Daniel Garcia - RNN Apple Stock Prediction

November 21, 2022

Apple Stock Market: https://www.kaggle.com/datasets/meetnagadia/apple-stock-price-from-19802021

[1]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
```

[2]:
```
apple = pd.read_csv("desktop/Apple/Apple_2005_2019.csv")
apple.head()
```

[2]:

	Date	Open	High	Low	Close	Adj Close	Volume
0	3/1/2005	1.156786	1.162679	1.117857	1.130179	0.966323	691992000
1	4/1/2005	1.139107	1.169107	1.124464	1.141786	0.976247	1096810400
2	5/1/2005	1.151071	1.165179	1.143750	1.151786	0.984798	680433600
3	6/1/2005	1.154821	1.159107	1.130893	1.152679	0.985561	705555200
4	7/1/2005	1.160714	1.243393	1.156250	1.236607	1.057321	2227450400

We will create a new feature called 'Average' that calculates the average between Open and Close. We will build our model using this feature.

[3]:
```
apple['Average'] = ( apple['Open'] + apple['Close'] ) / 2
apple.head()
```

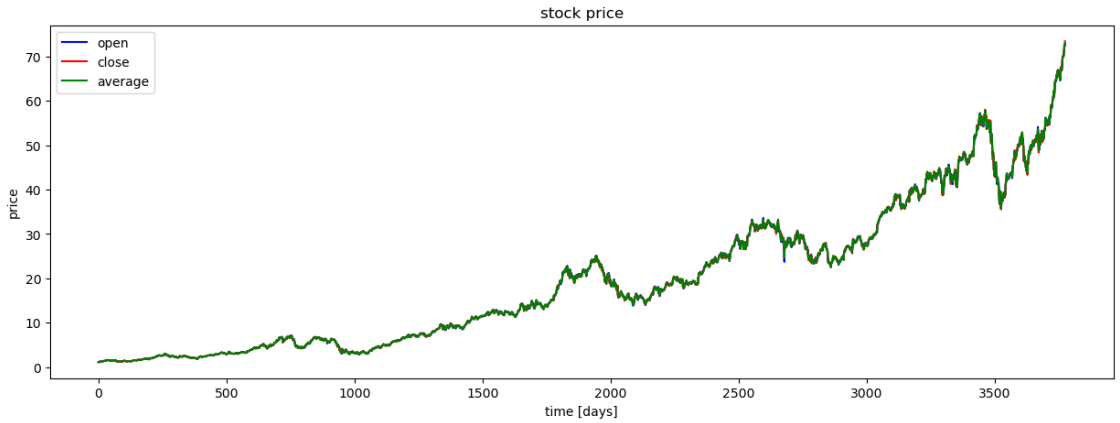
[3]:

	Date	Open	High	Low	Close	Adj Close	Volume	Average
0	3/1/2005	1.156786	1.162679	1.117857	1.130179	0.966323	691992000	1.143483
1	4/1/2005	1.139107	1.169107	1.124464	1.141786	0.976247	1096810400	1.140446
2	5/1/2005	1.151071	1.165179	1.143750	1.151786	0.984798	680433600	1.151428
3	6/1/2005	1.154821	1.159107	1.130893	1.152679	0.985561	705555200	1.153750
4	7/1/2005	1.160714	1.243393	1.156250	1.236607	1.057321	2227450400	1.198660

[4]:
```
plt.figure(figsize=(15,5));
plt.plot(apple.Open.values, color='blue', label='open')
```

```
plt.plot(apple.Close.values, color='red', label='close')
plt.plot(apple.Average.values, color='green', label='average')
plt.title('stock price')
plt.xlabel('time [days]')
plt.ylabel('price')
plt.legend(loc='best')
```

[4]: <matplotlib.legend.Legend at 0x14571fbb0>



0.1 Split Train and Test

If we randomly choose samples for train and test, we might find several train samples similar to the test ones and get high accuracy, but this would be fake.

Therefore we will split the train and test set between the first 80% samples and the last 20%.

[5]:
```
test_size = 0.2
k = np.round(len(apple)*(1-test_size)).astype(int)
apple_train, apple_test = apple[:k], apple[k:]
print("{} train samples, {} test samples".format(apple_train.shape[0],␣
  ↪apple_test.shape[0]))
```

```
3020 train samples, 755 test samples
```

[6]:
```
apple_train.head()
```

[6]:

	Date	Open	High	Low	Close	Adj Close	Volume	\
0	3/1/2005	1.156786	1.162679	1.117857	1.130179	0.966323	691992000	
1	4/1/2005	1.139107	1.169107	1.124464	1.141786	0.976247	1096810400	
2	5/1/2005	1.151071	1.165179	1.143750	1.151786	0.984798	680433600	
3	6/1/2005	1.154821	1.159107	1.130893	1.152679	0.985561	705555200	
4	7/1/2005	1.160714	1.243393	1.156250	1.236607	1.057321	2227450400	

```
    Average
0  1.143483
1  1.140446
2  1.151428
3  1.153750
4  1.198660
```

[7]:
```
average_train = apple_train.iloc[:,7:].values
average_train
```

[7]:
```
array([[ 1.1434825],
       [ 1.1404465],
       [ 1.1514285],
       …,
       [29.2225   ],
       [29.285    ],
       [29.1475   ]])
```

[8]:
```
from sklearn.preprocessing import MinMaxScaler

sc = MinMaxScaler(feature_range = (0,1))
apple_scaled = sc.fit_transform(average_train)
apple_scaled
```

[8]:
```
array([[9.48800286e-05],
       [0.00000000e+00],
       [3.43205690e-04],
       …,
       [8.77610685e-01],
       [8.79563914e-01],
       [8.75266811e-01]])
```

[9]:
```
x_train = []
y_train = []

k = 1
lent = apple_scaled.shape[0]

for i in range(k,lent):
    x_train.append(apple_scaled[i-k:i, 0])
    y_train.append(apple_scaled[i,0])
x_train,y_train = np.array(x_train),np.array(y_train)

print(x_train.shape, y_train.shape)
```

```
(3019, 1) (3019,)
```

[10]:
```
x_train = np.reshape(x_train, (x_train.shape[0],x_train.shape[1],1))
```

0.2 Baseline: RNN

[11]:
```
from keras.models import Sequential
from keras.layers import Dense
from keras.layers import SimpleRNN
from keras.layers import Dropout

apple_rnn = Sequential()
apple_rnn.add(SimpleRNN(units = 50,return_sequences = True,input_shape =␣
 ↪(x_train.shape[1],1)))
```

```
Metal device set to: Apple M1 Max

2022-11-21 20:08:33.079127: I
tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:306]
Could not identify NUMA node of platform GPU ID 0, defaulting to 0. Your kernel
may not have been built with NUMA support.
2022-11-21 20:08:33.079255: I
tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:272]
Created TensorFlow device (/job:localhost/replica:0/task:0/device:GPU:0 with 0
MB memory) -> physical PluggableDevice (device: 0, name: METAL, pci bus id:
<undefined>)
```

[12]:
```
apple_rnn.add(Dropout(0.2))
apple_rnn.add(SimpleRNN(units = 50,return_sequences = False))
apple_rnn.add(Dropout(0.2))
apple_rnn.add(Dense(units = 1))
```

[13]:
```
import tensorflow as tf

apple_rnn.compile(optimizer = 'adam',loss = 'mean_squared_error')

with tf.device('/cpu:0'):
    apple_rnn.fit(x_train,y_train,epochs = 100, batch_size = 32)
```

```
Epoch 1/100

2022-11-21 20:08:33.231620: W
tensorflow/core/platform/profile_utils/cpu_utils.cc:128] Failed to get CPU
frequency: 0 Hz

 1/95 […] - ETA: 1:07 - loss: 0.1917

2022-11-21 20:08:33.804013: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:114]
Plugin optimizer for device_type GPU is enabled.

95/95 [==============================] - 1s 5ms/step - loss: 0.0225
Epoch 2/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0065
Epoch 3/100
```

```
95/95 [==============================] - 0s 4ms/step - loss: 0.0043
Epoch 4/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0036
Epoch 5/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0034
Epoch 6/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0027
Epoch 7/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0026
Epoch 8/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0025
Epoch 9/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0022
Epoch 10/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0021
Epoch 11/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0018
Epoch 12/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0018
Epoch 13/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0017
Epoch 14/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0017
Epoch 15/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0016
Epoch 16/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0016
Epoch 17/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0016
Epoch 18/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0016
Epoch 19/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0016
Epoch 20/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0014
Epoch 21/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0016
Epoch 22/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0014
Epoch 23/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0014
Epoch 24/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0013
Epoch 25/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0013
Epoch 26/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0013
Epoch 27/100
```

```
95/95 [==============================] - 0s 4ms/step - loss: 0.0013
Epoch 28/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0013
Epoch 29/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0013
Epoch 30/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0012
Epoch 31/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0012
Epoch 32/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0012
Epoch 33/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0012
Epoch 34/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0012
Epoch 35/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0012
Epoch 36/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0012
Epoch 37/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0012
Epoch 38/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0012
Epoch 39/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0012
Epoch 40/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 41/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0012
Epoch 42/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 43/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0010
Epoch 44/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 45/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 46/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0012
Epoch 47/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 48/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 49/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0012
Epoch 50/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 51/100
```

```
95/95 [==============================] - 0s 4ms/step - loss: 0.0010
Epoch 52/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 53/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0012
Epoch 54/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 55/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 56/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 57/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0010
Epoch 58/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 59/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 60/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0012
Epoch 61/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 62/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 63/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 64/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0012
Epoch 65/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 66/100
95/95 [==============================] - 0s 4ms/step - loss: 9.7274e-04
Epoch 67/100
95/95 [==============================] - 0s 4ms/step - loss: 9.9490e-04
Epoch 68/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0010
Epoch 69/100
95/95 [==============================] - 0s 4ms/step - loss: 9.9720e-04
Epoch 70/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0010
Epoch 71/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 72/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0010
Epoch 73/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 74/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 75/100
```

```
95/95 [==============================] - 0s 4ms/step - loss: 0.0010
Epoch 76/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0010
Epoch 77/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0010
Epoch 78/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 79/100
95/95 [==============================] - 0s 4ms/step - loss: 9.9989e-04
Epoch 80/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0010
Epoch 81/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0010
Epoch 82/100
95/95 [==============================] - 0s 4ms/step - loss: 9.7641e-04
Epoch 83/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0010
Epoch 84/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 85/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0010
Epoch 86/100
95/95 [==============================] - 0s 4ms/step - loss: 9.9193e-04
Epoch 87/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0010
Epoch 88/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0010
Epoch 89/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0012
Epoch 90/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0010
Epoch 91/100
95/95 [==============================] - 0s 4ms/step - loss: 9.7822e-04
Epoch 92/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0010
Epoch 93/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 94/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0010
Epoch 95/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 96/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0010
Epoch 97/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 98/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 99/100
```

```
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 100/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0010
```

[14]:
```
real_stock_apple = apple_test.iloc[:,7:].values
```

[15]:
```
dataset_total = apple['Average']

inputs = dataset_total[len(dataset_total) - len(apple_test)-k:].values
```

[16]:
```
inputs = inputs.reshape(-1,1)
inputs = sc.transform(inputs)
```

[17]:
```
x_test = []

lent2 = apple_test.shape[0]

for i in range(k,lent2):
    x_test.append(inputs[i-k:i,0])

x_test = np.array(x_test)
x_test.shape
```

[17]:
```
(754, 1)
```

[18]:
```
x_test = np.reshape(x_test, (x_test.shape[0],x_test.shape[1],1))
x_test.shape
```

[18]:
```
(754, 1, 1)
```

0.3 RNN Prediction

[19]:
```
predicted_price = apple_rnn.predict(x_test)
```

```
24/24 [==============================] - 0s 6ms/step

2022-11-21 20:09:15.970435: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:114]
Plugin optimizer for device_type GPU is enabled.
```

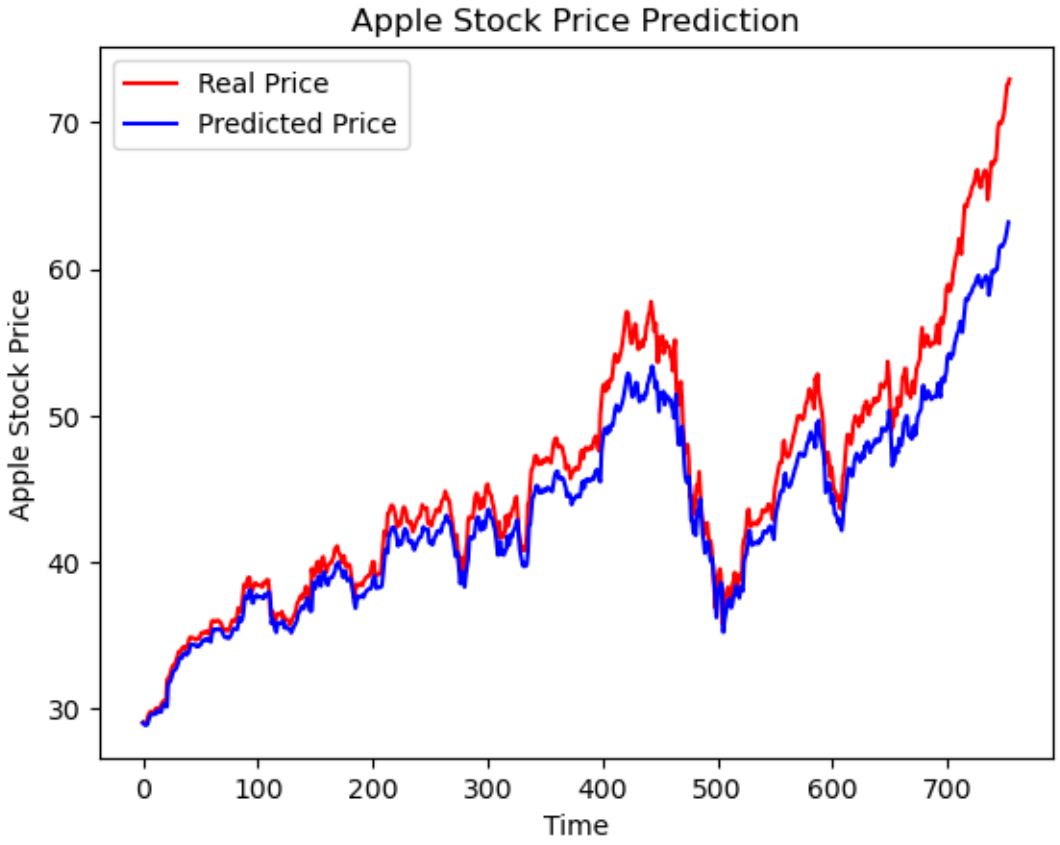
[20]:
```
predicted_price.shape
```

[20]:
```
(754, 1)
```

[21]:
```
predicted_price = sc.inverse_transform(predicted_price)
```

[22]:
```
plt.plot(real_stock_apple,color = 'red', label = 'Real Price')
plt.plot(predicted_price, color = 'blue', label = 'Predicted Price')
plt.title('Apple Stock Price Prediction')
```

```
plt.xlabel('Time')
plt.ylabel('Apple Stock Price')
plt.legend()
plt.show()
```



[23]:
```
real_stock_apple.shape
```

[23]: (755, 1)

[24]:
```
from sklearn.metrics import r2_score

real_stock_apple = real_stock_apple[:(len(real_stock_apple)-k)]

for i in range(real_stock_apple.shape[1]):
    print(r2_score(real_stock_apple[:, i], predicted_price[:, i]))
```

```
0.8943320267298761
```

0.4 Experiment 1 LSTM

[25]:
```
from keras.layers import LSTM

apple_lstm = Sequential()
apple_lstm.add(LSTM(units = 50,return_sequences = True,input_shape = (x_train.
 ↪shape[1],1)))
```

[26]:
```
apple_lstm.add(Dropout(0.2))
apple_lstm.add(LSTM(units = 50,return_sequences = False))
apple_lstm.add(Dropout(0.2))
apple_lstm.add(Dense(units = 1))
```

[27]:
```
apple_lstm.compile(optimizer = 'adam',loss = 'mean_squared_error')

with tf.device('/cpu:0'):
    apple_lstm.fit(x_train,y_train,epochs = 100, batch_size = 32)
```

```
Epoch 1/100

2022-11-21 20:09:17.714567: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:114]
Plugin optimizer for device_type GPU is enabled.

95/95 [==============================] - 2s 4ms/step - loss: 0.0853
Epoch 2/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0068
Epoch 3/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0032
Epoch 4/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0029
Epoch 5/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0026
Epoch 6/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0023
Epoch 7/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0021
Epoch 8/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0019
Epoch 9/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0018
Epoch 10/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0018
Epoch 11/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0018
Epoch 12/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0017
Epoch 13/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0016
```

```
Epoch 14/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0015
Epoch 15/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0015
Epoch 16/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0015
Epoch 17/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0016
Epoch 18/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0015
Epoch 19/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0014
Epoch 20/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0014
Epoch 21/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0013
Epoch 22/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0014
Epoch 23/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0014
Epoch 24/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0013
Epoch 25/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0013
Epoch 26/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0013
Epoch 27/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0012
Epoch 28/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0012
Epoch 29/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0012
Epoch 30/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0012
Epoch 31/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0012
Epoch 32/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0012
Epoch 33/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0012
Epoch 34/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0012
Epoch 35/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0012
Epoch 36/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 37/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
```

```
Epoch 38/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0013
Epoch 39/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 40/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 41/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 42/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 43/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0012
Epoch 44/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 45/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 46/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 47/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 48/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0010
Epoch 49/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 50/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0010
Epoch 51/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 52/100
95/95 [==============================] - 0s 4ms/step - loss: 9.9052e-04
Epoch 53/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0010
Epoch 54/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0010
Epoch 55/100
95/95 [==============================] - 0s 4ms/step - loss: 9.9594e-04
Epoch 56/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0010
Epoch 57/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0010
Epoch 58/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0010
Epoch 59/100
95/95 [==============================] - 0s 4ms/step - loss: 9.8468e-04
Epoch 60/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0010
Epoch 61/100
95/95 [==============================] - 0s 4ms/step - loss: 9.5674e-04
```

```
Epoch 62/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0010
Epoch 63/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0010
Epoch 64/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0010
Epoch 65/100
95/95 [==============================] - 0s 4ms/step - loss: 9.9133e-04
Epoch 66/100
95/95 [==============================] - 0s 4ms/step - loss: 9.5662e-04
Epoch 67/100
95/95 [==============================] - 0s 4ms/step - loss: 9.4235e-04
Epoch 68/100
95/95 [==============================] - 0s 4ms/step - loss: 9.2201e-04
Epoch 69/100
95/95 [==============================] - 0s 4ms/step - loss: 9.9706e-04
Epoch 70/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0010
Epoch 71/100
95/95 [==============================] - 0s 4ms/step - loss: 9.9587e-04
Epoch 72/100
95/95 [==============================] - 0s 4ms/step - loss: 9.8229e-04
Epoch 73/100
95/95 [==============================] - 0s 4ms/step - loss: 9.4019e-04
Epoch 74/100
95/95 [==============================] - 0s 4ms/step - loss: 9.7780e-04
Epoch 75/100
95/95 [==============================] - 0s 4ms/step - loss: 9.0760e-04
Epoch 76/100
95/95 [==============================] - 0s 4ms/step - loss: 9.7800e-04
Epoch 77/100
95/95 [==============================] - 0s 4ms/step - loss: 9.2996e-04
Epoch 78/100
95/95 [==============================] - 0s 4ms/step - loss: 9.3433e-04
Epoch 79/100
95/95 [==============================] - 0s 4ms/step - loss: 9.8926e-04
Epoch 80/100
95/95 [==============================] - 0s 4ms/step - loss: 9.3545e-04
Epoch 81/100
95/95 [==============================] - 0s 4ms/step - loss: 9.6886e-04
Epoch 82/100
95/95 [==============================] - 0s 4ms/step - loss: 9.0796e-04
Epoch 83/100
95/95 [==============================] - 0s 4ms/step - loss: 9.4303e-04
Epoch 84/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0010
Epoch 85/100
95/95 [==============================] - 0s 4ms/step - loss: 9.8892e-04
```

```
Epoch 86/100
95/95 [==============================] - 0s 4ms/step - loss: 9.6791e-04
Epoch 87/100
95/95 [==============================] - 0s 4ms/step - loss: 9.1647e-04
Epoch 88/100
95/95 [==============================] - 0s 4ms/step - loss: 9.7727e-04
Epoch 89/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0011
Epoch 90/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0010
Epoch 91/100
95/95 [==============================] - 0s 5ms/step - loss: 9.2718e-04
Epoch 92/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0010
Epoch 93/100
95/95 [==============================] - 0s 4ms/step - loss: 9.1944e-04
Epoch 94/100
95/95 [==============================] - 0s 4ms/step - loss: 9.2261e-04
Epoch 95/100
95/95 [==============================] - 0s 4ms/step - loss: 9.2377e-04
Epoch 96/100
95/95 [==============================] - 0s 4ms/step - loss: 9.5055e-04
Epoch 97/100
95/95 [==============================] - 0s 4ms/step - loss: 9.4539e-04
Epoch 98/100
95/95 [==============================] - 0s 4ms/step - loss: 9.1711e-04
Epoch 99/100
95/95 [==============================] - 0s 4ms/step - loss: 9.1197e-04
Epoch 100/100
95/95 [==============================] - 0s 4ms/step - loss: 9.4327e-04
```

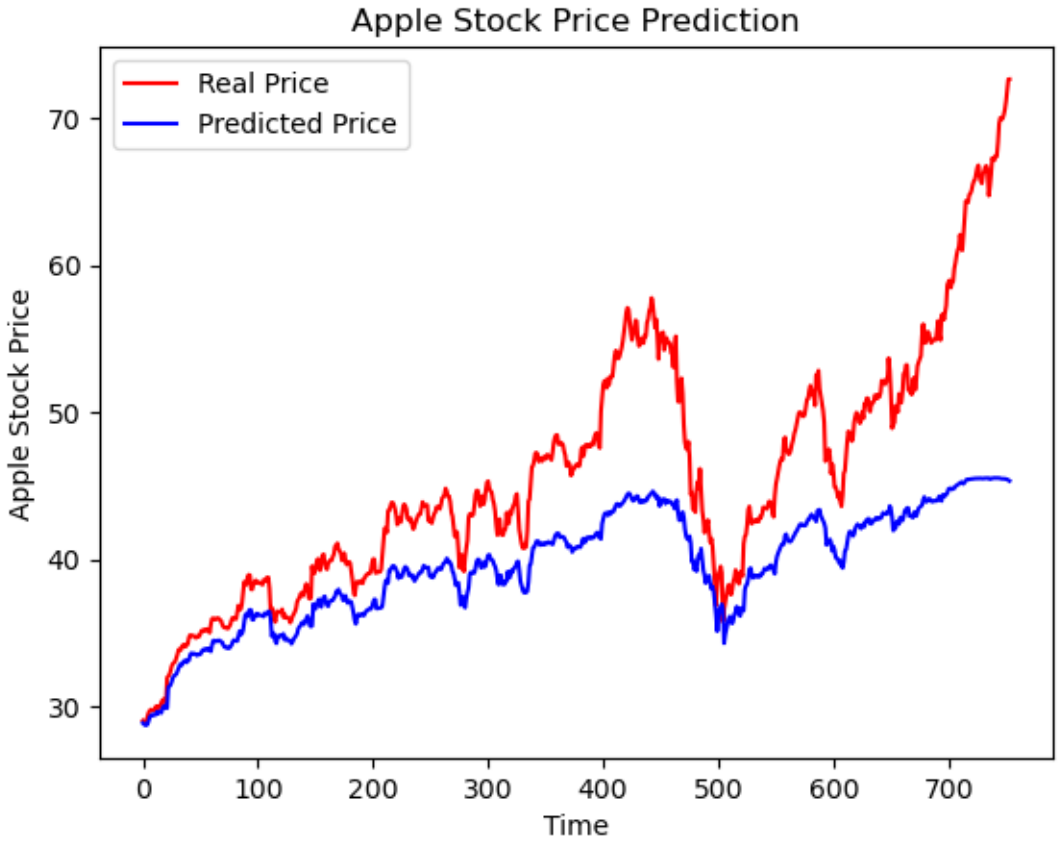
[28]:
```
predicted_price_lstm = apple_lstm.predict(x_test)
```

```
24/24 [==============================] - 1s 3ms/step

2022-11-21 20:09:57.617688: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:114]
Plugin optimizer for device_type GPU is enabled.
2022-11-21 20:09:57.665369: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:114]
Plugin optimizer for device_type GPU is enabled.
2022-11-21 20:09:57.691751: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:114]
Plugin optimizer for device_type GPU is enabled.
```

[29]:
```
predicted_price_lstm = sc.inverse_transform(predicted_price_lstm)
```

[30]:
```
plt.plot(real_stock_apple,color = 'red', label = 'Real Price')
plt.plot(predicted_price_lstm, color = 'blue', label = 'Predicted Price')
plt.title('Apple Stock Price Prediction')
plt.xlabel('Time')
plt.ylabel('Apple Stock Price')
plt.legend()
plt.show()
```



[31]:
```
for i in range(real_stock_apple.shape[1]):
    print(r2_score(real_stock_apple[:, i], predicted_price_lstm[:, i]))
```

```
0.1460723358988939
```

0.5 Experiment 2 LSTM - No Dropouts

[52]:
```
apple_lstm_2 = Sequential()
apple_lstm_2.add(LSTM(units = 50,return_sequences = True,input_shape = (x_train.
↪shape[1],1)))
```

[53]:
```
apple_lstm_2.add(LSTM(units = 50,return_sequences = False))
apple_lstm_2.add(Dense(units = 1))
```

[54]:
```
apple_lstm_2.compile(optimizer = 'adam',loss = 'mean_squared_error')

with tf.device('/cpu:0'):
    apple_lstm_2.fit(x_train,y_train,epochs = 100, batch_size = 32)
```

```
Epoch 1/100

2022-11-21 20:30:58.948517: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:114]
Plugin optimizer for device_type GPU is enabled.

95/95 [==============================] - 2s 4ms/step - loss: 0.0973
Epoch 2/100
95/95 [==============================] - 0s 4ms/step - loss: 0.0055
Epoch 3/100
95/95 [==============================] - 0s 4ms/step - loss: 5.6867e-04
Epoch 4/100
95/95 [==============================] - 0s 4ms/step - loss: 4.5155e-04
Epoch 5/100
95/95 [==============================] - 0s 4ms/step - loss: 3.4153e-04
Epoch 6/100
95/95 [==============================] - 0s 4ms/step - loss: 2.4534e-04
Epoch 7/100
95/95 [==============================] - 0s 4ms/step - loss: 1.6918e-04
Epoch 8/100
95/95 [==============================] - 0s 4ms/step - loss: 1.1437e-04
Epoch 9/100
95/95 [==============================] - 0s 4ms/step - loss: 8.1485e-05
Epoch 10/100
95/95 [==============================] - 0s 4ms/step - loss: 6.3541e-05
Epoch 11/100
95/95 [==============================] - 0s 4ms/step - loss: 5.6568e-05
Epoch 12/100
95/95 [==============================] - 0s 4ms/step - loss: 5.5052e-05
Epoch 13/100
95/95 [==============================] - 0s 4ms/step - loss: 5.2775e-05
Epoch 14/100
95/95 [==============================] - 0s 4ms/step - loss: 5.3874e-05
Epoch 15/100
95/95 [==============================] - 0s 4ms/step - loss: 5.3048e-05
Epoch 16/100
95/95 [==============================] - 0s 4ms/step - loss: 5.3837e-05
Epoch 17/100
95/95 [==============================] - 0s 4ms/step - loss: 5.2499e-05
Epoch 18/100
95/95 [==============================] - 0s 4ms/step - loss: 5.3277e-05
```

```
Epoch 19/100
95/95 [==============================] - 0s 4ms/step - loss: 5.2430e-05
Epoch 20/100
95/95 [==============================] - 0s 4ms/step - loss: 5.3659e-05
Epoch 21/100
95/95 [==============================] - 0s 4ms/step - loss: 5.4942e-05
Epoch 22/100
95/95 [==============================] - 0s 4ms/step - loss: 5.3598e-05
Epoch 23/100
95/95 [==============================] - 0s 4ms/step - loss: 5.4897e-05
Epoch 24/100
95/95 [==============================] - 0s 4ms/step - loss: 5.5488e-05
Epoch 25/100
95/95 [==============================] - 0s 4ms/step - loss: 5.3439e-05
Epoch 26/100
95/95 [==============================] - 0s 4ms/step - loss: 5.5708e-05
Epoch 27/100
95/95 [==============================] - 0s 4ms/step - loss: 5.7466e-05
Epoch 28/100
95/95 [==============================] - 0s 4ms/step - loss: 5.3833e-05
Epoch 29/100
95/95 [==============================] - 0s 4ms/step - loss: 5.6025e-05
Epoch 30/100
95/95 [==============================] - 0s 4ms/step - loss: 5.4087e-05
Epoch 31/100
95/95 [==============================] - 0s 4ms/step - loss: 5.4368e-05
Epoch 32/100
95/95 [==============================] - 0s 4ms/step - loss: 5.7645e-05
Epoch 33/100
95/95 [==============================] - 0s 4ms/step - loss: 5.7249e-05
Epoch 34/100
95/95 [==============================] - 0s 4ms/step - loss: 5.7133e-05
Epoch 35/100
95/95 [==============================] - 0s 4ms/step - loss: 5.6276e-05
Epoch 36/100
95/95 [==============================] - 0s 4ms/step - loss: 5.5308e-05
Epoch 37/100
95/95 [==============================] - 0s 4ms/step - loss: 5.8660e-05
Epoch 38/100
95/95 [==============================] - 0s 4ms/step - loss: 5.6722e-05
Epoch 39/100
95/95 [==============================] - 0s 4ms/step - loss: 6.6454e-05
Epoch 40/100
95/95 [==============================] - 0s 4ms/step - loss: 5.4815e-05
Epoch 41/100
95/95 [==============================] - 0s 4ms/step - loss: 5.5288e-05
Epoch 42/100
95/95 [==============================] - 0s 4ms/step - loss: 6.1391e-05
```

```
Epoch 43/100
95/95 [==============================] - 0s 4ms/step - loss: 6.3169e-05
Epoch 44/100
95/95 [==============================] - 0s 4ms/step - loss: 6.6915e-05
Epoch 45/100
95/95 [==============================] - 0s 4ms/step - loss: 6.5526e-05
Epoch 46/100
95/95 [==============================] - 0s 4ms/step - loss: 5.8455e-05
Epoch 47/100
95/95 [==============================] - 0s 4ms/step - loss: 5.7198e-05
Epoch 48/100
95/95 [==============================] - 0s 4ms/step - loss: 5.5334e-05
Epoch 49/100
95/95 [==============================] - 0s 4ms/step - loss: 5.5703e-05
Epoch 50/100
95/95 [==============================] - 0s 4ms/step - loss: 5.9288e-05
Epoch 51/100
95/95 [==============================] - 0s 4ms/step - loss: 6.4226e-05
Epoch 52/100
95/95 [==============================] - 0s 4ms/step - loss: 5.7623e-05
Epoch 53/100
95/95 [==============================] - 0s 4ms/step - loss: 5.7348e-05
Epoch 54/100
95/95 [==============================] - 0s 4ms/step - loss: 5.8113e-05
Epoch 55/100
95/95 [==============================] - 0s 4ms/step - loss: 5.5361e-05
Epoch 56/100
95/95 [==============================] - 0s 4ms/step - loss: 6.2664e-05
Epoch 57/100
95/95 [==============================] - 0s 4ms/step - loss: 5.8658e-05
Epoch 58/100
95/95 [==============================] - 0s 4ms/step - loss: 5.7652e-05
Epoch 59/100
95/95 [==============================] - 0s 4ms/step - loss: 6.3310e-05
Epoch 60/100
95/95 [==============================] - 0s 4ms/step - loss: 6.3272e-05
Epoch 61/100
95/95 [==============================] - 0s 4ms/step - loss: 5.8899e-05
Epoch 62/100
95/95 [==============================] - 0s 4ms/step - loss: 5.9426e-05
Epoch 63/100
95/95 [==============================] - 0s 4ms/step - loss: 6.5397e-05
Epoch 64/100
95/95 [==============================] - 0s 4ms/step - loss: 5.9143e-05
Epoch 65/100
95/95 [==============================] - 0s 4ms/step - loss: 5.8389e-05
Epoch 66/100
95/95 [==============================] - 0s 4ms/step - loss: 6.0170e-05
```

```
Epoch 67/100
95/95 [==============================] - 0s 4ms/step - loss: 5.6733e-05
Epoch 68/100
95/95 [==============================] - 0s 4ms/step - loss: 5.5411e-05
Epoch 69/100
95/95 [==============================] - 0s 4ms/step - loss: 5.5015e-05
Epoch 70/100
95/95 [==============================] - 0s 4ms/step - loss: 6.3014e-05
Epoch 71/100
95/95 [==============================] - 0s 4ms/step - loss: 5.6917e-05
Epoch 72/100
95/95 [==============================] - 0s 4ms/step - loss: 5.8880e-05
Epoch 73/100
95/95 [==============================] - 0s 4ms/step - loss: 6.8645e-05
Epoch 74/100
95/95 [==============================] - 0s 4ms/step - loss: 5.6968e-05
Epoch 75/100
95/95 [==============================] - 0s 4ms/step - loss: 5.6292e-05
Epoch 76/100
95/95 [==============================] - 0s 4ms/step - loss: 6.1965e-05
Epoch 77/100
95/95 [==============================] - 0s 4ms/step - loss: 6.1346e-05
Epoch 78/100
95/95 [==============================] - 0s 4ms/step - loss: 6.4141e-05
Epoch 79/100
95/95 [==============================] - 0s 4ms/step - loss: 6.1551e-05
Epoch 80/100
95/95 [==============================] - 0s 4ms/step - loss: 6.9901e-05
Epoch 81/100
95/95 [==============================] - 0s 4ms/step - loss: 5.9817e-05
Epoch 82/100
95/95 [==============================] - 0s 4ms/step - loss: 6.8410e-05
Epoch 83/100
95/95 [==============================] - 0s 4ms/step - loss: 6.5968e-05
Epoch 84/100
95/95 [==============================] - 0s 4ms/step - loss: 6.0216e-05
Epoch 85/100
95/95 [==============================] - 0s 4ms/step - loss: 5.8935e-05
Epoch 86/100
95/95 [==============================] - 0s 4ms/step - loss: 6.2860e-05
Epoch 87/100
95/95 [==============================] - 0s 4ms/step - loss: 5.8402e-05
Epoch 88/100
95/95 [==============================] - 0s 4ms/step - loss: 5.6867e-05
Epoch 89/100
95/95 [==============================] - 0s 4ms/step - loss: 5.5947e-05
Epoch 90/100
95/95 [==============================] - 0s 4ms/step - loss: 5.8004e-05
```

```
Epoch 91/100
95/95 [==============================] - 0s 4ms/step - loss: 5.6387e-05
Epoch 92/100
95/95 [==============================] - 0s 4ms/step - loss: 6.5132e-05
Epoch 93/100
95/95 [==============================] - 0s 4ms/step - loss: 6.2231e-05
Epoch 94/100
95/95 [==============================] - 0s 4ms/step - loss: 5.6792e-05
Epoch 95/100
95/95 [==============================] - 0s 4ms/step - loss: 5.6470e-05
Epoch 96/100
95/95 [==============================] - 0s 4ms/step - loss: 5.9217e-05
Epoch 97/100
95/95 [==============================] - 0s 4ms/step - loss: 5.9653e-05
Epoch 98/100
95/95 [==============================] - 0s 4ms/step - loss: 5.8124e-05
Epoch 99/100
95/95 [==============================] - 0s 4ms/step - loss: 5.6912e-05
Epoch 100/100
95/95 [==============================] - 0s 4ms/step - loss: 5.9632e-05
```

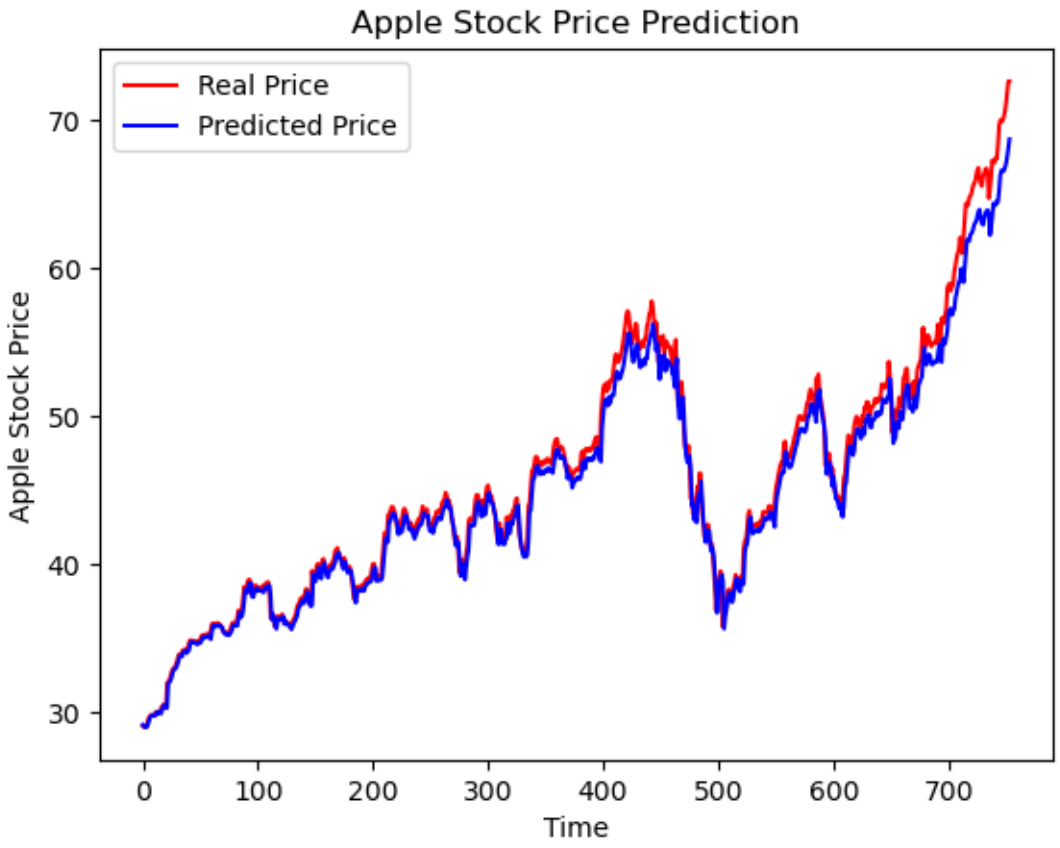
[55]:
```
predicted_price_lstm_2 = apple_lstm_2.predict(x_test)
```

```
24/24 [==============================] - 1s 3ms/step
```

```
2022-11-21 20:31:42.063794: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:114]
Plugin optimizer for device_type GPU is enabled.
2022-11-21 20:31:42.111951: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:114]
Plugin optimizer for device_type GPU is enabled.
2022-11-21 20:31:42.134861: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:114]
Plugin optimizer for device_type GPU is enabled.
```

[56]:
```
predicted_price_lstm_2 = sc.inverse_transform(predicted_price_lstm_2)
```

[57]:
```
plt.plot(real_stock_apple,color = 'red', label = 'Real Price')
plt.plot(predicted_price_lstm_2, color = 'blue', label = 'Predicted Price')
plt.title('Apple Stock Price Prediction')
plt.xlabel('Time')
plt.ylabel('Apple Stock Price')
plt.legend()
plt.show()
```



[58]:
```
for i in range(real_stock_apple.shape[1]):
    print(r2_score(real_stock_apple[:, i], predicted_price_lstm_2[:, i]))
```

```
0.9811742529412535
```