Detecting and Protecting Against Crosstalk With Reinforcement Learning

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Quantum computing has the potential to provide solutions to problems that are intractable on classical computers, but the accuracy of the current generation of quantum computers suffer from the impact of noise or errors such as leakage, crosstalk, dephasing, and amplitude damping among others [1, 2, 3, 4]. As the access to quantum computers is almost exclusively in a shared environment through cloud-based services, it is possible that an adversary can exploit crosstalk noise to disrupt quantum computations on nearby qubits, even carefully designing quantum circuits to purposely lead to wrong answers. In this work [5], we present a reinforcement learning model capable of learning the crosstalk noise model of a device, and laying out circuits to minimise the effect of crosstalk. We test the performance of the reinforcement model on isolated circuits, and when circuits are positioned adjacent to a disruptive crosstalk attack. To facilitate this work, we analyze the extent and characteristics of crosstalk noise through tomography conducted on IBM Quantum computers, leading to an enhanced crosstalk simulation model. Our results indicate that crosstalk noise is a significant source of errors on IBM quantum hardware, making crosstalk based attack a viable threat to quantum computing in a shared environment. Based on our crosstalk simulator benchmarked against IBM hardware, we assess the impact of crosstalk attacks and compare our reinforcement learning model to other strategies for mitigating crosstalk effects. Through a systematic set of simulations, we assess the effectiveness of three crosstalk attack mitigation strategies, namely qubit allocation optimization via reinforcement learning, circuit separation, and the use of spectator qubits [6, 7], and show that they all overcome crosstalk attacks with varying degrees of success and help to secure quantum computing in a shared platform.

References

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