Recycling Quantum Computation.

David Ponarovsky

April 25, 2023

Abstract

Quantum feasibility depends on the assumption that the basic gate's noise rate is below a certain threshold. Here, we study the behavior of computation models when the noise is slightly higher than that threshold. In particular, we ask if one can design a fault tolerance schema such that, even if the noise is above the threshold, the final generated state still has a value.

1 Introduction.

In this study, we investigate the noise regime near the threshold [AB99]. Specifically, we aim to develop a mapping such that, beneath the threshold, the original circuit is computed, while in situations where the noise is slightly above the threshold, there is still a guarantee that the result of the computation is meaningful.

To Do. Short term tasks:

1. Add an initial generalized entanglement definition.

2. Describe the quantum teleportation as an example for a simple Local-Measure-Circuit. "prove" something about it. Explain the importance of EPR pairs a computation resource. And present the question above as "is that possible to embed the teleportation inside a general circuit".

3. Given $|\psi\rangle$ and a local circuit C_0, What can we say about the $C_0|\psi\rangle$. What does it mean in terms of complexities class?

Definition 1 (General Entanglement State). *We say that $|\psi\rangle$ is general entanglement if ..*

Definition 2 (Local-Measure-Circuit). *We say that a quantum circuit C is a local measure circuit if it's can be described as a decomposition of poly classical circuit and a constant depth quantum circuit which contains only 1-qubit gates and measurements.*
We would think about local measure circuits as chip circuits.

Definition 3 ($p_0 - \Delta$ Fault Tolerance Circuit). *We say that $\mathcal{C}$ is $p_0 - \Delta$ fault tolerance presentation of abstract circuit C if there exists a local measure circuit C_0 2 such it's grunted that for noise $p < p_0$ $\mathcal{C}$ compute C w.h.p, And in addition, if $p \in (p_0, p_0 + \varepsilon)$ then by applying a C_0 on $\mathcal{C}$ output yields a general entanglement state 1*
*[**COMMENT**] We would like to add a complexity parameter for the above definition, for example, "a general entanglement state over more than $\frac{1}{5}$ of the qubits.*

The Obvious Solution. *Suppose that $p(C_0) \le p(C_1) - \varepsilon$, then we could attach the circuits next to each other by paying an additive cost. So, for the problem to be truly interesting, we have to ask if we can do that while paying less in the width of the circuit. Also, we have a trivial lower bound such that the final width of the circuit must be at least the maximum of the original circuits.*

References

[AB99]   Dorit Aharonov and Michael Ben-Or. *Fault-Tolerant Quantum Computation With Constant Error Rate*. 1999. arXiv: quant-ph/9906129 [quant-ph].