Structured and Adaptive Architectures for Quantum Machine Learning

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Variational Quantum Circuits (VQCs) are a promising model for near-term quantum machine learning, yet their scalability is often limited by high-dimensional inputs and unstable training dynamics. In this talk, I present a hybrid framework that integrates tensor network-based representation learning with adaptive quantum circuit architectures.

I first introduce our work on using Matrix Product States (MPS) as a learnable feature extraction and compression module for quantum models. In two complementary studies, we demonstrate that MPS-based representations can effectively reduce input dimensionality and improve training efficiency of VQCs, enabling robust performance in both classification tasks [1] and reinforcement learning settings [2].

Building on this foundation, I then discuss our recent efforts on adaptive and self-programming quantum learning systems [3][4], including learnable measurements [5] and dynamically generated quantum circuit parameters [6]. Rather than treating quantum circuits as static models, this approach allows their effective dimension and structure to be modulated by classical learning components.

Together, these results highlight a practical path toward scalable and robust quantum machine learning, where structured classical representations and adaptive quantum architectures jointly address the challenges of the NISQ era.

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