2023 Ephys Challenge-量子黑客松

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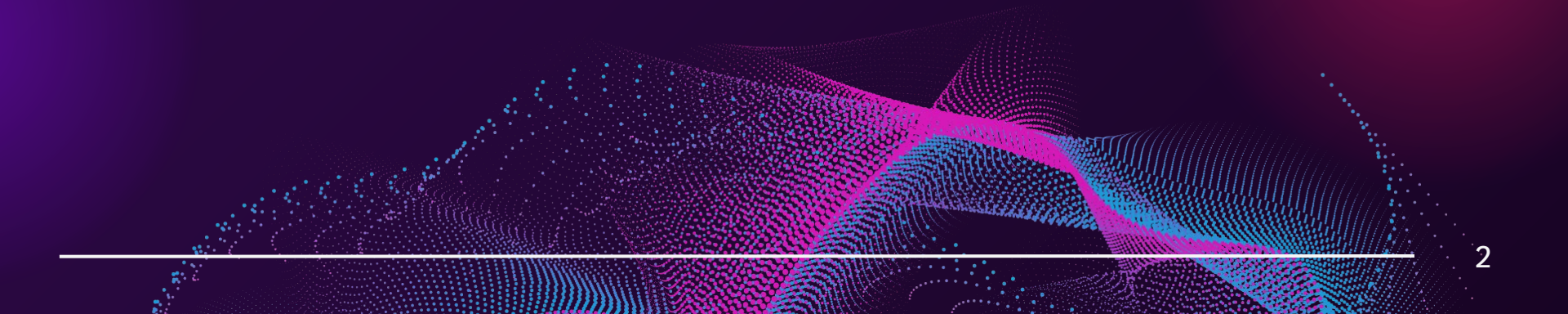
What is quantum machine learning?

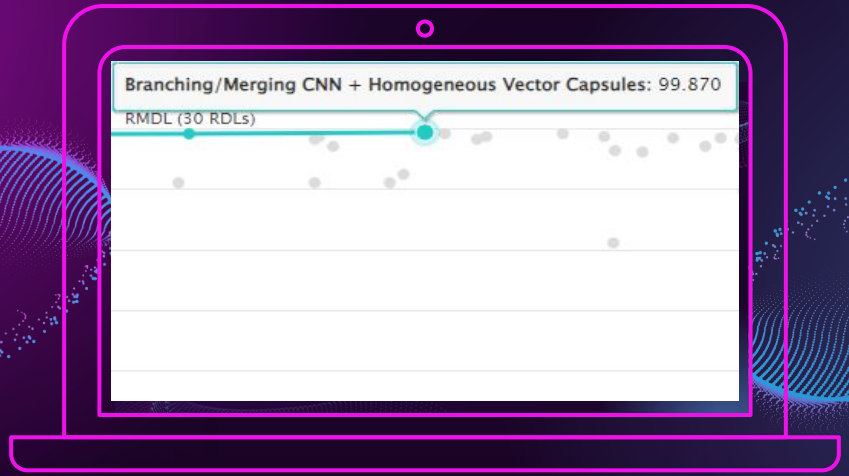


Machine learning

- Machine learning involves fitting data by adjusting parameters.
- Quantum neural network, on the other hand, achieves this by utilizing parameterized quantum gates, commonly using RX, RY, and RZ quantum gates to adjust parameters and fit the data.

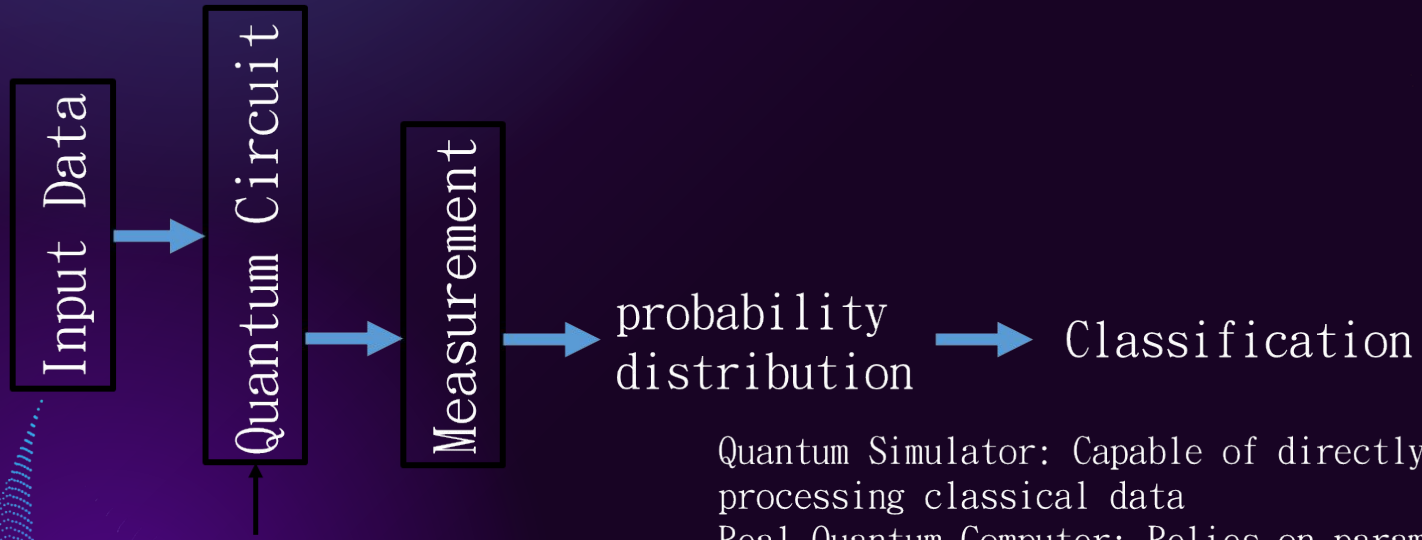
https://qiskit.org/documentation/stubs/qiskit.circuit.library.RXGate.html
https://qiskit.org/documentation/stubs/qiskit.circuit.library.RYGate.html
https://qiskit.org/documentation/stubs/qiskit.circuit.library.RZGate.html

Why choose a fully quantum layer?



https://paperswithcode.com/sota/image-classification-on-mnist?metric=Accuracy

Quantum Circuit Architecture



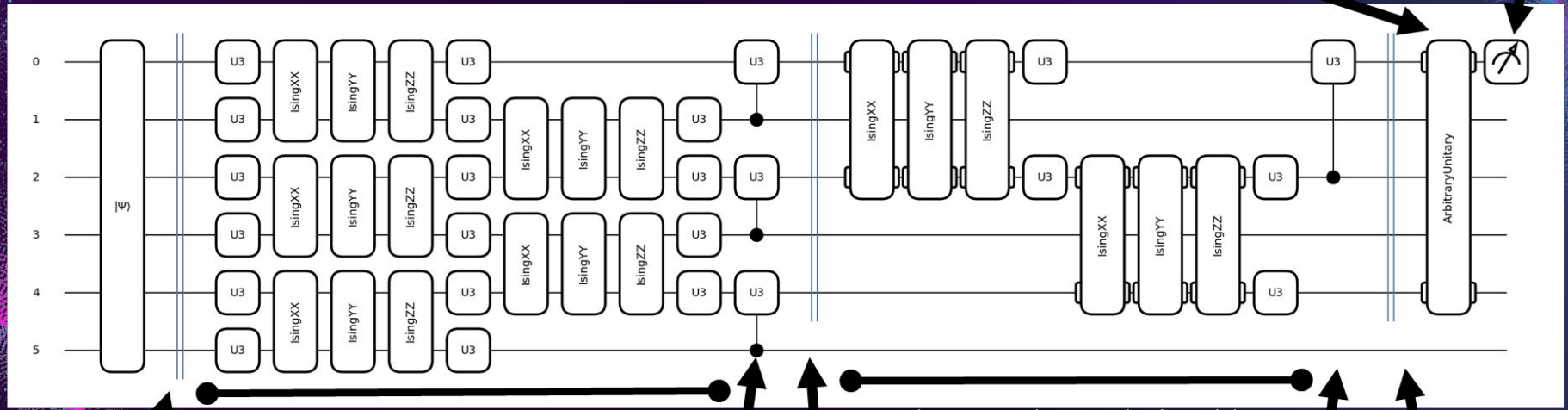
Quantum Simulator: Capable of directly processing classical data
Real Quantum Computer: Relies on parameterized quantum gates to generate quantum states analogous to classical data

- Quantum circuits consist of multiple layers of quantum gates.
- In each layer, different qubits undergo tensor product operations.
- Different layers follow general matrix multiplication operations.
- All quantum gates are unitary matrices.
- The relationship between input and output in a quantum circuit, regardless of its complexity, can always be described using unitary matrices.

The first Barrier layer

The dense layer

measure



The first convolutional layer

The second convolutional layer

The first pooling layer

The second pooling layer

The first Barrier layer

The second Barrier layer

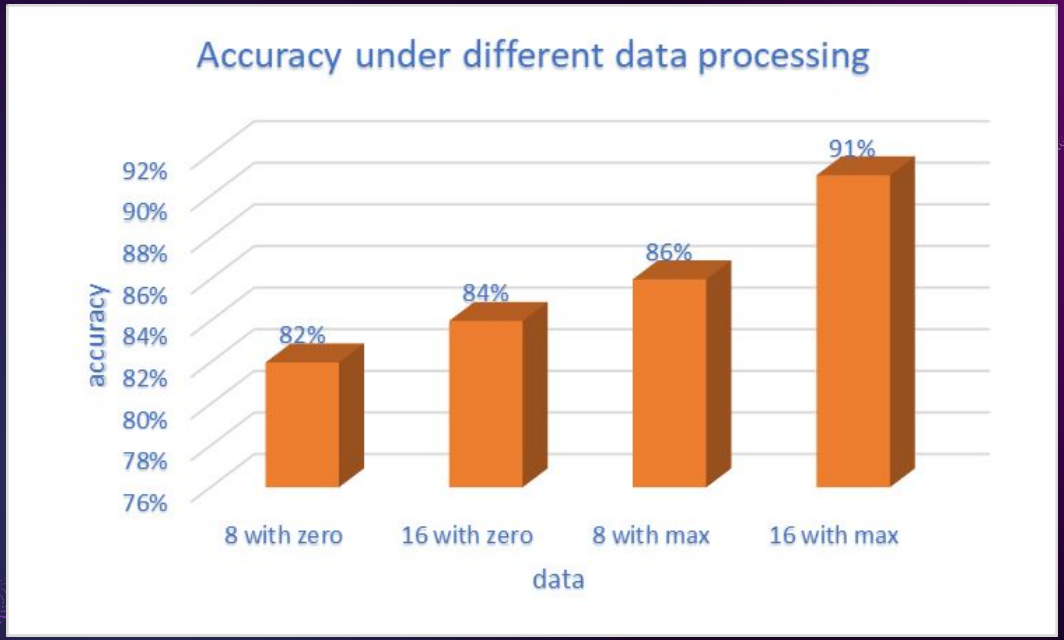
The third Barrier layer

https://pennylane.ai/qml/demos/tutorial_learning_few_data/#lenailnnsvg

Data and Development Environment

- n_train=10000
- n_test=3000
- n_epochs=30

Result

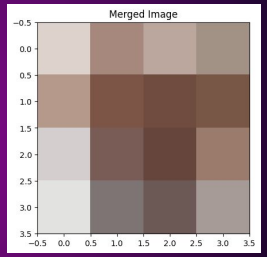

Accuracy under different data processing
92%
90%
88%
86%
84%
82%
80%
78%
76%
accuracy
82%
84%
86%
91%
8 with zero
16 with zero
8 with max
16 with max
data

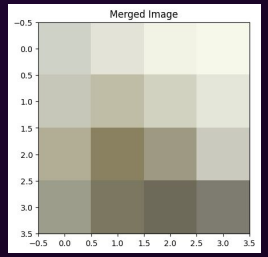
Why is it not accurate?

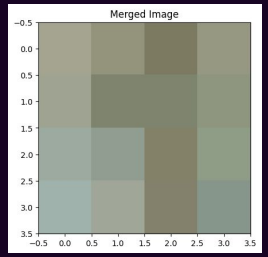
- It can't handle nonlinear functions because quantum computations are all linear.
- The loss function doesn't decrease with too many layers, so we can't have too many layers. However, deep learning requires many layers to be accurate. So, this thing is inaccurate.

McClean, J. R., Boixo, S., Smelyanskiy, V. N., Babbush, R., & Neven, H. (2018). Barren plateaus in quantum neural network training landscapes. *Nature communications*, *9*(1), 4812.

Demo


Merged Image


Merged Image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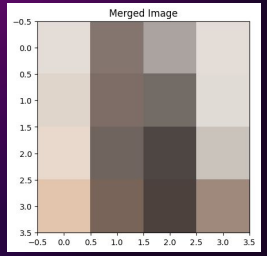
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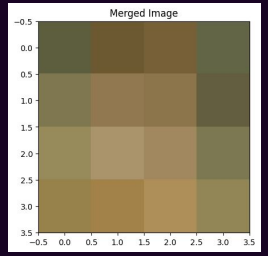
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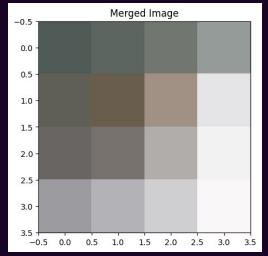
Merged Image

Thanks!

Do you have any questions?

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https://github.com/Ding-Dang-Yang/2023-Ephys-Challenge