

Can quantum computing improve practical machine learning in the near future?

An exploration of how nascent quantum computing could 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 is a field where large data-sets and massively parallel computing architectures have allowed for similar rapid improvements. We propose the use of quantum computing for state space search based selection of initial weights or parameters for a machine learning model before training on classical architectures. This avenue of research may yield actionable results in the near future as opposed to waiting, the possibly many years, for quantum computers to have the ability to run effective machine learning algorithms. We propose that while the development of quantum machine learning techniques has been an incredible area of active research, quantum computing hardware has not yet reached and will probably not reach in the near future the capability to run anything more realistic than the simplest proof-of-concept type examples. Leveraging the exponential speedup of a quantum computer for state-space search to select either initial weights or model parameters combined with traditional training on data may yield better or faster learning while being feasible in the very near future.

Introduction

The State of Quantum Computing Algorithms

1. Lorem ipsum dolor sit amet, consectetur.
2. Nullam at mi nisl. Vestibulum est purus, ultricies cursus volutpat sit amet, vestibulum eu.
3. Praesent tortor libero, vulputate quis elementum a, iaculis.
4. Phasellus a quam mauris, non varius mauris. Fusce tristique, enim tempor varius porta, elit purus commodo velit, pretium mattis ligula nisl nec ante.
5. Ut adipiscing accumsan sapien, sit amet pretium.
6. Estibulum est purus, ultricies cursus volutpat
7. Nullam at mi nisl. Vestibulum est purus, ultricies cursus volutpat sit amet, vestibulum eu.
8. Praesent tortor libero, vulputate quis elementum a, iaculis.

The Present and Future of Quantum Computing Hardware

Fusce magna risus, molestie ut porttitor in, consectetur sed mi. Vestibulum ante ipsum primis in faucibus orci luctus et ultrices posuere cubilia Curae; Pellentesque consectetur blandit pellentesque. Sed odio justo, viverra nec porttitor vel, lacinia a nunc. Suspendisse pulvinar euismod arcu, sit amet accumsan enim fermentum quis. In id mauris ut dui feugiat egestas. Vestibulum ac turpis lacinia nisl commodo sagittis eget sit amet sapien.

Problems and Drawbacks of Quantum ML

Nulla vel nisl sed mauris auctor mollis non sed.

$$E = mc^2 \quad (1)$$

Curabitur mi sem, pulvinar quis aliquam rutrum. (1) edf (2), $\Omega = [-1, 1]^3$, maecenas leo est, ornare at. $z = -1$ edf $z = 1$ sed interdum felis dapibus sem. x set y ytruem. Turpis j amet accumsan enim y -lacina; ref k -viverra nec porttitor x -lacina.

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

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

and

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

Nulla sed arcu arcu. Duis et ante gravida orci venenatis tincidunt. Fusce vitae lacinia metus. Pellentesque habitant morbi. $A \underline{\xi} = \underline{\beta}$ Vim $\underline{\xi}$ enum nidi $3(P+2)^2$ lacina. Id feugain A nun quis; magno.

Quantum Computing for Initialisation

Donec faucibus purus at tortor egestas eu fermentum dolor facilisis. Maecenas tempor dui eu neque fringilla rutrum. Mauris lobortis nisl accumsan. Aenean vitae risus ante.

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

Nulla ut porttitor enim. Suspendisse venenatis dui eget eros gravida tempor. Mauris feugiat elit et augue placerat ultrices. Morbi accumsan enim nec tortor consectetur non commodo. Pellentesque condimentum dui. Etiam sagittis purus non tellus tempor volutpat. Donec et dui non massa tristique adipiscing. Quisque vestibulum eros eu. Phasellus imperdiet, tortor vitae congue bibendum, felis enim sagittis lorem, et volutpat ante orci sagittis mi. Morbi rutrum laoreet semper. Morbi accumsan enim nec tortor consectetur non commodo nisi sollicitudin.

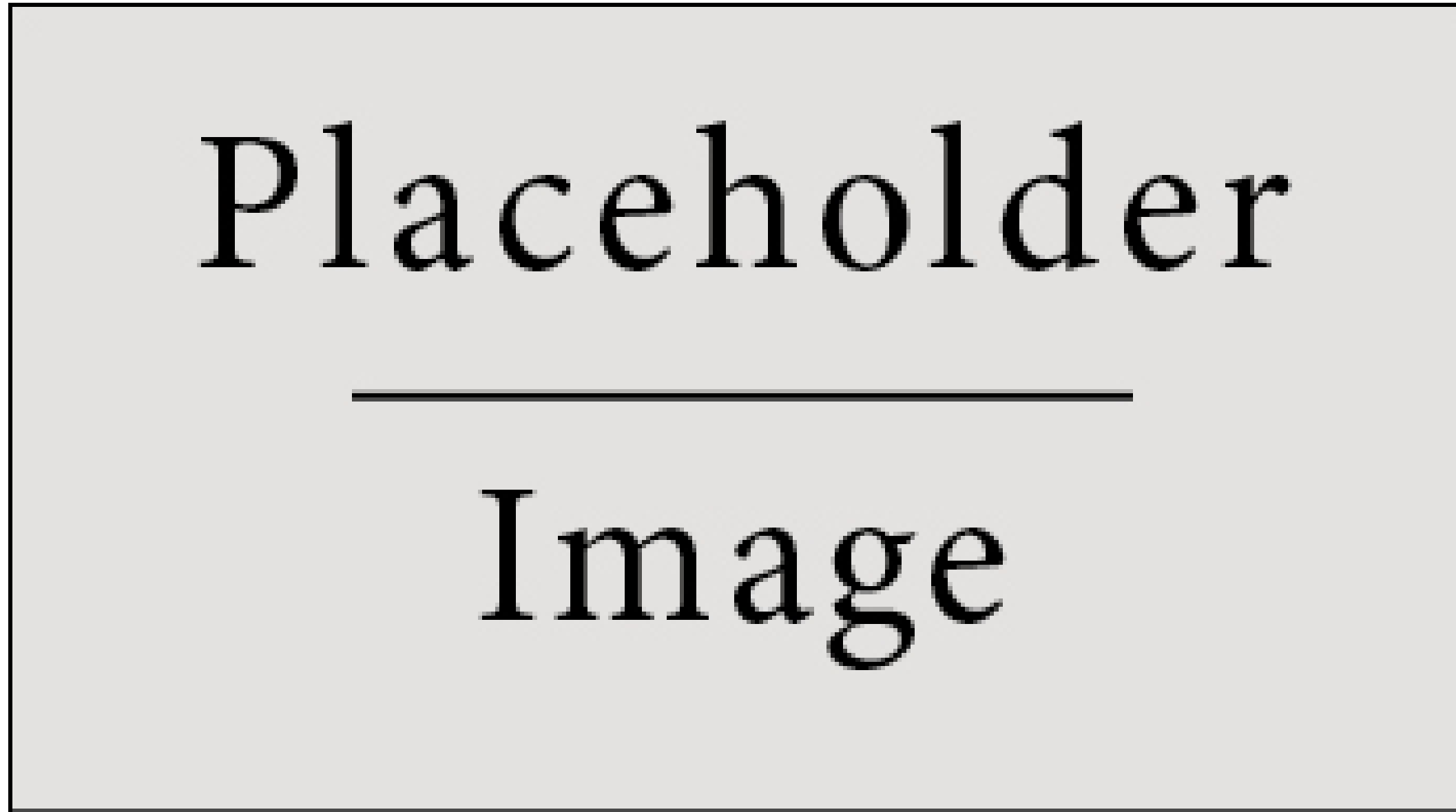


Figure 1: Figure caption

In hac habitasse platea dictumst. Etiam placerat, risus ac. Adipiscing lectus in magna blandit:

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

Table 2: Table caption

Vivamus sed nibh ac metus tristique tristique a vitae ante. Sed lobortis mi ut arcu fringilla et adipiscing ligula rutrum. Aenean turpis velit, placerat eget tincidunt nec, ornare in nisl. In placerat.



Figure 2: Figure caption

Quantum computing for Meta-learning

Aliquam non lacus dolor, a aliquam quam [2]. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Nulla in nibh mauris. Donec vel ligula nisi, a lacinia arcu. Sed mi dui, malesuada vel consectetur et, egestas porta nisi. Sed eleifend pharetra dolor, et dapibus est vulputate eu. Integer faucibus elementum felis vitae fringilla. In hac habitasse platea dictumst. Duis tristique rutrum nisl, nec vulputate elit porta ut. Donec sodales sollicitudin turpis sed convallis. Etiam mauris ligula, blandit adipiscing condimentum eu, dapibus pellentesque risus.

Aliquam auctor, metus id ultrices porta, risus enim cursus sapien, quis iaculis sapien tortor sed odio. Mauris ante orci, euismod vitae tincidunt eu, porta ut neque. Aenean sapien est, viverra vel lacinia nec, venenatis eu nulla. Maecenas ut nunc nibh, et tempus libero. Aenean vitae risus ante. Pellentesque condimentum dui. Etiam sagittis purus non tellus tempor volutpat. Donec et dui non massa tristique adipiscing.

Conclusions

- Pellentesque eget orci eros. Fusce ultricies, tellus et pellentesque fringilla, ante massa luctus libero, quis tristique purus urna nec nibh. Phasellus fermentum rutrum elementum. Nam quis justo lectus.
- Vestibulum sem ante, hendrerit a gravida ac, blandit quis magna.
- Donec sem metus, facilisis at condimentum eget, vehicula ut massa. Morbi consequat, diam sed convallis tincidunt, arcu nunc.
- Nunc at convallis urna. isus ante. Pellentesque condimentum dui. Etiam sagittis purus non tellus tempor volutpat. Donec et dui non massa tristique adipiscing.

Further Research

Vivamus molestie, risus tempor vehicula mattis, libero arcu volutpat purus, sed blandit sem nibh eget turpis. Maecenas rutrum dui blandit lorem vulputate gravida. Praesent venenatis mi vel lorem tempor at varius diam sagittis. Nam eu leo id turpis interdum luctus a sed augue. Nam tellus.

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

Etiam fermentum, arcu ut gravida fringilla, dolor arcu laoreet justo, ut imperdiet urna arcu a arcu. Donec nec ante a dui tempus consectetur. Cras nisi turpis, dapibus sit amet mattis sed, laoreet.