QSUN
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S E M I N A R

Learning Quantum States and Unitaries of Bounded Gate Complexity

Matthias Caro (University of Warwick, UK)

Thursday, 5 December 2024 @ 14h00-15h00 SAST

Venues: Online and Physics Seminar Room, Stellenbosch University

ABSTRACT

While quantum state tomography is notoriously hard, most states hold little interest to practically minded tomographers. Given that states and unitaries appearing in nature are of bounded gate complexity, it is natural to ask if efficient learning becomes possible. In this work, we prove that to learn a state generated by a quantum circuit with G two-qubit gates to a small trace distance, a sample complexity scaling linearly in G is necessary and sufficient. We also prove that the optimal query complexity to learn a unitary generated by G gates to a small average-case error scales linearly in G. While sample-efficient learning can be achieved, we show that under reasonable cryptographic conjectures, the computational complexity for learning states and unitaries of gate complexity G must scale exponentially in G. We illustrate how these results establish fundamental limitations on the expressivity of quantum machine-learning models and provide new perspectives on no-free-lunch theorems in unitary learning. Together, our results answer how the complexity of learning quantum states and unitaries relate to the complexity of creating these states and unitaries.

BIOGRAPHY

Matthias C. Caro is an Assistant Professor at the Department of Computer Science of the University of Warwick. His research lies at the intersection of quantum computing and machine learning theory, contributing to a rigorous understanding of the potential and limitations of quantum machine learning. Before joining Warwick, he was a postdoctoral researcher at the Free University of Berlin and a postdoctoral visiting research fellow at the California Institute of Technology, funded by a fellowship of the German Academic Exchange Service. He completed his PhD, which was recognized with multiple awards, under the supervision of Michael M. Wolf at the Technical University of Munich, where he worked mainly on statistical properties of variational quantum machine learning models.

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