Topic: Building Faster Quantum Algorithms for Machine Learning (ML) in 2022

Short Term Goal: Demonstrate higher speedup than existing (i.e. proven) methods
Long Term Goal: Run classic ML routines completely on existing hardware

Problem Description

Deep learning algorithms show best results when trained on sufficiently large (TBs) data. One may also get good results on smaller amounts of data, using augmentation etc., although by cutting some corners. Faith on your trained algorithm is of essence in safety-critical tasks e.g. medical analysis, autonomous vehicles (AV), nuclear physics, and so on. Some AV companies are known to train their autopilot AI on PBs of data, generated over more than 10 years and counting. This comes at the cost of hardware and energy for running massive computations.

Even if we can reduce computations by small amount, it will be a big boost for such tasks, not to mention reducing environmental footprints. Google [1] has already come up with deep neural network algorithm, ready to train on a quantum computer, whenever suitable hardware becomes available. Looking at recent breakthroughs in general AI [2], we can be even more optimistic about getting more out of quantum computers. Other works have shown quantum advantage in certain areas. Quantum algorithm HHL [3] was proposed for solving linear systems, which are at the basis of many technologies, including ML. This algorithm has shown exponential speedup in SVM, PCA and discriminant analysis. Researchers have already succeeded in implementing single-layer neural network on a quantum computer [4].

Test Instances

As different hardware suits different algorithms, it will be necessary to give an initial try to every existing hardware. However, ultimately one has to be chosen for conducting reproducible trials.

Classical Methods

Classical computing methods are inching closer to stagnation, in fact, increasing cloud storage capability (providers include Google, AWS, etc.) is what has been holding Moore's Law. This problem is still seeking solutions. Quantum computing may become an alternative, if we can introduce specific algorithms which work on near term quantum hardware.

References

[1] Farhi, E. and Neven, H., 2018. Classification with quantum neural networks on near term processors. *arXiv preprint arXiv:1802.06002*.

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[3] Harrow, A.W., Hassidim, A. and Lloyd, S., 2009. Quantum algorithm for linear systems of equations. *Physical review letters*, *103*(15), p.150502.

[4] Tacchino, F., Macchiavello, C., Gerace, D. and Bajoni, D., 2019. An artificial neuron implemented on an actual quantum processor. *npj Quantum Information*, *5*(1), pp.1-8.