Quantum-inspired machine learning for exponentially big neural data analysis

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Introduction

Machine learning algorithms specialized for neural data have allowed the extraction of information encoded in the brain. As an example, in previous studies, the images human subjects see were reconstructed from their brain activity measured via functional magnetic resonance imaging (fMRI) [1]. However, the application of those machine learning algorithms to high-resolution fMRI data, which may become mainstream in the near future, is limited due to their high computational cost. To solve this problem, scalable machine learning algorithms are being designed by utilizing computational techniques developed in the field of quantum computation [2,3]. In this report, taking one of the popular statistical methods, principal component analysis (PCA), as an example, we show that machine algorithms can be approximated with the use of such quantum-inspired techniques. The computational time and approximation performance of quantum-inspired PCA are demonstrated. The main results of this report have been presented in a previous paper by the author [3].

Methods

In this report, the computational time and performance were compared between quantum-inspired PCA and its exact counterpart (*i.e.*, exact PCA). Due to space limitations, the details of the algorithms and datasets used are omitted in this report; however, they have been explained in the previous study [3]. Briefly, the computational times of the two algorithms were measured by applying them to simulation data. To characterize the dependence on the input dimensionality, the number of input dimensions in the simulation data was systematically changed. The performances of those two algorithms were evaluated by applying them to five benchmark datasets, and the variance explained by the top 100 PCs was measured and used as a performance metric in this report.

Results

Both the computational time and performance (*i.e.*, explained variance) are shown in Figure 1. Results show that quantum-inspired PCA was significantly faster than the exact PCA, and its performance was maximally 7% worse than the exact PCA for these five datasets.

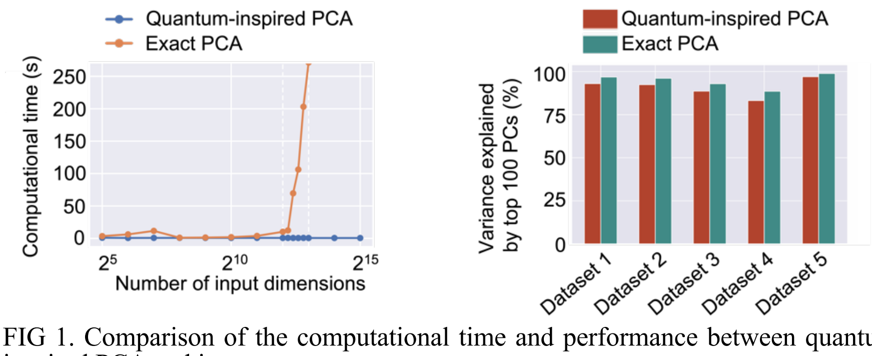

FIG 1. Comparison of the computational time and performance between quantum-inspired PCA and its exact counterpart.

Discussion and Conclusions

In this report, quantum-inspired PCA was applied to simulation and real benchmark datasets, and its computational time and performance were compared with those of the exact PCA. As results, quantum-inspired PCA was significantly faster than its exact counterpart, and it showed moderate approximation performance on the five datasets. These results suggest a possibility that high-dimensional neural data whose size is intractable with previous machine learning algorithms can be efficiently analyzed using such quantum-inspired algorithms.

References

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