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Learned harmonic mean estimation of the Bayesian evidence with normalizing flows

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Computing the Bayesian evidence is an important task in Bayesian model selection, providing a principled quantitative way to compare models. In this work, we introduce normalizing flows to improve the learned harmonic mean estimator of the Bayesian evidence. This recently presented estimator leverages machine learning to address the exploding variance problem associated with the original harmonic mean. The improved method provides an accurate, robust and scalable estimator of the Bayesian evidence. Moreover, it is agnostic to the sampling strategy, meaning it can be combined with various efficient MCMC sampling techniques or variational inference approaches. We present numerical experiments demonstrating the effectiveness of the use of normalizing flows for the learned harmonic mean. We also apply the method to practical cosmological examples, including a 37-dimensional cosmic shear analysis using CosmoPower-JAX, a JAX-based implementation of the CosmoPower framework that accelerates cosmological inference by building differentiable neural emulators of cosmological power spectra, observing significant speed-up compared to the conventional method. We also successfully perform a 3x2pt analysis in a 157-dimensional setting, where using conventional methods is not feasible. This shows that the scalability CosmoPower-JAX and the learned harmonic mean estimator offer could allow for the comparison between models of unprecedented complexity, thus unlocking the full potential of Bayesian analysis even in high-dimensional settings.

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