先端科学技術研究科　修士論文要旨

所属研究室 (主指導教員)	数理情報学 (池田　和司　(教授))		
学籍番号	2411068	提出日	令和 8年 1月 16日
学生氏名	尾上　圭介		
論文題目	Closed-Form Coordinate Ascent Variational Inference for Student-t Process Regression with Student-t Likelihood		

要旨

Gaussian Process regression is a powerful Bayesian nonparametric model, yet its reliance on thin-tailed Gaussian assumptions makes it highly sensitive to outliers.
To address this, the doubly robust Student-t Process Regression with Student-t likelihood (TPRT) model has been introduced, replacing Gaussian components with heavy-tailed Student-t distributions. However, the inherent non-conjugacy of this model renders the posterior distribution intractable, presenting a formidable computational barrier.
Existing approaches are often forced to choose between the limited expressiveness of Laplace approximations and the high computational cost of sampling-based variational methods.

This thesis proposes a novel coordinate ascent variational inference (CAVI) framework that enables efficient, closed-form updates for the TPRT model.
By leveraging the scale-mixture representation of the Student-t distribution, we design a structured variational family that preserves the critical dependency between the latent function and its global scaling variable. To overcome the lack of conjugacy, we introduce a unique projection-based subroutine within CAVI: finding the optimum in a simplified factorized family and analytically projecting it back onto our structured one. This framework is further extended to sparse and stochastic settings, ensuring scalability to large-scale datasets.

Evaluation across diverse benchmark datasets demonstrates that this method achieves superior predictive performance and significantly faster convergence compared to existing approaches. The proposed framework effectively bridges the gap between the theoretical appeal of doubly-robust models and their practical application, establishing TPRT as an attractive tool for real-world data analysis.