HyperQUEEN: Hyperspectral Quantum Deep Network for Satellite Image Restoration

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Abstract

Quantum science just winning the 2022 Nobel Prize in Physics is of high potential to lead future development of remote sensing technologies. Given the very limited number of entangled quantum bits (qubits) even in the most advanced quantum computers, processing remotely sensed hyperspectral image (featured by its large data volume) using current quantum computer does not seem to be technically feasible. Even if the quantum image state can be well processed to the quantum state of the target image (QSTI), it cannot be perfectly retrieved/output as the QSTI will collapse to some eigenstate once it is measured. Owing to these challenges, current quantum image processing technologies can only achieve classification-level applications requiring just a few output qubits. We design a hyperspectral quantum deep network (HyperQUEEN) to encode the hyperspectral information using very few qubits, as well as to learn the mapping from some measuring statistics (associated with the collapsed-QSTI) to the target image (instead of directly retrieving the unobservable QSTI), thereby solving the challenges. HyperQUEEN is the first quantum architecture that makes a breakthrough to blindly reconstruct NASA's damaged hyperspectral images, which means a lot for the upcoming space era. As the immature quantum facility nowadays does not yet allow us to fully exhibit its high potential, we are not aiming at developing state-of-the-art methods, but are demonstrating the feasibility of quantum hyperspectral remote sensing. Mathematical analysis guiding our design toward the low-rank quantum deep network, together with comprehensive experiments, will also be presented.