Centre for Quantum Materials and Technologies

Ph.D. Project 2022-2025

Quantifying Energetic Resources in Quantum Machine Learning: A Comprehensive Analysis

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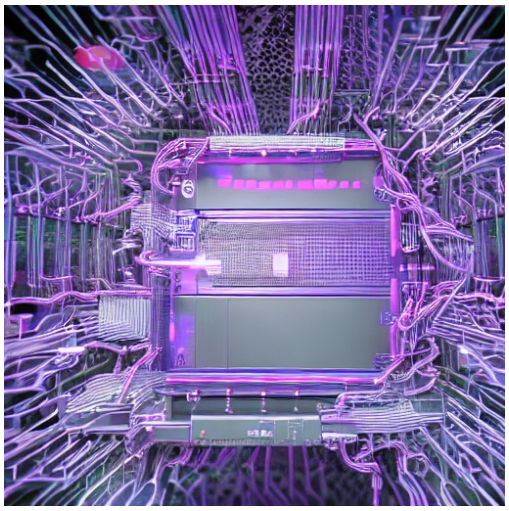
State of the art and objectives

Quantum Machine Learning (QML) represents a cutting-edge intersection of quantum computing and machine learning, promising unprecedented computational capabilities. As the field advances, understanding and quantifying the energetic resources associated with QML becomes a pivotal aspect of its feasibility and sustainability. This project aims to conduct a comprehensive analysis of the energetic requirements of QML, encompassing quantum hardware and algorithms.



Quantifying energetic resources in QML is an intricate undertaking that requires a multidimensional approach. As QML progresses from a theoretical concept to practical applications, understanding and optimising its energy efficiency are essential for realising its potential impact on the future of computational technology.

Quantum Hardware Energy Consumption:
The quantum hardware forms the bedrock of QML, demanding specialised conditions for its operation. The cooling systems required to maintain temperatures near absolute zero contribute significantly to the overall energy footprint. Moreover, the energy consumption associated with qubit manipulation, entanglement generation, and other quantum operations is a critical metric. Quantifying the energy consumed per quantum gate operation provides insights into the efficiency of the quantum processor.

Algorithmic Energy Requirements:
The energy requirements of quantum algorithms constitute a key aspect of the overall energetic resources of QML. The complexity and depth of quantum circuits, along with the number of qubits necessary for specific tasks, directly impact the energy consumption during algorithmic execution. Assessing the energy costs of running quantum algorithms is essential for understanding their practical viability.

Required skills
A good knowledge of quantum theory is necessary. The candidate should be familiar with at least a programming language and basic numerical techniques. Ideally the candidate is familiar with quantum information concepts including the basics of quantum computing.

Further information
For further information, please contact me, g.dechiara@qub.ac.uk.

References

[1] Jacob Biamonte et al.: Quantum Machine Learning
Nature, **505**, 2014, pp. 217-219.
https://doi.org/10.1038/nature23474.

[2] John Preskill: Quantum Computing in the NISQ era and beyond.
Quantum, **2**, 2018, Article ID 79
https://doi.org/10.22331/q-2018-08-06-79.

[3] Alexia Auffèves: Quantum Technologies Need a Quantum Energy Initiative
PRX Quantum, **3**, 2022, pp. 020101.
https://journals.aps.org/prxquantum/abstract/10.1103/PRXQuantum.3.020101.