realize and experimentally test a neural-network-based approach for quantum state tomography. We discuss its performance and possible extensions for tomography of quantum processes.

Another important area is learning quantum phases of matter [3]. This includes revealing exotic quantum states (phase transitions, many-body localization, and etc.) and understanding quantum dynamics. Here we demonstrate that conventional machine learning methods, such as convolution neural networks, can be used for precise identification of the transition between regular and non-integrable regimes as well as for learning complex features of quantum chaotic states with remarkably high accuracy >99%.

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