An efficient quantum algorithm for the time evolution of parameterized circuits

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Abstract

In this oral presentation I will introduce a novel hybrid algorithm to simulate the real-time evolution of quantum systems using parameterized quantum circuits.
The method, named "projected - Variational Quantum Dynamics" (p-VQD)[1] realizes an iterative, global projection of the exact time evolution onto the parameterized manifold (see Fig 1). In the small time step limit, this is equivalent to the McLachlan's variational principle [2]. The approach is efficient in the sense that it exhibits an optimal linear scaling with the total number of variational parameters. Furthermore, it is global in the sense that it uses the variational principle to optimize all parameters at once. The global nature of the approach then significantly extends the scope of existing efficient variational methods, that instead typically rely on the iterative optimisation of a restricted subset of variational parameters [3]. I will show through numerical experiments (see Fig 2) that the new approach is particularly advantageous over existing global optimisation algorithms based on the time-dependent variational principle that, due to a demanding quadratic scaling with parameter numbers, are unsuitable for large parameterized quantum circuits [4].
In the end, I will also discuss more recent findings that extend the results of the original paper [1].

References

[1] Barison S. & Vicentini F. & Carleo G., Quantum 5 (2021) 512
[2] McLachlan, A., Molecular Physics 8, (1964) 39–44
[3] Benedetti, M., Fiorentini, M. & Lubasch, M. Phys. Rev. Research, 3 (2021)
[4] Li, Y. & Benjamin, S. C., Phys. Rev. X, 7 (2017)

Figures

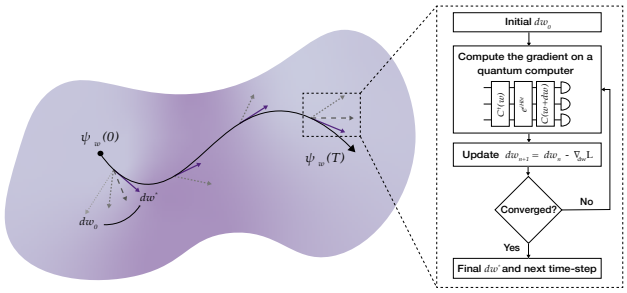

Figure 1: Sketch of the p-VQD algorithm. We follow the real time evolution of the ansatz state in the Hilbert space by optimizing the parameter variation at every time step. The optimization is performed through the gradient of the step-infidelity function L , computed using a quantum computer

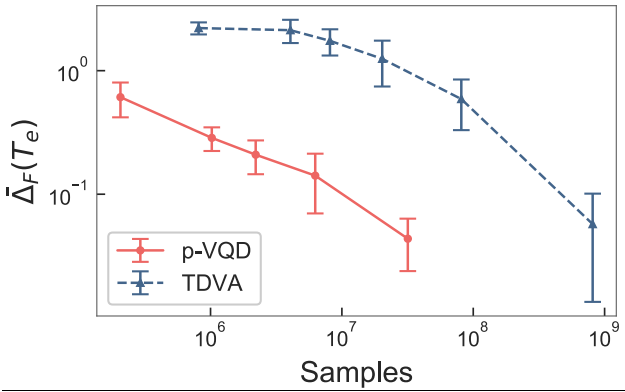

Figure 2: Mean error on fidelity accumulated over an entire time evolution for the two different methods. The plot shows, as a function of the total samples required, the fidelity error accumulated by the algorithm over an entire time evolution. TDVA refers to the method presented in [4].