Quantum Computing: Implementing Grover’s Algorithm on IBM Q

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The purpose of this project was to implement Grover’s search algorithm for a small number of qubits on the IBM Q Experience. IBM Q offers three public-access quantum computers, from 5 qubits to 16 qubits, and quantum computer simulators. We accessed IBM Q through the Quantum Information Science Kit (QISKit) via Jupyter Notebook in Python programming language. Quantum computers are the future of technology; for example, they can run computations much faster, even exponentially faster, than their classical counterparts for certain tasks. These machines utilize quantum-mechanical phenomena to gain this added power such as superposition, the ability of a qubit to be multiple distinct states simultaneously. Grover’s algorithm is a quantum search algorithm requiring onlyruntime in contrast to classical computers requiring runtime, achieving quadratic speedup. Although this speedup is not exponential, search algorithms are an essential function in many applications and thus it is quite useful. It operates in two parts: the first marks the amplitude of the item being searched for negative and the second does an inversion about the mean amplitude. To implement Grover’s algorithm searching on 3-qubit circuits, I first learned the 2-qubit implementation through literature and IBM Q’s Experience Documentation. Then, we created a circuit to run Grover’s algorithm for 3-qubits. We utilized a series of Toffoli, Hadamard, and X logic gates to construct the quantum circuit. While both the 2-qubit Grover simulation and actual run returned clean results, only the 3-qubit simulation returned a high (0.953) probability of obtaining. The data from IBM’s 5-qubit quantum computer gave only a 0.271 probability of obtaining. This was due to noise--environmental disturbances which perturb the coherence of the qubits; further research should focus on mitigating the effects of noise. This work was supported by the Simons Foundation and the National Science Foundation.