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[CANCELED] Analysis of Data-encoding Induced Barren Plateau in Quantum Machine Learning

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In recent years, Variational Quantum Algorithms (VQA) have been actively studied as a promising approach on Noisy Intermediate Scale Quantum computers (NISQ). VQA solve problems by minimizing a cost function through the updating of parameters in a variational quantum circuit on a classical computer. Quantum Machine Learning (QML), which utilizes variational quantum circuits for machine learning, is one such approach.

However, it has been noted that vanishing gradients of the cost function, referred to as Barren Plateau (BP), can occur in VQA, posing challenges for optimization. Various causes of Barren Plateaus have been investigated, including the structure of the ansatz, the cost function, noise, and data encoding. Nevertheless, the effect of data encoding remains not fully understood.

This study analytically investigates the effect of data encoding on the variance of the cost function gradient. Specifically, we derive upper and lower bounds on the variance of the cost function gradient for a given data encoding circuit and cost function. Additionally, we numerically confirm that the scaling of the variance of the cost function gradient is independent of the form of the cost function, such as mean absolute error, mean squared error, and cross-entropy.

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