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Comparing Automated Posterior Estimation Techniques for Modeling Strong Lenses In Ground-based Survey Data

Current and future ground-based cosmological surveys, such as the Dark Energy Survey (DES), and the Vera Rubin Observatory Legacy Survey of Space and Time (LSST), are predicted to discover thousands to tens of thousands of strong gravitational lenses. The large number of strong lenses discoverable in future surveys will make strong lensing a highly competitive and complementary cosmic probe. However, conventional lens modeling techniques are unable to scale up to the sheer number of lenses that will be discovered through upcoming surveys. Therefore, the use of automated lens analysis techniques is necessary. We demonstrate that machine learning methods can be used to automate the inference of informative model posteriors of strong lensing systems in ground-based surveys with credible uncertainty estimation. We present two Simulation-Based Inference (SBI) approaches for lens parameter estimation of galaxy-galaxy lenses. We demonstrate applications of Neural Posteriors Estimators (NPEs) and Bayesian Neural Network (BNNs) to automate the inference of a 12-parameter lensing system for DES-like ground-based imaging data. We apply a suite of diagnostics (e.g., posterior coverage and SBC) to validate the performance of our methods. We find that NPEs outperform the BNN, producing posterior distributions that are for the most part both more accurate and more precise; in particular, several source-light model parameters are systematically biased in the BNN implementation.

Primary authors: POH, Jason (University of Chicago); Mr SAMUDRE, Ashwin (Simon Fraser); Dr ĆIPRIJANOVIĆ, Aleksandra (Fermilab); NORD, Brian (Fermilab)

Co-authors: Dr KHULLAR, Gourav (University of Pittsburgh); Dr TANOGLIDIS, Dimitrios (University of Pennsylvania); Prof. FRIEMAN, Joshua (University of Chicago)

Presenter: POH, Jason (University of Chicago)

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