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IMAGE PROCESSING IN QUANTUM COMPUTING

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Abstract

In this article, quantum computing technologies can radically change the process of image processing. Their computing power and parallel operation capabilities help to quickly and efficiently solve complex tasks. With the development of this technology in the future, quantum algorithms can become a new standard of image processing.in image processing, quantum algorithms were analyzed.

Keywords: Image, quantum computing, algorithms, image processing, classification, visualization.

INTRODUCTION

Image processing is the process of performing certain operations to extract some useful information from an image. Classification, feature extraction, pattern recognition, and projection are some of the image processing techniques. Medical imaging, surveillance, remote sensing, robotics, AR and VR, biometrics, character recognition, entertainment, etc. Quantum computing can detect edges in an image in (n) time, where n is the number of pixels in the image. It takes much faster $O(n^2)$ time than the classical algorithm to detect these edges, and in the worst case it can even be $O(2^n)$. Moreover, it has the ability to process large data sets. Various quantum imaging methods, including the Adaptive Quantum Image Representation (FRQI), Enhanced Quantum Image Representation

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(NEQR), and Quantum Probabilistic Image Encoding (QPIE), form the basis of modern technologies. These methods take advantage of the unique properties of quantum computing to encode images in a higher quality and optimized manner.

METHODS

Quantum computing is based on completely different principles than traditional computing. While ordinary computers use bits, quantum computers use quantum bits, or qubits. Qubits have properties such as superposition and quantum entanglement, which allow them to process very large amounts of data in parallel.
Classical computers. Raster or bitmap formats and vector-based image formats are the most common representation of images on classical computers. Images on classical computers can be stored in various ways. The simplest can be matrices of intensity values present in each pixel of an image.
Quantum computers. Like classical computers, quantum computers have many ways to represent images. They are:
- flexible quantum image representation (FRQI);
- enhanced quantum image representation (NEQR);
- quantum probabilistic image encoding (QPIE);
- qubit lattice;
- real ket representation.

Flexible Quantum Image Representation (FRQI). Flexible Quantum Image Representation (FRQI) requires the fewest qubits to encode an image, but it can be difficult to reconstruct the original image from the quantum state. In the FRQI case, we need $2n+1$ qubit, where a $2^n \times 2^n$ dimensional image is captured.

RESULTS

Flexible Quantum Image Representation (FRQI). Flexible Quantum Image Representation (FRQI) requires the fewest qubits to encode an image, but it can

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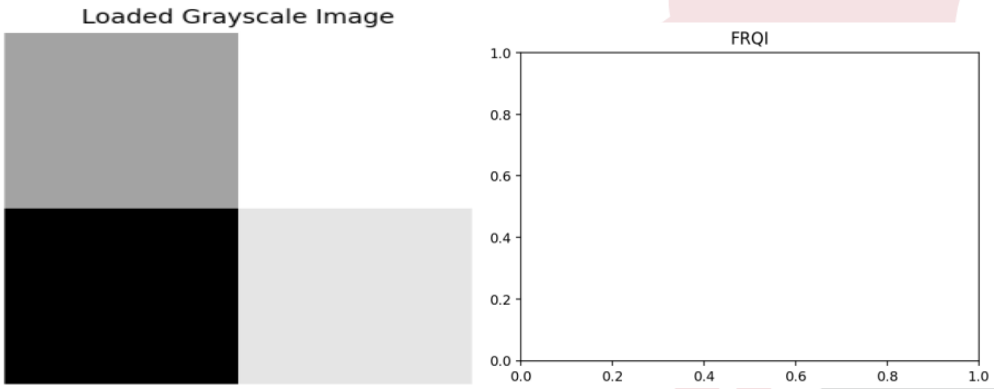
be difficult to reconstruct the original image from the quantum state. In the FRQI case, we need $2n+1$ qubit, where a $2^n \times 2^n$ dimensional image is captured.

$\theta_0, \lvert 00\rangle$	$\theta_1, \lvert 01\rangle$
$\theta_2, \lvert 10\rangle$	$\theta_3, \lvert 11\rangle$

2x2 For the picture

$$|I(\theta)\rangle = \frac{1}{2^n}\sum_{i=0}^{2^{2n}-1}\left(\cos\theta_i|0\rangle + \sin\theta_i|1\rangle\right)\otimes|i\rangle \qquad (1)$$



Enhanced Quantum Imaging (NEQR). NEQR is more accurate than FRQI and can be used to more easily recover the original image from the quantum state. However, it requires more qubits to encode the image than FRQI. We can have two registers, one for the pixel position and one for the gray (or color) value. For a scale of 255, we can represent our 2x2 image as (2).

$$|I\rangle = \frac{1}{2^n}\sum_{i=0}^{2^{2n}-1}|f(i)\rangle\otimes|i\rangle$$

|i⟩: piksel pozitsiyasi (2n qubit)
|f(i)⟩: kulrang qiymat (q qubit, odatta 8 bit)

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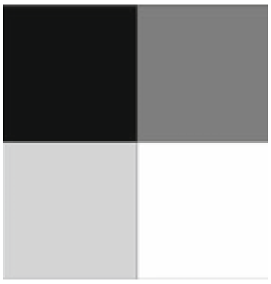

Location	Binary array	Grayscale intersity
$\|00\rangle$	$\|00000000\rangle$	0- black
$\|01\rangle$	$\|01100100\rangle$	100- Dark shade
$\|10\rangle$	$\|11001000\rangle$	200- Light shade
$\|11\rangle$	$\|11111111\rangle$	255- white

This method demonstrates the advantages of quantum computing in image compression and optimization, and is an important step towards the practical application of quantum technologies.

Quantum Probabilistic Image Encoding (QPIE). QPIE requires significantly smaller $n = [\log_2 N]$ qubits, allowing for a much more compact representation of image data. This method, unlike traditional image coding, uses the probability amplitudes of quantum states. In this process, the image is efficiently and compactly represented by normalizing it so that the sum of the squares of all probability amplitudes is equal to 1. in pixel intensities converted into probability amplitudes of quantum states by. The image is encoded in a quantum-probability

$$I = \left(I_{yx}\right)_{N_1 \times N_2} \qquad c_i = \frac{I_{yx}}{\sqrt{\sum I_{yx}^2}} \qquad (3)$$

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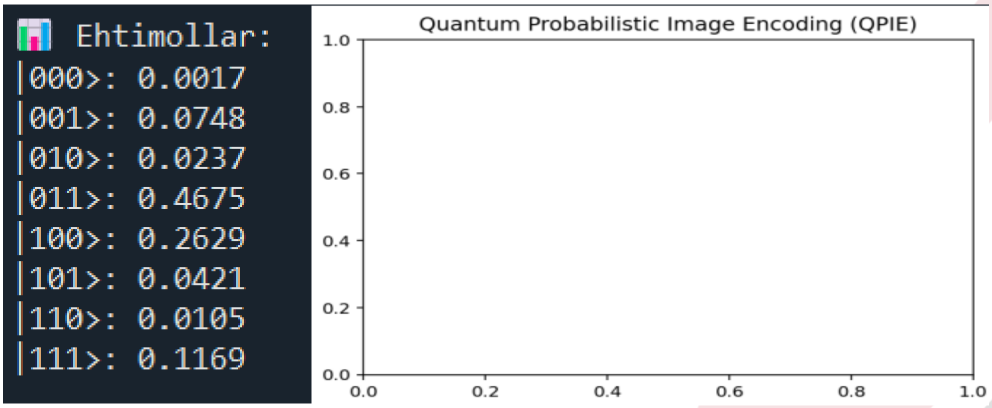
With (3) the image can be represented by 2×2 qubit state. With $|\mathrm{Im}\,g\rangle = c_0|00\rangle + c_1|01\rangle + c_2|10\rangle + c_3|11\rangle$ the image can be represented by n qubit states. This gives $|\mathrm{Im}\,g\rangle = \sum_{i=0}^{2^n-1} c_i|i\rangle$. In this case the image can be represented as:



CONCLUSION

There are various methods for representing quantum images, including FRQI (Flexible Representation of Quantum Images), NEQR (Novel Enhanced Quantum Representation), and QPIE (Quantum Probabilistic Image Encoding).

FRQI requires the fewest qubits and allows for compact representation of the image. However, it may be difficult to reconstruct the original image using this method.

NEQR is a more accurate quantum image encoding method that facilitates the image reconstruction process. It requires additional qubits and the image data is represented in terms of pixel coordinates and their gray intensity values.

QPIE uses quantum probability amplitudes to represent image data in a more compact form. In this case, the image pixel intensities are normalized and represented by qubits.

These methods pave the way for efficient compression and encoding of images using quantum computing capabilities. This creates an important basis for the practical application of quantum technologies in the field of image processing.

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