Discrete-time Semiclassical Szegedy Quantum Walks

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Quantum walks are promising tools based on classical random walks, with plenty of applications such as many variants of optimization. Here we introduce the semiclassical walks in discrete time [1], which are algorithms that combines classical and quantum dynamics. Specifically, a semiclassical walk can be understood as a classical walk where the transition matrix encodes the quantum evolution. We have applied this algorithm to Szegedy's quantum walk [2], which can be applied to any arbitrary weighted graph. We first have solved the problem analytically on regular 1D cycles to show the performance of the semiclassical walks. Next, we have simulated our algorithm in a general inhomogeneous symmetric graph, finding that the inhomogeneity drives a symmetry breaking on the graph. Moreover, we show that this phenomenon is useful for the problem of ranking nodes in symmetric graphs, where the classical PageRank fails. We have demonstrated experimentally that the semiclassical walks can be applied on real quantum computers using the platform IBM Quantum [3].

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[1] S. A. Ortega and M. A. Martin-Delgado. arXiv preprint arXiv:2303.18202. (2023).

[2] M. Szegedy. 45th Annual IEEE Symposium on Foundations of a Computer Science 32 (2004).

[3] IBM Quantum. https://quantum-computing.ibm.com/ (2021).

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