Implementation of Quantum Image Representation Technique Using Different Tools and Environment

Vrushali Sunil Nikam
MET's Institute of Engineering, BKC, Adgaon, Nashik, Maharashtra, India

Shirish Sane
GES's, R.H. Sapat College of Engineering, Management Studies and Research, Nashik, Maharashtra, India

Abstract

Quantum image representation provides the foundation for storing, processing, and retrieving images on quantum computers by exploiting quantum parallelism and superposition. Several techniques have been proposed, each with distinct trade-offs in qubit cost, retrieval accuracy, and circuit complexity. The Flexible Representation of Quantum Images (FRQI) pioneered angle-based encoding, offering compact qubit usage and efficient global operations, though limited by probabilistic intensity retrieval and costly multi controlled rotations. The Novel Enhanced Quantum Representation (NEQR) improved precision by encoding pixel values directly in computational basis states, enabling exact retrieval at the expense of higher qubit requirements. Building on these, the Generalized Quantum Image Representation (GQIR) extended encoding to arbitrary dimensions and color images, while the Multi-channel Quantum Image Representation (MCQI) addressed multi-channel data such as RGB. Other approaches include the Qubit Lattice Representation (QLR), which directly maps pixels to qubits but is highly resource-intensive, and umbrella Quantum Image Representation (QIR) frameworks that laid the groundwork for later refinements. Optimizations such as Enhanced FRQI (EFRQI) and Improved QIR (IQIR) reduce circuit complexity or balance angle-based and bit-based methods, while the Two Dimensional Quantum State with Normalized Amplitude (2DQSNA) achieves extreme qubit efficiency through amplitude encoding but suffers from nondeterministic retrieval. Domain specific extensions, such as the Quantum Representation of Multi-Wavelength Images (QRMW), enable hyperspectral and multispectral image processing, while the Normal Arbitrary Superposition State (NASS) method provides a theoretical basis for generalized superposition-based encoding. Finally, hybrid approaches including angle–bit trade-offs, block-based representations, and compressed encoding seek to combine the strengths of multiple methods for more practical implementations. Together, these representations highlight the evolution of quantum image models from compact theoretical constructs to more versatile and application-specific frameworks, while also underscoring the ongoing challenges of scalability, retrieval fidelity, and resource efficiency. In this we used Microsoft Quantum Development Tool Kit to represent the image in quantum environment.

Keywords

Image representation, quantum computing, gates, circuits, encoding, superposition.