CS 496 Project

Due Date: December 5

Instructions

For the final project for this class, read any paper(s), parts of a textbook, or survey that is relevant to any of the topics we covered in class, and write a report about the paper.

The report should:

- Describe the landmark results in the area that your reading is related to.
- Describe the contribution of the paper, and a high-level description of the proof.
- Identify one technical idea in the paper you find cool, and articulate it by writing a lemma/theorem statement along with a proof. It could be one ingredient in the proof you find cool, or the core technical idea simplified to communicate the essence without technical details.
- Identify an open problem, and write about why you find it interesting.

As long as you can justify the connection between the paper and the theme of the class, any paper that was not already covered in class should be fine!

Please turn in your report via email by **December 5**.

Candidate papers

Here is a (very non-exhaustive) list of candidate papers:

- Recent breakthroughs on classical locally testable codes (and quantum LDPC codes): [DEL+22, PK22] (see also the alternate construction [LH22]).
- Bias reduction in codes via expander walks [TS17], which led to the breakthrough of the first explicit codes achieving the GV bound.
- Algebraic constructions of expander graphs (see Yehudayoff's survey: https://www.cs.princeton.edu/~zdvir/expanders/amir-3steps.pdf, or this book of Davidoff, Sarnak and Valette: https://math.bme.hu/~gabor/oktatas/SztoM/DavidoffSarnakValette.pdf).
- Elementary construction of high-dimensional expanders [KO17]. (See also, this note [HS19].)

- An alternate way to obtain Ramanujan graphs via interlacing families [MSS15], that is amenable to an algorithmization [Coh16].
- An umbrella framework for proving Markov chain mixing times, and a bunch of applications [CE22].
- A way to relate zerofreeness of the partition function to spectral independence [CLV24].
- Check out this book by Sinho Chewi for a lot of content related to Markov chains in continuous space: `https://chewisinho.github.io/main.pdf`.
- Higher-order Cheeger inequalities: [LGT14, LRTV12].
- The paper that pioneered the connection between local codes and hypergraph spectral methods that led to a bunch of progress on improved lower bounds for locally decodable/-correctable codes [AGKM23].

References

[AGKM23] Omar Alrabiah, Venkatesan Guruswami, Pravesh K Kothari, and Peter Manohar. A near-cubic lower bound for 3-query locally decodable codes from semirandom CSP refutation. In *Proceedings of the 55th Annual ACM Symposium on Theory of Computing*, pages 1438–1448, 2023. 2

[CE22] Yuansi Chen and Ronen Eldan. Localization schemes: A framework for proving mixing bounds for markov chains. In *2022 IEEE 63rd Annual Symposium on Foundations of Computer Science (FOCS)*, pages 110–122. IEEE, 2022. 2

[CLV24] Zongchen Chen, Kuikui Liu, and Eric Vigoda. Spectral independence via stability and applications to holant-type problems. *TheoretiCS*, 3, 2024. 2

[Coh16] Michael Cohen. Ramanujan graphs in polynomial time. In *Proceedings of the 57th Annual IEEE Symposium on Foundations of Computer Science*, pages 276–281, 2016. 2

[DEL+22] Irit Dinur, Shai Evra, Ron Livne, Alexander Lubotzky, and Shahar Mozes. Good locally testable codes. *arXiv preprint arXiv:2207.11929*, 2022. 1

[HS19] Prahladh Harsha and Ramprasad Saptharishi. A note on the elementary construction of high-dimensional expanders of Kaufman and Oppenheim. *arXiv preprint arXiv:1912.11225*, 2019. 1

[KO17] Tali Kaufman and Izhar Oppenheim. High dimensional expanders and coset geometries. *arXiv preprint arXiv:1710.05304*, 2017. 1

[LGT14] James R Lee, Shayan Oveis Gharan, and Luca Trevisan. Multiway spectral partitioning and higher-order cheeger inequalities. *Journal of the ACM (JACM)*, 61(6):1–30, 2014. 2

[LH22] Ting-Chun Lin and Min-Hsiu Hsieh. c^3-locally testable codes from lossless expanders. In *2022 IEEE International Symposium on Information Theory (ISIT)*, pages 1175–1180. IEEE, 2022. 1

[LRTV12] Anand Louis, Prasad Raghavendra, Prasad Tetali, and Santosh Vempala. Many sparse cuts via higher eigenvalues. In *Proceedings of the forty-fourth annual ACM symposium on Theory of computing*, pages 1131–1140, 2012. 2

[MSS15] Adam Marcus, Daniel Spielman, and Nikhil Srivastava. Interlacing families IV: Bipartite Ramanujan graphs of all sizes. In *Proceedings of the 56th Annual IEEE Symposium on Foundations of Computer Science*, pages 1358–1377, 2015. 2

[PK22] Pavel Panteleev and Gleb Kalachev. Asymptotically good quantum and locally testable classical ldpc codes. In *Proceedings of the 54th annual ACM SIGACT symposium on theory of computing*, pages 375–388, 2022. 1

[TS17] Amnon Ta-Shma. Explicit, almost optimal, epsilon-balanced codes. In *Proceedings of the 49th Annual ACM SIGACT Symposium on Theory of Computing*, pages 238–251, 2017. 1