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Physics-guided Machine Learning methods in QUBIC

Today, many physics experiments rely on Machine Learning (ML) methods to support their data analysis pipelines. Although ML has revolutionized science, most models are still difficult to interpret and lack clarity of the process with which they calculate results and the way they utilize information from used datasets. In this work, we introduce physics-guided ML methods that keep the reliability of traditional statistical techniques (e.g. minimization, likelihood analysis), which are accurate but often slow, and use the speed and efficiency of deep learning - without loosing interpretability. We show methods that offer insight into details of the dataset by informing the models with the underlying physics and analyzing information gain, allowing interpretability while also optimizing data usage. The approach is presented in the context of QUBIC, an unconventional experiment designed to investigate the Cosmic Microwave Background using bolometric interferometry, with the goal of detecting primordial gravitational waves. Methods are applied to the process of convolved map reconstruction, and show how physics-guided methods can aid in interpretability, parameter estimation, fitting, memory optimization, and more. This approach is not limited to cosmology, and can be applied in many areas of research.

AI keywords

physics-guided machine learning; interpretable AI; map reconstruction; deconvolution

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