Advancing of Earth Observation Methodologies by using a Quantum Computer

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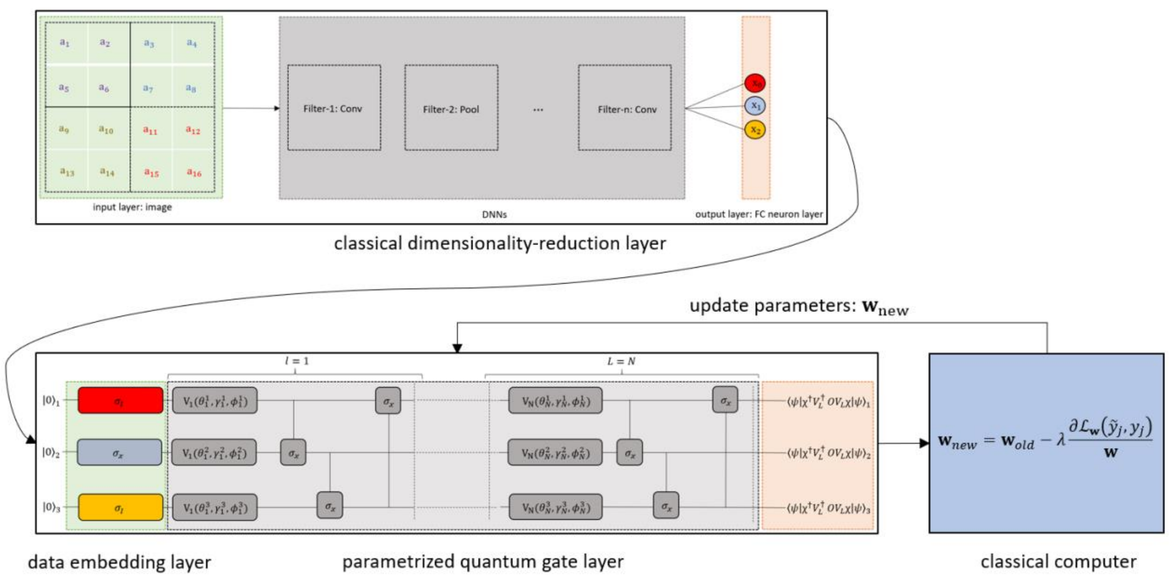
Abstract

Remotely-sensed images obtained from aircraft and satellite platforms are used for Earth observation tasks. The remotely-sensed images are available in digital format and contain information on the number of spectral bands, radiometric resolution, and spatial resolution. We performed the first exploratory studies for applying quantum computers to remotely-sensed images and problems. Parametrized quantum circuits solve optimization problems and can be utilized as a learning model exploiting different mechanisms and techniques of quantum physics. As a case example, we present therefore the result that parametrized quantum circuits are very competitive in contrast with its classical neural networks.

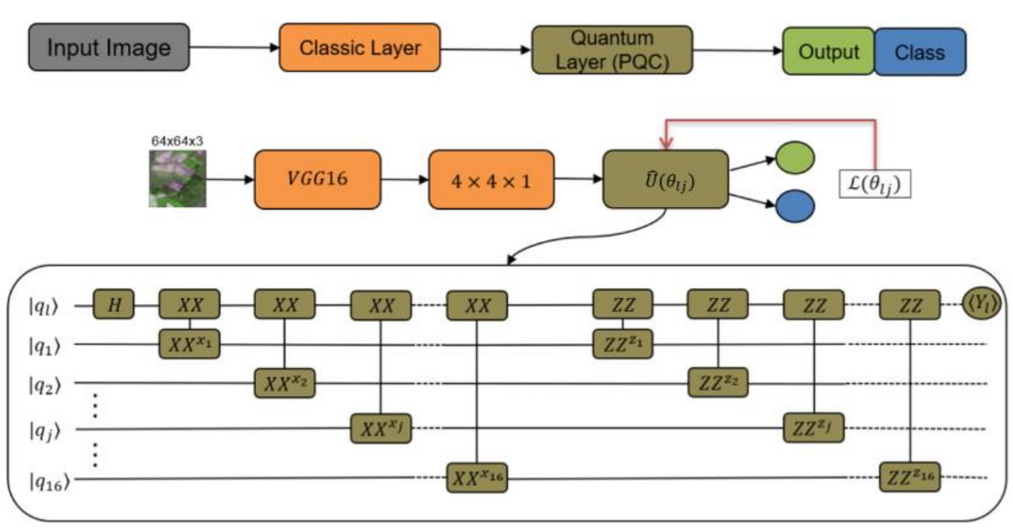
A parametrized quantum circuit with real-world applications in remote sensing

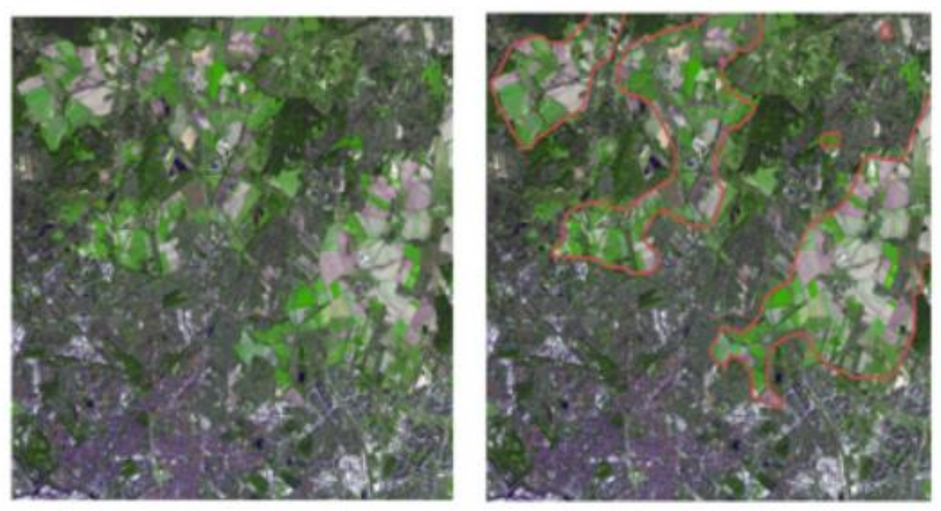
Gate-based Quantum Computer

1. Currently available gate-based quantum computers are small quantum computers with around 20 noisy qubits (publicly accessible).
2. Parametrized quantum circuits can be used as a classical neural network.
3. It might prove relevant for Machine Learning tasks even if no quantum advantage is intended.

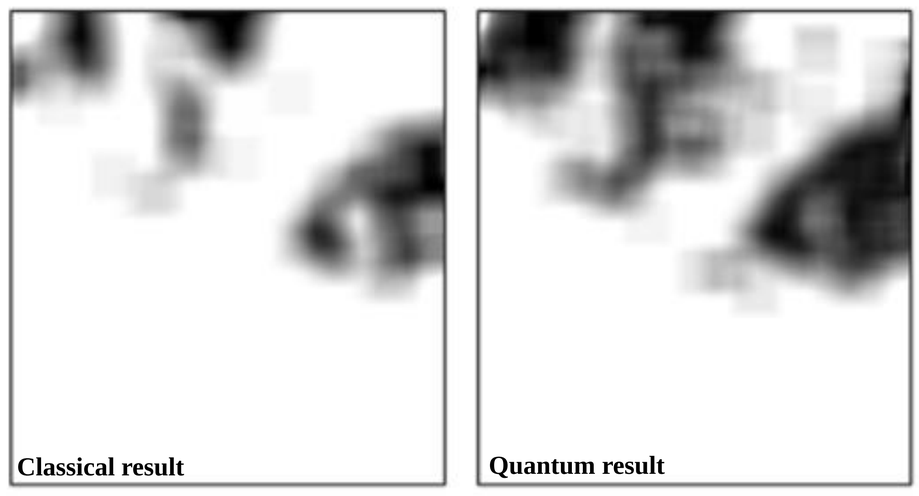


This kind of a learning network is called a hybrid quantum-classical network: 1) The classical layer (classical dimensionality-reduction layer) extracts the informative features of data such that available qubits are satisfied, and it encodes informative features in those qubits (data embedding layer), 2) A parametrized gate layer (parametrized quantum circuit) is utilized in the role of a classical deep leaning network, and 3) A classical computer is employed for optimizing the loss function and then updates the parameters of the parametrized gate layer.





This test image of Berlin, Germany is not a part of our benchmark dataset (EuroSAT). In particular, this test image is a real-world RGB image. Our task is to identify an area contoured by *red* lines after training a hybrid quantum-classical network on the EuroSAT dataset: The inside of this red lines is an Annual Crop class, and the outside of this red line is a Residential Area class.



The test results of the classical deep Learning network VGG16 (Bottom Left) and the hybrid quantum-classical network (Bottom Right) are shown for classification of Berlin (Top). The *white* denotes a Residential class (Top Right), and the *Black* denotes an Annual Crop class (Top Right). The visual image shows that the quantum classification is better for detecting the vegetation even among building areas than a classical neural network.

References

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