Unsupervised Quantum Anomaly Detection on Noisy Quantum Processors

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Whether in fundamental physics, cybersecurity or finance, the detection of anomalies with machine learning approaches is a highly relevant and active field of research, as it potentially accelerates the discovery of novel physics beyond the standard model or criminal activities [1]. We provide a systematic analysis of the generalization properties of the One-Class Support Vector Machine (OCSVM) algorithm [2, 3], using projected quantum kernels [4] for a realistic dataset of the latter application. These results were experimentally obtained on trapped-ion and superconducting quantum processors, by leveraging partial shadow tomography [5, 4, 6] to obtain a precise approximation of quantum states that are used to estimate the quantum kernels. Moreover, we benchmark the platforms respective hardware-efficient feature maps over a wide range of anomaly ratios and show that in all regimes the quantum-enhanced OCSVMs lead to better generalization compared to the purely classical approach. As such our work bridges the gap between theory and practice in the NISQ era and paves the path towards useful quantum applications.

References

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