STAT656 Project Proposal

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1 Bayesian Causal Inference for Privatized Data

Our project focuses on the methodological development of Bayesian causal inference methodologies specifically tailored for differentially privatized data. Causal inference plays a pivotal role across numerous domains, including science, technology, engineering, and medicine. The potential outcome framework (Imbens and Rubin, 2015) serves as an effective tool to discern causal relationships between treatments and outcomes. Within this framework, Bayesian inference emerges as a prominent inferential mode. Compared to the frequentist approaches, the Bayesian approach offers several established advantages for general statistical analysis, including automatic uncertainty quantification, coherently incorporating prior knowledge, and offering a rich collection of advanced models for complex data.

On the other hand, differential privacy (DP), introduced by Dwork et al. (2006), is another growing domain in science and business, as privacy protection has become a core concern for many organizations in the modern data-rich world. DP is a mathematical framework that provides a probabilistic guarantee that protects private information about individuals when publishing statistics about a dataset. This probabilistic guarantee is often achieved by adding random noise to the data. Drawing causal conclusions from privatized data clearly lays out unique challenges. While the added random noise helps safeguard individual privacy, it also distorts the actual patterns in the data.

Despite the growing interest in these two pivotal domains, there is a noticeable scarcity in literature that melds causal inferential methodologies with privatized data considerations. Our group project aims to bridge this gap by develping a Bayesian causal inferential approach specifically designed for privatized data.

1.1 Schedule

To begin, we will familiarize ourselves with the domain by reviewing an article about Bayesian causal inference (Li et al., 2022). We intend to present a literature review to provide audiences with a comprehensive understanding of Bayesian causal inference, highlighting both its advantages and challenges. For our final project, we aim to develop a Bayesian methodology specifically designed for differentially private data. We also plan to showcase simulation studies to demonstrate the efficacy of our proposed methodology. The members responsible for each task are as follows:

- Yi-ting and Satoshi will present a review of Li et al. (2022).
- Yuki is in charge of the methodological development and the final presentation.

References

Dwork, C., F. McSherry, K. Nissim, and A. Smith (2006). Calibrating noise to sensitivity in private data analysis. In *Theory of cryptography conference*, pp. 265–284. Springer.

Imbens, G. W. and D. B. Rubin (2015). *Causal Inference for Statistics, Social, and Biomedical Sciences: An Introduction*. Cambridge University Press.

Li, F., P. Ding, and F. Mealli (2022). Bayesian causal inference: A critical review.