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Direct Learning of Systematics-Aware Summary Statistics

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Complex machine learning tools, such as deep neural networks and gradient boosting algorithms, are increasingly being used to construct powerful discriminative features for High Energy Physics analyses. These methods are typically trained with simulated or auxiliary data samples by optimising some classification or regression surrogate objective. The learned feature representations are then used to build a sample-based statistical model to perform inference (e.g. interval estimation or hypothesis testing) over a set of parameters of interest. However, the effectiveness of the mentioned approach can be reduced by the presence of known uncertainties that cause differences between training and experimental data, included in the statistical model via nuisance parameters. This work presents an end-to-end algorithm, which leverages on existing deep learning technologies but directly aims to produce inference-optimal sample-summary statistics. By including the statistical model and a differentiable approximation of the effect of nuisance parameters in the computational graph, loss functions derived form the observed Fisher information are directly optimised by stochastic gradient descent. This new technique leads to summary statistics that are aware of the known uncertainties and maximise the information that can be inferred about the parameters of interest object of a experimental measurement.

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