Paper chosen

[1] Sainsbury-Dale, M., Zammit-Mangion, A., Richards, J., and Huser, R. (2025), "Neural Bayes Estimators for Irregular Spatial Data Using Graph Neural Networks," *Journal of Computational and Graphical Statistics*, 1–16. https://doi.org/10.1080/10618600.2024.2433671.

Scientific Introduction

In traditional Bayesian inference, we often run into the issue of intractable likelihood. For example, in the presence of high-dimensional latent variables, evaluating a high-dimensional integral makes the likelihood function intractable. One possible solution is likelihood-free inference, where we take advantage of simulations to perform inference, and Neural Bayes Estimators (NBE) are one such method.

Neural Bayes Estimators are neural networks that approximate Bayes estimators in a likelihood-free fashion. They offer appealing characteristics such as amortized computing cost and wider applicability than traditional likelihood-based inference methods. One application of NBE is on spatial models, where estimation often runs into computational bottleneck. However, state-of-the-art development of such application is restrained on requiring data to be on a regular grid, limiting it applicability in irregular spatial data as different spatial patterns require training a entrely new model.

The authors employs Graph Neural Network (GNN) to tackle the irregular spatial data problem, enabling estimation over arbitrary spatial locations. They also propose training an accompanying GNN to estimate marginal posterior quantiles for fast uncertainty quantification.

Proposed project plan

For the final project, I plan to

- discuss and implement the Neural Bayes Estimators using GNN for both point estimation and uncertainty quantification, potentially using the Gaussian process example examined in the paper.
- implement some traditional Bayesian MCMC algorithms (e.g. Hamiltonian MC, Metroplis-hastings algorithm) and carry out simulation studies to contrast scalability and applicability of different algorithms.