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Quantum Majority Vote

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Abstract

Majority vote is a basic method for amplifying correct outcomes that is widely used in computer science and beyond. While it can amplify the correctness of a quantum device with classical output, the analogous procedure for quantum output is not known. We introduce quantum majority vote as the following task: given a product state \(|\psi_1\rangle \otimes \cdots \otimes |\psi_n\rangle\) where each qubit is in one of two orthogonal states \(|\psi\rangle\) or \(|\psi^\perp\rangle\), output the majority state. We show that an optimal algorithm for this problem achieves worst-case fidelity of \(1/2 + \Theta(1/\sqrt{n})\). Under the promise that at least \(2/3\) of the input qubits are in the majority state, the fidelity increases to \(1 - \Theta(1/n)\) and approaches 1 as \(n\) increases.

We also consider the more general problem of computing any symmetric and equivariant Boolean function \(f : \{0,1\}^n \rightarrow \{0,1\}\) in an unknown quantum basis, and show that a generalization of our quantum majority vote algorithm is optimal for this task. The optimal parameters for the generalized algorithm and its worst-case fidelity can be determined by a simple linear program of size \(O(n)\). The time complexity of the algorithm is \(O(n^4 \log n)\) where \(n\) is the number of input qubits.

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