A new approach for the QERC based on AE

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Quantum devices with tens to hundreds of noisy qubits are known as Noisy Intermediate-Scale Quantum (NISQ) devices. These devices are expected to be applied to various social issues despite their lack of error correction capabilities.Traditional quantum algorithms require highly accurate computations, making them challenging to implement on NISQ devices. However, due to the relatively large number of qubits in NISQ devices, they are becoming popular for applications that do not demand precise computation.

One such application is quantum machine learning [1,2], which has recently gained significant attention. The integration of quantum and classical models, particularly for tasks that do not necessitate precise quantum calculations, is expected to grow in importance. The design of composite quantum-classical models is crucial, especially since many social problems involve classical data inputs and outputs that are typically processed using classical methods. By combining classical and quantum models, our objective is to implement transfer learning, a technique commonly used in classical models. Specifically, we focus on the design of the classical-to-quantum map using an image classification example with a hybrid model consisting of a quantum reservoir [3] and a classical model. In this setup, the classical component functions as an autoencoder to extract relevant information from the images. By optimizing the classical part independently of the quantum reservoir, we mimic a transfer learning scenario.

Furthermore, because the input to the quantum system is angle-based [3], we show that the activation function of the classical component must be carefully designed. In this poster, we will show results of QERC based on AE with Fashion-MNIST dataset. We will reveal that variations in the activation function lead to significant differences in overall performance, even when using the same quantum system. This insight highlights the importance of a well-coordinated design between the classical and quantum parts to achieve optimal performance in composite models.

References:

[1] K. Mitarai, M. Negoro, M. Kitagawa, and K. Fujii, Phys. Rev. A **98**, 032309 (2018)
[2] K. Fujii et al., PR Applied **8**(2) 024030 (2017)
[3] Akitada Sakurai et al.,Phys. Rev. Applied **17**, 064044 (2022).