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Tuning neural posterior estimation for gravitational wave inference

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Modern simulation-based inference techniques leverage neural networks to solve inverse problems efficiently. One notable strategy is neural posterior estimation (NPE), wherein a neural network parameterizes a distribution to approximate the posterior. This approach is particularly advantageous for tackling low-latency or high-volume inverse problems. However, the accuracy of NPE varies significantly within the learned parameter space. This variability is observed even in seemingly straightforward systems like coupled-harmonic oscillators. This paper emphasizes the critical role of prior selection in ensuring the consistency of NPE outcomes. Our findings indicate a clear relationship between NPE performance across the parameter space and the number of similar samples trained on by the model. Thus, the prior should match the sample diversity across the parameter space to promote strong, uniform performance. Furthermore, we introduce a novel procedure, in which amortized and sequential NPE are combined to swiftly refine NPE predictions for individual events. This method substantially improves sample efficiency, on average from nearly 0% to 10-80% within ten minutes. Notably, our research demonstrates its real-world applicability by achieving a significant milestone: accurate and swift inference of posterior distributions for low-mass binary black hole (BBH) events with NPE.

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