

Presenting Images as Qubits in Quantum Computation

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I. INTRODUCTION

The field of machine learning is one of the largest research areas in computer science and engineering. It has become a very important technology in many fields. Quantum programming, on the other hand, entered people's lives a very short time ago. And people began to investigate which of the applications that used classical computers, quantum computers could be more efficient. These researches, which have been done in many fields, have of course spread to the field of machine learning. All over the world, people tried to transfer different models, methods, and algorithms to quantum programming and evaluated their performance. At some points, it was discovered that it was more efficient in terms of performance and speed than the computational techniques performed on classical computers. For these reasons, we discussed our topic, which is one of the top places in quantum programming in the field of machine learning. We attempted to categorize two photos using a quantum neural network (cat and frog). A similar investigation was conducted using the mnist data set; however, because the three-color channel was fixed in the cifar data set, we encountered some challenges and determined our accuracy value to be about 0.50. A 28x28 picture is far too huge for today's quantum computers. Resize the picture to 4x4 and 3x3 pixels. We achieve better results with 4X4, but we plan to use Quantum Image Processing - FRQI and NEQR Image Representations in the future because it's more accurate.

While the Fourier transform is one of the most significant signals and image processing algorithms, it is also a key component of most recent quantum algorithms. When we looked at the research, we saw that there are several ways to present images as qubits in quantum computations. One of them is the Flexible Representation of Quantum Images (FRQI), which allows us to present images as qubits based on the Fourier transform, and the other one is NEQR (Novel Enhanced Quantum Representation). We will explore FRQI and NEQR methods and use at least one method to present images as qubits in the initial step of our study. We will then attempt to implement this part to the QNN algorithm that we created during QJam 2021.

A. Approach

Can be possible implement a model example in quantum computing environment by making circuit that show some kind of result about computer vision to understand the behavior solution and have some insights of the classification?

In classical neural networks is a Deep Learning algorithm that is designed to work with images, taking these as input, assigning importance (weights) to certain elements in the image in order to differentiate them from each other. This is one of the main algorithms that has contributed to the development and improvement of the field of Computer Vision. We want to study hybrid-quantum algorithm using QTF and Cirq to make circuits including an method approach employed in those solutions, having in this case an attempt to build a working example for addressing a step in a quantum computer vision process. We use a type of database called cifar10 which provides us with a prepared set of images in a certain dimension and thus want to establish an analysis method in which it can be interpreted, analyzed and manipulated in vector form for the execution of the algorithm, for that reason we first;

- Research various papers and search for an easily implementable solution in these variou papers.
- Implement the circuit described based in our needs.
- Attempt to run the circuit using real data using quantum libraries.
- Analyze the outcome.
- Write a technical report.

1. Tools

Cirq is a Python software library for writing, manipulating, and optimizing quantum circuits, and then running them on quantum computers and quantum simulators. Cirq provides useful abstractions for dealing with today's noisy intermediate-scale quantum computers, where details of the hardware are vital to achieving state-of-the-art results. TensorFlow Quantum (TFQ) is a Python framework for quantum machine learning. As an application framework, TFQ allows ML application and quantum algorithm researchers to take advantage of Google's quantum computing frameworks, all from TensorFlow. It focuses on quantum data and the construction of hybrid quantum-classical models. Provides tools for interleaving logic and quantum algorithms designed in Cirq with TensorFlow. TensorFlow Quantum implements the components necessary to integrate TensorFlow with quantum computing hardware. To that end, TensorFlow Quantum introduces two data type primitives:

- Quantum Circuit: Represents a quantum circuit defined by Cirq within TensorFlow. Create batches of circuits of different sizes, similar to batches of different real-value data points.

- Pauli sum: represents linear combinations of tensor products of Pauli operators defined in Cirq. Like circuits, create batches of different sized operators.

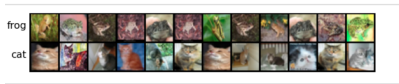
2. *What is Computer Vision?*

Computer vision is a scientific discipline that includes methods for acquiring, processing, analyzing and understanding images of the real world in order to produce numerical or symbolic information so that they can be treated by a computer. One of the first milestones that Computer Vision has to solve is related to the capture of images of real life. These are not accurate and have distortions, which can be noise, blur or another image aspect. The main differences with other branches of artificial intelligence are in the first phase of exploitation and initial interpretation of information provided by images. We can fix three key techniques, Classification, Segmentation, Object detection. In our case we will select Classification.

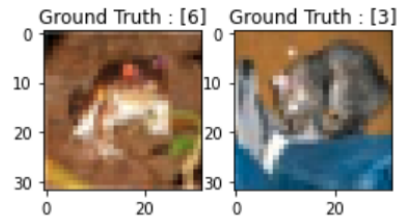
Quantum computation, which exploits quantum parallelism, is in principle faster than a classical computer for certain problems. Quantum image is encoding the image information in quantum- mechanical systems instead of classical ones and replacing classical with quantum information processing may alleviate some of these challenges.

B. Creating a quantum neural network model

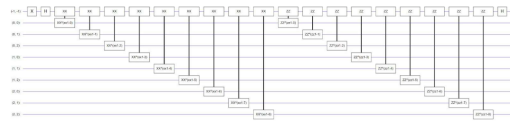
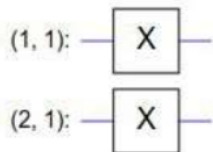
In the first step of our work, we filtered the Cifar dataset so that the frog and cat images were left



In the next step, we convert these 32x32 pictures to 4X4. When it comes to quantum computing, qubits start



with a zero. The x gate is used to convert the pixel value 1 that is in our code. For our images, we used the circuit shown below. Then, we create our model given as the below.



C. Performans

After running the model in 3x3 dimension and 4x4 dimension we obtain those results.

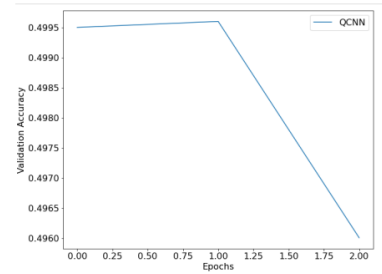


FIG. 1. The model for the 3x3 dimension.

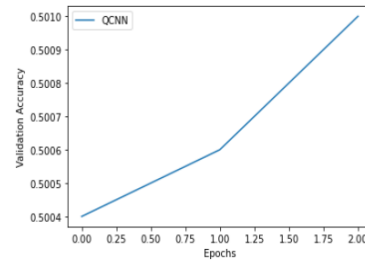


FIG. 2. The model for the 4x4 dimension.

D. References

- <https://www.tensorflow.org/quantum/tutorials/mnist>
- <https://qiskit.org/textbook/ch-applications/image-processing-frqi-neqr.html>
- NEQR: A novel enhanced quantum representation of digital images (DOI:10.1007/s11128-013- 0567-z)
- Quantum Computation-Based Image Representation, Processing Operations and Their Applications (DOI:10.3390/e16105290)

