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Simulation of Z2 model using Variational Autoregressive Network (VAN).

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Markov chain Monte Carlo (MCMC) simulations is a very powerful approach to tackle a large variety of problems in all computational science. The recent advances in machine learning techniques have provided new ideas in the domain of Monte Carlo simulations. The ability of artificial neural networks to model a very wide class of probability distributions through the Variational Autoregressive Network (VAN) approach allow for instance to approximate the free energy of statistical systems.

The study focuses on a lattice model with local Z_2 group symmetry, specifically chosen for its simplicity and the presence of local gauge symmetry. In lattice gauge theories, Z_2 represents link degrees of freedom, taking discrete values of +1 or -1 for different gauge field states. Autoregressive neural networks are employed for Z_2 gauge systems to capture dependencies among lattice sites, facilitating the generation of realistic configurations. The joint probability of spins $p(s)$, described by Boltzmann's distribution, enables exploration of the system's behavior under diverse conditions.

In the VAN approach, the probability is written as a product of conditional probabilities of consecutive spins using Bayes rule. The goal of the training is to find parameters, θ, such that the probability distribution modeled by the neural network $q_\theta(\bar{s})$ resembles $p(\bar{s})$, where $q_\theta(\bar{s})$ is sampling probability distribution and $\bar{s}$ is final configuration. For that, Kullback–Leibler (KL) divergence is the loss function used to determine the closeness between these two distributions. Training of the network employs the policy gradient approach in reinforcement learning, which unbiasedly estimates the gradient of variational parameters. The emphasis of the study lies in exploring the applicability of Neural Markov Chain Monte Carlo (NMCMC) simulations using Variational Autoregressive Network (VAN) in exploring the dynamics of systems with local gauge symmetry.

References

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