Hardware requirements of option pricing with the quantum Monte Carlo method

Zoltán Udvarnoki
Gábor Fáth

Department of Physics of Complex Systems, Eötvös Loránd University, Budapest, Hungary

zoltan.andras.udvarnoki@ttk.elte.hu

Abstract

One of the promising future applications of quantum computers is the quantum Monte Carlo method, leading to a quadratic speed-up above the classical approach. However, it is impossible to run the Monte Carlo algorithm with reasonable error on current devices because of the decoherence, which is the most crucial limiting factor for the practical usage of quantum computers. In our work, we quantify the necessary hardware requirements for a quantum Monte Carlo simulation - namely financial option pricing [1] - by utilizing noisy simulations and theoretical error bounds on maximum likelihood quantum amplitude estimation [2]. We do that in terms of quantum volume - a universal single number metric to measure the power of quantum hardware - and noise strength. This can be done by measuring the quantum volume of a simulated quantum device with a specific noise model and estimating the error of the given algorithm in parallel. To validate the methods and our results, we used IBM quantum processors.
Our estimates show relatively high requirements for such an easy task even if the type of the noise model is assumed to be known and the likelihood function is modified accordingly. Nonetheless, it can be compared to the roadmap of manufacturers to get an insight into the future of the field.

References

[1] Stamatopoulos, Nikitas, et al. "Option pricing using quantum computers." Quantum 4 (2020): 291.
[2] Tanaka, Tomoki, et al. "Amplitude estimation via maximum likelihood on noisy quantum computer." Quantum Information Processing 20.9 (2021): 1-29.

Figures

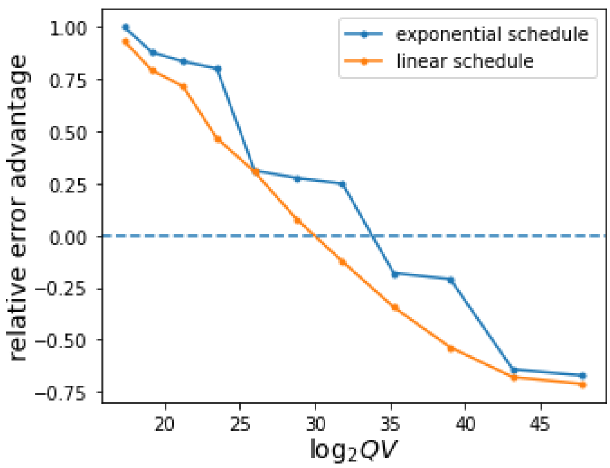

Figure 1: The relative difference between the standard deviation of the classical method and QAE with specific schedules at different quantum volume values. The simulations assumed depolarizing noise model with two-qubit gate error rate 20x larger than one-qubit gate error. Quantum advantage is seen from 2^{30} quantum volume.