Quantum Kernel Principal Components Analysis-Enabled Compact Readout of Chemiresistive Sensor Arrays

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This investigation assesses the relative effectiveness of quantum principal component analysis (qPCA) compared to classical PCA (cPCA) for experimental data compression in the Internet of Things (IoT) applications. By conducting an in-depth analysis of kernel matrices and leveraging various machine learning (ML) algorithms, we establish qPCA's enhanced capability to preserve vital information during the process of dimensionality reduction. This leads to more efficient and reliable modeling, particularly beneficial in applications requiring compact data representations. The study shows that qPCA surpasses cPCA in performance across multiple ML models with our IoT data, especially notable in lower-dimensional contexts critical for maintaining multidimensional data integrity. Furthermore, our results highlight the potential of noisy intermediate-scale quantum (NISQ) computers, despite their current limitations in logical qubit numbers, to significantly contribute to real-world IoT applications.

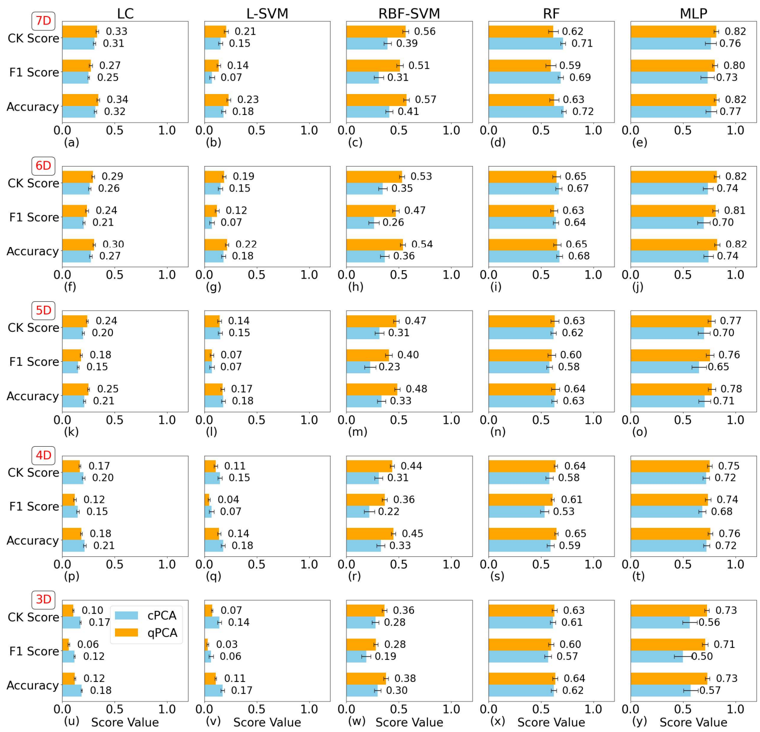

Fig. 1. The evaluation scores of each model (each column) in different data spaces: (a)-(e) 7D (same dimensional as original data); (f)-(i) 6D; (k)-(o) 5D; (p)-(t) 4D; (u)-(y) 3D. Note that the PCA-based dimensional reduction process is the same for both cPCA and qPCA, the difference being the kernel-base mapping.