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Learning to Optimize Cosmic Initial Conditions with Non-Differentiable Structure Formation Models

Traditional gradient-based optimization and statistical inference methods often rely on differentiable models, making it challenging to optimize models with non-differentiable components. In this talk, I'll introduce Learning the Universe by Learning to Optimize (LULO), a novel deep learning-based framework designed to fit non-differentiable simulators at non-linear scales to data. By employing a neural optimizer in an iterative scheme while keeping full physics simulations in the loop, LULO ensures both scalability and reliability. In particular, I will demonstrate how LULO accurately reconstructs the 3D cosmological initial conditions and corresponding late-time structures from mock data generated by a non-differentiable and non-linear simulator pipeline. Our method provides a promising path forward for performing detailed field-level inference with next-generation galaxy clustering survey data, without the need for differentiable models.

AI keywords

Learning-to-optimize; neural optimizers; convolutional neural networks; physics-in-the-loop

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Track Classification: Simulations & Generative Models