Information Flow in Non-Unitary Quantum Cellular Automata

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The information flow in a quantum system is a fundamental feature of the dynamics. An important class of dynamics are quantum cellular automata (QCA) that are systems invariant in time and space, for which an index [1] has been proposed that quantifies the net flow of quantum information across a boundary. While the index is invariant under finite-depth local circuits, it is not defined when the system is coupled to an environment, i.e. for non-unitary time evolution of open quantum systems.

We propose a new measure of quantum information flow for non-unitary QCA we call a current which is not rigid, but can be computed locally based on the matrix-product operator representation of the map. [2]

[1] D. Gross, V. Nesme, H. Vogts and R.F. Werner, *Index Theory of One Dimensional Quantum Walks and Cellular Automata*, Commun. Math. Phys. **310**, 419–454 (2012). https://doi.org/10.1007/s00220-012-1423-1

[2] E. Wagner, R. Nigmatullin, A. Gilchrist, G. K. Brennen, *Information flow in one-dimensional non-unitary quantum cellular automata*, pre-print arXiv:2204.09922 (2022). https://doi.org/10.48550/arXiv.2204.09922