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Quantum Anomaly Detection for Collider Physics

Quantum Machine Learning (QML) is an exciting tool that has received significant recent attention due in part to advances in quantum computing hardware. While there is currently no formal guarantee that QML is superior to classical ML for relevant problems, there have been many claims of an empirical advantage with high energy physics datasets. These studies typically do not claim an exponential speedup in training, but instead, usually focus on an improved performance with limited training data. Most actual problems in collider physics are not limited by training data and so it is not clear thus far where these potential improvements could be deployed in practice. We study a particular anomaly detection task in the four-lepton final state at the Large Hadron Collider that is limited by a small dataset. We explore the application of QML in a semi-supervised mode to look for new physics without specifying a particular signal model hypothesis. We find no evidence that QML provides any advantage over classical ML. It could be that a case where QML is superior to classical ML for collider physics will be established in the future, but for now, classical ML is a powerful tool that will continue to expand the science of the LHC and beyond.

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