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Machine learning renormalization group actions

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RG improved lattice actions provide a possible way to extract continuum physics with coarser lattices, thereby allowing to circumvent problems with critical slowing down and topological freezing toward the continuum limit. So-called fixed point (FP) lattice actions for example have continuum classical properties unaffected by discretization effects, while lattice actions on the renormalized trajectory are quantum perfect and have no lattice artefacts at all. A crucial ingredient for practical applications is to find an accurate and compact parametrization of such actions, since many of its properties are only implicitly defined. Here we use machine learning methods to revisit the question of how to parametrize quantum perfect and fixed point actions. In particular, we obtain a fixed point action for four-dimensional SU(3) gauge theory using convolutional neural networks with exact gauge invariance. The large operator space allows us to find superior parametrizations compared to previous studies, a necessary first step for Monte Carlo simulations. Furthermore, we demonstrate the classically perfect properties of the FP lattice actions in the case of gradient flow observables, and discuss how quantum perfect actions can be obtained in practice.

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