Identification of Correlated Qubit Errors for Quantum Computing Error Correction

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Quantum computing is an emerging technology that, with its exponential computational speedup, will allow us to solve a new level of hard problems. From rapid vaccine development, efficient discovery of exotic materials, and complex AI models, to quickly cracking RSA encryption, quantum computers have the potential to revolutionize science. However, for quantum computing to solve these problems, quantum error correction methods are needed to eliminate qubit errors. An underlying assumption of current quantum error correction is that qubit errors are not correlated. If correlated qubit errors are prevalent, quantum error correction will be difficult, if not impossible. In this work, I developed a method to identify correlated errors between pairs of qubits and used this method to determine if correlations exist on current small-scale quantum computers. My method uses independence of error probabilities [$P(a,b) \approx P(a)P(b)$] to determine correlation. After running 40 million experiments to collect error probabilities by varying the quantum gates, number of gates, and pairs of qubits on multiple quantum computers, I found that these computers have a high occurrence of correlated qubit errors when qubits are topological neighbors. For example, I found that Hadamard gate operations can cause correlated errors, supported by a p-value of 0.0160. My work shows that the assumption that qubit errors are not correlated is incorrect for current quantum computers. In the future, scientists can use these methods to test for correlated errors as they develop new quantum computers, enabling quantum computing to achieve its full potential.

Awards Won:

Third Award of $1,000