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Machine learning for multi-scale action matching

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Critical slowing-down of HMC algorithms presents a significant challenge in achieving LQCD calculations at fine lattice spacings. A number of methods have been proposed that circumvent this issue by acting at multiple physical length scales, including perfect actions that aim to achieve almost-continuum physics at finite lattice spacings, and multi-scale thermalisation techniques. Such approaches require careful renormalisation-group matching of the LQCD actions defined at different scales such that they describe the same long-distance physics. An essential challenge is to solve the parametric regression task: Which action parameters best represent the coarse-scale physics of an ensemble of samples generated at a finer resolution, and vice-versa? Similar parameter regression problems of LQCD ensembles arise in the context of mixed-action LQCD simulations. I will discuss the applicability of machine learning to this regression task. Deep neural networks are found to provide an efficient solution even in cases where approaches such as principal component analysis fail. The high information content and complex symmetries inherent in lattice QCD datasets require custom neural network layers to be introduced and present opportunities for further development.

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