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Quantum State Preparation using Dynamical Invariants and Machine Learning

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Quantum technology is expected to have revolutionary impact on different areas including computation, communication, and sensing. The first step in any quantum application is state preparation, where it is required to transfer the system from a fixed initial state to a final target state. This task can be challenging to perform, especially in non-Markovian open quantum systems. Invariant-based inverse engineering provides an effective way to achieve desired state in quantum systems. However, the current methods mostly use parametrizations which could result in unrealistic pulses, limiting their applicability. Recently, noise mitigation methods have been proposed based on minimizing the overlap between the invariant operator and the dissipation operators in a Lindblad master equation, which is only valid for special classes of noise. In this paper, we address both these limitations and propose an invariant-based protocol for preparing single-qubit states under a general noise setting. We introduce two variants of the protocol, one based on the assumption of exact knowledge of the noise affecting the qubit, and the other for the more realistic case of unknown noise. Our numerical results show high fidelity for various target states in both scenarios showcasing the versatility of our approach. This opens new pathways for quantum control of NISQ devices.

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