Translational AI Center (TrAC) Seminar
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Physical location: 2206 Student Innovation Center

Zoom: https://iastate.zoom.us/j/92178103551?pwd=dlNCa2l0ckVBTEVyR1JEN2Y3b21XQT09

Using ML techniques within Variational Quantum Eigensolver Algorithms

Abstract

Quantum computation is tantalizingly poised to be the computing technology of the future. Unlike a classical bit on a classical computer, a qubit exists in superposition simultaneously in both the 0 and the 1 state. This allows for exploiting the so-called quantum parallelism for certain important problems, e.g. factoring. However, the current generation of quantum devices only allow for noisy-intermediate-scale-quantum computation (NISQ) and have at most ≈ 100 qubits. Thus, there is a real need to come up with algorithms that leverage quantum parallelism while still being able to operate in the NISQ regime. In this scenario, variational quantum algorithms have played a key role thus far.

In this talk, we shall present an overview of the Variational Quantum Eigensolver (VQE) algorithm. Quantum mechanics postulates that the state of these elementary particles can be specified by a wave function that evolves under the Hamiltonian of the corresponding system. The states are classified into different types and the ground state corresponds to the lowest energy state of the system. Finding the ground state is often a critical calculation that needs to be performed by quantum chemists. Classically, this is essentially computationally intractable. For a n-qubit system, finding the ground state corresponds to finding the eigenvector corresponding to the minimum eigenvalue of a Hamiltonian which is a $2^n \times 2^n$ Hermitian matrix $\boldsymbol{H}$. Thus, even when $n \approx 30$, this can be a very costly calculation on a classical computer.

A quantum computer allows the calculation of a quadratic form $x' \boldsymbol{H} x$ as a unit-complexity operatiom. Thus, one can in principle determine the ground state if one can find the minimizer of this function over x. The Variational Quantum Eigensolver (VQE) algorithm is a hybrid classical-quantum method to do this in a tractable manner. In this talk we will overview the VQE algorithm and overview challenges that arise in this domain and discuss our recent work on using ML methods to improve certain classes of VQE methods.

Short Bio

Aditya Ramamoorthy is the Northrop Grumman Professor of Electrical and Computer Engineering and (by courtesy) of Mathematics at Iowa State University. He received his B. Tech. degree in Electrical Engineering from the Indian Institute of Technology, Delhi and the M.S. and Ph.D. degrees from the University of California, Los Angeles (UCLA). His research interests are in the areas of classical/quantum information theory and coding techniques with applications to distributed computation, content distribution networks and machine learning.

Dr. Ramamoorthy currently serves as an editor for the IEEE Transactions on Information Theory (and served a previous term from 2016 — 2019) and the IEEE Transactions on Communications from 2011 — 2015. He is the recipient of the 2020 Mid-Career Achievement in Research Award, the 2019 Boast-Nilsson Educational Impact Award, and the 2012 Early Career Engineering Faculty Research Award from Iowa State University, the 2012 NSF CAREER award, and the Harpole-Pentair professorship in 2009 and 2010. He is a senior member of the IEEE.