Fall 2023 6.S891 Final Project

Initial Proposal Due: November 6, 2023

Full Report Due: December 13, 2023

For the final project, you may work individually or in groups of two. Please submit a write-up PDF, typed in LaTeX, of one of the following:

- **Original Research:** Describe an open problem and your attempt to solve it. Please give background on motivation, importance, and if applicable, previous works/approaches in that direction. It is OK if your progress does not meet the bar for publication, but please provide complete proofs, references, justification for your approach, etc.
- **Survey:** Please select at least 2 (preferably 3) papers to read in depth, and write a summary. The goal here is to have a *unified* perspective of that body of research, as opposed to a list of isolated results. At the most basic level, discuss the underlying context, state the main results, and provide proofs of the key lemmas. However, your report should also contain some (though not necessarily all) of the following elements:
  - Comparisons between different approaches to a problem. As an example, one ideal version of this is to formulate precisely the key barriers that must be overcome, and why each such approach does/does not achieve this. Avoid simply saying "this approach works in X regime of parameters whereas this other approach works in Y regime of parameters".
  - Alternative proofs of key lemmas.
  - Discussion of why certain hypotheses were made, and to what extent they can be relaxed or modified.
  - Simplified exposition. It is OK to weaken the theorem statements, as long as the most novel conceptual contributions are still captured.
  - More "intuitive" exposition, by way of analogies, representative special cases, Ansatz, etc. which are not mentioned in the paper(s). This is particularly valuable if some proofs contain definitions/manipulations/lemmas which really make you wonder "How did they come up with that?"
  - Representative special cases/examples which can be worked through explicitly.
  - Discussion of remaining open problems.
  - If applicable, implementations in code along with visualizations.

Please submit a half-page initial proposal describing who you plan to work with, and what you plan to do.

1 Examples of Possible Survey Topics

The following papers are just roughly categorized by topic, and listed in no particular order. Feel free to pick any subset of them and look at related literature. You can also ignore this list entirely and study another body of work as long as it is related to the content of this course.

1.1 Cut-Off Phenomenon

- https://arxiv.org/abs/2102.05597
- https://arxiv.org/abs/1407.1761
- https://arxiv.org/abs/1507.04725

1.2 Nonreversible Markov Chains and Related Topics

- https://arxiv.org/abs/2102.07217
- https://arxiv.org/abs/1606.03432
- https://arxiv.org/pdf/1705.08253.pdf
- https://arxiv.org/abs/2208.04751

1.3 Sampling from Multi-Modal Distributions

- https://arxiv.org/abs/2208.13153
- https://arxiv.org/abs/2106.11296
- https://arxiv.org/abs/2310.01762
- https://arxiv.org/abs/1812.00793

1.4 Perfect Sampling and Related Topics

- https://arxiv.org/abs/2106.15992
- https://arxiv.org/abs/2007.06360
- https://arxiv.org/abs/2211.03487
- https://arxiv.org/abs/2305.02450

1.5 Random Cluster Model

- https://arxiv.org/abs/2304.03182
- https://arxiv.org/abs/1804.08111
- https://arxiv.org/abs/1605.00139
- https://arxiv.org/abs/2006.11580

1.6 More on Zeros of Polynomials

- https://arxiv.org/abs/2309.10928
- https://arxiv.org/abs/1911.01504
- https://arxiv.org/abs/1910.09071
- https://arxiv.org/abs/1911.11962

1.7 More on #BIS

- https://arxiv.org/abs/2109.03744
- https://arxiv.org/abs/2307.09533
- https://arxiv.org/abs/1311.4839v3

1.8 Sampling via Diffusion Processes

- https://arxiv.org/abs/2305.10690
- https://arxiv.org/pdf/2203.05093
- https://arxiv.org/abs/2304.11449
- https://arxiv.org/abs/2209.11215

1.9 Continuous Distributions (e.g. Log-Concave)

- https://arxiv.org/abs/2112.12662
- https://arxiv.org/abs/1909.05503
- https://arxiv.org/abs/2203.15551 (see also https://arxiv.org/abs/2011.13661)
- https://arxiv.org/abs/2212.00297
- https://arxiv.org/pdf/1911.05656.pdf

1.10 Miscellaneous

- https://dl.acm.org/doi/abs/10.1145/3564246.3585207
- https://arxiv.org/abs/2206.04883
- https://arxiv.org/abs/1512.06304
- https://arxiv.org/abs/1911.05725
- https://arxiv.org/abs/2011.05417
- https://arxiv.org/abs/1608.02014
- https://arxiv.org/abs/2007.02729
- https://arxiv.org/abs/2212.06028
- https://arxiv.org/abs/2004.05833
- https://arxiv.org/abs/1301.6268
- https://arxiv.org/abs/2304.13203
- https://arxiv.org/abs/1203.2226
- https://arxiv.org/pdf/1604.06859
- https://arxiv.org/abs/2305.03307
- http://hariharan-ramesh.com/papers/mcmc.pdf
- https://arxiv.org/abs/2307.07625