“Quantum Image Scaling Using Nearest Neighbor Interpolation” - *Nan Jiang · Luo Wang*

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Abstract

Although image scaling algorithms in classical image processing have been extensively studied and widely used as basic image transformation methods, the quantum versions do not exist. Therefore, this paper proposes quantum algorithms and circuits to realize the quantum image scaling based on the improved novel enhanced quantum representation (INEQR) for quantum images. It is necessary to use interpolation in image scaling because there is an increase or a decrease in the number of pixels. The interpolation method used in this paper is nearest neighbor which is simple and easy to realize. First, NEQR is improved into INEQR to represent images sized $2^{n1} \times 2^{n2}$. Based on it, quantum circuits for image scaling using nearest neighbor interpolation from $2^{n1} \times 2^{n2}$ to $2^{m1} \times 2^{m2}$ are proposed. It is the first time to give the quantum image processing method that changes the size of an image. The quantum strategies developed in this paper initiate the research about quantum image scaling.

Objectives

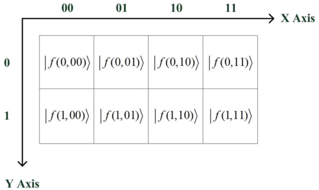
In this paper, a quantum correlative to image scaling is presented. We aim to perform image scaling using qubits to maximize efficiency in terms of speed and scalability. This research marks the start of image scaling using quantum computing. In this paper, we focus on image scaling which is a basic QIP algorithms. Image scaling is the process of resizing a digital image which has been extensively studied and widely used as a basic image transformation method in classical image processing field. However, no such strategies on quantum computers have emerged. We develop an improved version of NEQR to account for the constraint of not being able to represent images of rectangular dimensions. We implement a simple image scaling algorithm i.e Nearest Neighbor Interpolation. It is a crude method, but is used to demonstrate the applicability of Quantum Image Processing.

The main contributions are:

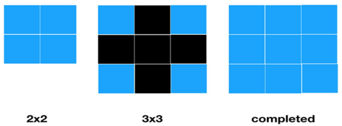
1. Improve NEQR to store a quantum image from 2n × 2n to 2n1 × 2n2 .
2. Give a QIP algorithm that can change the size of images for the first time.
3. Start the research of quantum image scaling.

Method

The approach begins by determining the best representation of a digital image in terms of quantum qubits. We improve upon an existing method for quantum representation. The image is represented using q + 2n qubits to represent a $2^n \times 2^n$ image with gray range 2^q. The below figure represents A 2 × 4 INEQR quantum image



Once the images are in this format, we develop an algorithm for Quantum Image Scaling. Nearest Neighbors Interpolation is a simple method applied in classical image processing using interpolation to create new or delete redundant pixels. It can either scale an image up or down.

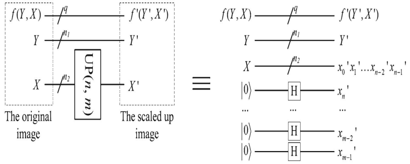


Example of Nearest Neighbor Scaling.

The quantum counterpart of this algorithm are divided into 2 subcategories.

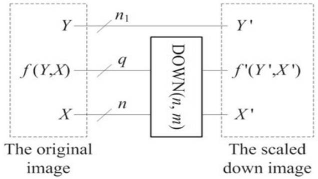
1) Upscaling

Here we expand the size of an image. The quantum circuit for image scaling up on one direction is notated by a quantum module UP(n, m) with n, m representing that an image is scaled up from 2^n to 2^m. We Prepare m − n|0> qubits as the new position qubits of X axis and add m − n Hadamard gates.



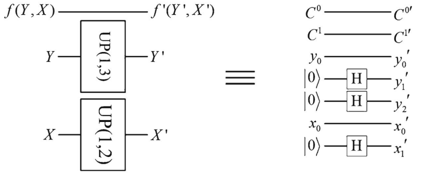
2) Downscaling

Here we shrink an image. We split the original image into groups of size”m” and map them to pixels in our processed image. All the pixels that belong to one group have the same $|x_0x_1 \ldots x_{m-1}\rangle$ and it is equal to the label of the group, i.e., the location information of the pixel in the scaled down image that the group produced.

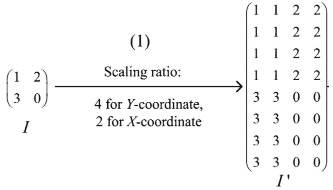


Results

Quantum circuits have successfully been generated and have scaled the image based on pixel locations and intensities represented by qubits



The transformation carried out by the previous quantum circuit is shown below.



Conclusion

In this paper, the quantum image scaling circuits using nearest neighbor are proposed which can scale images from $2^{n1} \times 2^{n2}$ to $2^{m1} \times 2^{m2}$. Firstly, NEQR is improved into INEQR to store a quantum image sized $2^{n1} \times 2^{n2}$. Then, quantum circuits that can scale a quantum image are proposed. Some examples of quantum circuits are given to illustrate the circuits more detailed.

Future work may include:

- Implementation of more complex scaling algorithms i.e bilinear, bicubic interpolation.
- Quantum counterparts to classical image processing transforms i.e restoration, enhancement.
- Design quantum image scaling methods if the scale ratio is not in the form of 2^r

References

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