Temple University
College of Engineering

PhD Prelim Exam Presentation
Department of Electrical and Computer Engineering

1:00 PM – 2:00 PM, Friday, October 24, 2025
ECE Conference Room (ENGR 709B)

Quantum Correlations Enabling Quantum Advantage in Machine Learning

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Committee:

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Abstract:

This presentation investigates how quantum correlations — specifically entanglement and quantum discord — enable measurable quantum advantages in machine learning systems. It synthesizes findings from three research papers that together establish a theoretical and experimental foundation for understanding how different quantum correlation contribute to performance gains over classical machine learning methods.

The first study, “Entanglement-Induced Provable and Robust Quantum Learning Advantages,” demonstrates that quantum models using entanglement can achieve exponential speedups in sequence learning tasks. The work further proves that this advantage persists even under moderate quantum noise, revealing entanglement as a computational substitute for classical communication.

The second paper, “Reformulation of the No-Free-Lunch Theorem for Entangled Datasets,” introduces the concept of entangled datasets, showing that data entanglement can dramatically reduce the number of training samples needed for effective learning. By reformulating the Quantum No-Free-Lunch theorem, the authors prove that stronger quantum entanglement reduces the lower bound on generalization error. In essence, entanglement functions as a resource that increases data efficiency, redefining the relationship between dataset size and learnability. This theoretical insight implies that quantum systems could learn from far fewer examples than classical models.

The third study, “The Power of One Clean Qubit in Supervised Machine Learning,” explores the Deterministic Quantum Computing with One Qubit (DQC1) framework, where quantum discord — a weaker form of correlation than entanglement—plays a central role. The authors show that DQC1 can efficiently estimate complex kernel functions for supervised learning tasks using only a single pure qubit, while the rest of the system remains in a mixed state.

Collectively, these studies establish that quantum correlations as a resource for achieving quantum advantage in learning systems. Entanglement provides theoretical and computational breakthroughs by allowing quantum models to outperform classical architectures in complexity and efficiency. Quantum discord, though weaker, enables robust and scalable implementations under realistic noise conditions. Together, these findings bridge the gap between theoretical quantum learning advantages and their experimental realization, offering a roadmap for developing quantum-enhanced machine learning systems capable of outperforming their classical counterparts in speed, data efficiency, and noise resilience.

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