Quantum Adversarial Learning in Emulation of Monte-Carlo Methods

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Abstract:

One of the leading candidates for near-term quantum advantage is the class of Variational Quantum Algorithms, but these algorithms suffer from classical difficulty in optimizing the variational parameters as the number of parameters increases. Therefore, it is important to understand the expressibility and power of various ansätze to produce target states and distributions. To this end, we apply notions of emulation to Variational Quantum Annealing and the Quantum Approximate Optimization Algorithm (QAOA) to show that QAOA is outperformed by variational annealing schedules with equivalent numbers of parameters. Our Variational Quantum Annealing schedule is based on a novel polynomial parameterization that can be optimized in a similar gradient-free way as QAOA, using the same physical ingredients. In order to compare the performance of ansätze types, we have developed statistical notions of Monte-Carlo methods. Monte-Carlo methods are computer programs that generate random variables that approximate a target number that is computationally hard to calculate exactly. While the most well-known Monte-Carlo method is Monte-Carlo integration (e.g. Diffusion Monte-Carlo or path-integral quantum Monte-Carlo), QAOA is itself a Monte-Carlo method that finds good solutions to NP-complete problems such as Max-cut. We apply these statistical Monte-Carlo notions to further elucidate the theoretical framework around these quantum algorithms.