Contribution ID: **124** Type: **not specified**

Parallel Gradient Estimation of Parameterized Quantum Circuit

Friday, 29 August 2025 15:35 (20 minutes)

The Variational Quantum Algorithm (VQA) [1], which utilizes parameterized quantum circuits (PQCs), is one approach to solving problems that are challenging for classical computers using Noisy Intermediate-Scale Quantum (NISQ) devices. Utilizing gradients in VQA is expected to accelerate convergence [2]. However, as the number of parameters increases, the number of required quantum circuit types also increases, leading to longer execution times on actual devices and higher financial cost. Therefore, it's necessary to reduce the number of quantum circuit types required for gradient estimation.
Existing methods require at least one type of quantum circuit per parameter to estimate its gradient [3,4]. For example, the Hadamard Test [4] utilizes a single quantum circuit with an additional ancilla qubit to estimate the gradient of a single parameter in a PQC with N qubits.
In this study, we propose a novel method for estimating the gradients of multiple parameters in parallel using a single type of quantum circuit, thereby reducing the number of circuit types required for gradient estimation. In this method, by utilizing mid-circuit measurement and reset, only two ancilla qubits are needed. Based on indicators such as circuit type and shot count cost, the required accuracy for gradient estimation, and the number of parameters for which gradients need to be estimated, we discuss the conditions under which the proposed method is advantageous.
References:
[1] M. Cerezo, et al., Nat. Rev. Phys. 3, 625–644 (2021).
[2] A. W. Harrow & J. C. Napp, Phys. Rev. Lett. 126, 140502 (2021).
[3] K. Mitarai, et al., Phys. Rev. A 98, 032309 (2018).
[4] G. G. Guerreschi & M. Smelyanskiy, arXiv:1701.01450

Primary author: IMAMURA, Soichiro (The University of Tokyo)

Co-author: TODO, Synge (The University of Tokyo)

Presenter: IMAMURA, Soichiro (The University of Tokyo)

Session Classification: Contributed talks

Track Classification: Invited talk