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Grover's unstructured search by using a transverse field ZHANG JIANG, ELEANOR RIEFFEL, ZHIHUI WANG, NASA Ames Research Center — We design a circuit-based quantum algorithm to search for a needle in a haystack, giving the same quadratic speedup achieved by Grover's original algorithm. In our circuit-based algorithm, the problem Hamiltonian (oracle) and a transverse field (instead of Grover's diffusion operator) are applied to the system alternatively. We construct a periodic time sequence such that the resultant unitary drives a closed transition between two states, which have high degrees of overlap with the initial state (even superposition of all states) and the target state, respectively. Let $N = 2^n$ be the size of the search space. The transition rate in our algorithm is of order $\Theta(1/\sqrt{N})$, and the overlaps are of order $\Theta(1)$, yielding a nearly optimal query complexity of $T \simeq \sqrt{N}(\pi/2\sqrt{2})$. Our algorithm is inspired by a class of algorithms proposed by Farhi et al. [arXiv:1411.4028], namely the Quantum Approximate Optimization Algorithm (QAOA); our method offers a route to optimizing the parameters in QAOA by restricting them to be periodic in time.

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