STAT 548: PhD Qualifying Course Papers

Overview. My research primarily concerns high-performance algorithms for Bayesian modeling and Probabilistic Machine Learning. An outcome of this research is the development of algorithms which support probabilistic programming languages such as Stan and TensorFlow Probability. These algorithms must be efficient, easy-to-use ("black box"), and general-purpose in order to accommodate a large range of models and to support a model development workflow. Two important classes of algorithms in this space are *Markov chain Monte Carlo* and *variational inference*.

My research is at the intersection of theory, computation, and application. The papers I have selected demonstrate how to work at this intersection. When considering the topic of each paper, you might ask yourself: would a practitioner using Bayesian modeling benefit from this paper's contribution? Can the proposed method be implemented in a general-purpose statistical software? Does the paper provide a sufficiently thorough analysis to answer these questions?

Paper list

- "Nested $\widehat{R}$: Assessing the Convergence of Markov chain Monte Carlo when Running Many Short Chains." Margossian et al. *Bayesian Analysis* (2024)
- "Incorporating Local Step-Size Adaptivity into the No-U-Turn Sampler using Gibbs Self Tuning." Bou Rabee et al. *arXiv:2408.08259* (2024)
- "Pathfinder: Parallel quasi-Newton variational inference." Zhang et al. *Journal of Machine Learning Research* (2022)
- "Advances in Black Box VI: Normalizing Flows, Importance Weighting, and Optimization." Agrawal et al. *Advances in Neural Information Processing Systems* (2020) (read appendix in arXiv version: arXiv:2006.10343)
- "Variational Inference in Location-Scale Families: Exact Recovery of the Mean and Correlation Matrix." Margossian and Saul. *Artificial Intelligence and Statistics* (2025)

Evaluation.

- For each paper you will write a critical analysis which summarizes the contributions of the paper. Your analysis should (i) contextualize the paper and discuss recent literature, (ii) highlight the strengths and limitations as a reviewer might do, and (iii) discuss open questions and propose future research directions—ones which might actually lead to your own research project! If the paper has theoretical contributions, you should be able to reproduce the proofs step-by-step and fill in gaps which may have been glossed over in the paper. If the paper proposes a new algorithm, should be able to explain the associated pseudo-code and run the code associated with the paper. Finally, you should be able to explain in great details the figures in the paper.
- In addition, we will come up with a small project for each paper. For example, you might extend one of the numerical experiments which evaluates the performance of a method across several models by adding a new model. In doing so, you will write code to implement the method, evaluate the performance and produce a figures describing your findings. Another example: you might extend a theoretical result by coming up with a new conjecture, and either prove it, provide empirical evidence supports the conjecture, or produce a counter-example.

As you work through the paper, I will be particularly interested in your ability to identify which parts of the paper you understand thoroughly and which ones remain unclear to you. I might grill you on some of the details in the papers with the goal to help you develop the ability to grill yourself when you read papers. It's ok if some of the paper is unclear—these papers are challenging—and it is my expectation that we will spend time together clarifying various concepts.

Your assignment will be graded according to the following break down:

- Critical Analysis (50%):
  - Context and motivation (10%)
  - Conceptual analysis (10%)
  - Technical analysis (10%)
  - Critic (10%)
  - Discussion of future research (10%)
- Project (45%):
  - Scope and originality (15%)
  - Technical content (15%)
  - Presentation (15%)
- Communication and basic requirements (5%)

A passing grade is 83%.