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Extending Neural Likelihood Estimators for Gravitational-Wave Data Analysis through Transfer Learning

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Since the first detection of a gravitational wave (GW) in 2015, more than 300 confident detections have been made, making data analysis increasingly computationally demanding. As the next generation of ground-based detectors is expected to increase the number of detections by three orders of magnitude, new and efficient inference methods are needed. A Neural Likelihood Estimator (NLE) has recently been applied to real GW data for the first time. This approach, in which the NLE is trained on the fly, demonstrates that neural networks can robustly approximate likelihood functions for GW parameter estimation, achieving posterior inference with up to two orders of magnitude fewer likelihood evaluations than traditional Bayesian methods.

We provide an overview of FLEX, a FLEXible NLE, and present robustness tests and features validating its use over an extensive range of parameters. We will show that transfer learning between NLEs trained on different waveform models can further reduce both training time and the number of required likelihood evaluations, while maintaining convergence and accuracy.

These findings highlight the potential of neural likelihood methods as fast, flexible, and scalable tools for gravitational-wave inference in the era of large-scale GW astronomy.

Primary author: TEUNISSEN, Martijn (Utrecht University)

Co-authors: SAMAJDAR, Anuradha (Utrecht University); NEGRI, Luca (Utrecht University)

Presenter: TEUNISSEN, Martijn (Utrecht University)

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