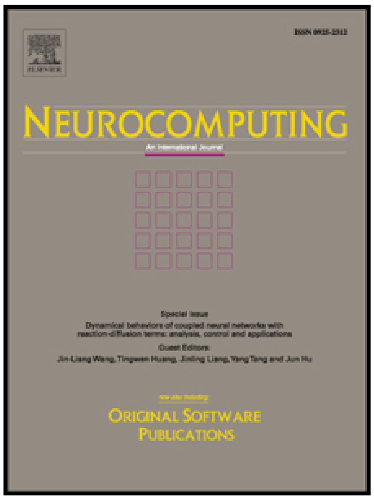

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Learning in Quantum Control: High-Dimensional Global Optimization for Noisy Quantum Dynamics

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Abstract

Quantum control is valuable for various quantum technologies such as high-fidelity gates for universal quantum computing, adaptive quantum-enhanced metrology, and ultra-cold atom manipulation. Although supervised machine learning and reinforcement learning are widely used for optimizing control parameters in classical systems, quantum control for parameter optimization is mainly pursued via gradient-based greedy algorithms. Although the quantum fitness landscape is often compatible with greedy algorithms, sometimes greedy algorithms yield poor results, especially for large-dimensional quantum systems. We employ differential evolution algorithms to circumvent the stagnation problem of non-convex optimization. We improve quantum control fidelity for noisy system by averaging over the objective function. To reduce computational cost, we introduce heuristics for early termination of runs and for adaptive selection of search subspaces. Our implementation is massively parallel and vectorized to reduce run time even further. We demonstrate our methods with two examples, namely quantum phase estimation and quantum gate design, for which we achieve superior fidelity and scalability than obtained using greedy algorithms.

1. Introduction

Quantum mechanics has been recognized as a superior foundation for performing computation [1, 2, 3], secure communication [4, 5] and metrology [6, 7], also leading to technological advancements such as nuclear magnetic resonance and other resonators [8, 9, 10, 11, 12], femtosecond lasers [13, 14] and laser-driven molecular reactions [15, 16]. Central to these applications is the ability to steer

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