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Tests for model misspecification in simulation-based inference: from local distortions to global model checks

Model misspecification analysis strategies, such as anomaly detection, model validation, and model comparison are a key component of scientific model development. Over the last few years, there has been a rapid rise in the use of simulation-based inference (SBI) techniques for Bayesian parameter estimation, applied to increasingly complex forward models. To move towards fully simulation-based analysis pipelines, however, there is an urgent need for a comprehensive simulation-based framework for model misspecification analysis.

In this talk, I will describe a solid and flexible foundation for a wide range of model discrepancy analysis tasks, using *distortion-driven model misspecification tests*. From a theoretical perspective, I will introduce the statistical framework built around performing many hypothesis tests for distortions of the simulation model. I will also make explicit analytic connections to classical techniques: anomaly detection, model validation, and goodness-of-fit residual analysis. Furthermore, I will introduce an efficient self-calibrating training algorithm that is useful for practitioners. I will demonstrate the performance of the framework in multiple scenarios, making the connection to classical results where they are valid. Finally, I will show how to conduct such a distortion-driven model misspecification test for real gravitational wave data, specifically on the event GW150914.

Related work at https://arxiv.org/abs/2412.15100 .

AI keywords

simulation-based inference, misspecification tests, out-of-distribution, anomaly detection

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Track Classification: Patterns & Anomalies