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Bayesian active learning for converging posteriors in latent variable inference for control systems

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Inferring latent variables, such as Courant-Snyder parameters in particle accelerators, is challenging due to noisy, partial observations that often produce multi-modal posterior distributions, despite the true latent variable being unique. We present a Bayesian Active Learning (BAL) framework to enhance latent variable inference in simulation-equipped control systems. BAL actively selects control settings (e.g., quadrupole magnet configurations) to maximize information gain, efficiently refining multi-modal posteriors into unimodal ones for improved inference accuracy. Using an ensemble of physics-informed beam envelope simulations in PyTorch, our approach approximates posterior sampling and mutual information to guide data acquisition. This interpretable framework holds broad potential for improving latent variable inference in control systems.

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Footnotes

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