Title

Fast and Efficient Creation of an Universal Quantum Gate Set Using Reinforcement Learning Methods

Abstract

The design and implementation of universal quantum gate sets are foundational to the advancement of quantum computing, enabling the realization of complex quantum algorithms and error correction protocols. This thesis explores the use of reinforcement learning (RL) methods to efficiently construct a universal quantum gate set comprising the Hadamard (H), the π/8 (T), and controlled-NOT (CNOT) gates. These gates, recognized for their minimality and universality, serve as essential building blocks for arbitrary quantum operations. The problem is formulated as a control optimization task, where various RL agents are deployed to determine the optimal Rabi Frequency, Detuning and coupling strength timing of quantum pulses to implement these gates with high fidelity. The investigation includes an evaluation of multiple reinforcement learning algorithms to assess their performance in balancing computational efficiency, physical constraints, and scalability across single- and multi-qubit systems. The proposed approach is validated through numerical simulations, demonstrating the ability of RL techniques to automate and enhance the design of universal gate sets. This work contributes to the growing synergy between machine learning and quantum technologies, offering a flexible and scalable framework for optimizing quantum control. The finding highlight the potential of RL-based methodologies in advancing practical and robust implementations of quantum computing.

Keywords

Reinforcement Learning, Machine Learning, Deep Learning, Quantum Control, Quantum Computing, Quantum Technologies