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Renormalization Group Approach for Machine Learning Hamiltonian

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We develop a multiscale approach to estimate high-dimensional probability distributions. Our approach applies to cases in which the energy function (or Hamiltonian) is not known from the start. Using data acquired from experiments or simulations we can estimate the underlying probability distribution and the associated energy function. Our method—the wavelet-conditional renormalization group (WCRG)—proceeds scale by scale, estimating models for the conditional probabilities of "fast degrees of freedom"conditioned by coarse-grained fields, which allows for fast sampling of many-body systems in various domains, from statistical physics to cosmology. Our method completely avoids the "critical slowing-down"of direct estimation and sampling algorithms. This is explained theoretically by combining results from RG and wavelet theories, and verified numerically for the Gaussian and φ4-field theories, as well as weak-gravitational-lensing fields in cosmology.

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