How can Quantum Computing improve practical Machine Learning today?

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

Tau Merand† **& David Merand**‡

†School of Computer Science and Applied Mathematics, University of the Witwatersrand
†Academic Development Unit, Faculty of Engineering and Built Environment, University of the Witwatersrand
tau.taylor.merand@gmail.com david.merand@wits.ac.za

Abstract

Quantum Computing (QC) has grown in leaps and bounds in the last 5-10 years; both in hardware and software . 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 QC as viable technology for boosting existing classical ML algorithms. The exponential nature of super-positioned qubits can be leveraged to perform classically hard optimisations efficiently, however many existing difficulties in QC hardware are not clearly tractable. Therefore while the development of Quantum ML (QML) 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. We suggest that more actionable improvements may be made in ML by focusing on leveraging QC on smaller, tangential optimisation problems to the actual learning rather than solely trying to learn or implement learning algorithms on a QC. We suspect that using QC to either select effective model meta-learning parameters or to select useful initial values 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. Hopefully this will be a more immediately actionable approach to improving existing ML on practical problems. Good results have been achieved by QC on combinatorial optimisation problems so it seems promising to reframe meta-learning parameter or initial value selection as a in this way and then execute a classical training-on-data gradient descent type algorithm on classical computing architectures. This approach seems likely to yield practical speed-ups or improvements in the ML sphere while QC hardware is still ill equipped to deal with real data sets.

Introduction

The Present and Future of Quantum Computing Hardware

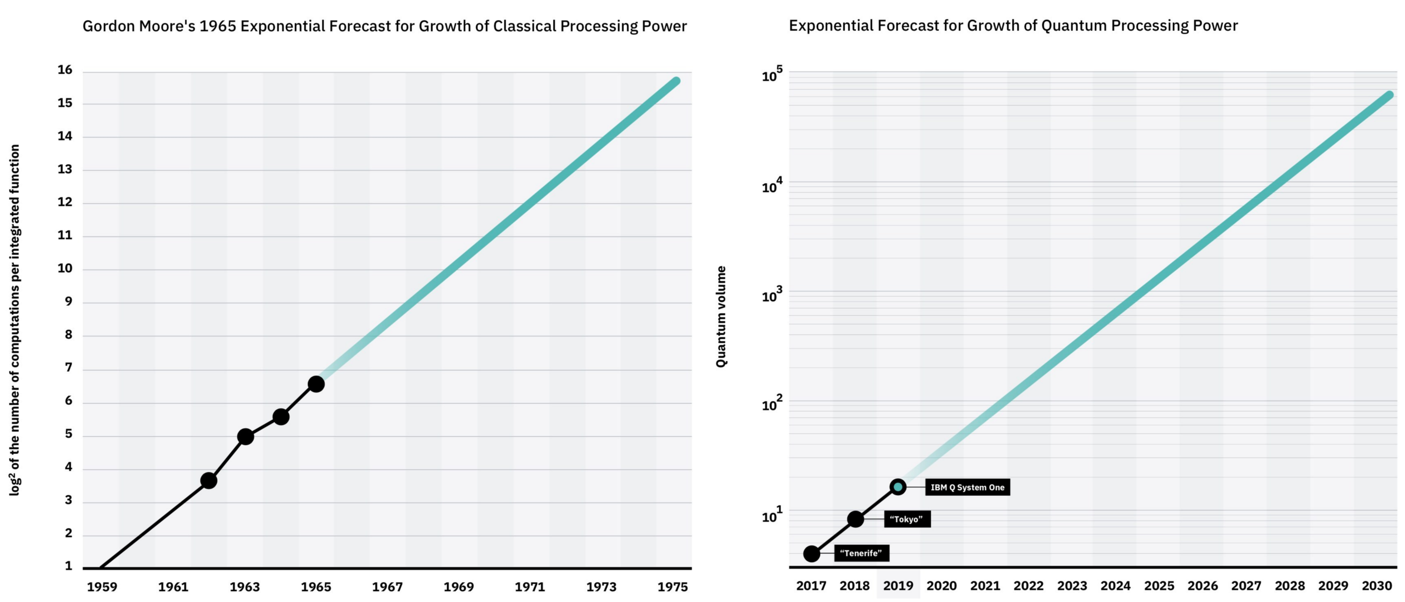

Figure 1: Moores's Law for classical architectures vs IBM's goal for Quantum Volume

The State of Quantum Computing Optimisation Algorithms

The Problems and Drawbacks of Quantum ML

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$$E = mc^2 \tag{1}$$

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

and

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

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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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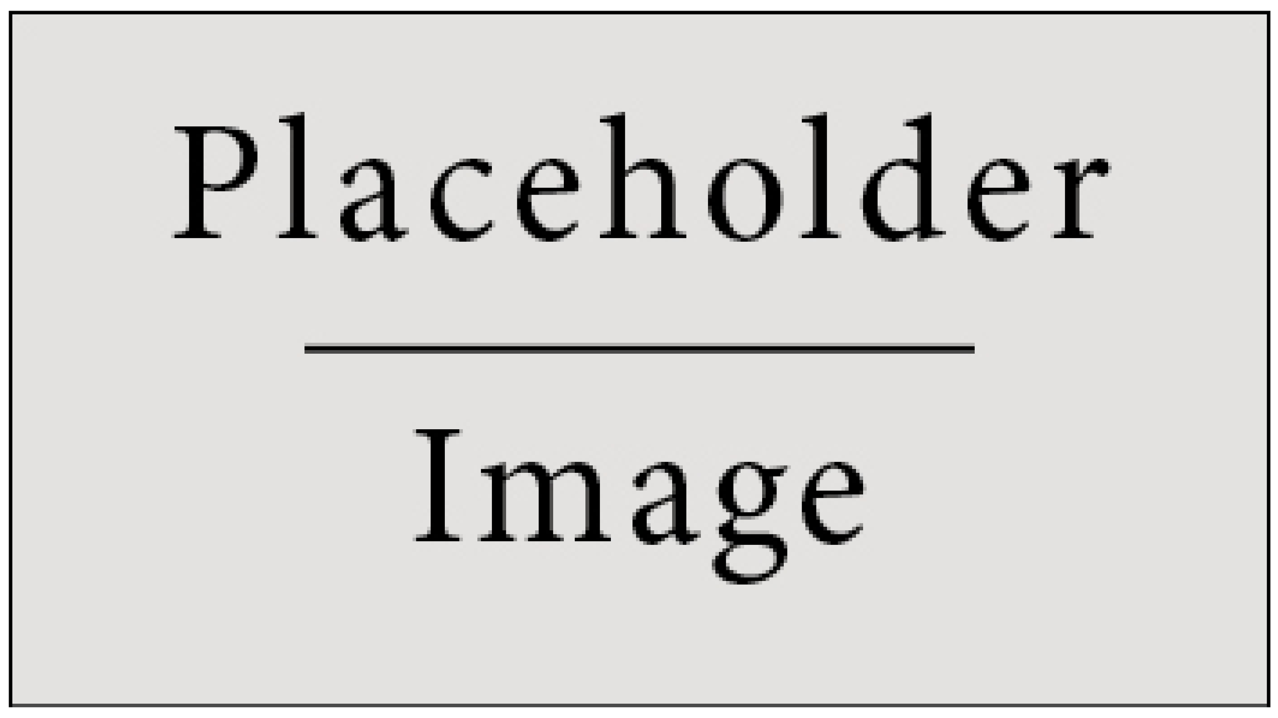

Figure 2: Figure caption

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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