

Variational Neural Annealing: Optimization in Physics, Biology, and Finance

Abstract:

Variational Neural Annealing (VNA) is an innovative optimization framework that emulates classical and quantum annealing processes by integrating variational principles with neural network parameterizations. It effectively utilizes autoregressive models to represent classical and quantum probability distributions during the annealing process, creating a new avenue for exploring complex energy landscapes, such as those encountered in disordered Ising glasses, protein folding, and portfolio optimization. In this presentation, we will explore the foundational aspects of VNA, starting with its original formulation and extending to its applications across various domains. We will demonstrate, through case studies on prototypical spin glass Hamiltonians, that VNA outperforms traditional simulated classical and quantum annealing methods, particularly in asymptotic limits. Furthermore, we will emphasize VNA's capacity to identify the folded states of lattice protein models and optimize investment portfolios in complex financial environments, achieving results comparable to—and sometimes surpassing—the capabilities of state-of-the-art algorithms and commercial solvers.