

國立陽明交通大學應用數學系

演講公告

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講題：Geometry-Aware Iterative and Direct Methods for
Unitary Quantum Channel Reconstruction

時間：115 年 3 月 10 日(星期二) 下午 14:00 –15:00

地點：(光復校區) 科學一館 213 室

Abstract

Unitary quantum channels play a central role in modeling coherent quantum dynamics and quantum circuits. Reconstructing such channels from finite input–output data is inherently challenging, particularly in the presence of noise, and is closely related to nonconvex optimization on matrix manifolds.

In this work, we develop a unified geometry-aware framework for unitary quantum channel reconstruction by formulating the problem as a constrained optimization task on the Stiefel manifold. For noisy measurement data, we propose an iterative algorithm based on polar decomposition that embeds the unitary constraint directly into the update rule. We prove that the resulting sequence monotonically decreases the objective function and converges to a critical point on the manifold.

In the noise-free setting, we further introduce a direct reconstruction methodology. We show that the global minimizers of the objective function form an equivalence class of unitary matrices, differing only by a global phase factor, and establish conditions under which the underlying quantum channel can be recovered exactly. Leveraging spectral properties of non-degenerate quantum states, we derive a reconstruction procedure that significantly reduces the effective search dimension and requires only a minimal number of quantum observables.

Together, the proposed iterative and direct methods provide a theoretically rigorous and computationally efficient approach for approximating or exactly recovering unitary quantum channels from limited data.

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