Evaluating Gradients of Quantum Neural Nets

by Dr. Robert R. Tucci

Khyber Pass, mountain pass between Pakistan and Afghanistan

choke point

noun

a point of congestion or blockage. "the tunnel is a choke point at rush hour"

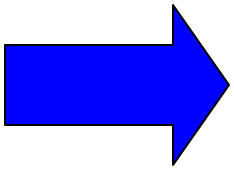
Evaluating Gradients is a choke point of classical and quantum AI

Classical Neural Networks

Minimize "cost" function using "gradient descent"

Gradients calculated using "back-propagation"

Python software libs:
- TensorFlow (Google),
- PyTorch (Facebook),
- Pyro(Uber)



Quantum Neural Networks

same

Gradients calculated using Our New Algo

Rigetti PyQuil,
IBM QisKit,
Google Cirq,
Our Qubiter

Our Algo uses Multi-threading

So what do I (Tucci) mean by threading?

(I and most people use the words threading and multi-threading synonymously) I believe I am one of the first persons to use the word threading in connection with quantum computing. What I mean by it is the strategy of partitioning the qubits in a (gate model) quantum computer into small, disjoint sets ("islands") that are uncorrelated from each other and run concurrently. The qubits within one of these islands are strongly correlated but qubits from different islands are probabilistically independent. This is an ideal scenario for NISQ (Noisy Intermediate Scale Quantum) devices and HQC (Hybrid Quantum Classical) computing being pursued by Rigetti Inc. and others. It is also a good fit for calculating the gradient of quantum cost functions: Each island, after many shots and final measurements, yields a mean value, and a linear combination of the mean values from all the islands equals the gradient. In an artistic, poetical sense, qc threading reminds me of what is commonly called "digital rain", especially if one draws quantum circuits with time pointing downwards, like Qubiter does.

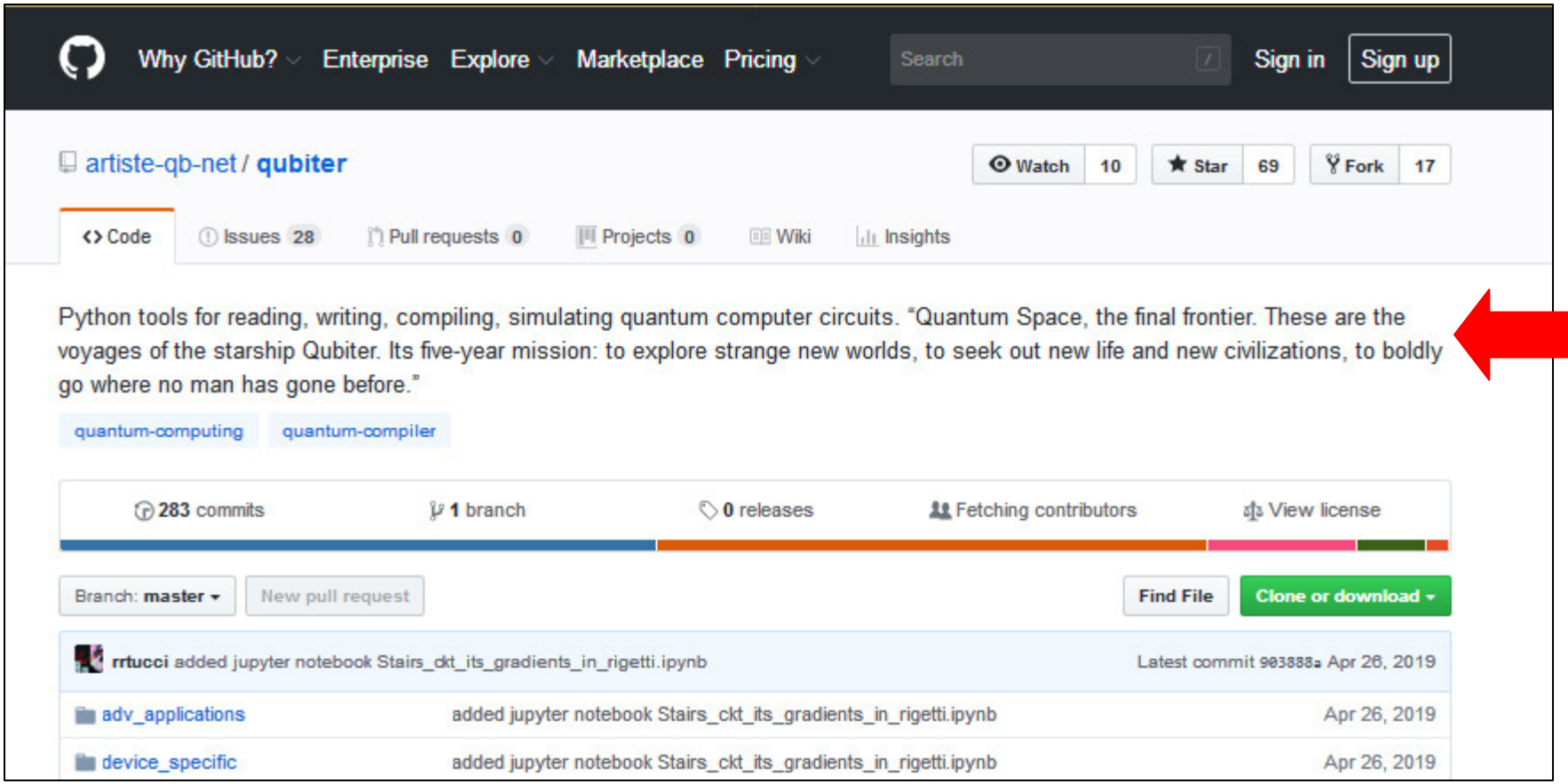
Digital Rain

Made famous by The Matrix movie series

Animated gif from
https://en.wikipedia.org/wiki/Matrix_digital_rain

Our Algo is fully implemented
As part of Qubiter Software Library
(Free, Open Source, BSD license)

https://github.com/artiste-qb-net/qubiter



White Paper Describing Algo

Calculation of the Gradient of a Quantum Cost Function using "Threading". Application of these "threaded gradients" to a Quantum Neural Net inspired by Quantum Bayesian Networks

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1 Introduction

Hybrid Quantum Classical (HQC) computation as being pursued by Rigetti Inc. involves minimizing a "quantum cost function", i.e., the mean value of a Hermitian operator, wherein that mean value is calculated empirically from the data yielded by a physical quantum computer.

There are many methods available for minimizing a cost function on a classical computer. Which minimizing method performs best for a particular case depends on the nature of the cost function and of the computing

Available at GitHub repository for Qubiter

https://github.com/artiste-qb-net/qubiter/blob/master/qubiter/adv_applications/threaded_grad.pdf

Two Jupyter Notebooks put our algo through its paces

https://github.com/artiste-qb-net/qubiter/blob/master/qubiter/jupyter_notebooks/Stairs_circuit_and_its_gradients_in_native.ipynb

This notebook evaluates Gradients using Qubiter's native simulator

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https://github.com/artiste-qb-net/qubiter/blob/master/qubiter/jupyter_notebooks/Stairs_ckt_its_gradients_in_rigetti.ipynb

This notebook evaluates Gradients using Rigetti's actual physical device (QPU) Or their simulator (Quantum Virtual Machine, QVM) Both are accessible via Rigetti Cloud Service