Enhance Qiskit Database + Replication Study

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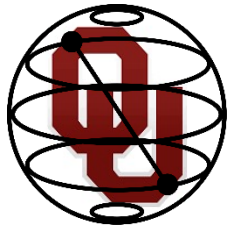
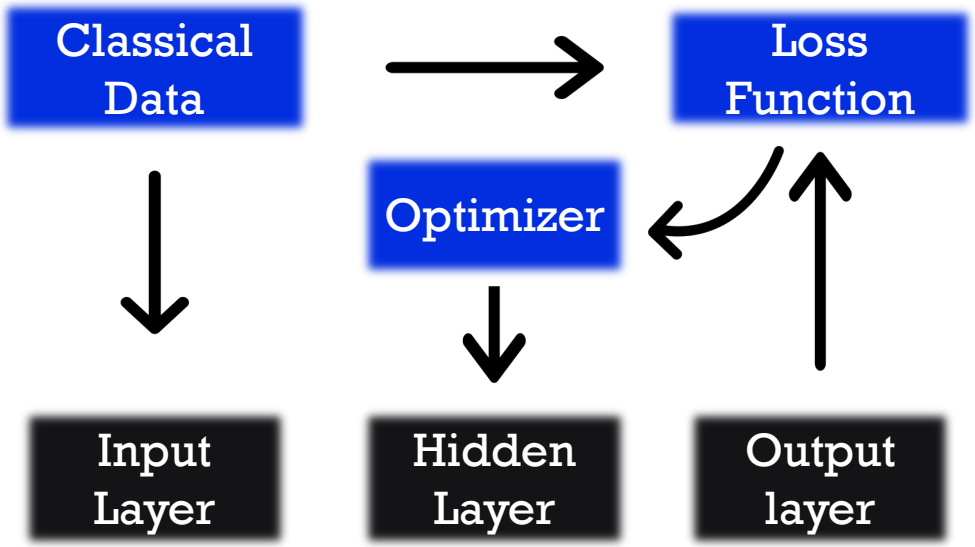
Travis L Scholten



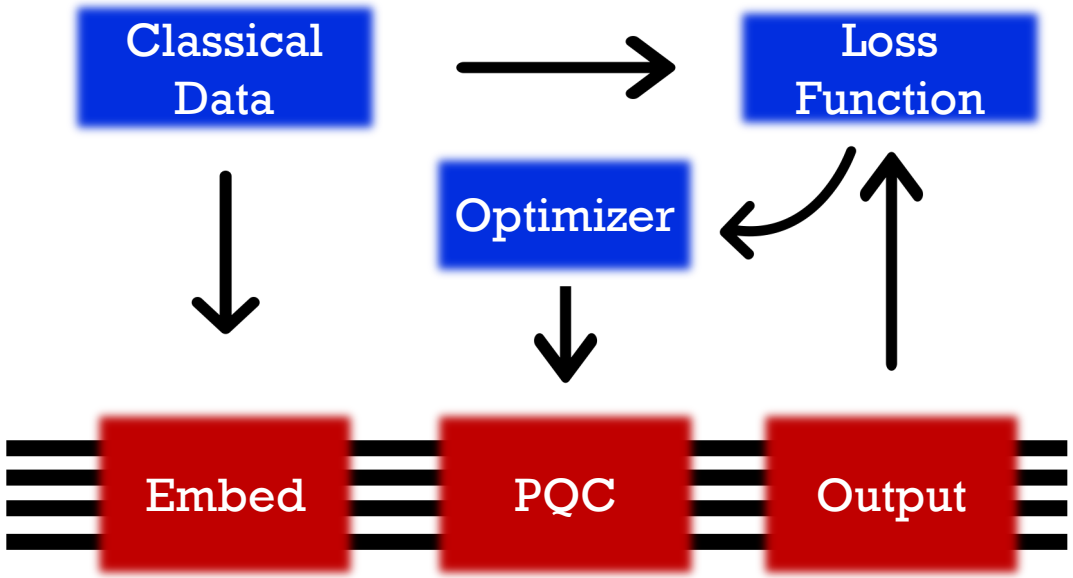
Motivation

Machine Learning



Motivation

Parametric Quantum Circuit



arXiv:2003.09887

Motivation

Two Papers

Expressibility and entangling capability of parameterized quantum circuits for hybrid quantum-classical algorithms

Sukin Sim,[1,2,*] Peter D. Johnson,[2] and Alán Aspuru-Guzik[2,3,4,5,†]

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(Dated: May 28, 2019)

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Quantum Machine Intelligence manuscript No.
(will be inserted by the editor)

Evaluation of Parameterized Quantum Circuits: on the relation between classification accuracy, expressibility and entangling capability

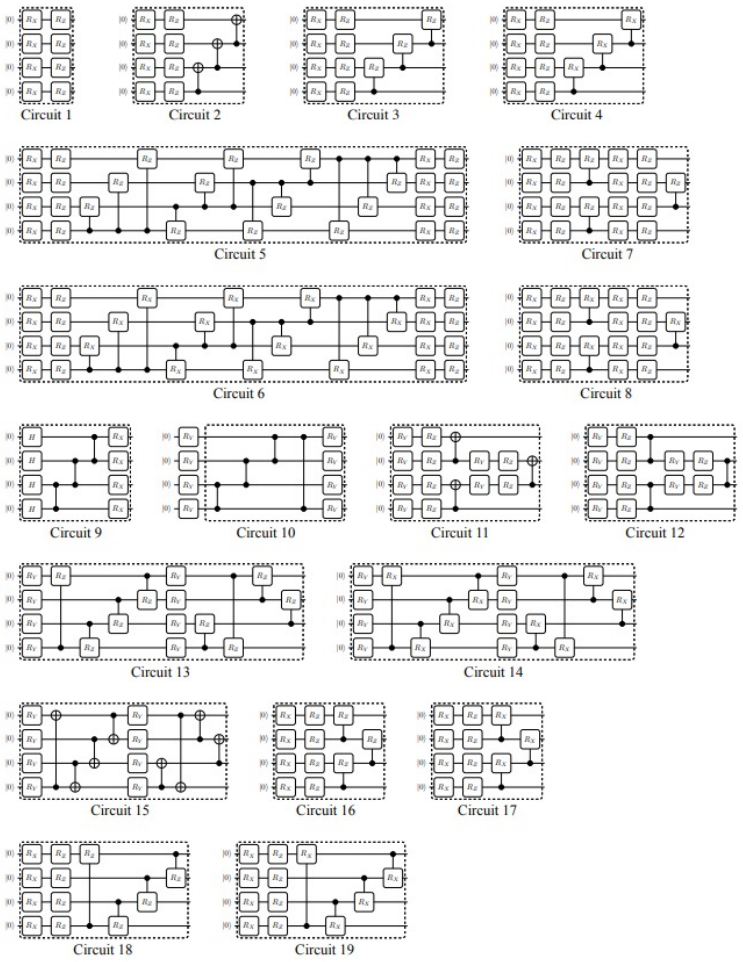
Thomas Hubregtsen [1,2,3] · **Josef Pichlmeier** [3] · **Patrick Stecher** [4] · **Koen Bertels** [3]

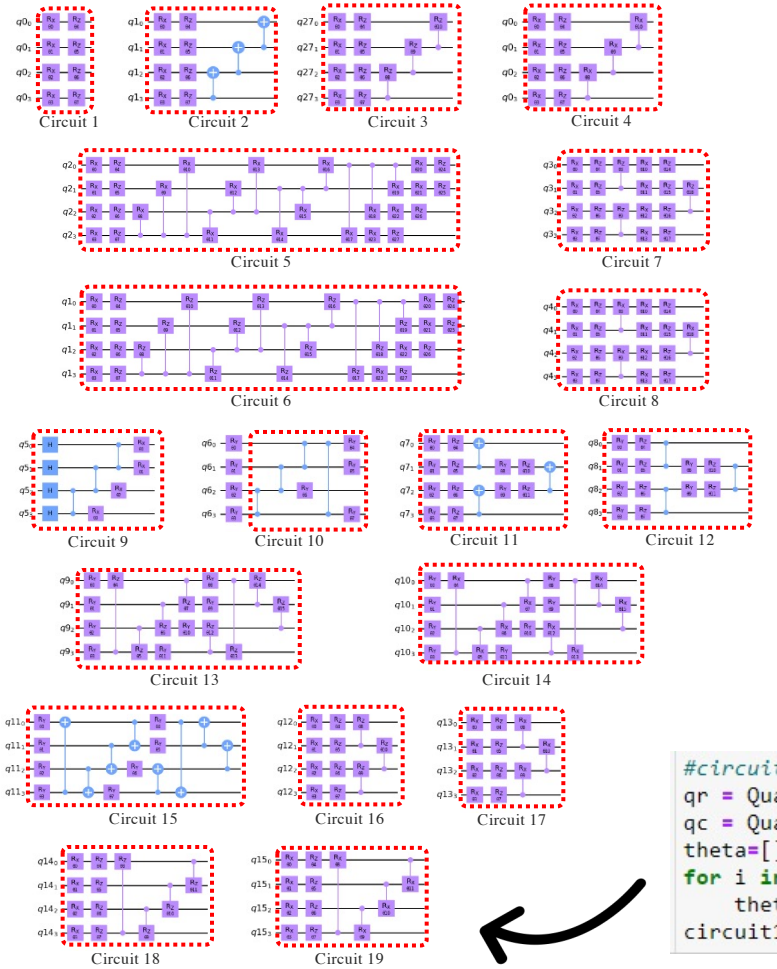
XANADU

1) Define the quality of parameterized quantum circuit (PQC)
2) Investigate the relationship between the expressibility and accuracy.

What was Done

19 Circuits






```
#circuit 19
qr = QuantumRegister(4)
qc = QuantumCircuit(qr)
theta=[]
for i in range(62):
    theta.append((Parameter('θ'+str(i))))
circuit19(qc,qr,theta,1,0).draw('mpl')
```

arXiv:1905.10876

What was Done

Two-Qubits Expressibility

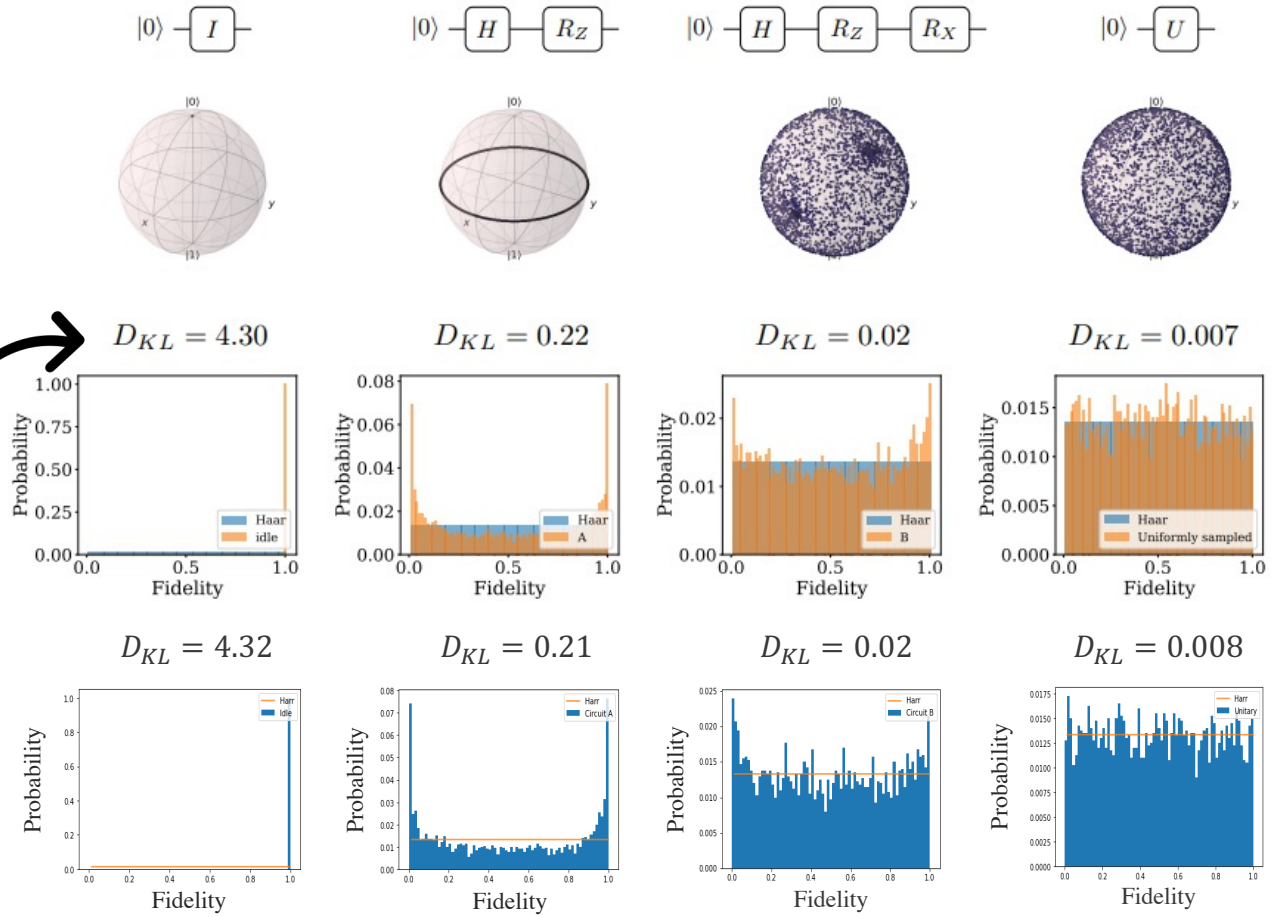
$$\mathcal{F}^{(t)} = \int_{\Theta}\int_{\Phi} |\langle\psi_{\boldsymbol{\theta}}|\psi_{\boldsymbol{\phi}}\rangle|^{2t}\, d\boldsymbol{\theta}\, d\boldsymbol{\phi}$$

$$= \mathbb{E}_{\boldsymbol{\theta}}\, \mathbb{E}_{\boldsymbol{\phi}}[(|\langle\psi_{\boldsymbol{\theta}}|\psi_{\boldsymbol{\phi}}\rangle|^2)^t]$$

$$= \mathbb{E}[F^t], \quad F = |\langle\psi_{\boldsymbol{\theta}}|\psi_{\boldsymbol{\phi}}\rangle|^2.$$

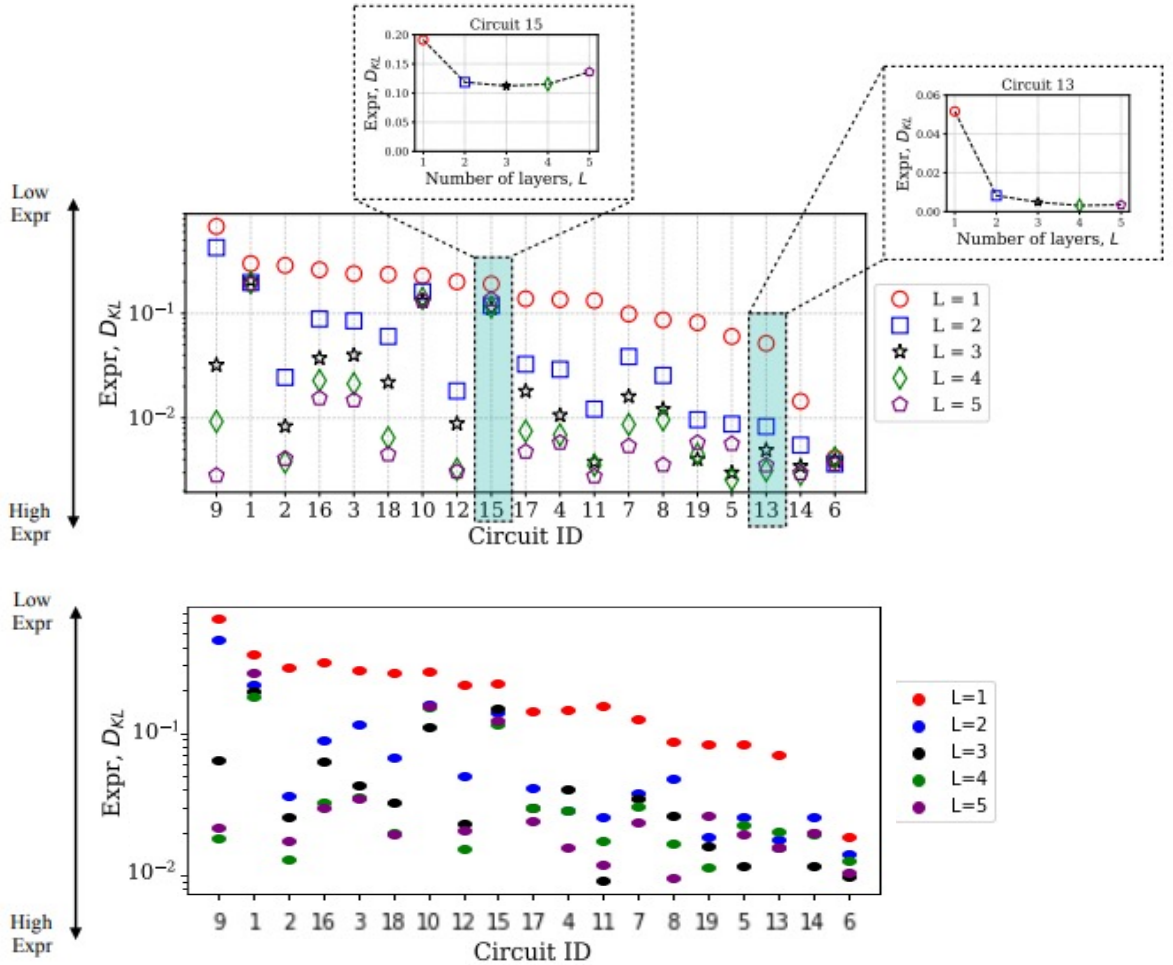
$$\text{Expr} = D_{\text{KL}}(\hat{P}_{\text{PQC}}(F;\boldsymbol{\theta}) \parallel P_{\text{Haar}}(F))$$

arXiv:1905.10876



What was Done

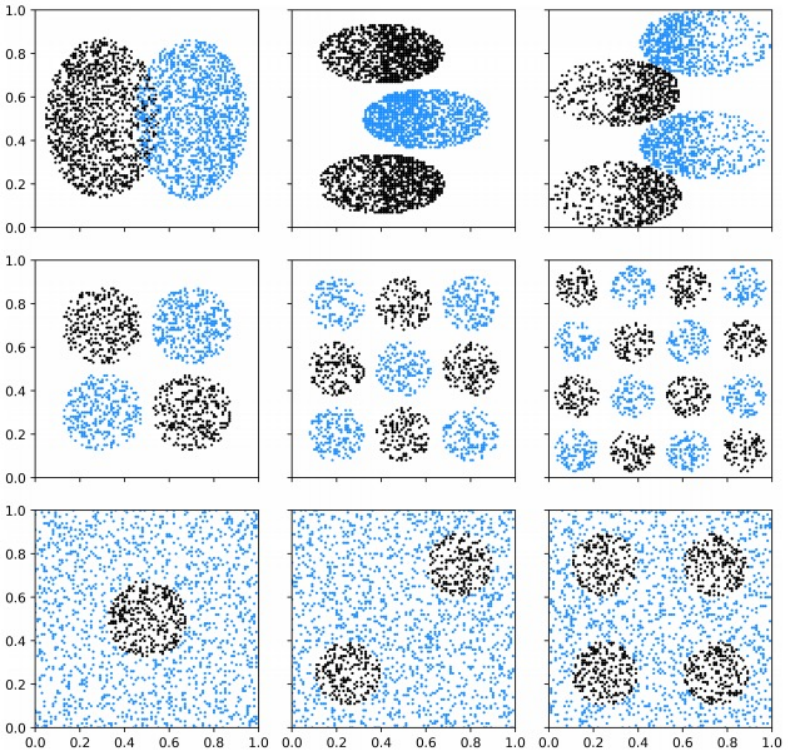
Four-Qubits Expressibility

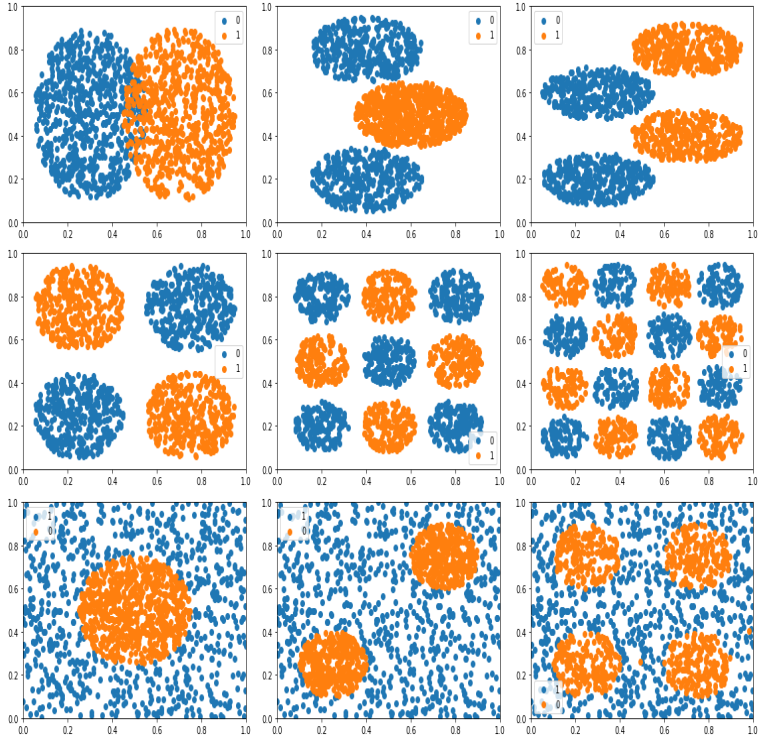


What was Done

Dataset

```
numpy.set_printoptions(threshold=sys.maxsize)
filePath=r'C:\Users\Saesun Kim\Documents\GitHub\Quantum_
data1a = np.array(strtoeval1(readfile(filePath)))
data1alabel = np.array(strtoeval2(readfile(filePath)))
ct=Counter(data1alabel)
```

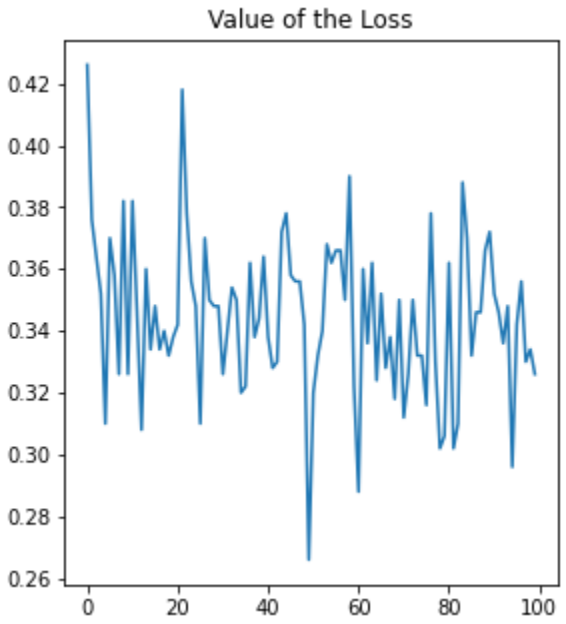


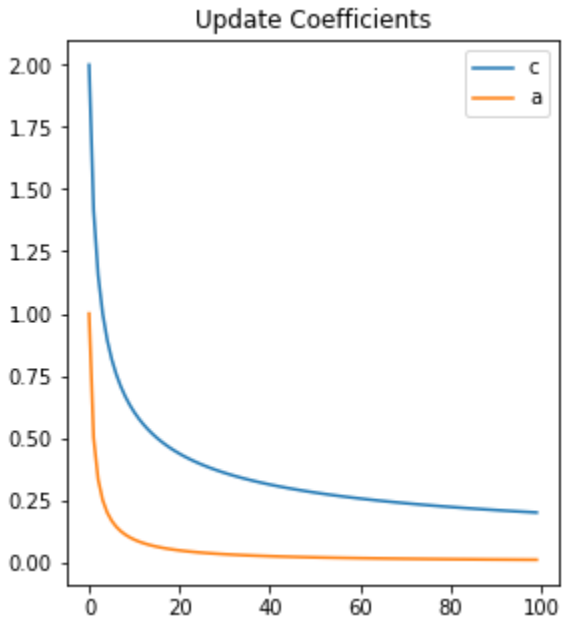


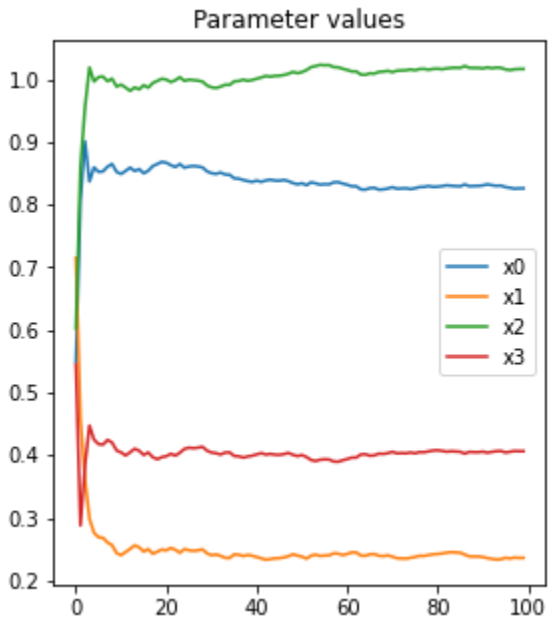
arXiv:2003.09887

What was Done

SPSA Optimizer For Single Point

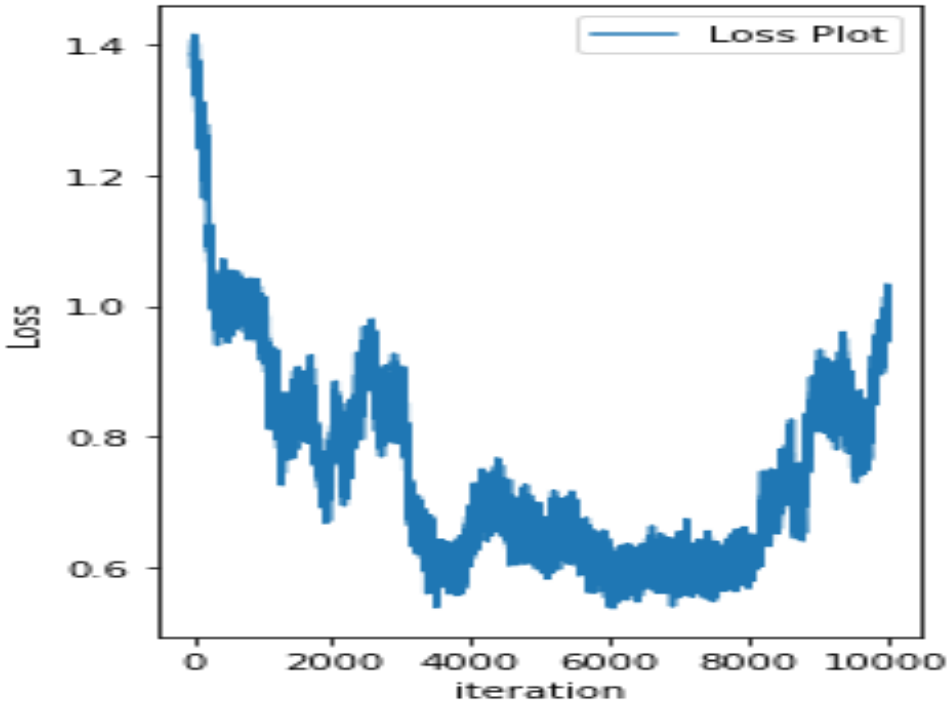


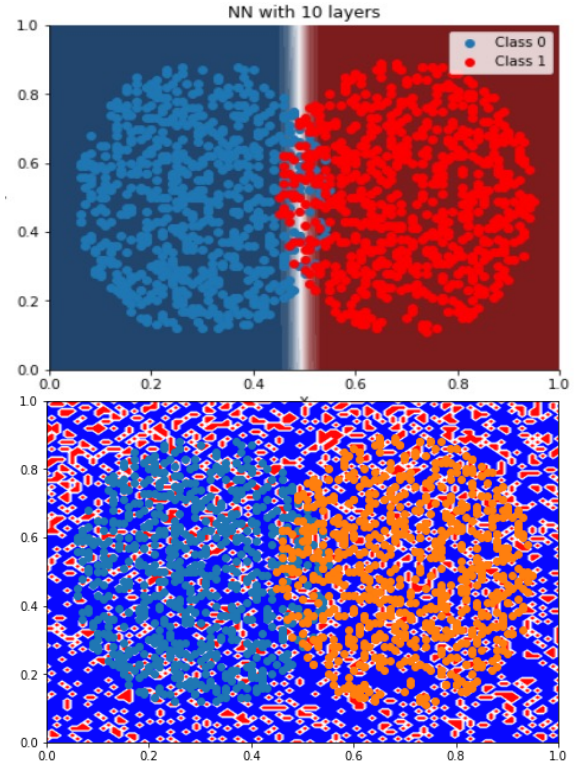




What was Done

SPSA Optimizer For Dataset





Future Plan

Milestones

~~1. Code up the 9-classification datasets~~
~~2. Code up the 19 four-qubits circuits~~
~~3. Calculate the expressibility~~
4. Optimization function
5. Integrating with Pytorch
6. Evaluate accuracy of the classifier
7. Qiskit textbook or blog post