IRIS

August 27, 2019

```
In [1]: %matplotlib inline
        # Importing standard Qiskit libraries and configuring account
        from qiskit import QuantumCircuit, execute, Aer, IBMQ
        from qiskit.compiler import transpile, assemble
        from qiskit.tools.jupyter import *
        from qiskit.visualization import *
        # Loading your IBM Q account(s)
        provider = IBMQ.load_account()
```

```
In [2]: import numpy as np
        import pandas as pd
        import seaborn as sns
        import matplotlib.pyplot as plt
        from sklearn import datasets
        from sklearn.model_selection import train_test_split
        from sklearn.preprocessing import StandardScaler
        from sklearn.preprocessing import MinMaxScaler
        from sklearn.decomposition import PCA
        from qiskit import Aer
        from qiskit.aqua.utils import split_dataset_to_data_and_labels, map_label_to_class_name
        from qiskit.aqua import run_algorithm, QuantumInstance
        from qiskit.aqua.input import ClassificationInput
        from qiskit.aqua.components.feature_maps import SecondOrderExpansion
        from qiskit.aqua.components.multiclass_extensions.one_against_rest import OneAgainstRes
        from qiskit.aqua.algorithms.many_sample.qsvm import _QSVM_Estimator
        from qiskit.aqua.algorithms import QSVM
        from sklearn.metrics import classification_report
        from sklearn.metrics import confusion_matrix
```

```
In [3]: def Data(dataset, n, PLOT_DATA):
            class_labels = [r'Setosa', r'Versicolor', r'Virginica']
            data, target = datasets.load_iris(True)
            sample_train, sample_test, label_train, label_test = train_test_split(data, target

            # Now we standarize for gaussian around 0 with unit variance
            std_scale = StandardScaler().fit(sample_train)
            sample_train = std_scale.transform(sample_train)
            sample_test = std_scale.transform(sample_test)
```

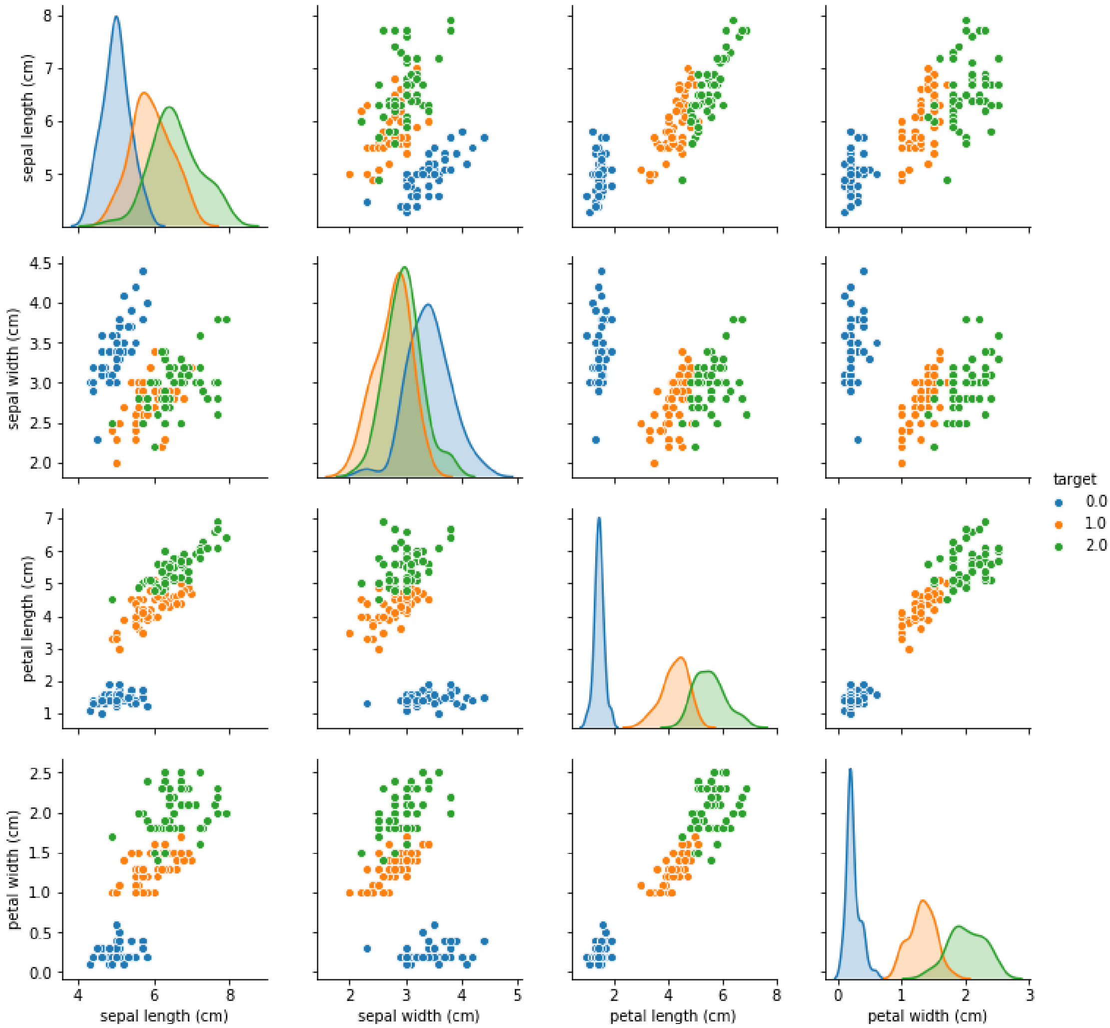
```
        # Now reduce number of features to number of qubits
        pca = PCA(n_components=n).fit(sample_train)
        sample_train = pca.transform(sample_train)
        sample_test = pca.transform(sample_test)

        # Scale to the range (-1,+1)
        samples = np.append(sample_train, sample_test, axis=0)
        minmax_scale = MinMaxScaler((-1, 1)).fit(samples)
        sample_train = minmax_scale.transform(sample_train)
        sample_test = minmax_scale.transform(sample_test)

        training_input = {key: (sample_train[label_train == k, :]) for k, key in enumerate
        test_input =  {key: (sample_test[label_test == k, :]) for k, key in enumerate(clas

        if PLOT_DATA:
            for k in range(0, 3):
                plt.scatter(sample_train[label_train == k, 0],
                            sample_train[label_train == k, 1])

            plt.title("Iris dataset")
            plt.show()

        return sample_train, training_input, test_input, class_labels
```

```
In [4]: feature_dim = 2 # dimension of each data point

        dataset=datasets.load_iris()
        sample_Total, training_input, test_input, class_labels = Data(datasets.load_iris(True)
                                                                       n=feature_dim, PLOT_DATA

        datapoints, class_to_label = split_dataset_to_data_and_labels(test_input)
        print(class_to_label)
```

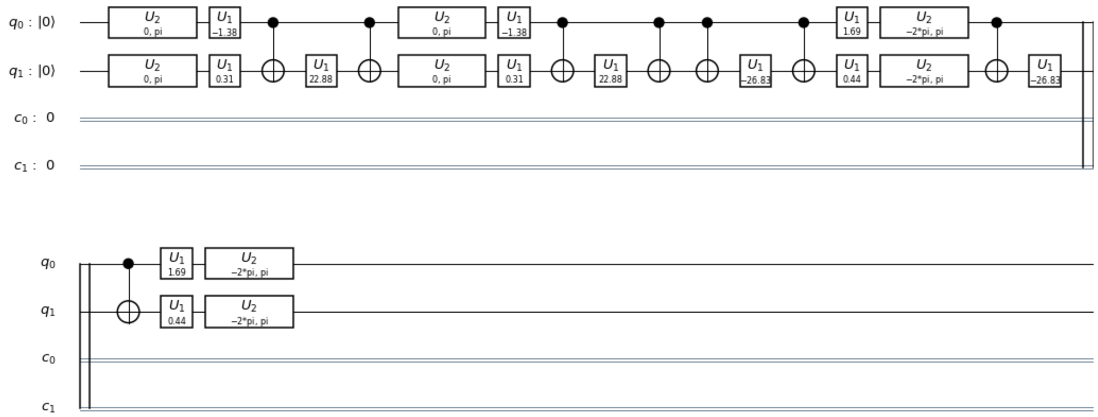
```
{'Setosa': 0, 'Versicolor': 1, 'Virginica': 2}
```

```
In [5]: df = pd.DataFrame( np.c_[dataset['data'], dataset['target']],
                           columns = np.append(dataset['feature_names'], ['target']))
        sns.pairplot(df, hue = 'target',
                     vars = ['sepal length (cm)', 'sepal width (cm)',
                             'petal length (cm)', 'petal width (cm)'] )
```

```
Out[5]: <seaborn.axisgrid.PairGrid at 0x7f41d0ae5828>
```




```
In [6]: params={
            'problem': {'name': 'classification', 'random_seed': 10598},
            'algorithm': {'name': 'QSVM'},
            'feature_map': {'name': 'SecondOrderExpansion', 'depth': 2},
            'multiclass_extension': {'name': 'AllPairs'},
            'backend': { 'name': 'ibmq_20_tokyo', 'shots': 1024}}

        backend = Aer.get_backend('qasm_simulator')
        algo_input = ClassificationInput(training_input, test_input, datapoints[0])

In [7]: feature_map = SecondOrderExpansion(feature_dimension=feature_dim, depth=2, entanglemen
        qsvm = QSVM(feature_map, training_input, test_input, datapoints[0], OneAgainstRest(_QS
        qc = qsvm.construct_circuit(x1=datapoints[0][0], x2=datapoints[0][1]) # these are two 
        qc.draw()

Out[7]:
```



```
In [8]: %time result = run_algorithm(params, algo_input, backend=backend)

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Entry point 'UCCSD = qiskit.chemistry.aqua_extensions.components.variational_forms:UCCSD' requi
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  DeprecationWarning)
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CPU times: user 9min 28s, sys: 1min 5s, total: 10min 34s
Wall time: 24min 12s
```

```
In [9]: print("ground truth:    {}".format(datapoints[1]))
        print("prediction:      {}".format(result['predicted_labels']))
        print("predicted class: {}".format(result['predicted_classes']))
        print("accuracy:        {}".format(result['testing_accuracy']))
```

```
ground truth:    [0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2
 2 2 2 2 2 2 2 2]
prediction:      [0 0 1 2 0 0 0 0 0 0 0 0 0 1 1 1 2 1 1 2 1 1 1 1 2 1 1 2 1 1 2 2 2 2 2 2 2
 2 1 2 2 2 1 2 2]
predicted class: ['Setosa', 'Setosa', 'Versicolor', 'Virginica', 'Setosa', 'Setosa', 'Setosa',
accuracy:        0.8222222222222222
```

```
In [10]: print(classification_report(datapoints[1], result['predicted_labels'],
                                     target_names=dataset.target_names))
```

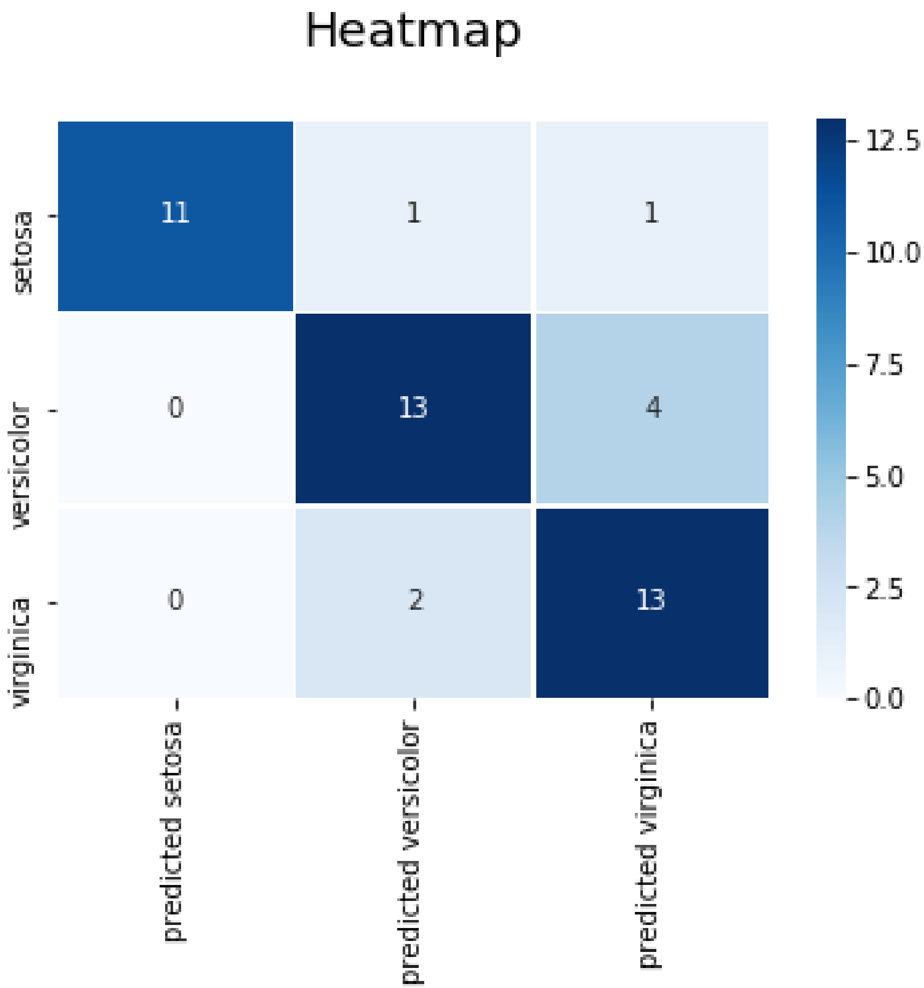
```
              precision    recall  f1-score   support

      setosa       1.00      0.85      0.92        13
  versicolor       0.81      0.76      0.79        17
   virginica       0.72      0.87      0.79        15

    accuracy                           0.82        45
   macro avg       0.84      0.83      0.83        45
weighted avg       0.84      0.82      0.83        45
```

```
In [11]: cm = np.array(confusion_matrix(datapoints[1], result['predicted_labels']))
         confusion = pd.DataFrame(cm, index=dataset.target_names,
                                  columns= ['predicted ' + s for s in dataset.target_names])

         sns.heatmap(confusion, annot=True, fmt="d", linewidths=.5, cmap="Blues")
         plt.title("Heatmap\n", fontdict = {'fontsize': 18})
         plt.show()
```


Heatmap
setosa
versicolor
virginica
11
1
1
0
13
4
0
2
13
predicted setosa
predicted versicolor
predicted virginica
12.5
10.0
7.5
5.0
2.5
0.0

```
In [ ]:
```