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Research Statement

Research Interest

My research interest is in developing quantum machine learning (QML) methods. QML merges quantum computing with machine learning principles, offering immense potential to revolutionize fields like drug discovery, materials science, and artificial intelligence. Classical machine learning techniques often struggle with complex problems, whereas QML could solve them more efficiently. As a computer science graduate, I possess a strong foundation in machine learning techniques, highly transferable to quantum applications. Furthermore, I am eager to explore quantum error correction, aiming for fault-tolerant quantum computing systems.

I am driven to develop algorithms for hybrid classical-quantum systems Specifically, I aim to seek answers to three key questions: *(1) How can hybrid quantum-classical algorithms be optimized for large-scale machine learning tasks? (2) How can Quantum Convolutional Neural Networks (QCNNs) be designed to surpass classical CNNs in image recognition? (3) Is reinforcement learning applicable to quantum error correction?*

I focus on exploring the design and optimization of hybrid algorithms that effectively distribute workloads between quantum and classical systems, particularly for large datasets or complex models. This research may involve developing new algorithms, analyzing trade-offs between quantum and classical processing, and testing these algorithms on real-world datasets. Additionally, I am interested in investigating the potential of QCNNs in image recognition, which includes designing quantum circuits that replicate classical CNN layers and testing their performance against classical CNNs regarding accuracy and resource efficiency. Furthermore, I aim to enhance quantum error correction strategies using reinforcement learning techniques, potentially bridging the gap between machine learning and error correction for robust quantum computing systems.

Research Accomplishments

During the Womanium Quantum + AI 2024 global summer program, I developed a hybrid Quanvolutional Neural Network (QCNN) model for anomaly detection in production. This experience illuminated both the challenges and rewards of developing quantum machine learning models, igniting my passion for research. My efforts led to a nomination for the Womanium Quantum Solution Launchpad (QSL) fellowship.

Previously, for my undergraduate thesis, I focused on brain tumor detection using deep learning models. My proposed CNN model and preprocessing technique outperformed state-of-the-art methods, culminating in a publication at the ICCIT 2023 conference (Rahman, Touhid Islam, Islam, Sohrawordi, & Sultan, 2023).

Current Research

Currently, my master's thesis focuses on MRI image denoising techniques. Specifically, I am working on "Mitigating Noise from MRI Images using Wavelet Denoising and Deep Learning Methods." My goal is to find the optimal threshold for wavelet transformation while developing a hybrid model that combines mathematical and deep learning methods for effective MRI image denoising.

In parallel, at the IoThink Research Lab, we are investigating healthy and diseased Guava (Psidium guajava), a fruit of significant agricultural importance in my country. Our research includes data collection and analysis as well as comparative studies to foster interdisciplinary collaboration.

Future Vision

Looking ahead, I plan to delve into quantum-enhanced kernel methods to improve machine learning models' generalization capabilities significantly. I also intend to investigate variational quantum algorithms (VQAs) for solving optimization problems in machine learning with an emphasis on scalability and noise resilience. By advancing these areas, I aim to contribute meaningfully to leveraging quantum computing for next-generation machine learning solutions.

References

Rahman, A. B., Touhid Islam, M., Islam, M. R., Sohrawordi, M., & Sultan, M. N. (2023). Enhanced brain tumor classification from mri images using deep learning model. In *2023 26th international conference on computer and information technology (iccit)* (p. 1-6). doi: 10.1109/ICCIT60459.2023.10441064