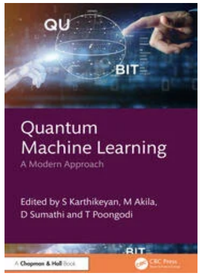

Chapter

Quantum Process Tomography and Regression

By
Kanaga Priya Palanisamy (/search?contributorName=Kanaga Priya Palanisamy&contributorRole=author&redirectFromPDP=true&context=ubx) (https://orcid.org/0000-0002-4710-2026)
,
Thanga Revathi Shanmugakani (/search?contributorName=Thanga Revathi Shanmugakani&contributorRole=author&redirectFromPDP=true&context=ubx) (https://orcid.org/0000-0003-1518-006X)
,
Gomathy Balasubramanian (/search?contributorName=Gomathy Balasubramanian&contributorRole=author&redirectFromPDP=true&context=ubx) (https://orcid.org/0000-0002-0418-2150)
,
Reethika Anandan (/search?contributorName=Reethika Anandan&contributorRole=author&redirectFromPDP=true&context=ubx) (https://orcid.org/0000-0002-0912-1242)

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ABSTRACT

This chapter delves deeply into quantum process tomography (QPT) and regression: two critical approaches in the field of processing quantum information. The process of characterizing and estimating unknown quantum processes executed on quantum systems is known as quantum process tomography, while regression aims to find optimal parameters for input states to achieve desired unitary transformations. The chapter begins by introducing the concept of channel-state duality, which establishes a fundamental connection between quantum channels and quantum states. This duality enables the analysis of quantum processes by examining the input and output states, providing insights into their properties and behavior. Quantum process tomography is then discussed in detail, covering various tomographic methods and strategies used to reconstruct unknown quantum processes. Then the mathematical foundations, experimental techniques, and statistical analysis involved in quantum process tomography are explored to provide a comprehensive understanding of the field. Next, the chapter delves into the role of groups, the unitary group, and compact lie groups in the study of quantum processes. These mathematical concepts provide a framework for understanding the structure and symmetries of quantum processes, and representation theory is introduced as a powerful tool for decomposing and analyzing quantum processes into irreducible representations. The concept of storage of unitary and parallel application operations is crucial for the practical implementation of quantum processes insights about techniques such as parallelization and matrix factorization, which optimize the computational resources required for large-scale quantum systems, enabling efficient and scalable execution of quantum processes. The chapter also addresses the concept of finding optimal input states for learning quantum processes, adaptive measurement, and statistical optimization techniques, which enables researchers to identify the input states that provide the most informative data for accurate process estimation. Finally, the chapter concentrates on establishing the unitary operation and defining the parameterization for the initial state to achieve desired transformations. The effective learning criteria and quantum machine learning (QML) for leveraging quantum states provides advantages of QML over classical methods. In summary, this chapter provides a comprehensive exploration of quantum process tomography and regression. By leveraging channel-state duality, representation theory, and optimization techniques, researchers and practitioners can accurately characterize and estimate quantum processes. It also offers insights into the mathematical foundations, experimental methodologies, and practical applications of these techniques, contributing to the advancement of quantum information processing and technology.

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