Search on a Hypercubic Lattice using Quantum Random Walk: d>2

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Random walks describe diffusion processes, where movement at every time step is restricted to only the neighbouring locations. We construct a quantum random walk algorithm, based on discretisation of the Dirac evolution operator inspired by staggered lattice fermions. We use it to investigate the spatial search problem, i.e. finding a marked vertex on a d-dimensional hypercubic lattice. The restriction on movement hardly matters for $d>2$, and scaling behaviour close to Grover's optimal algorithm (which has no restriction on movement) can be achieved. Using numerical simulations, we optimise the proportionality constants of the scaling behaviour, and demonstrate the approach to that for Grover's algorithm (equivalent to the mean field the or the $d\to\infty$ limit). In particular, the scaling behaviour for $d=3$ is only about 25% higher than the optimal $d\to\infty$ value.

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