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METHODS FOR ACCELERATING GEOSPATIAL DATA PROCESSING USING ADIABATIC AND UNIVERSAL QUANTUM COMPUTERS

Abstract

Quantum computing is a transformative technology with the potential to enhance operations in the space industry through the acceleration of optimization and machine learning processes. Optimization processes enable effective scheduling of satellite constellations. Machine learning processes enable automated image classification in geospatial data. New quantum algorithms able to be executed on a quantum computer provide new approaches for these problems, and a potential future advantage over current, classical techniques.

Two quantum computational models are being developed for implementation in hardware: Adiabatic Quantum Optimization and Universal Quantum Computation. Adiabatic Quantum Optimization is a technique that uses quantum properties to rapidly solve an Ising model optimization problem. Such problems can be executed on early-stage quantum hardware including the NASA D-Wave 2000Q. Universal Quantum Computation enables fully general quantum algorithms to be executed, with theoretically proven speed-up over classical algorithms in certain cases. Universal quantum computers are currently being developed by technology leaders including Google, IBM and Rigetti Computing.

This paper describes an approach to satellite tasking using either Adiabatic Quantum Optimization or a universal quantum algorithm known as the Quantum Approximate Optimization Algorithm, and contrasts the benefits of each. This paper also describes an approach to image classification in geospatial data using either the Quantum Boltzmann Machine or a compressed machine learning representation generated by a Quantum Variational Autoencoder, and discusses sensitivities to the finite temperature behavior of quantum computers when used as samplers. Preliminary results from current generation quantum computing hardware is included, as well as a summary roadmap for the space industry to take advantage of this emerging technology for its computationally challenging problems.