Quantum Majority Vote

Buhrman, Harry; Linden, Noah; Mancinska, Laura; Montanaro, Ashley; Ozols, Maris

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Quantum Majority Vote

Harry Buhrman
QuSoft, CWI, Amsterdam, The Netherlands
University of Amsterdam, The Netherlands

Noah Linden
University of Bristol, UK

Laura Mančinska
University of Copenhagen, Denmark

Ashley Montanaro
Phasecraft Ltd., Bristol, UK
University of Bristol, UK

Maris Ozols
QuSoft, Amsterdam, The Netherlands
University of Amsterdam, The Netherlands

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 $\ket{\psi_1} \otimes \cdots \otimes \ket{\psi_n}$ where each qubit is in one of two orthogonal states $\ket{\psi}$ or $\ket{\psi^\perp}$, 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 $f : \{0,1\}^n \to \{0,1\}$ 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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