How quantum computing practically improve real life machine learning now and in the near future?

An exploration of how near term quantum computing can practically be used for machine learning applications

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Abstract

Quantum Computing has grown in leaps and bounds in the last 5-10 years. Machine learning (ML) is a field where large data-sets and massively parallel computing architectures have allowed for similar rapid improvements. We propose the use of current and near term quantum computing as viable technology for boosting existing classical ML algorithms. The exponential nature of super-positioned qubits can be leveraged to conduct fast state space searches for either better initial weights or more efficient learning parameters for a machine learning model. We suspect that while the development of quantum machine learning techniques has been an incredible area of active research, quantum computing hardware has not yet reached the capability to run anything more realistic than the simplest proof-of-concept type examples, due to limitations in memory, qubit capacity and coherence time. Leveraging this exponential speed-up of a quantum computer for a state-space search to select either initial weights or model parameters combined with traditional training of the resultant model on large data sets may yield better or faster learning while being feasible to implement now or in the very near future. This avenue is suggested as a more actionable, in the near term, approach to improving ML via quantum computing while quantum architectures are still ill equipped to deal with large data sets. Good results have been achieved with quantum computing on combinatorial optimisation problems, in particular with applying quantum genetic algorithms, so it seems promising to reframe model parameter selection or weight initialisation as a quantum combinatorial optimisation problem and then execute a classical training-on-data algorithm on classical computing architectures. Thjis approach seems more likely to yield practical speed-ups or improvements in the ML sphere than simply continuing to develope theoretical quantum ML techniques that can't as yet be run on real data.

Introduction

The Present and Future of Quantum Computing Hardware

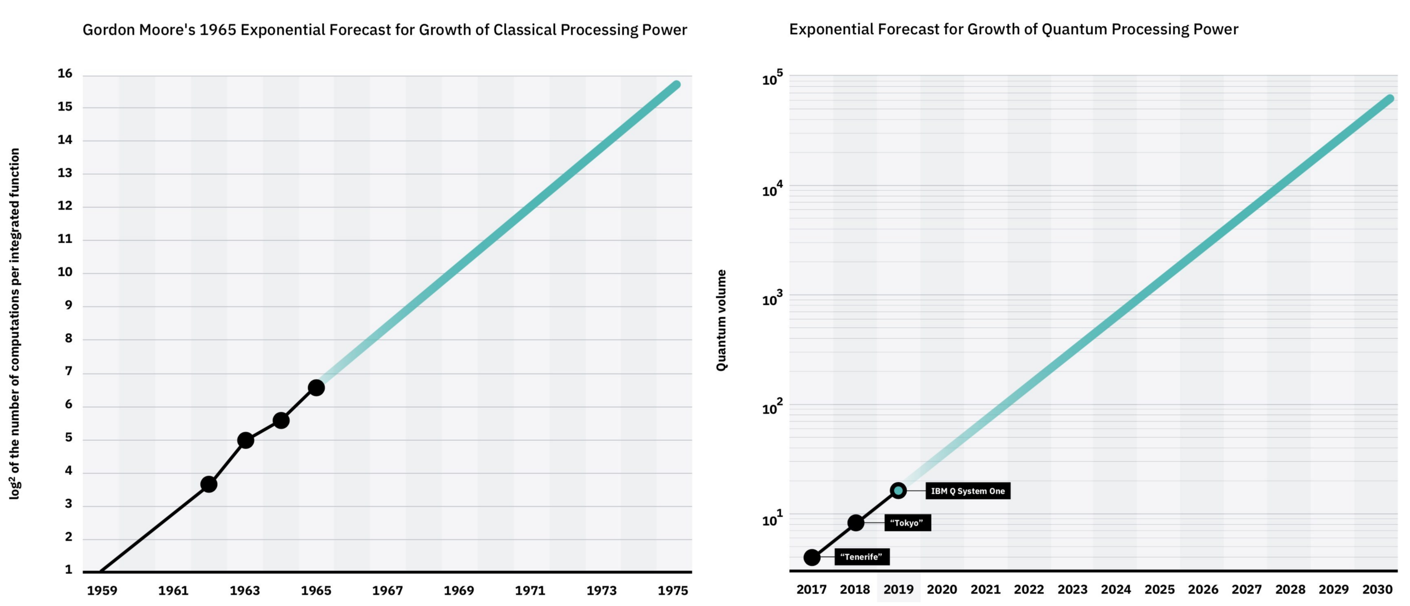

Figure 1: Moores's Law for classical architectures vs IBM's goal for Quantum Volume

The State of Quantum Computing Optimisation Algorithms

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2. Nullam at mi nisl. Vestibulum est purus, ultricies cursus volutpat sit amet, vestibulum eu.
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The Problems and Drawbacks of Quantum ML

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Vestibulum ac diam a odio tempus congue. Vivamus id enim nisi:

$$\begin{aligned}\cos\bar{\phi}_k Q_{j,k+1,t} + Q_{j,k+1,x} + \frac{\sin^2\bar{\phi}_k}{T\cos\bar{\phi}_k} Q_{j,k+1} = \\ -\cos\phi_k Q_{j,k,t} + Q_{j,k,x} - \frac{\sin^2\phi_k}{T\cos\phi_k} Q_{j,k}\end{aligned} \tag{2}$$

and

$$\begin{aligned}\cos\bar{\phi}_j Q_{j+1,k,t} + Q_{j+1,k,y} + \frac{\sin^2\bar{\phi}_j}{T\cos\bar{\phi}_j} Q_{j+1,k} = \\ -\cos\phi_j Q_{j,k,t} + Q_{j,k,y} - \frac{\sin^2\phi_j}{T\cos\phi_j} Q_{j,k}.\end{aligned} \tag{3}$$

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Quantum Computing for Initialisation

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Treatments	Response 1	Response 2
Treatment 1	0.0003262	0.562
Treatment 2	0.0015681	0.910
Treatment 3	0.0009271	0.296

Table 1: Table caption

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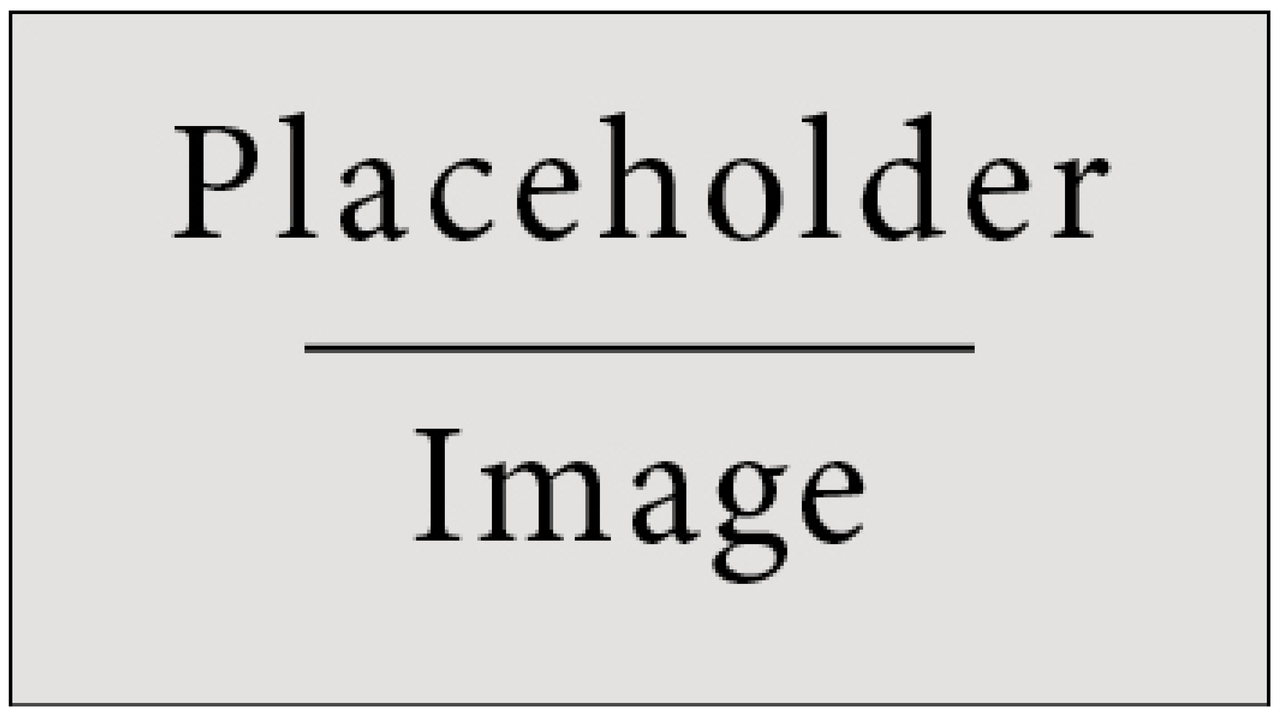

Figure 2: Figure caption

Quantum computing for Parameter Selection

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Conclusions

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Further Research

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References

[1] A. B. Jones and J. M. Smith. Article Title. *Journal title*, 13(52):123–456, March 2013.
[2] J. M. Smith and A. B. Jones. *Book Title*. Publisher, 7th edition, 2012.

Acknowledgements

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