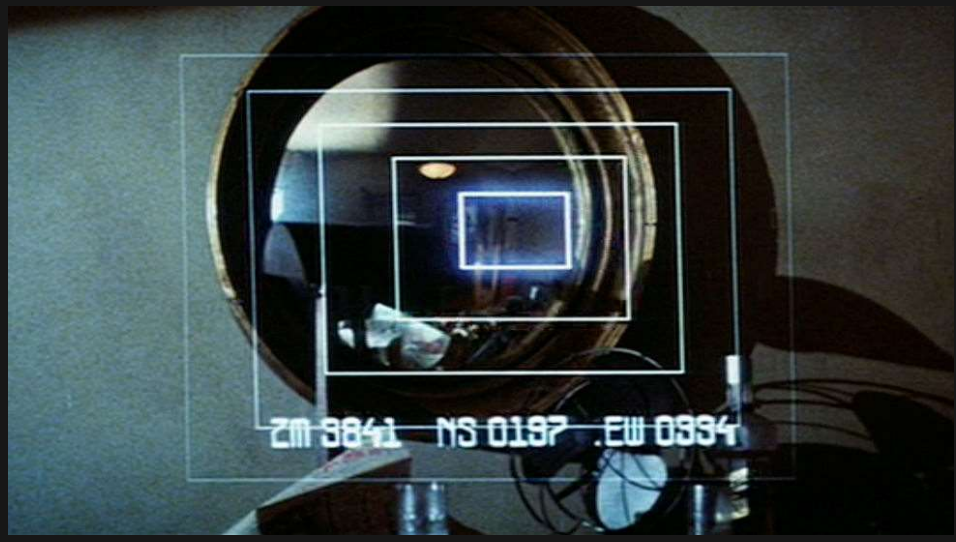
Quantum Image Processing: Super Resolution Filters

Mentor: Robert Loredo

IBM Quantum Ambassador worldwide lead, Qiskit Advocate, IBM Master Inventor



Blade Runner. Directed by Ridley Scott. Warner Bros, 1982.

Qiskit

Team presentation

Amaury de Miguel

France

Into QC since Sept 2020

Studying ML to experiment and compare quantum and classical models

Dennis Hwang

South Korea

Into QC since May 2021

Member of Qiskit translating team and studying various Qiskit examples in textbook and documents

Inho Choi

South Korea

Into QC since Sept 2020

Interested in Quantum Hardware for implementation of Quantum Algorithm.

Ginés Carrascal

Spain

Into QC since April 2017

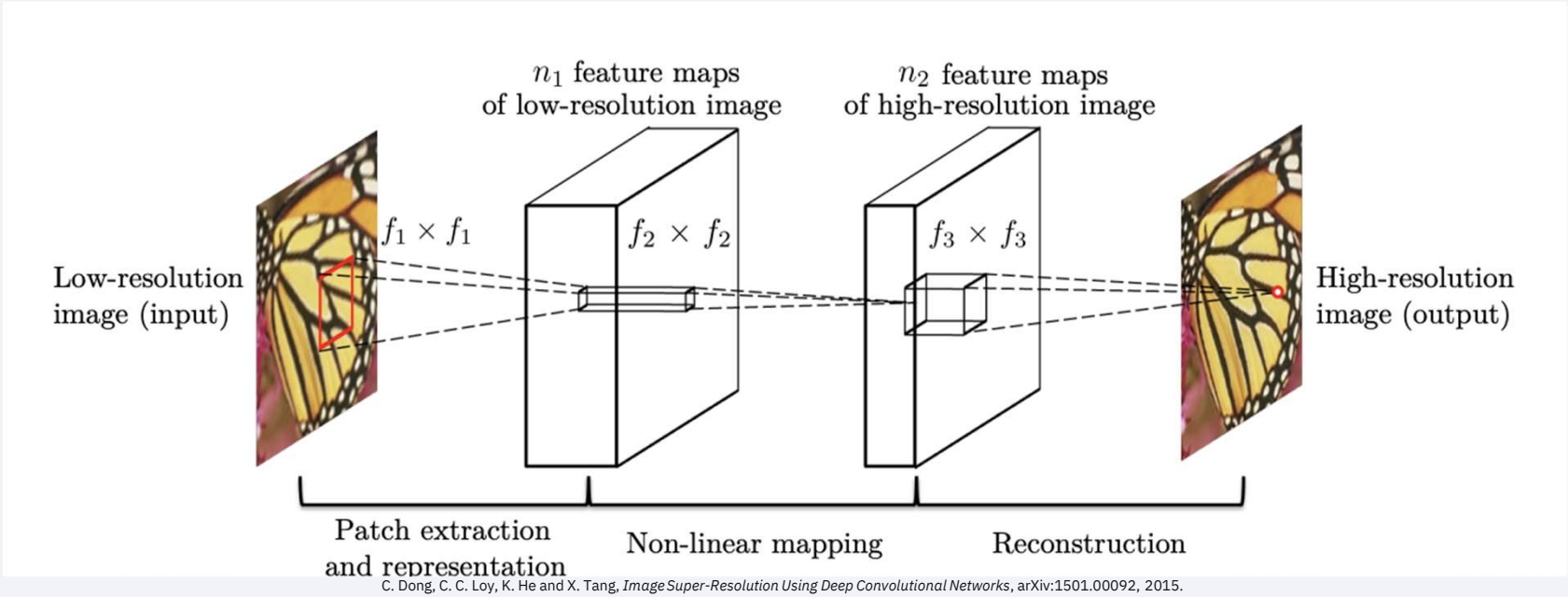
IBMQuantum Ambassador

Searching for business applications of near term QC

Project statement: Image enhancement and resolution filtering

Qiskit

Classical architecture



C. Dong, C. C. Loy, K. He and X. Tang, *Image Super-Resolution Using Deep Convolutional Networks*, arXiv:1501.00092, 2015.

Initial researches: Quantum layer for SRCNN model

Qiskit

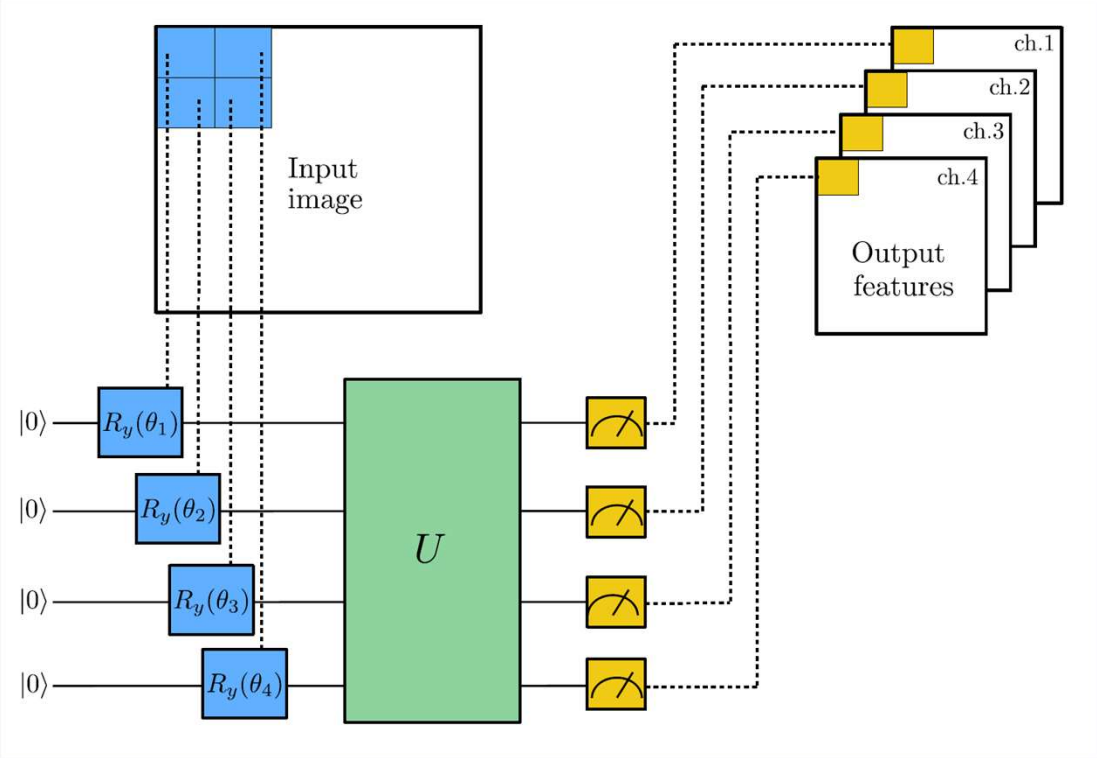
Add quantum layer to classical architecture

```
==========================================================================================
Layer (type:depth-idx)                   Output Shape              Param #
==========================================================================================
SRCNN                                    --                        --
├─Conv2d: 1-1                            [64, 64, 29, 29]          5,248
├─Conv2d: 1-2                            [64, 32, 33, 33]          2,080
├─Conv2d: 1-3                            [64, 1, 33, 33]           801
├─Linear: 1-4                            [64, 4]                   4,360
├─TorchConnector: 1-5                    [64, 1]                   8
├─Linear: 1-6                            [64, 1089]                2,178
==========================================================================================
Total params: 14,675
Trainable params: 14,675
Non-trainable params: 0
Total mult-adds (M): 483.68
==========================================================================================
Input size (MB): 0.28
Forward/backward pass size (MB): 46.52
Params size (MB): 0.06
Estimated Total Size (MB): 46.86
==========================================================================================
```

Initial researches: Quantum Neural Network

Qiskit

Building a full quantum neural network model with Pennylane

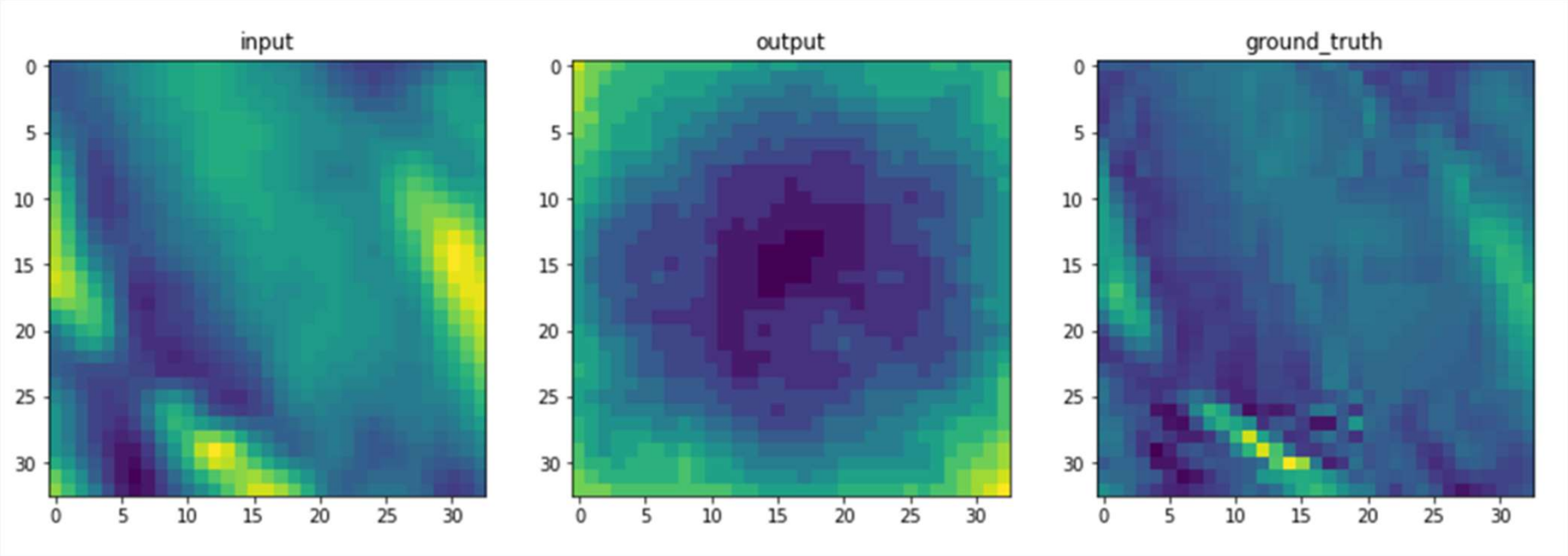


https://pennylane.ai/qml/demos/tutorial_quanvolution.html

Initial researches: Results after training of both models

Qiskit

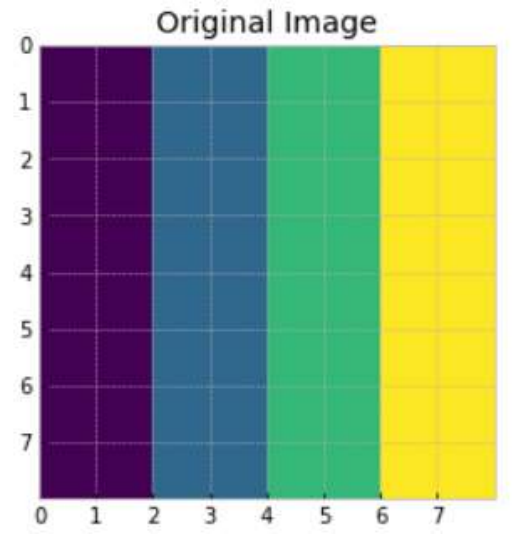
Approach unexploitable for our problem

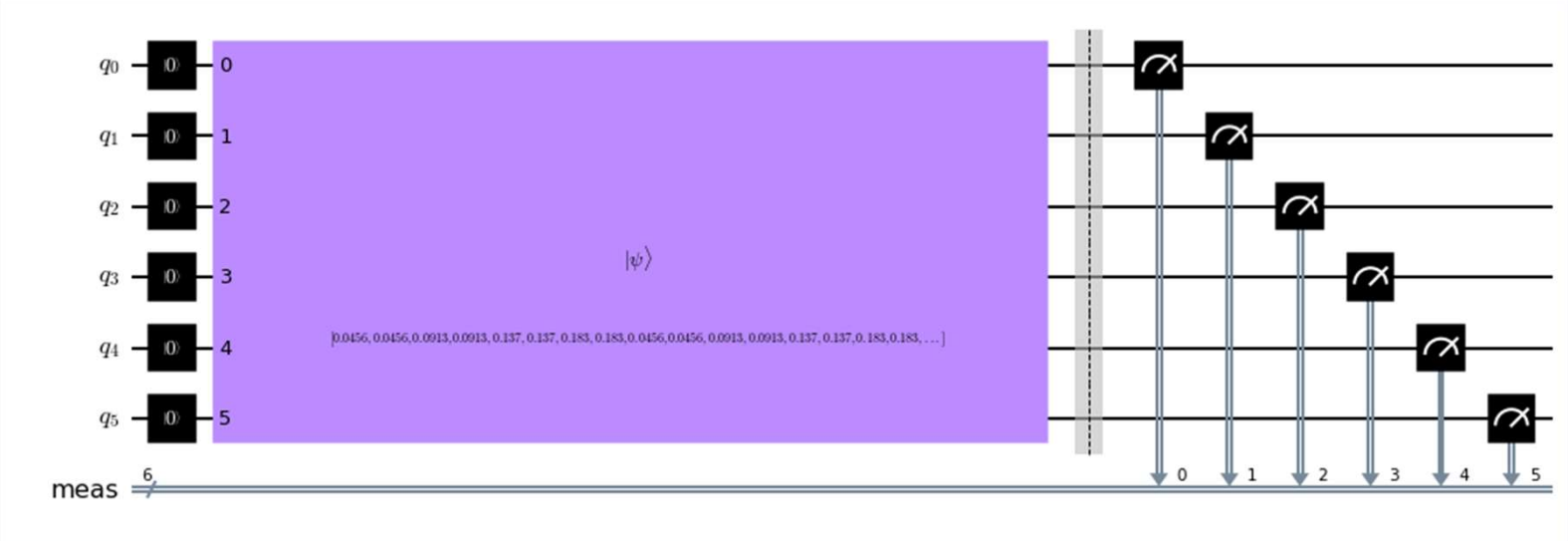


Back to basics: Image encoding in quantum computing

Qiskit

Properties of amplitude encoding

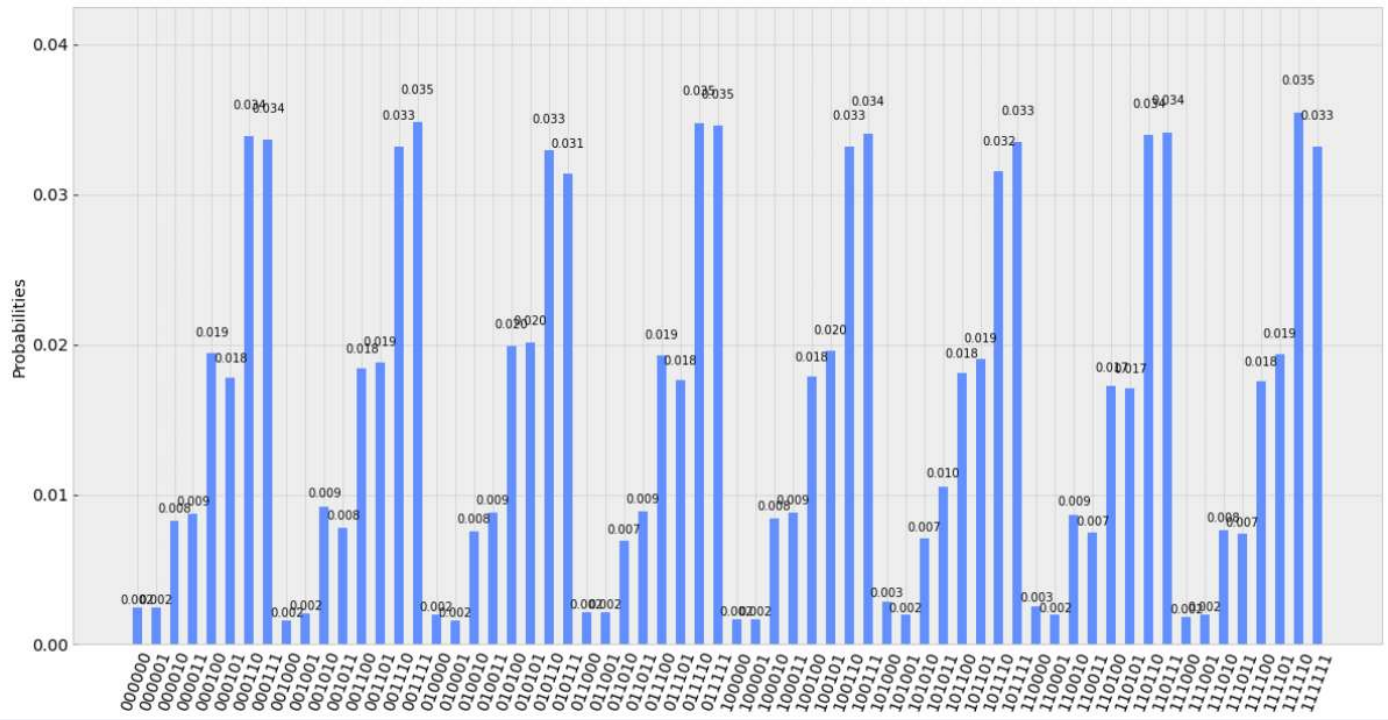


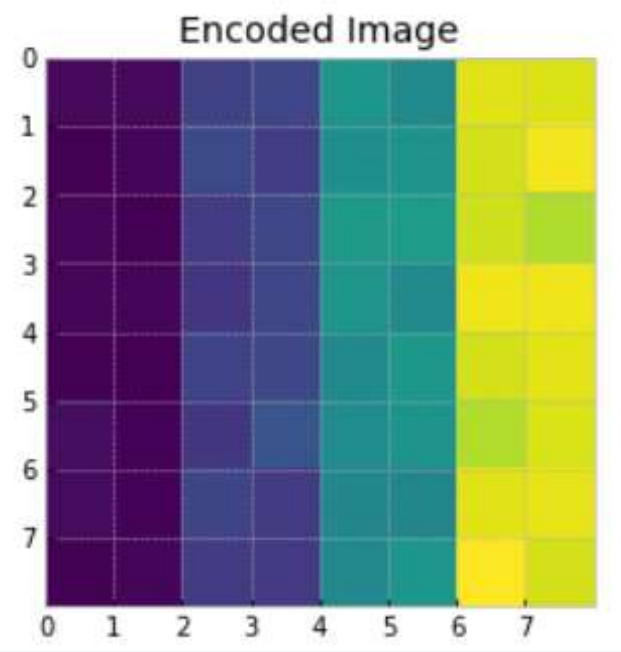


Back to basics: Image encoding in quantum computing

Qiskit

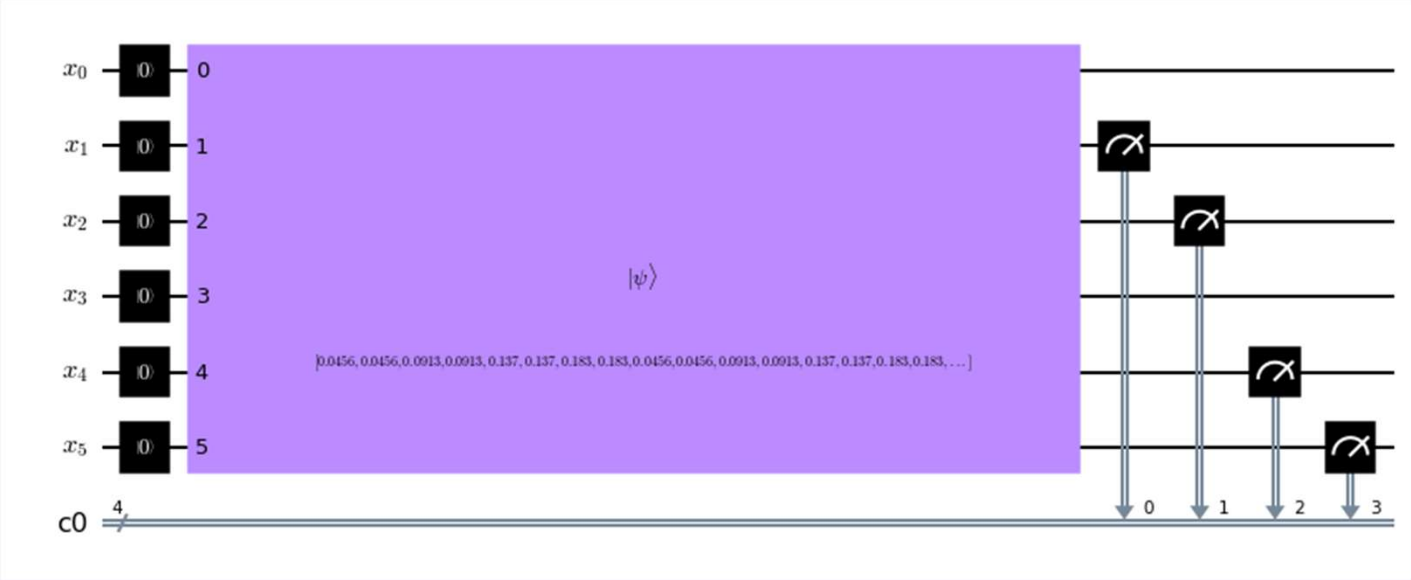
Interpret the results using number of shots

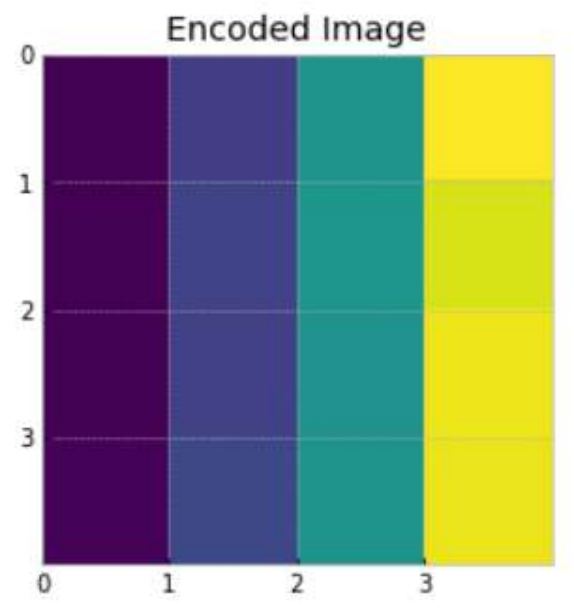




From FRQI to Quantum Image Reduction using measurement

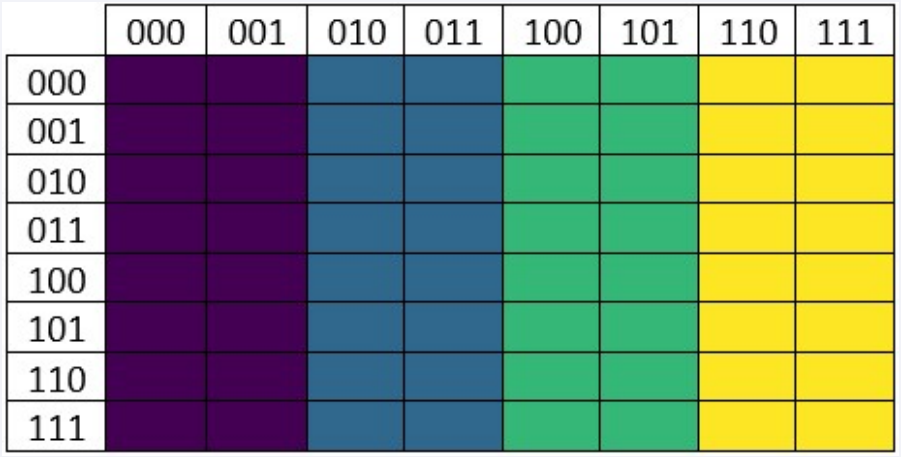
Measuring the correct qubits to apply new pixel coordinates

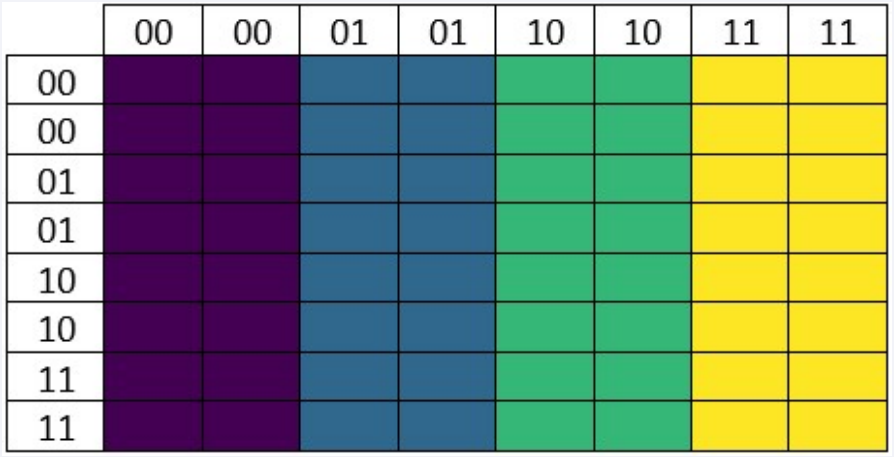




From FRQI to Quantum Image Reduction using measurement

Measuring the correct qubits to apply new pixel coordinates

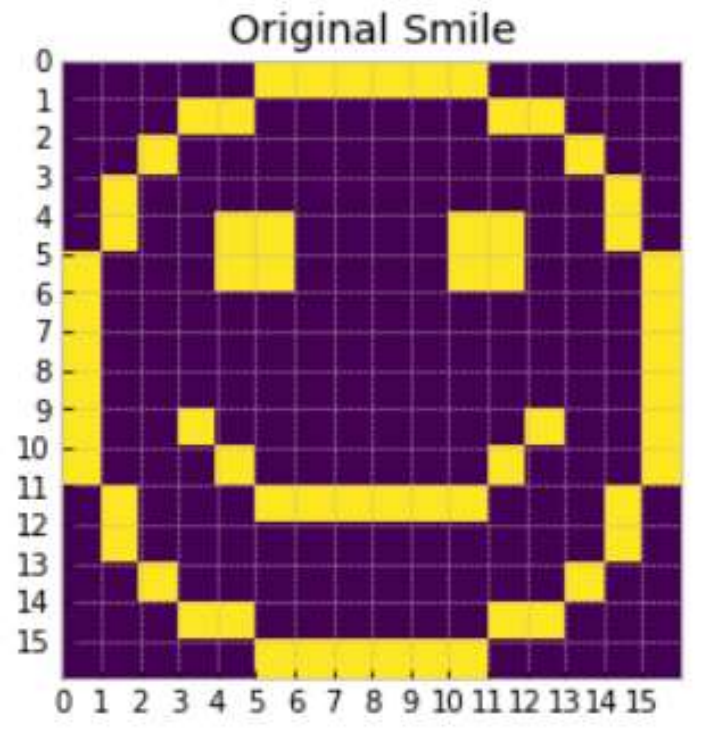


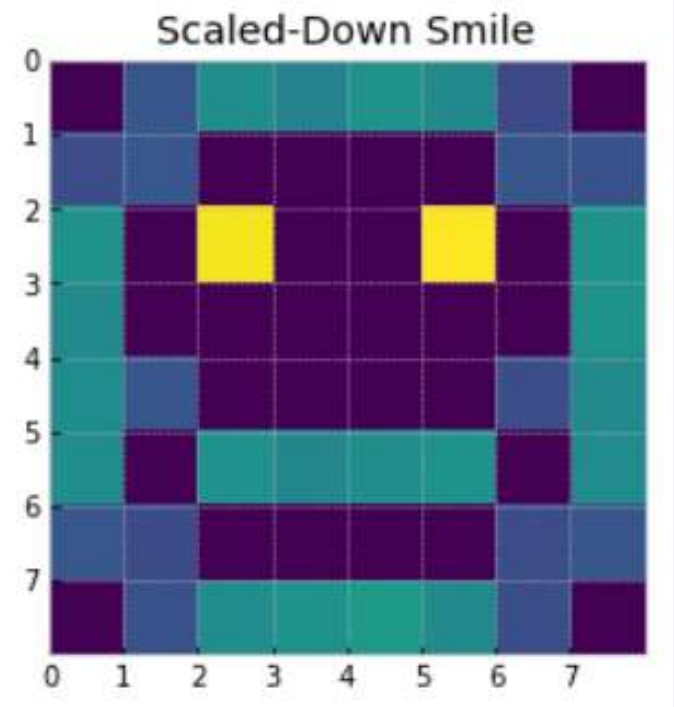


From FRQI to Quantum Image Reduction using measurement

Qiskit

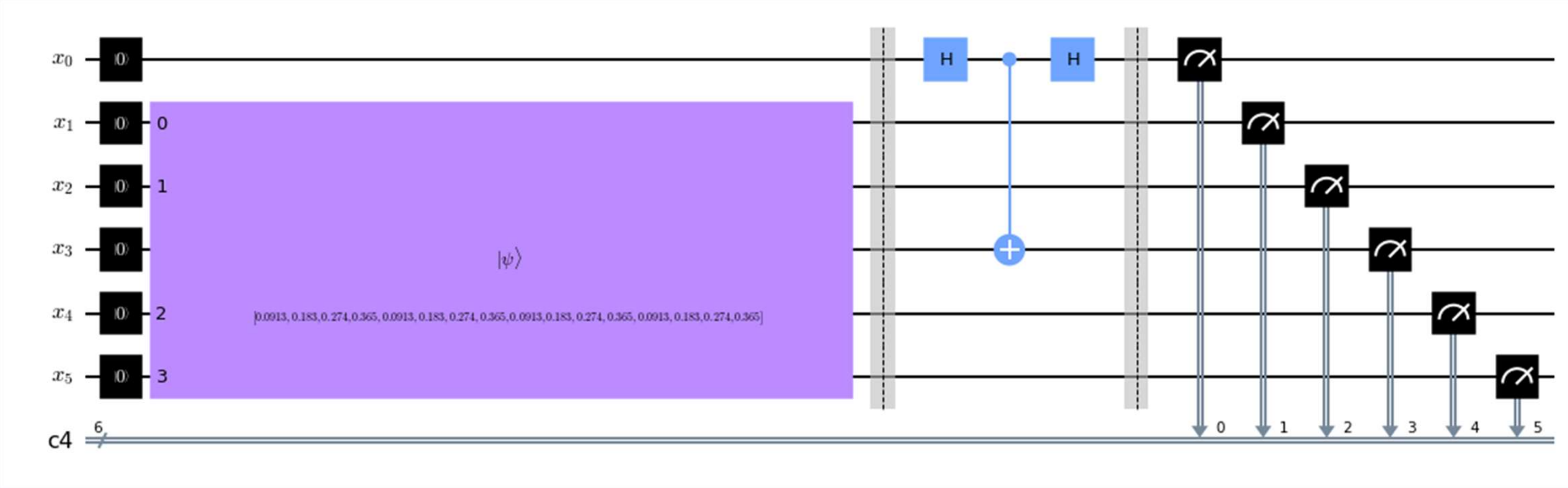
Experimenting with higher dimensions





From image reduction to Quantum Image Enhancement

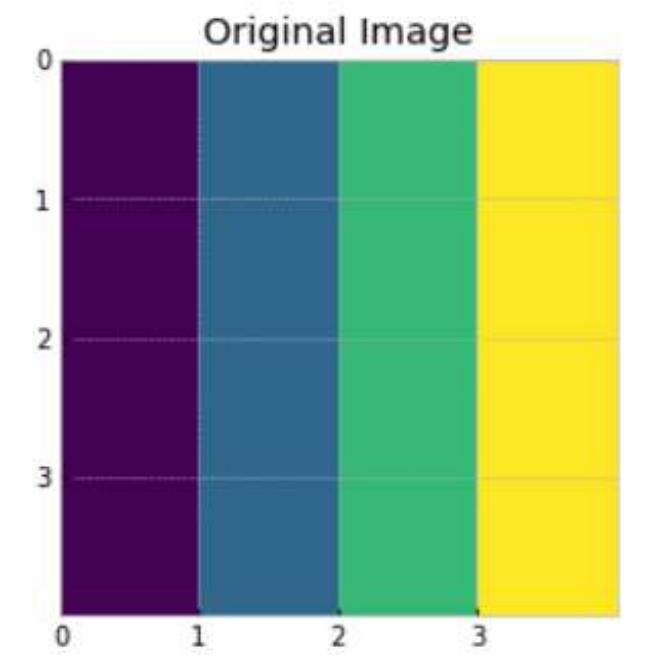
Properties of entanglement and superposition for image enhancement

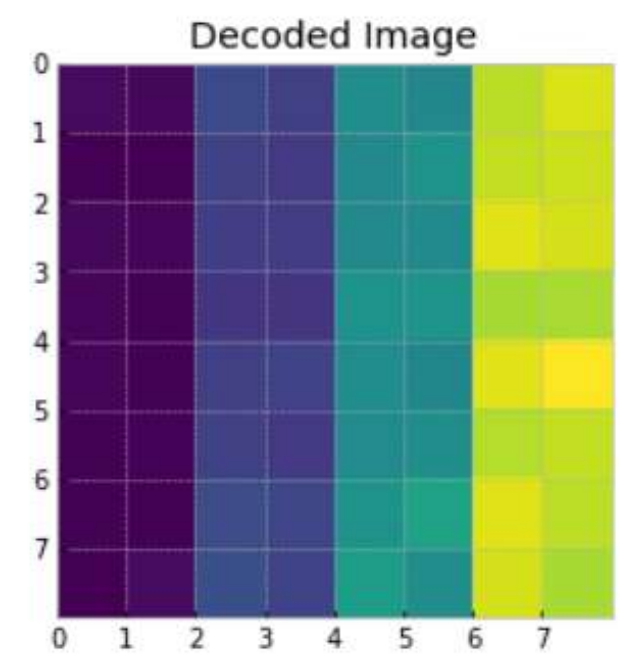


From image reduction to Quantum Image Enhancement

Qiskit

Results for test dimensions

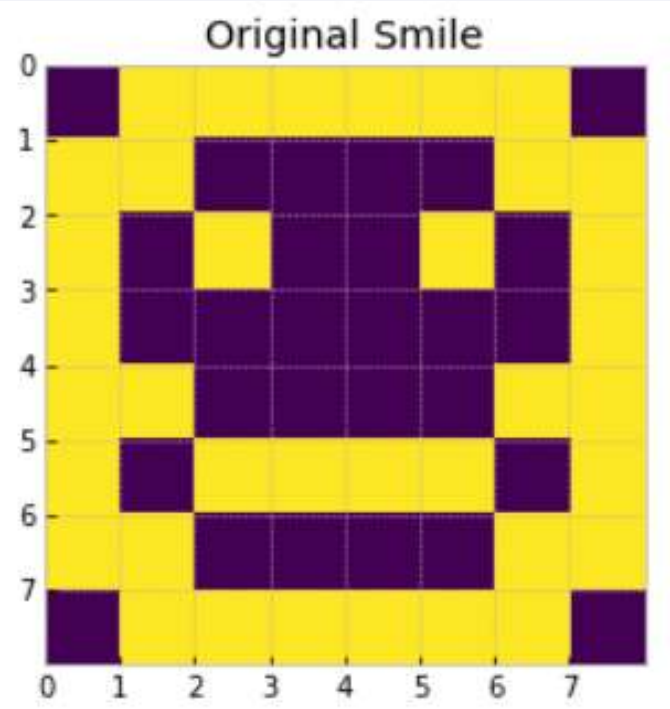


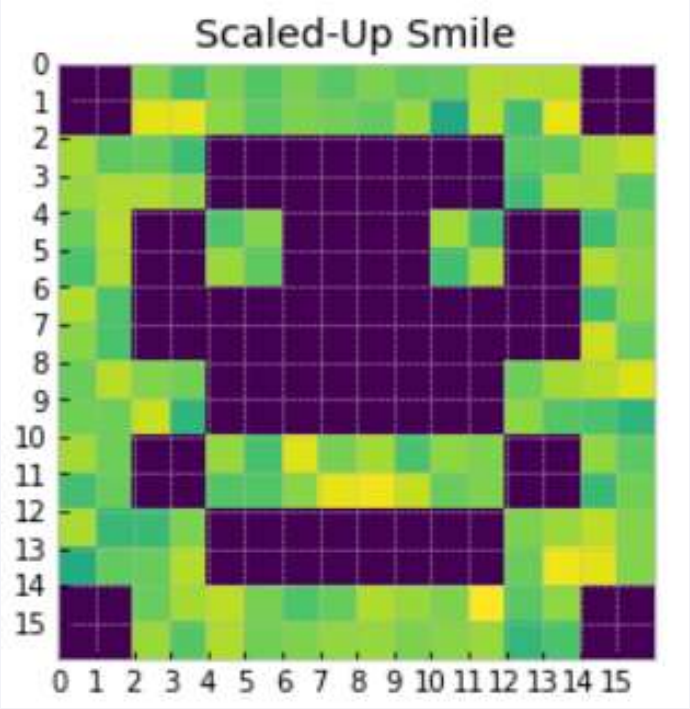


From image reduction to Quantum Image Enhancement

Qiskit

Experimenting with higher dimensions

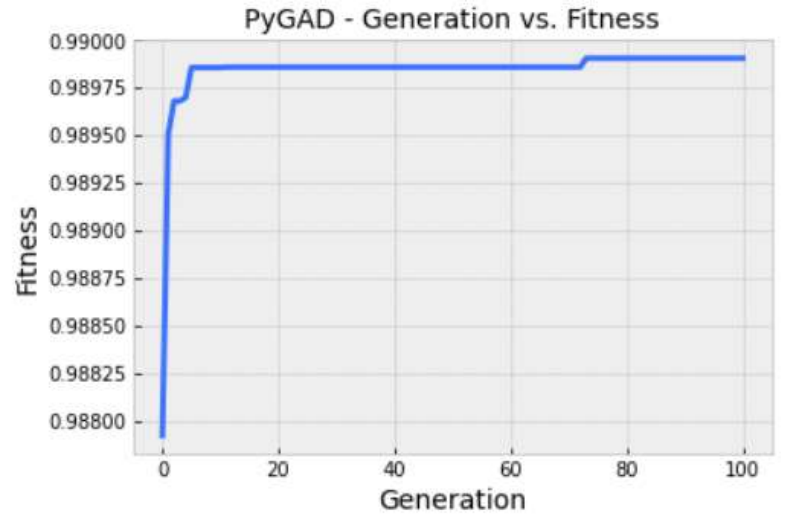


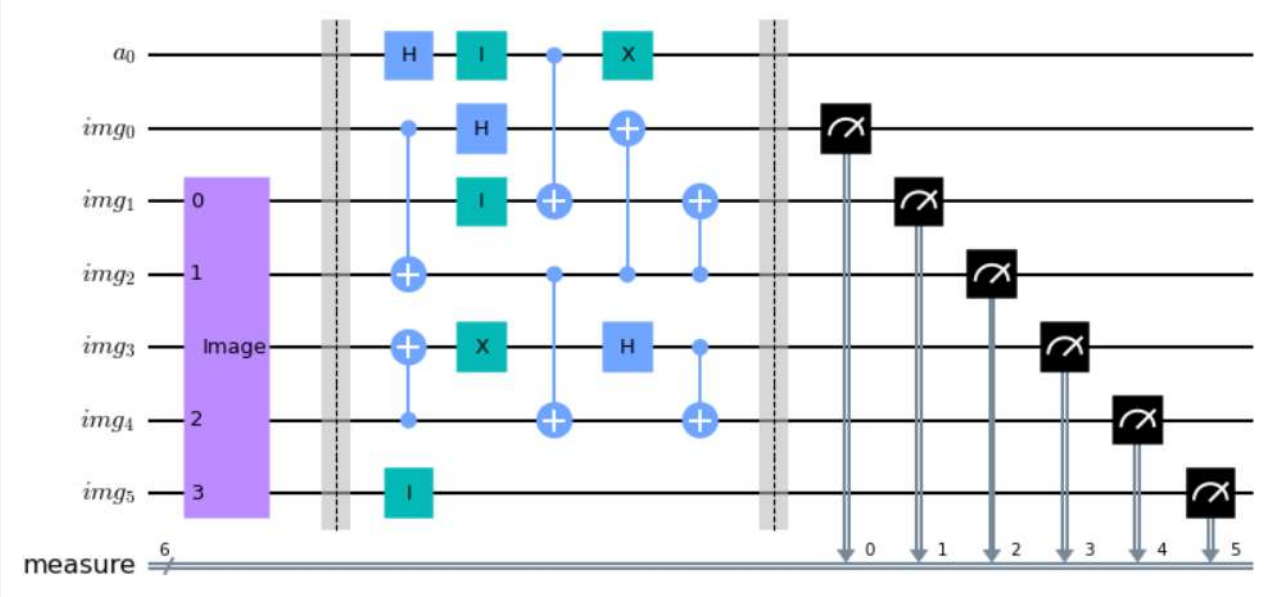


Improving the results: Overcome the nearest neighbours behaviour

Qiskit

Genetic neural network to test different forms of circuits



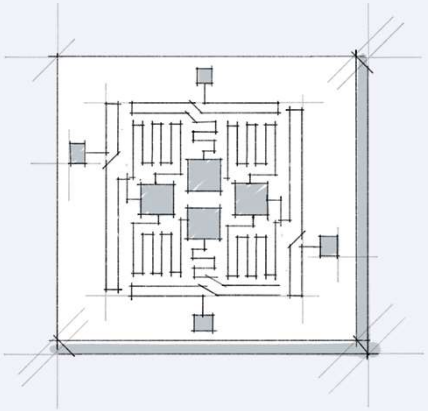


Continuing the work

Qiskit

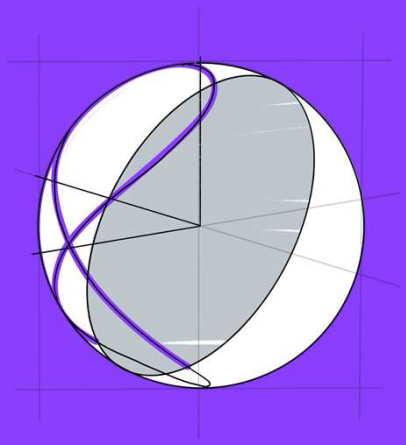
Performance improvements

Explore new encodings and other operations to apply to the identified qubits



Technical improvements

Add postprocessing operations to smooth the intensities of neighbours pixels



Theoretical improvements

Design a theory of the pixel encoding in quantum computing to develop new applications