Research Statement

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Background

My primary research interest is in disruptive technology, especially in the finance industry. The two particular technologies I focus on are blockchain (also called distributed ledger technologies (DLT)), and quantum computing.

The use of blockchain and smart contracts continues to increase amongst corporations and governments and whilst first uses are being driven from the financial sector, any industry can benefit from its use.

In recent years, quantum computing has been emerging from being purely theoretical and quantum hardware is having increasingly larger capacity, higher quality and becoming more accessible. The properties of quantum computing are uniquely different than conventional computing and the potential for disruption is huge in many areas especially for solving non-deterministic problems which are common in finance.

While there are many applications of blockchain and quantum computing in many industries, I am researching the application of these technologies for finance in particular. Current work focusses on simulations of financial markets, optimization of trade settlement, quantum machine learning for credit rating and DLT consensus in collaboration with industry partners with externally funded projects.

Research Areas

Quantum Computing

My interest in quantum computing started in the late 1990's but now, with newly accessible quantum hardware it is possible to program quantum algorithms for real business problems. I have completed two research projects working with industry partners, TradeTeq and Oneconnect, to investigate potential quantum advantage for assessing credit risk in trade financing for SMEs [1] and for decentralised consensus mechanisms [2]. The quantum algorithms implement hybrid quantum/classical neural networks which, in theory, could deliver better neural network optimization for binary classification, as needed for credit ratings, in a shorter time. The results of this work have been published at Techinnovations conferences and published in a top journal – Nature Scientific Reports [3].

This year I continued with two 3 year projects, one with UOB and another with SGX using quantum Monte Carlo (QMC) and quantum optimisation respectively. These have begun to deliver interesting results to be published for QMC and in pre-print for optimization [4,5]. Furthermore, visualizing quantum states in qubits and the effect of quantum gate operations on qubits is difficult and I have been working with Prof.

Yong Wang on a number of papers that show improved visualization of quantum circuits [6] and for quantum neural networks [7]. These are all very exciting projects that work towards bring the enormous processing power of quantum computers to bear on useful use cases.

Blockchain

The use of Decentralized Ledger Technologies (DLTs) is underpinned by the consensus mechanism. Current consensus mechanisms have attributes that do not translate well to enterprise solutions such as privacy and performance. In particular, off-chain data sources, called oracles, and the interoperability between DLTs. I have been working on a project with an industry partner, OneConnect, to research solutions to these problems using quantum computing. The results of this have been published at an IEEE [1] and Techinnovations 2020 and 2021 conferences and presented at the Singapore Blockchain Association. Recently, there is an increase in interest in Web 3.0 and decentralised finance (DeFi) particularly associated with the growth of the Metaverse. While the current focus of DeFi is for public cryptocurrencies there is an interesting connection to central bank digital currencies (CBDCs) that the I am exploring with MAS and SKBI and other potential hybrid approaches.

Summary

Initial learnings from quantum computing work have been published as the first chapter in a book [7] as a framework for the application of quantum computing in business applications. The research for these projects is continuing and expanding as quantum computers continue to improve. The quantum algorithms for consensus, machine learning, optimization and modelling are expected to be applied to real industry issues of the funders using hybrid approaches in the near term. The various models are be explored for real industry data and on simulators and real quantum backends.

Selected Publications and Outputs

[1] P. Griffin and R. Sampat, "Quantum Computing for Supply Chain Finance," 2021 IEEE International Conference on Services Computing (SCC), 2021, pp. 456-459, doi: 10.1109/SCC53864.2021.00066. (Download at https://ink.library.smu.edu.sg/sis_research/6923/)
[2] Quantum consensus, by SEET, Jorden; GRIFFIN, Paul. (2020.0). 2019 IEEE Asia-Pacific Conference on Computer Science and Data Engineering (CSDE) 2019: December 9-11, Melbourne, Australia: Proceedings, (pp. 1-8) Piscataway, NJ: IEEE. https://doi.org/10.1109/CSDE48274.2019.9162386 (Published)
[3] N. Schetakis, D. Aghamalyan, P. Griffin, and M. Boguslavsky, “Review of some existing QML frameworks and novel hybrid classical–quantum neural networks realising binary classification for the noisy datasets,” Sci. Rep., vol. 12, no. 1, Art. no. 1, Jul. 2022, doi: 10.1038/s41598-022-14876-6.
[4] "Exponential Qubit Reduction in Optimization for Financial Transaction Settlement", Elias X. Huber, Benjamin Y. L. Tan, Paul R. Griffin, Dimitris G. Angelakis, https://arxiv.org/abs/2307.07193

[5] A quantum photonic chip for binary classification, by Lin, H. X.; Zhang, H.; Cai, H.; Griffin Paul; Liu, A. Q.(2023.0). CLEO: Conference on Lasers and Electro-Optics: Applications and Technology 2023: San Jose, CA,7-12 May: Proceedings, Washington, DC: Optica. https://opg.optica.org/abstract.cfm?uri=cleo_at-2023-JW2A.64 (Published)
[6] QuantumEyes: Towards Better Interpretability of Quantum Circuits.
Shaolun Ruan, Qiang Guan, Paul Griffin, Ying Mao and Yong Wang.
IEEE Transactions on Visualization and Computer Graphics. 2024. To Appear.
[7] VIOLET: Visual Analytics for Explainable Quantum Neural Networks, IEEE 17th Pacific Visualization Symposium (PVIS24) – conditional acceptance