```
import random as rn
import numpy as np
from sklearn import model_selection, datasets, svm
from qiskit import QuantumCircuit, Aer, QuantumRegister, ClassicalRegister
from qiskit import execute
IBMQ.save_account('554935130320e98e089a1e743e077bae098a7c13a236f21c4d4f4c71896df5586202ae68a34de97f97d8c3cf4a853ff8832afe8fdec0

import qiskit
import matplotlib.pyplot as plt
import copy
```

```
configrc.store_credentials:WARNING:2023-08-07 16:04:22,866: Credentials already present. Set overwrite=True to overwrite.
```

```
! pip install qiskit-ibmq-provider
```

```
Collecting qiskit-ibmq-provider
  Downloading qiskit_ibmq_provider-0.20.2-py3-none-any.whl (241 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 241.5/241.5 kB 2.6 MB/s eta 0:00:00
Requirement already satisfied: qiskit-terra>=0.18.0 in /usr/local/lib/python3.10/dist-packages (from qiskit-ibmq-provider) (0.25.0)
Requirement already satisfied: requests>=2.19 in /usr/local/lib/python3.10/dist-packages (from qiskit-ibmq-provider) (2.27.1)
Collecting requests-ntlm<=1.1.0 (from qiskit-ibmq-provider)
  Downloading requests_ntlm-1.1.0-py2.py3-none-any.whl (5.7 kB)
Requirement already satisfied: numpy<1.24 in /usr/local/lib/python3.10/dist-packages (from qiskit-ibmq-provider) (1.22.4)
Requirement already satisfied: urllib3>=1.21.1 in /usr/local/lib/python3.10/dist-packages (from qiskit-ibmq-provider) (1.26.16)
Requirement already satisfied: python-dateutil>=2.8.0 in /usr/local/lib/python3.10/dist-packages (from qiskit-ibmq-provider) (2.8.2)
Requirement already satisfied: websocket-client>=1.5.1 in /usr/local/lib/python3.10/dist-packages (from qiskit-ibmq-provider) (1.6.1)
Collecting websockets>=10.0 (from qiskit-ibmq-provider)
  Downloading websockets-11.0.3-cp310-cp310-manylinux_2_5_x86_64.manylinux1_x86_64.manylinux_2_17_x86_64.manylinux2014_x86_64.whl (129 k
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 129.9/129.9 kB 6.5 MB/s eta 0:00:00
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.10/dist-packages (from python-dateutil>=2.8.0->qiskit-ibmq-provider) (
Requirement already satisfied: rustworkx>=0.13.0 in /usr/local/lib/python3.10/dist-packages (from qiskit-terra>=0.18.0->qiskit-ibmq-prov
Requirement already satisfied: ply>=3.10 in /usr/local/lib/python3.10/dist-packages (from qiskit-terra>=0.18.0->qiskit-ibmq-provider) (3
Requirement already satisfied: psutil>=5 in /usr/local/lib/python3.10/dist-packages (from qiskit-terra>=0.18.0->qiskit-ibmq-provider) (5
Requirement already satisfied: scipy>=1.5 in /usr/local/lib/python3.10/dist-packages (from qiskit-terra>=0.18.0->qiskit-ibmq-provider) (
Requirement already satisfied: sympy>=1.3 in /usr/local/lib/python3.10/dist-packages (from qiskit-terra>=0.18.0->qiskit-ibmq-provider) (
Requirement already satisfied: dill>=0.3 in /usr/local/lib/python3.10/dist-packages (from qiskit-terra>=0.18.0->qiskit-ibmq-provider) (0
Requirement already satisfied: stevedore>=3.0.0 in /usr/local/lib/python3.10/dist-packages (from qiskit-terra>=0.18.0->qiskit-ibmq-provi
Requirement already satisfied: symengine<0.10,>=0.9 in /usr/local/lib/python3.10/dist-packages (from qiskit-terra>=0.18.0->qiskit-ibmq-p
Requirement already satisfied: typing-extensions in /usr/local/lib/python3.10/dist-packages (from qiskit-terra>=0.18.0->qiskit-ibmq-prov
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.10/dist-packages (from requests>=2.19->qiskit-ibmq-provider)
Requirement already satisfied: charset-normalizer~=2.0.0 in /usr/local/lib/python3.10/dist-packages (from requests>=2.19->qiskit-ibmq-pr
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.10/dist-packages (from requests>=2.19->qiskit-ibmq-provider) (3.4)
Collecting ntlm-auth>=1.0.2 (from requests-ntlm<=1.1.0->qiskit-ibmq-provider)
  Downloading ntlm_auth-1.5.0-py2.py3-none-any.whl (29 kB)
Requirement already satisfied: cryptography>=1.3 in /usr/lib/python3/dist-packages (from requests-ntlm<=1.1.0->qiskit-ibmq-provider) (3.
Requirement already satisfied: pbr!=2.1.0,>=2.0.0 in /usr/local/lib/python3.10/dist-packages (from stevedore>=3.0.0->qiskit-terra>=0.18.
Requirement already satisfied: mpmath>=0.19 in /usr/local/lib/python3.10/dist-packages (from sympy>=1.3->qiskit-terra>=0.18.0->qiskit-ib
Installing collected packages: websockets, ntlm-auth, requests-ntlm, qiskit-ibmq-provider
Successfully installed ntlm-auth-1.5.0 qiskit-ibmq-provider-0.20.2 requests-ntlm-1.1.0 websockets-11.0.3
```

```
! pip install qiskit
```

```
Collecting qiskit
  Downloading qiskit-0.44.0.tar.gz (8.9 kB)
  Installing build dependencies ... done
  Getting requirements to build wheel ... done
  Installing backend dependencies ... done
  Preparing metadata (pyproject.toml) ... done
Collecting qiskit-terra==0.25.0 (from qiskit)
  Downloading qiskit_terra-0.25.0-cp38-abi3-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (6.1 MB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 6.1/6.1 MB 14.6 MB/s eta 0:00:00
Collecting rustworkx>=0.13.0 (from qiskit-terra==0.25.0->qiskit)
  Downloading rustworkx-0.13.1-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (2.0 MB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 2.0/2.0 MB 27.0 MB/s eta 0:00:00
Requirement already satisfied: numpy>=1.17 in /usr/local/lib/python3.10/dist-packages (from qiskit-terra==0.25.0->qiskit) (1.22.4)
Collecting ply>=3.10 (from qiskit-terra==0.25.0->qiskit)
  Downloading ply-3.11-py2.py3-none-any.whl (49 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 49.6/49.6 kB 5.3 MB/s eta 0:00:00
Requirement already satisfied: psutil>=5 in /usr/local/lib/python3.10/dist-packages (from qiskit-terra==0.25.0->qiskit) (5.9.5)
Requirement already satisfied: scipy>=1.5 in /usr/local/lib/python3.10/dist-packages (from qiskit-terra==0.25.0->qiskit) (1.10.1)
Requirement already satisfied: sympy>=1.3 in /usr/local/lib/python3.10/dist-packages (from qiskit-terra==0.25.0->qiskit) (1.11.1)
Collecting dill>=0.3 (from qiskit-terra==0.25.0->qiskit)
  Downloading dill-0.3.7-py3-none-any.whl (115 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 115.3/115.3 kB 14.2 MB/s eta 0:00:00
Requirement already satisfied: python-dateutil>=2.8.0 in /usr/local/lib/python3.10/dist-packages (from qiskit-terra==0.25.0->qiskit) (2.
Collecting stevedore>=3.0.0 (from qiskit-terra==0.25.0->qiskit)
  Downloading stevedore-5.1.0-py3-none-any.whl (49 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 49.6/49.6 kB 5.4 MB/s eta 0:00:00
Collecting symengine<0.10,>=0.9 (from qiskit-terra==0.25.0->qiskit)
```

```
  Downloading symengine-0.9.2-cp310-cp310-manylinux2010_x86_64.whl (37.5 MB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 37.5/37.5 MB 16.1 MB/s eta 0:00:00
Requirement already satisfied: typing-extensions in /usr/local/lib/python3.10/dist-packages (from qiskit-terra==0.25.0->qiskit) (4.7.1)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.10/dist-packages (from python-dateutil>=2.8.0->qiskit-terra==0.25.0->q
Collecting pbr!=2.1.0,>=2.0.0 (from stevedore>=3.0.0->qiskit-terra==0.25.0->qiskit)
  Downloading pbr-5.11.1-py2.py3-none-any.whl (112 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 112.7/112.7 kB 12.7 MB/s eta 0:00:00
Requirement already satisfied: mpmath>=0.19 in /usr/local/lib/python3.10/dist-packages (from sympy>=1.3->qiskit-terra==0.25.0->qiskit) (
Building wheels for collected packages: qiskit
  Building wheel for qiskit (pyproject.toml) ... done
  Created wheel for qiskit: filename=qiskit-0.44.0-py3-none-any.whl size=7614 sha256=fd10af8051d984c74a28b974b4be8a427211fc7159f79ad208a
  Stored in directory: /root/.cache/pip/wheels/45/90/00/70879ea1304b7b44cde9f737d2a819a87346d62666b3a89de1
Successfully built qiskit
Installing collected packages: ply, symengine, rustworkx, pbr, dill, stevedore, qiskit-terra, qiskit
Successfully installed dill-0.3.7 pbr-5.11.1 ply-3.11 qiskit-0.44.0 qiskit-terra-0.25.0 rustworkx-0.13.1 stevedore-5.1.0 symengine-0.9.2
```

```
1 pip install qiskit-aer
```

```
Collecting qiskit-aer
  Downloading qiskit_aer-0.12.2-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (12.8 MB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 12.8/12.8 MB 22.5 MB/s eta 0:00:00
Requirement already satisfied: qiskit-terra>=0.21.0 in /usr/local/lib/python3.10/dist-packages (from qiskit-aer) (0.25.0)
Requirement already satisfied: numpy>=1.16.3 in /usr/local/lib/python3.10/dist-packages (from qiskit-aer) (1.22.4)
Requirement already satisfied: scipy>=1.0 in /usr/local/lib/python3.10/dist-packages (from qiskit-aer) (1.10.1)
Requirement already satisfied: rustworkx>=0.13.0 in /usr/local/lib/python3.10/dist-packages (from qiskit-terra>=0.21.0->qiskit-aer) (0.1
Requirement already satisfied: ply>=3.10 in /usr/local/lib/python3.10/dist-packages (from qiskit-terra>=0.21.0->qiskit-aer) (3.11)
Requirement already satisfied: psutil>=5 in /usr/local/lib/python3.10/dist-packages (from qiskit-terra>=0.21.0->qiskit-aer) (5.9.5)
Requirement already satisfied: sympy>=1.3 in /usr/local/lib/python3.10/dist-packages (from qiskit-terra>=0.21.0->qiskit-aer) (1.11.1)
Requirement already satisfied: dill>=0.3 in /usr/local/lib/python3.10/dist-packages (from qiskit-terra>=0.21.0->qiskit-aer) (0.3.7)
Requirement already satisfied: python-dateutil>=2.8.0 in /usr/local/lib/python3.10/dist-packages (from qiskit-terra>=0.21.0->qiskit-aer)
Requirement already satisfied: stevedore>=3.0.0 in /usr/local/lib/python3.10/dist-packages (from qiskit-terra>=0.21.0->qiskit-aer) (5.1.
Requirement already satisfied: symengine<0.10,>=0.9 in /usr/local/lib/python3.10/dist-packages (from qiskit-terra>=0.21.0->qiskit-aer) (
Requirement already satisfied: typing-extensions in /usr/local/lib/python3.10/dist-packages (from qiskit-terra>=0.21.0->qiskit-aer) (4.7
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.10/dist-packages (from python-dateutil>=2.8.0->qiskit-terra>=0.21.0->q
Requirement already satisfied: pbr!=2.1.0,>=2.0.0 in /usr/local/lib/python3.10/dist-packages (from stevedore>=3.0.0->qiskit-terra>=0.21.
Requirement already satisfied: mpmath>=0.19 in /usr/local/lib/python3.10/dist-packages (from sympy>=1.3->qiskit-terra>=0.21.0->qiskit-ae
Installing collected packages: qiskit-aer
Successfully installed qiskit-aer-0.12.2
```

```
1 iris=datasets.load_iris()
2 X=iris.data[0:100]
3 y=iris.target[0:100]
4 X_train, X_test, y_train, y_test=model_selection.train_test_split(X,y, test_size=0.33, random_state=42)
```

```
1 print(y_train)
```

```
[0 1 0 1 1 0 0 0 0 0 1 0 0 1 0 1 0 0 0 0 0 0 1 0 1 0 1 1 1 1 0 1 1 0 1 1 1
 1 0 1 0 1 1 1 0 1 1 1 1 0 0 0 1 0 0 0 1 1 1 1 1 0 1 1 0 1 1]
```

```
1 print(X_train)
```

```
[5.  3.4 1.5 0.2]
[5.7 3.  4.2 1.2]
[5.2 3.5 1.5 0.2]
[5.1 3.8 1.5 0.3]
[5.5 2.4 3.7 1. ]
[5.  3.  1.6 0.2]
[6.  2.2 4.  1. ]
[4.3 3.  1.1 0.1]
[4.8 3.4 1.9 0.2]
[4.6 3.1 1.5 0.2]
[5.1 3.5 1.4 0.3]
[4.4 3.  1.3 0.2]
[4.4 2.9 1.4 0.2]
[6.  2.9 4.5 1.5]
[4.6 3.4 1.4 0.3]
[5.6 2.9 3.6 1.3]
[5.5 3.5 1.3 0.2]
[5.5 2.5 4.  1.3]
```

```
[6.2 2.9 4.3 1.3]
[5.7 2.6 3.5 1. ]
[4.5 2.3 1.3 0.3]
[6.6 2.9 4.6 1.3]
[5.3 3.7 1.5 0.2]
[5.1 2.5 3.  1.1]
[4.9 2.4 3.3 1. ]
[6.6 3.  4.4 1.4]
[5.2 4.1 1.5 0.1]
[5.6 2.7 4.2 1.3]
[5.2 2.7 3.9 1.4]
[6.1 2.9 4.7 1.4]
[5.4 3.  4.5 1.5]
[4.9 3.6 1.4 0.1]
[4.7 3.2 1.6 0.2]
[4.9 3.  1.4 0.2]
[6.9 3.1 4.9 1.5]
[5.1 3.7 1.5 0.4]
[4.7 3.2 1.3 0.2]
[5.1 3.3 1.7 0.5]
[6.3 2.3 4.4 1.3]
[6.1 3.  4.6 1.4]
[6.4 2.9 4.3 1.3]
[6.7 3.1 4.7 1.5]
[5.8 2.7 3.9 1.2]
[5.4 3.4 1.7 0.2]
[5.  2.  3.5 1. ]
[6.1 2.8 4.  1.3]
[5.8 4.  1.2 0.2]
[5.8 2.6 4.  1.2]
[6.4 3.2 4.5 1.5]]
```

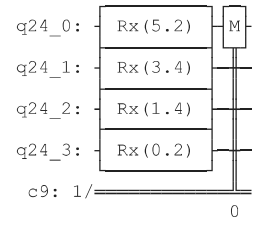
```
print(X_train[0])
```

```
[5.2 3.4 1.4 0.2]
```

```
N=4
```

```
def feature_map(X):

    q=QuantumRegister(N)
    c=ClassicalRegister(1)

    qc=QuantumCircuit(q,c)

    for i, x in enumerate(X_train[0]):
      qc.rx(x,i)

    return qc, c
```

```
qc, c=feature_map(X_train[0])

qc.measure(0,c)
qc.draw()
```



```
def variational_circuit(qc, theta):
    for i in range(N-1):
      qc.cnot(i, i+1)
    qc.cnot(N-1,0)

    for i in range(N):
      qc.ry(theta[i],i)
    return qc
```

```
def quantum_nn(x_theta,simulator=True):
  qc,c=feature_map(X_train[5])
  qc=variational_circuit(qc,np.random.rand(N))
  qc.measure(0,c)

  shots=1E4
  backend=Aer.get_backend('qasm_simulator')

  #if simulator ==False:
     # shots=5000
      #provider=IBMQ.load_account()
      #backend=provider.get_backend('ibm_kyiv')

  job= qiskit.execute(qc,backend, shots=shots)
  result = job.result()
  counts=result.get_counts(qc)

  return counts['1']/shots
```

```


def loss(prediction, target):
  return (prediction-target)**2
```

```
target=y_train[6]
```

```
prediction=quantum_nn(X_train[5], np.random.rand(N))
```

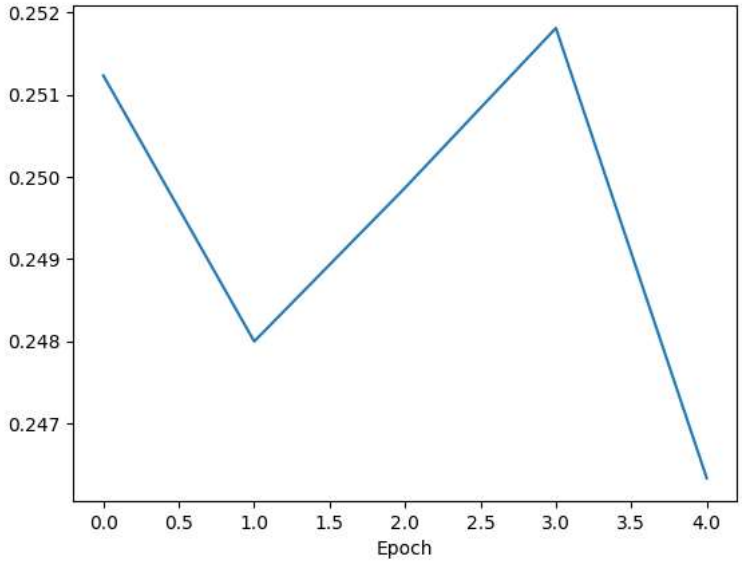
```
def gradient(X, y, theta):
  delta=0.01
  grad=[]
  for i in range(len(theta)):
    dtheta=copy.copy(theta)
    dtheta[i]+=delta

    pred1=quantum_nn(X, dtheta)
    pred2=quantum_nn(X,theta)

    grad.append((loss(pred1,y)-loss(pred2,y))/delta)

  return np.array(grad)
```

```
def accuracy(X, y, theta):
  counter=0
  for X_i, y_i in zip(X,y):
    prediction=quantum_nn(X_i, theta)

    if prediction<0.5 and y_i==0:
      counter+=1

    elif prediction >=0.5 and y_i==1:
      counter+=1

  return counter/len(y)
```

```
eta=0.05
loss_list=[]
theta=np.ones(N)
for i in range(5): # change values inside range to observe accuracy
  loss_tmp=[]
  for X_i, y_i in zip(X_train, y_train):

      prediction=quantum_nn(X_i, theta)
      loss_tmp.append(loss(prediction, y_i))
      theta=theta - eta * gradient (X_i,y_i, theta)

  loss_list.append(np.mean(loss_tmp))
  acc=accuracy(X_train,y_train, theta)

  print(f'{i} \t {loss_list[-1]:.3f} \t {acc:.3f}')
```

```
1       0.250   0.537
2       0.252   0.537
3       0.250   0.537
4       0.251   0.537
```

```
plt.plot(loss_list)
plt.xlabel('Epoch')
plt.show('Loss')
plt.show
```




```
<function matplotlib.pyplot.show(close=None, block=None)>
```

```
accuracy(X_test, y_test, theta)
```

```
0.42424242424242425
```

```
clf=svm.SVC()
clf.fit(X_train,y_train)
```

SVC
SVC()

```
print(clf.predict(X_test))
print(y_test)
```

```
[1 1 1 0 0 0 0 1 0 0 0 0 1 0 1 0 1 1 0 0 1 1 0 0 1 0 0 1 0 1 0 0 1]
[1 1 1 0 0 0 0 1 0 0 0 0 1 0 1 0 1 1 0 0 1 1 0 0 1 0 0 1 0 1 0 0 1]
```

```
quantum_nn(X_test[0], theta)
```

```
0.5624
```

```
1 y_test[6]
```

```
    0
```