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EXPLORING QUANTUM MACHINE LEARNING FOR REMOTE SENSING-BASED LAND COVER CLASSIFICATION: CASE TEST IN SARDINIA

Abstract

Our objective is to conduct a comprehensive evaluation of Quantum Machine Learning (QML) in comparison to traditional Machine Learning (ML) techniques such as Support Vector Machine, Random Forest, and Convolutional Neural Networks for land cover classification. The accurate delineation of land cover types is crucial for various sectors including urban planning, agricultural management, disaster response, and biodiversity conservation. Our previous testing in Sardinia yielded promising results, with accuracy, recall, and F1 score reaching an impressive 0.99. Notably, our networks demonstrated exceptional accuracy in identifying burnable classes, with broadleaf around 0.99, conifer around 0.79, shrub around 0.76, and grass around 0.84 (https://doi.org/10.3390/fire6100395).

As Remote Sensing (RS) technology evolves, the complexity and volume of RS data have grown exponentially, posing challenges in processing, and analyzing this vast amount of information. With global archived observation data projected to exceed one Exabyte imminently, the need for robust and efficient classification methodologies becomes increasingly urgent. While traditional ML methods have shown commendable performance, limitations imposed by classical 2-bit computing architectures are evident. In response, interest has surged in harnessing quantum computing to revolutionize ML. Though initial research in domains such as chemistry, physics, and pharmacology has shown promise, uncertainties persist regarding QML's adaptability to complex applications like land cover detection using remote sensing data. Our study aims to bridge this gap by conducting a rigorous comparative analysis between QML and traditional ML approaches in land cover classification within the context of Sardinia, utilizing previous studies as benchmarks.

Preliminary investigations suggest that QML may excel in recognizing complex or closely related patterns, such as distinguishing between grass and shrubs, or broadleaf and conifer classes. By elucidating the strengths and limitations of QML in this domain, our research contributes to advancing the understanding and applicability of quantum-enhanced machine learning techniques in environmental monitoring and resource management. The study design encompasses cross-validation procedures to ensure robustness and reliability of results. Additionally, we conducted computational simulations to evaluate the scalability and efficiency of QML algorithms compared to traditional ML methods, considering computational resources and runtime performance.