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Using Machine Learning based Unfolding to reduce error on lattice QCD observables

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In lattice QCD studies, physical observables like the chiral condensate or baryon number density are computed as the trace of a combination of products of the inverse fermion matrix, typically estimated stochastically using the random noise method. The accuracy of this method depends on the number of random sources used; ideally, an infinite number of sources would yield true physical results. However, practical limitations introduce systematic errors due to the finite number of sources. We propose using an unfolding algorithm based on a sequential neural network to learn the inverse transformation from a "true"distribution (obtained with a large number of random sources) to a "measured" distribution (obtained with fewer sources). Applying this learned transformation to observables measured with fewer sources can improve accuracy. We demonstrate that this method's effectiveness is strongly dependent on the distribution of the random noise vectors and only weakly dependent on the matrix structure of the observable, making it a viable approach for lattice studies.

Primary authors: SCHMIDT, Christian (Universitaet Bielefeld); SINGH, Simran (University of Bielefeld)

Presenter: SINGH, Simran (University of Bielefeld)

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