Machine learning for certification of photonic quantum information

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Photonic technologies provide a promising platform to address at a fundamental level the connection between quantum information and machine learning. We will exploit machine learning as a tool to validate quantum devices such as Boson Samplers [1]. Indeed, the difficulty of validating large-scale quantum devices poses a major challenge for any research program that aims to show quantum advantages over classical hardware. To address this problem, we propose a novel data-driven approach wherein models are trained to identify common pathologies using supervised and unsupervised machine learning.

First, we propose a novel data-driven approach wherein models are trained to identify common pathologies using unsupervised machine learning methods [1]. We train a classifier that exploits K-means clustering to distinguish between Boson Samplers that use indistinguishable photons from those that do not. We train the model on numerical simulations of small-scale Boson Samplers and then validate the pattern recognition technique on larger numerical simulations as well as on photonic chips in both traditional Boson Sampling and scattershot experiments. The effectiveness of such method relies on particle-type-dependent internal correlations present in the output distributions. This approach performs substantially better on the test data than previous methods and underscores the ability to further generalize its operation beyond the scope of the examples that it was trained on.

As complementary approach, we experimentally identify genuine many-body quantum interference via a recent efficient protocol, which exploits statistical signatures at the output of a multimode quantum device [3]. We successfully apply the test to validate three-photon experiments in an integrated photonic circuit, providing an extensive analysis on the resources required to perform it. Moreover, drawing upon established techniques of machine learning, we show how such tools help to identify the—a priori unknown—optimal features to witness these signatures. Our results provide evidence on the efficacy and feasibility of the method, paving the way for its adoption in large-scale implementations. Our results provide evidence on the efficacy and feasibility of this approach, paving the way for its adoption in large-scale implementations.

References

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