# Automating Quantum Efficiency: An Algorithm for Gate-Based Optimization of Quantum Circuits

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Quantum Computers hold immense potential for solving complex problems beyond the capabilities of classical computers. However, their potential is limited by challenges such as decoherence. Decoherence necessitates quantum circuits to be reduced as much as possible, a task often achieved through manual, time-consuming optimization techniques. This study investigated the potential of automating a technique called gate merging to significantly reduce optimization time, improve the performance of quantum computers and potentially accelerate research. The proposed algorithm works based on two principles: gate merging and gate commutativity. It addresses circuit optimization in a step-by-step manner. First, gates are categorized based on their corresponding qubits. Then, all potential pairs for merging identified and established commutativity rules are utilized to bring them closer within the circuit. The algorithm then searches for redundant gate pairs and removes them from the circuit. Finally, the algorithm prioritizes and merges the remaining pairs. The effectiveness of the algorithm was validated on around 100 benchmark reversible quantum circuits obtained from online databases, such as RevLib and tweedledum databases. While the exact optimization value varied between algorithms, the average improvement based on the tests reached approximately 6.25%, and the time spent on optimization was significantly reduced. This project demonstrates the potential of automated optimization for improving quantum circuit efficiency and accelerating the development of quantum algorithms. The findings suggest that further advancements in this area can significantly reduce the time and resources required for creating and running quantum algorithms.