README

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1 About

This is a project for the "Quantum Futures Hackathon" event at CERN from Saturday afternoon 19th to Sunday afternoon 20th. The theme is "Classical Vs. Quantum". In a classical random walk, a coin that lands with probability p on heads and a probability $1-p$ on tails is flipped. Upon the result of different options, a "walker" will walk either left or right. After a large number of coin flips, the destination of a walker landing on a point at n unit distances away from the starting point is, in the case of a fair coin, gaussian.

Similar of character is the concept of random walks in the quantum world - quantum random walks. Here, one starts with a ground state of the form $|\psi\rangle = a\,|{\leftarrow},0\rangle + b\,|{\rightarrow},0\rangle$. Here, the walker will walk in the next time unit to the right with probability a^2 and to the left with probability b^2 (a la the Born rule). A "coin flip" will send a measured state that has "collapsed" to an eigenstate to a state with equal probability of being in either one of the directions. Moreover, for probability conservation, the evolution needs to be unitary. This suggests using the Hadamard operator for as our "quantum coin" which satisfies both of these conditions:

$$\hat{F} = \frac{1}{\sqrt{2}} \begin{matrix} 1 & 1 \\ 1 & -1 \end{matrix}$$

For movement, we will define the translation operator:

$$\hat{S}\left|\leftarrow, n\right\rangle = \left|\leftarrow, n-1\right\rangle$$
$$\hat{S}\left|\rightarrow, n\right\rangle = \left|\rightarrow, n+1\right\rangle$$

Given an initial state, a *quantum random walk* is then a sequence of flipping the quantum coin by applying $\hat{F}$ and moving by applying $\hat{S}$.

2 Team members

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