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Deep Learning and Hierarchical Inference to infer H0 from Strong Gravitational Lenses

To achieve a high precision measurement of the Hubble constant from strongly lensed AGN, we need to take advantage of the 1,000s of new strong lens observations that will come from the next generation of survey telescopes. In preparation for modeling roughly 10 times more lenses than are currently known, we have been developing a machine learning lens modeling technique. We use a deep convolutional neural network for neural posterior estimation of lens model posterior PDFs. These posteriors are then combined in a hierarchical inference to recover population hyperparameters and correct individual posteriors for bias from the choice of interim training prior. As a first step in preparing our pipeline, we validate our technique by testing it on real lens images for the first time, using a sample of 14 quadruply-lensed quasars imaged by HST for the STRIDES collaboration. Given our flexible and fast training methodology, we test how key potential sources of systematic error, such as image rizzling, PSF modeling, and source morphology, affect the network predictions. We also test the robustness of our methods, including a direct comparison to lensing constraints from traditional modeling. Our
results show that deep learning lens modeling is a powerful probe of systematics, providing insights that are not possible with traditional modeling. We find improved simulation realism and further algorithmic development are required before further scientific application of the pipeline to real data.

Primary author: ERICKSON, Sydney (Stanford)

Presenter: ERICKSON, Sydney (Stanford)

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