Graybox quantum system identification and control

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Understanding and controlling engineered quantum systems is key to developing practical quantum technology. However, given the current technological limitations, such as fabrication imperfections and environmental noise, this is not always possible. To address these issues, a great deal of theoretical and numerical methods for quantum system identification and control have been developed. These methods range from traditional curve fittings, which are limited by the accuracy of the model that describes the system, to machine learning methods, which provide efficient control solutions but no control beyond the output of the model, nor insights into the underlying physical process.

We present a hybrid "graybox" approach which integrates machine learning structures with physics-based elements. Using this data-driven approach, a more accurate model of the underlying quantum system and the noise affecting it can be obtained. This learned model can then be utilized to optimize control pulses to achieve high-fidelity targets such as desired states or gates. We have demonstrated this approach for various settings including closed quantum systems [1], which has been recently experimentally verified for photonic integrated circuits [2], as well as open quantum systems subjected to non-Markovian classical noise [3] and quantum noise [4]. The results show superior performance in terms of obtained target fidelities compared to whitebox and blackbox approaches.

Herein, we focus on our recent results [5] that address the challenge of controlling a qubit strongly-coupled to an unknown non-Markovian noise. This problem is extremely challenging to solve, with most traditional control methods either failing or are intractable. The proposed graybox solution generates remarkable results for this formidable problem.

References

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