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# Machine Learning Hamiltonian by A Renormalization Group Approach

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### Abstract:

For a long time, physicists have determined Hamiltonian for a given problem by following a bottom-up approach starting from physical principles such as symmetry. Nowadays, thanks to a large amount of data available, it has become possible to estimate Hamiltonian by machine learning, i.e., inferring it from a large dataset of observations from experiments or simulations. The majority of physical systems are characterized by a probability distribution. At thermal equilibrium, this distribution has the Boltzmann-Gibbs form. Estimating such probability distributions and generating new samples efficiently is now a major endeavor at the center of intense research activity. In this study, we develop a multiscale approach to estimate high-dimensional probability distributions and associated Hamiltonians from a dataset of physical fields or configurations. In this way, we can estimate Hamiltonian and efficiently generate new samples of many-body systems in various domains, from statistical physics to cosmology. Our method uses the idea of the renormalization group, which proceeds scale by scale, estimating models for the conditional probabilities of "fast degrees of freedom" conditioned by coarse-grained fields. This approach has a large number of potential applications in equilibrium and non-equilibrium systems where the underlying distribution is not known a priori. We verified our method for the Gaussian and  $\phi^4$  field models and mass distributions in astrophysics [1].

[1] Tanguy Marchand, Misaki Ozawa, Giulio Biroli, and Stéphane Mallat, arXiv:2207.04941.

### Bio:

Misaki Ozawa is a CNRS researcher in the Interdisciplinary Physics Lab at the University of Grenoble Alpes. He received Ph.D. at the University of Tsukuba in Japan. He did a postdoc at the University of Montpellier in France, and he moved to Ecole Normale Supérieure (ENS) in Paris as the second postdoc. He received the Young Scientist Award from the Physical Society of Japan. He has broad research experiences in the field of disordered systems, from supercooled liquids, structural glasses, and jammed granular materials up to magnets in random fields, considering thermodynamic, dynamical, and mechanical aspects, as well as the development of efficient simulation algorithms and computational methodologies. He is currently working on interdisciplinary subjects between physics and machine learning in order to tackle challenging problems in physics, as well as understand the mechanism of machine learning in view of statistical physics.