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Sampling high-dimensional inverse problem posteriors with neural score estimation

Monday, 30 October 2023 18:35 (20 minutes)

I will present a novel methodology to address many ill-posed inverse problems, by providing a description of the posterior distribution, which enables us to get point estimate solutions and to quantify their associated uncertainties. Our approach combines Neural Score Matching and a novel posterior sampling method based on an annealed HMC algorithm to sample the full high-dimensional posterior of our problem.

In the astrophysical problem we address, by measuring the lensing effect on a large number of galaxies, it is possible to reconstruct maps of the Dark Matter distribution. But because of missing data and noise dominated measurement, this constitutes a challenging ill-posed inverse problem.

We propose to reformulate the problem in a Bayesian framework, where the target becomes the posterior distribution of mass given the galaxies shape observations. The likelihood factor, describing how light-rays are bent by gravity, how measurements are affected by noise, and accounting for missing observational data, is fully described by a physical model. Besides, the prior factor is learned over cosmological simulations using Neural Score Matching and takes into account theoretical knowledge. We are thus able to obtain samples from the full Bayesian posterior and can perform Dark Matter mass-map reconstruction alongside uncertainty quantifications.

Brainstorming idea [title]

Training diffusion models from corrupted data

Brainstorming idea [abstract]

Training generative models from corrupted data, a task that is currently only possible with Latent Variable Models like VAEs and GANs, is still an open challenge for state-of-the-art models based on diffusion. This would enable an efficient combination of generative models and physical models, which is a promising avenue for astrophysical data analysis, as this approach has the potential to extract maximum information from data.

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