Project Report

1 Gradient calculation

Last week I mainly did some calculation with Mathematica to see whether the two methods in VQS can provide the same gradient at the same point. Since for a general Hermite Hamiltonian H and a general unitary operator U of dimension n, the result of the gradient in the two methods are very complex to compare, I chose another method, that is to just do some checking work of some examples with qubit number up to 4. Fortunately, the two gradients are all the same in all the checking works.

1.1 Discussion

- Since they give the same result at each point, Q's VQS is more complex not only from quantum simulation aspect but also classical matrix computation, therefore we need to consider where its advantage is.
- Either VQS or VQE needs to a variational ansatz. But VQE needs much resource to optimize the parameters on a classical computer, Differently, VQS needs a lot of measurements to determine the gradient direction. Then we should to find out that which is more hard.

  The assumption is that they maybe belong to the same complexity class, because whether to direct measure the gradient or optimization may booth use the gradient-based method.

2 Paper reading

2.1 Accelerated VQE [1]

There are two main algorithms to compute the eigenvalue of a specific Hamiltonian, phase estimation and VQE.

- The PEA uses measurement number $N = O(1)$ and circuit depth $D = O(1/\epsilon)$ to get the eigenvalue with precision ϵ
- The VQE uses measurement number $N = O(1/\epsilon^2)$ and circuit depth $D = O(1)$ to get the eigenvalue with precision ϵ, (though it needs an extra optimization procedure, it overcomes the difficulty in long coherent in PEA)

The paper provides a modified accelerated VQE which reduced the measurement numbers N. That is to replace the expectation value estimation subroutine by the a-PEA.

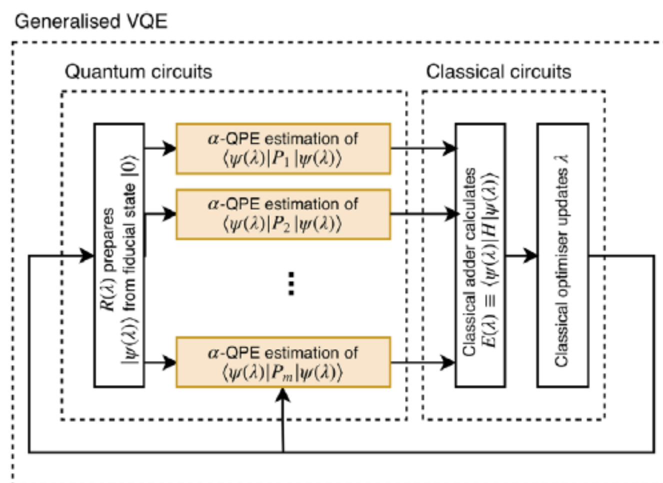

Figure 1: Scheme foe accelerated VQE

References

[1] D. Wang, O. Higgott, and S. Brierley. Accelerated variational quantum eigensolver. *Physical review letters*, 122(14):140504, 2019.