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CS 880: Quantum Algorithm

1 Multidimensional Quantum Walks

Tentative Topics

1. Classical Random Walks
2. Multidimensional Random Walks [1, p. 295-299]
   (a) Null-Recurrent Random Walk for $d \leqslant 2$
   (b) Non-Recurrent Random Walk for $d \geqslant 3$
3. Electric Network Framework [2, p. 17] [3] (briefly)
4. Multidimensional Quantum Walks [2, p.]
   (a) Alternating Neiborhoods
   (b) Edge Composition
5. Welded Tree [2]
   (a) Welded Trees Problem
   (b) Previous Work [4]
   (c) Algorithm (exponentially speed up)
6. k-distinctness [2] (if we have time)

We plan to cover some interesting topics about classical Multidimensional Random Walk (about whether Multidimensional Random Walk is transient or (null) recurrent), which is might be a bit out of topic, but likely be interesting.

Besides that, we will focus on the Multidimensional Quantum Walks paper itself. Firstly we would like to talk about their framework and the framework they are based on (Electric Network Framework). Then we will talk about their framework, and the technique that are majorly discussed in the talk (Alternating Neiborhoods and Edge Composition).

Finally, we will talk about the Welded Tree Problem, and how the Multidimensional Quantum Walk may present an exponential speed up.

If we have time, we might also talk about the previous work about Welded Tree Problem (according to their talk it involves continuous quantum walk).

They also discussed k-distinctness problem, and how the time complexity bound get improved to match the query complexity. We might want to talk about if we have time.

References

[1] Rick Durrett. *Probability: theory and examples*, volume 49. Cambridge university press, 2019.

[2] Stacey Jeffery and Sebastian Zur. Multidimensional quantum walks, with application to k-distinctness. *arXiv preprint arXiv:2208.13492*, 2022.

[3] Aleksandrs Belovs. Quantum walks and electric networks. *arXiv preprint arXiv:1302.3143*, 2013.

[4] Andrew M. Childs, Richard Cleve, Enrico Deotto, Edward Farhi, Sam Gutmann, and Daniel A. Spielman. Exponential algorithmic speedup by a quantum walk. In *Proceedings of the thirty-fifth annual ACM symposium on Theory of computing*. ACM, jun 2003.