Issue #43: Real-World QML Algorithms

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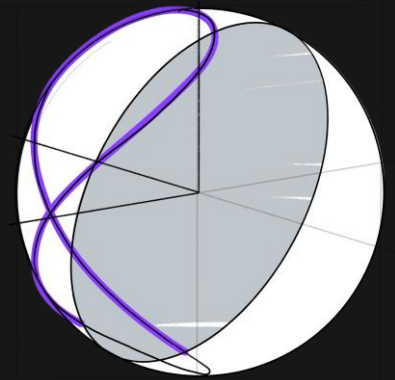

Qiskit

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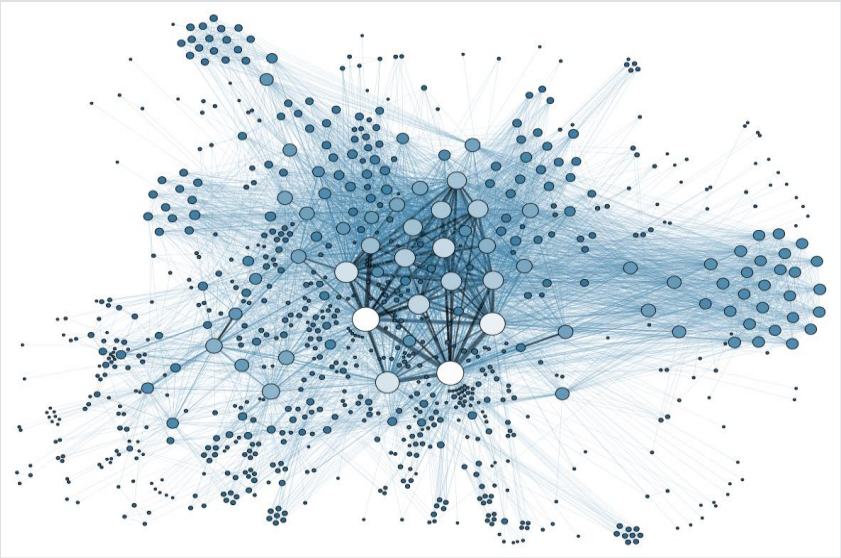
Motivation

- *In ML, theorems don't always translate well to the real world*
- **Real-world data is different**
- Classical ML → **Heuristics**



Issue #43: Real-World QML Algorithms

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Initial Idea

To **Benchmark** recently proposed **QML algorithms** using **real-world examples**

Breakdown

1. ***Implementation*** *using qiskit-machine-learning*
2. *Selection of 1 or more* ***real-world tasks***
3. *Selection of relevant* ***metrics/criteria & comparison***

Issue #43: Real-World QML Algorithms

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Initial Idea

TANGENT

Focus on **Single Qubit Universal Quantum Classifier** by Pérez-Salinas et al.

Breakdown

1. ***Implementation*** *using qiskit-machine-learning*
2. *Selection of 1 or more* ***real-world tasks***
3. *Selection of relevant* ***metrics/criteria & comparison***

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Insights from Pérez-Salinas et al.

[1] → *Data re-uploading for a **universal** quantum classifier* **(2020)**

[2] → *One qubit as a **universal** approximant* **(2021)**

In **theory**, and when tested on synthetic datasets, the proposed single qubit QNN can **learn data distributions** of an **arbitrary dimension**.

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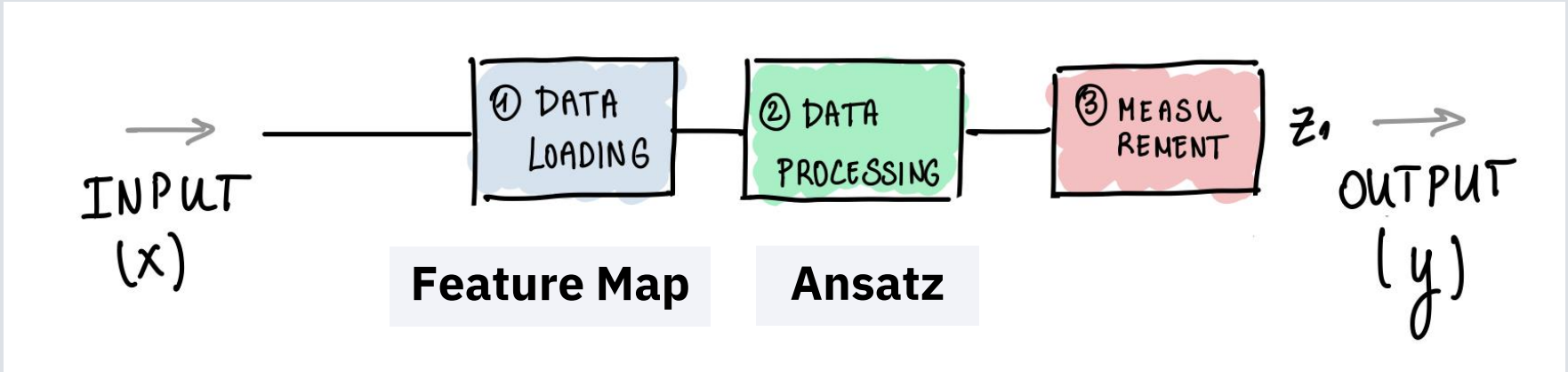
Single-Qubit QNN



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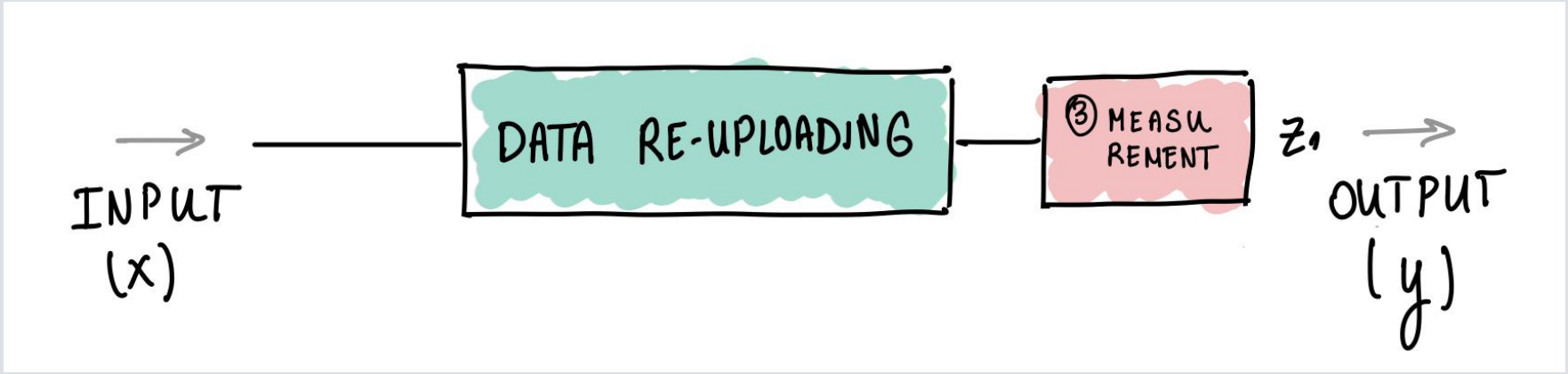
Single-Qubit Universal Classifier



Concept of **Data Re-Uploading** → Data loading = data processing

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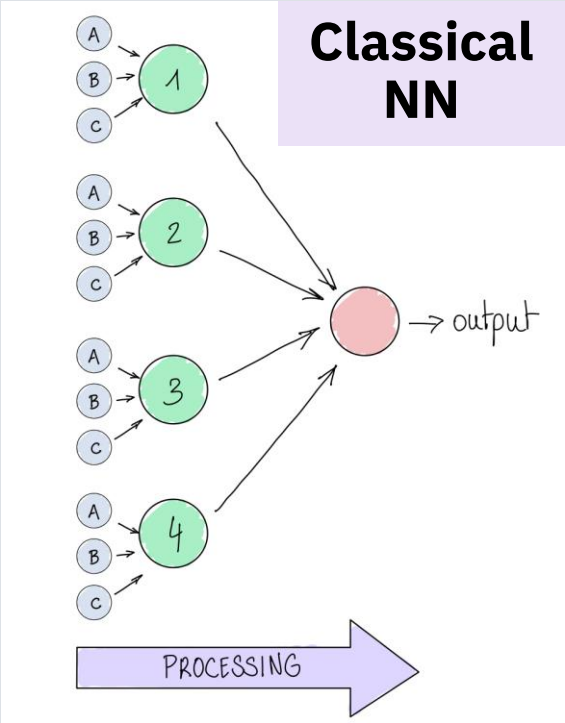
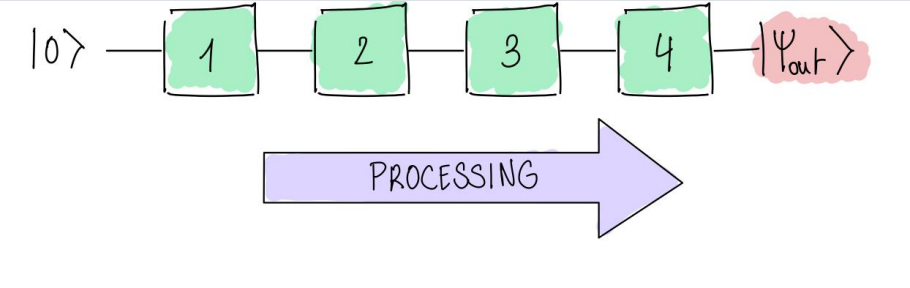


Data Re-Uploading QNN



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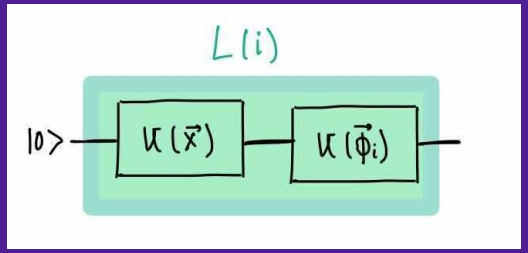
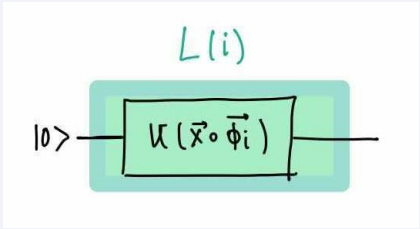
Different Layer formulations

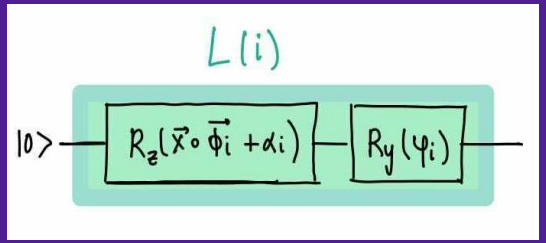
Unitary Layer



Compressed Unitary Layer



UAT Layer



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Implementation in Qiskit

→ **`SQUClassifier()`** extends **`NeuralNetworkClassifier()`**
→ Sample use:

```
classifier = SQUClassifier(num_inputs=3,
                           num_layers=3,
                           layer_type="UAT",
                           optimizer=L_BFGS_B(maxiter=50),
                           callback=callback_graph)

classifier.fit(X_train, y_train)
classifier.score(X_test, y_test)
```

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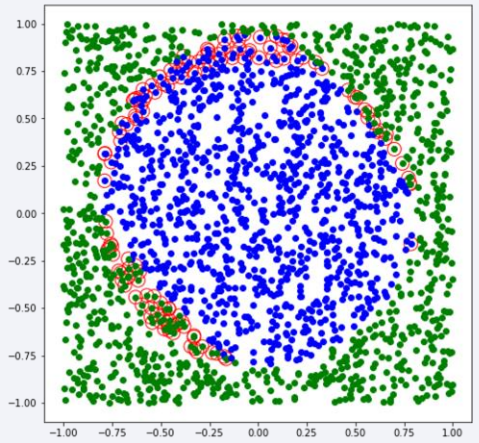
Testing Layer Types → Circle Dataset

Unitary Layer

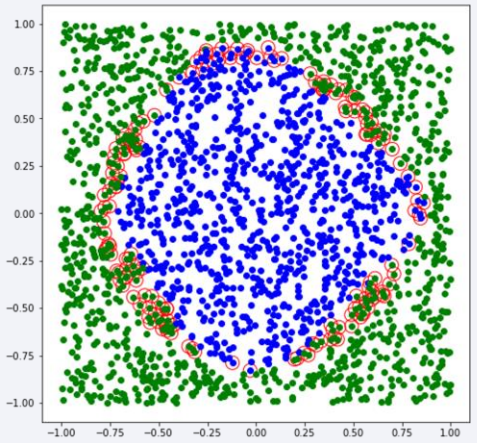
(Test Set)



Accuracy: 92.9%

Compressed Unitary Layer

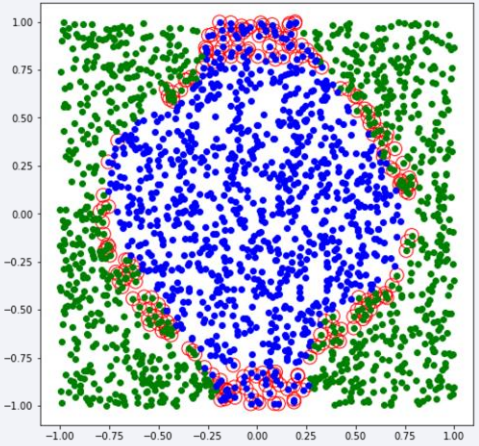
(Test Set)



Accuracy: 90.9%

UAT Layer

(Test Set)



Accuracy: 88%

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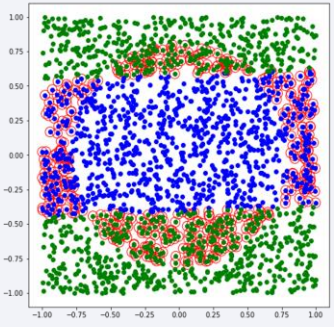
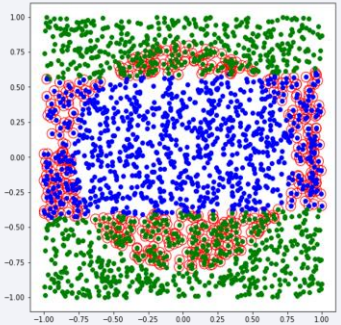
Testing # Layers → Circle Dataset

1 Layer
(Test Set)



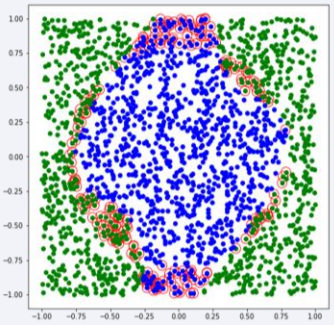
Accuracy:
74%

2 Layers
(Test Set)



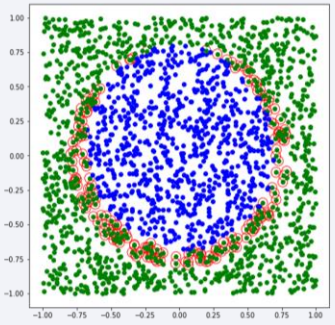
Accuracy:
73%

3 Layers
(Test Set)



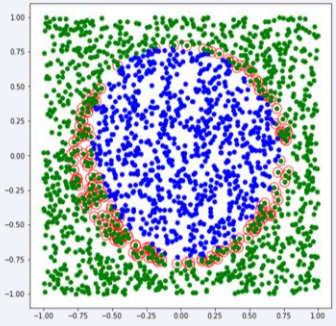
Accuracy:
88%

4 Layers
(Test Set)



Accuracy:
90%

5 Layers
(Test Set)



Accuracy:
90%

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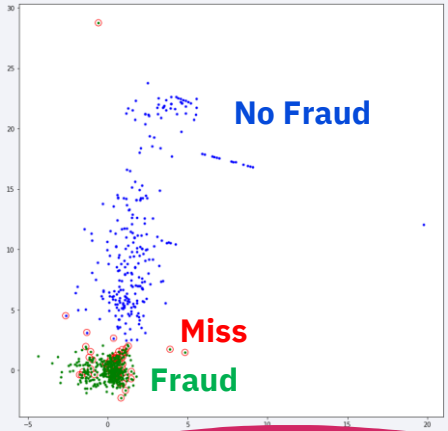
Kaggle Credit Card Fraud Detection Test

BEST QUANTUM NN

1 Qubit, 2 Layers

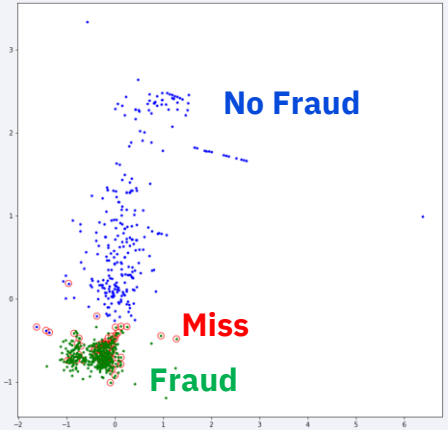


Accuracy: 90.2%

Vs.

BEST CLASSICAL NN

1 Hidden Dense Layer



Accuracy: 89.8%

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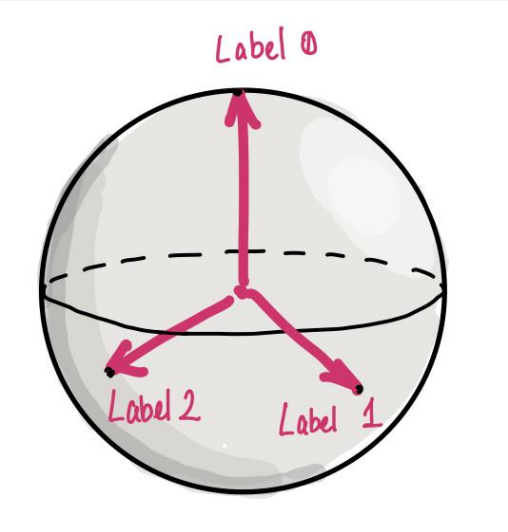
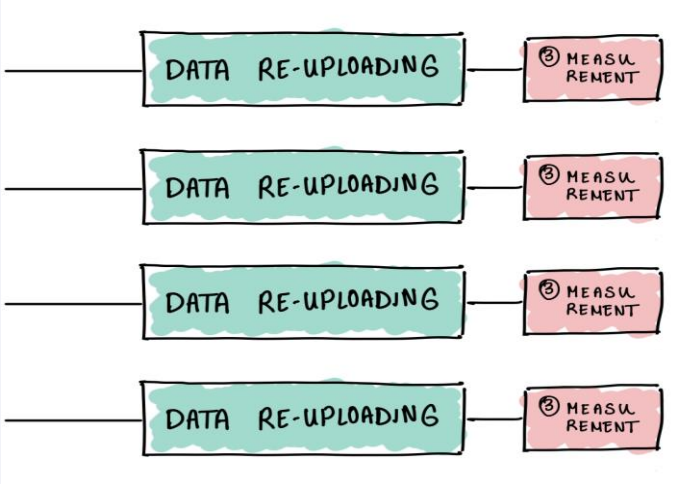
How can we take our qubit further??

Multi-Class Classification



Multi-Qubit Architectures