Initial Results and Code

March 25, 2021

[1]:
```
pip install pandas
```

```
Requirement already satisfied: pandas in /opt/conda/lib/python3.7/site-packages
(1.0.3)
Requirement already satisfied: python-dateutil>=2.6.1 in
/opt/conda/lib/python3.7/site-packages (from pandas) (2.8.1)
Requirement already satisfied: pytz>=2017.2 in /opt/conda/lib/python3.7/site-
packages (from pandas) (2020.1)
Requirement already satisfied: numpy>=1.13.3 in /opt/conda/lib/python3.7/site-
packages (from pandas) (1.19.5)
Requirement already satisfied: six>=1.5 in /opt/conda/lib/python3.7/site-
packages (from python-dateutil>=2.6.1->pandas) (1.15.0)
Note: you may need to restart the kernel to use updated packages.
```

[2]:
```
pip install sklearn
```

```
Requirement already satisfied: sklearn in /opt/conda/lib/python3.7/site-packages
(0.0)
Requirement already satisfied: scikit-learn in /opt/conda/lib/python3.7/site-
packages (from sklearn) (0.22.2.post1)
Requirement already satisfied: joblib>=0.11 in /opt/conda/lib/python3.7/site-
packages (from scikit-learn->sklearn) (0.15.1)
Requirement already satisfied: numpy>=1.11.0 in /opt/conda/lib/python3.7/site-
packages (from scikit-learn->sklearn) (1.19.5)
Requirement already satisfied: scipy>=0.17.0 in /opt/conda/lib/python3.7/site-
packages (from scikit-learn->sklearn) (1.4.1)
Note: you may need to restart the kernel to use updated packages.
```

[3]:
```
pip install numpy
```

```
Requirement already satisfied: numpy in /opt/conda/lib/python3.7/site-packages
(1.19.5)
Note: you may need to restart the kernel to use updated packages.
```

[4]:
```
pip install keras
```

```
Requirement already satisfied: keras in /opt/conda/lib/python3.7/site-packages
(2.4.3)
```

```
Requirement already satisfied: numpy>=1.9.1 in /opt/conda/lib/python3.7/site-
packages (from keras) (1.19.5)
Requirement already satisfied: scipy>=0.14 in /opt/conda/lib/python3.7/site-
packages (from keras) (1.4.1)
Requirement already satisfied: h5py in /opt/conda/lib/python3.7/site-packages
(from keras) (2.10.0)
Requirement already satisfied: pyyaml in /opt/conda/lib/python3.7/site-packages
(from keras) (5.3.1)
Requirement already satisfied: six in /opt/conda/lib/python3.7/site-packages
(from h5py->keras) (1.15.0)
Note: you may need to restart the kernel to use updated packages.
```

[5]:
```
pip install tensorflow
```

```
Requirement already satisfied: tensorflow in /opt/conda/lib/python3.7/site-
packages (2.4.1)
Requirement already satisfied: absl-py~=0.10 in /opt/conda/lib/python3.7/site-
packages (from tensorflow) (0.12.0)
Requirement already satisfied: flatbuffers~=1.12.0 in
/opt/conda/lib/python3.7/site-packages (from tensorflow) (1.12)
Requirement already satisfied: keras-preprocessing~=1.1.2 in
/opt/conda/lib/python3.7/site-packages (from tensorflow) (1.1.2)
Requirement already satisfied: opt-einsum~=3.3.0 in
/opt/conda/lib/python3.7/site-packages (from tensorflow) (3.3.0)
Requirement already satisfied: tensorboard~=2.4 in
/opt/conda/lib/python3.7/site-packages (from tensorflow) (2.4.1)
Requirement already satisfied: wrapt~=1.12.1 in /opt/conda/lib/python3.7/site-
packages (from tensorflow) (1.12.1)
Requirement already satisfied: typing-extensions~=3.7.4 in
/opt/conda/lib/python3.7/site-packages (from tensorflow) (3.7.4.2)
Requirement already satisfied: tensorflow-estimator<2.5.0,>=2.4.0 in
/opt/conda/lib/python3.7/site-packages (from tensorflow) (2.4.0)
Requirement already satisfied: numpy~=1.19.2 in /opt/conda/lib/python3.7/site-
packages (from tensorflow) (1.19.5)
Requirement already satisfied: six~=1.15.0 in /opt/conda/lib/python3.7/site-
packages (from tensorflow) (1.15.0)
Requirement already satisfied: google-pasta~=0.2 in
/opt/conda/lib/python3.7/site-packages (from tensorflow) (0.2.0)
Requirement already satisfied: termcolor~=1.1.0 in
/opt/conda/lib/python3.7/site-packages (from tensorflow) (1.1.0)
Requirement already satisfied: grpcio~=1.32.0 in /opt/conda/lib/python3.7/site-
packages (from tensorflow) (1.32.0)
Requirement already satisfied: protobuf>=3.9.2 in /opt/conda/lib/python3.7/site-
packages (from tensorflow) (3.11.4)
Requirement already satisfied: wheel~=0.35 in /opt/conda/lib/python3.7/site-
packages (from tensorflow) (0.36.2)
Requirement already satisfied: h5py~=2.10.0 in /opt/conda/lib/python3.7/site-
packages (from tensorflow) (2.10.0)
```

```
Requirement already satisfied: astunparse~=1.6.3 in
/opt/conda/lib/python3.7/site-packages (from tensorflow) (1.6.3)
Requirement already satisfied: gast==0.3.3 in /opt/conda/lib/python3.7/site-
packages (from tensorflow) (0.3.3)
Requirement already satisfied: werkzeug>=0.11.15 in
/opt/conda/lib/python3.7/site-packages (from tensorboard~=2.4->tensorflow)
(1.0.1)
Requirement already satisfied: requests<3,>=2.21.0 in
/opt/conda/lib/python3.7/site-packages (from tensorboard~=2.4->tensorflow)
(2.23.0)
Requirement already satisfied: markdown>=2.6.8 in /opt/conda/lib/python3.7/site-
packages (from tensorboard~=2.4->tensorflow) (3.3.4)
Requirement already satisfied: tensorboard-plugin-wit>=1.6.0 in
/opt/conda/lib/python3.7/site-packages (from tensorboard~=2.4->tensorflow)
(1.8.0)
Requirement already satisfied: setuptools>=41.0.0 in
/opt/conda/lib/python3.7/site-packages (from tensorboard~=2.4->tensorflow)
(46.1.3.post20200325)
Requirement already satisfied: google-auth<2,>=1.6.3 in
/opt/conda/lib/python3.7/site-packages (from tensorboard~=2.4->tensorflow)
(1.16.1)
Requirement already satisfied: google-auth-oauthlib<0.5,>=0.4.1 in
/opt/conda/lib/python3.7/site-packages (from tensorboard~=2.4->tensorflow)
(0.4.3)
Requirement already satisfied: idna<3,>=2.5 in /opt/conda/lib/python3.7/site-
packages (from requests<3,>=2.21.0->tensorboard~=2.4->tensorflow) (2.9)
Requirement already satisfied: chardet<4,>=3.0.2 in
/opt/conda/lib/python3.7/site-packages (from
requests<3,>=2.21.0->tensorboard~=2.4->tensorflow) (3.0.4)
Requirement already satisfied: certifi>=2017.4.17 in
/opt/conda/lib/python3.7/site-packages (from
requests<3,>=2.21.0->tensorboard~=2.4->tensorflow) (2020.4.5.2)
Requirement already satisfied: urllib3!=1.25.0,!=1.25.1,<1.26,>=1.21.1 in
/opt/conda/lib/python3.7/site-packages (from
requests<3,>=2.21.0->tensorboard~=2.4->tensorflow) (1.25.9)
Requirement already satisfied: importlib-metadata; python_version < "3.8" in
/opt/conda/lib/python3.7/site-packages (from
markdown>=2.6.8->tensorboard~=2.4->tensorflow) (1.6.0)
Requirement already satisfied: rsa<4.1,>=3.1.4 in /opt/conda/lib/python3.7/site-
packages (from google-auth<2,>=1.6.3->tensorboard~=2.4->tensorflow) (4.0)
Requirement already satisfied: cachetools<5.0,>=2.0.0 in
/opt/conda/lib/python3.7/site-packages (from google-
auth<2,>=1.6.3->tensorboard~=2.4->tensorflow) (4.1.0)
Requirement already satisfied: pyasn1-modules>=0.2.1 in
/opt/conda/lib/python3.7/site-packages (from google-
auth<2,>=1.6.3->tensorboard~=2.4->tensorflow) (0.2.8)
Requirement already satisfied: requests-oauthlib>=0.7.0 in
/opt/conda/lib/python3.7/site-packages (from google-auth-
```

```
oauthlib<0.5,>=0.4.1->tensorboard~=2.4->tensorflow) (1.3.0)
Requirement already satisfied: zipp>=0.5 in /opt/conda/lib/python3.7/site-
packages (from importlib-metadata; python_version <
"3.8"->markdown>=2.6.8->tensorboard~=2.4->tensorflow) (3.1.0)
Requirement already satisfied: pyasn1>=0.1.3 in /opt/conda/lib/python3.7/site-
packages (from rsa<4.1,>=3.1.4->google-
auth<2,>=1.6.3->tensorboard~=2.4->tensorflow) (0.4.8)
Requirement already satisfied: oauthlib>=3.0.0 in /opt/conda/lib/python3.7/site-
packages (from requests-oauthlib>=0.7.0->google-auth-
oauthlib<0.5,>=0.4.1->tensorboard~=2.4->tensorflow) (3.0.1)
Note: you may need to restart the kernel to use updated packages.
```

[6]:
```
pip install matplotlib
```

```
Requirement already satisfied: matplotlib in /opt/conda/lib/python3.7/site-
packages (3.2.1)
Requirement already satisfied: pyparsing!=2.0.4,!=2.1.2,!=2.1.6,>=2.0.1 in
/opt/conda/lib/python3.7/site-packages (from matplotlib) (2.4.7)
Requirement already satisfied: cycler>=0.10 in /opt/conda/lib/python3.7/site-
packages (from matplotlib) (0.10.0)
Requirement already satisfied: python-dateutil>=2.1 in
/opt/conda/lib/python3.7/site-packages (from matplotlib) (2.8.1)
Requirement already satisfied: numpy>=1.11 in /opt/conda/lib/python3.7/site-
packages (from matplotlib) (1.19.5)
Requirement already satisfied: kiwisolver>=1.0.1 in
/opt/conda/lib/python3.7/site-packages (from matplotlib) (1.2.0)
Requirement already satisfied: six in /opt/conda/lib/python3.7/site-packages
(from cycler>=0.10->matplotlib) (1.15.0)
Note: you may need to restart the kernel to use updated packages.
```

[7]:
```
pip install pydot
```

```
Requirement already satisfied: pydot in /opt/conda/lib/python3.7/site-packages
(1.4.2)
Requirement already satisfied: pyparsing>=2.1.4 in
/opt/conda/lib/python3.7/site-packages (from pydot) (2.4.7)
Note: you may need to restart the kernel to use updated packages.
```

[8]:
```
pip install pydotplus
```

```
Requirement already satisfied: pydotplus in /opt/conda/lib/python3.7/site-
packages (2.0.2)
Requirement already satisfied: pyparsing>=2.0.1 in
/opt/conda/lib/python3.7/site-packages (from pydotplus) (2.4.7)
Note: you may need to restart the kernel to use updated packages.
```

[9]:
```
pip install graphviz
```

```
Requirement already satisfied: graphviz in /opt/conda/lib/python3.7/site-
packages (0.16)
Note: you may need to restart the kernel to use updated packages.
```

[10]:
```
import pandas as pd
from sklearn import preprocessing
import numpy as np
np.random.seed(1)
import keras
from keras.models import Model
from keras.layers import Activation, Dense, Dropout, Input, LSTM, concatenate
from keras import optimizers
import tensorflow as tf
tf.random.set_seed(1)
```

[11]:
```
#Function to calculate Exponential Moving Average using simple moving average
def ema(values, i):
    #Simple moving average
    sma = np.mean(values[:, 3])
    ema_values = [sma]
    k = 2 / (1 + i)
    for i in range(len(his) - i, len(his)):
        close = his[i][3]
        ema_values.append(close * k + ema_values[-1] * (1 - k))
    return ema_values[-1]
```

[12]:
```
#history_points represents the set number of days that affect the next
history_points = 50
```

[13]:
```
#Import .csv data and remove the Date attribute
data = pd.read_csv('SPY.csv')
data = data.drop('Date', axis=1)
data = data.drop('Adj Close', axis=1)
data = data.values
```

[14]:
```
#Normalize the data to a MinMaxScaler
data_normaliser = preprocessing.MinMaxScaler()
data_normalised = data_normaliser.fit_transform(data)
```

[15]:
```
print(data_normalised.shape)
```

```
(7075, 5)
```

[16]:
```
#Using history_points, open, close, high, low, volume, data, points create␣
↪OpenHighLowChart and next day open values
ohlcv_histories_normalised = np.array([data_normalised[i:i + history_points].
↪copy() for i in range(len(data_normalised) - history_points)])
```

```
next_day_open_values_normalised = np.array([data_normalised[:, 0][i +␣
↪history_points].copy() for i in range(len(data_normalised) -␣
↪history_points)])
next_day_open_values_normalised = np.
↪expand_dims(next_day_open_values_normalised, -1)
```

[17]:
```
next_day_open_values = np.array([data[:, 0][i + history_points].copy() for i in␣
↪range(len(data) - history_points)])
next_day_open_values = np.expand_dims(next_day_open_values, -1)
```

[18]:
```
#Normalize the data to a MinMaxScaler
y_normaliser = preprocessing.MinMaxScaler()
y_normaliser.fit(next_day_open_values)
```

[18]:
```
MinMaxScaler(copy=True, feature_range=(0, 1))
```

[19]:
```
#Create technical indicators using simple and exponential moving average
technical_indicators = []
for his in ohlcv_histories_normalised:
    #Simple moving average of the closing price
    sma = np.mean(his[:, 3])
    macd = ema(his, 12) - ema(his, 26)
    #Add the simple and exponential moving average to the technical indicator
    technical_indicators.append(np.array([sma,macd,]))
```

[ ]:
```

```

[20]:
```
technical_indicators = np.array(technical_indicators)

tech_ind_scaler = preprocessing.MinMaxScaler()
technical_indicators_normalised = tech_ind_scaler.
↪fit_transform(technical_indicators)
```

[21]:
```
assert ohlcv_histories_normalised.shape[0] == next_day_open_values_normalised.
↪shape[0] == technical_indicators_normalised.shape[0], "data shapes are␣
↪inconsistent"
```

[22]:
```
#Data Preparation
#Split the data into Training and Testing 9-1 ratio
test_split = 0.9
#Split number (6322)
n = int(ohlcv_histories_normalised.shape[0] * test_split)
```

[23]:
```
print(ohlcv_histories_normalised.shape)
print(technical_indicators_normalised.shape)
```

```
(7025, 50, 5)
```

```
(7025, 2)
```

[24]:
```
ohlcv_train = ohlcv_histories_normalised[:n]
tech_ind_train = technical_indicators_normalised[:n]
y_train = next_day_open_values_normalised[:n]
```

[25]:
```
ohlcv_test = ohlcv_histories_normalised[n:]
tech_ind_test = technical_indicators_normalised[n:]
y_test = next_day_open_values_normalised[n:]

unscaled_y_test = next_day_open_values[n:]
```

[26]:
```
print(ohlcv_train.shape)
print(ohlcv_test.shape)
```

```
(6322, 50, 5)
(703, 50, 5)
```

[27]:
```
#Create LSTM model
#Define two sets of inputs
lstm_input = Input(shape=(history_points, 5), name='lstm_input')
dense_input = Input(shape=(technical_indicators_normalised.shape[1],),␣
 ↪name='tech_input')
```

[28]:
```
#First branch operates on the first input
x = LSTM(history_points, name='lstm_0')(lstm_input)
x = Dropout(0.2, name='lstm_dropout_0')(x)
lstm_branch = Model(inputs=lstm_input, outputs=x)
```

[29]:
```
#Second branch opreates on the second input
y = Dense(20, name='tech_dense_0')(dense_input)
y = Activation("relu", name='tech_relu_0')(y)
y = Dropout(0.2, name='tech_dropout_0')(y)
technical_indicators_branch = Model(inputs=dense_input, outputs=y)
```

[30]:
```
#Combine the output of the two branches
combined = concatenate([lstm_branch.output, technical_indicators_branch.
 ↪output], name='concatenate')
```

[31]:
```
z = Dense(64, activation="sigmoid", name='dense_pooling')(combined)
z = Dense(1, activation="linear", name='dense_out')(z)
```

[32]:
```
#Model will accept the inputs of the two branches and then output a single value
model = Model(inputs=[lstm_branch.input, technical_indicators_branch.input],␣
 ↪outputs=z)
adam = optimizers.Adam(lr=0.0005)
model.compile(optimizer=adam, loss='mse')
```

[33]:
```
#Print model diagram
import pydot
import pydotplus
import graphviz
from keras.utils.vis_utils import plot_model
plot_model(model, to_file='model_plot.png', show_shapes=True,␣
 ↪show_layer_names=True)
```

```
('Failed to import pydot. You must `pip install pydot` and install graphviz
(https://graphviz.gitlab.io/download/), ', 'for `pydotprint` to work.')
```

[34]:
```
#Train Model model.fit(x_train, y_train, validation_data = (x_test, y_test),␣
 ↪epochs = 100, batch_size = 64, verbose = 1)
model.fit(x=[ohlcv_train, tech_ind_train], y=y_train,␣
 ↪validation_data=([ohlcv_test, tech_ind_test],y_test), batch_size=32,␣
 ↪epochs=history_points, shuffle=True, validation_split=0.1)
```

```
Epoch 1/50
178/178 [==============================] - 8s 37ms/step - loss: 0.1816 -
val_loss: 0.0053
Epoch 2/50
178/178 [==============================] - 6s 33ms/step - loss: 0.0012 -
val_loss: 0.0019
Epoch 3/50
178/178 [==============================] - 6s 32ms/step - loss: 8.2286e-04 -
val_loss: 1.9965e-04
Epoch 4/50
178/178 [==============================] - 6s 32ms/step - loss: 6.8733e-04 -
val_loss: 1.6722e-04
Epoch 5/50
178/178 [==============================] - 6s 33ms/step - loss: 5.9437e-04 -
val_loss: 1.6238e-04
Epoch 6/50
178/178 [==============================] - 6s 32ms/step - loss: 5.1363e-04 -
val_loss: 5.6247e-04
Epoch 7/50
178/178 [==============================] - 6s 32ms/step - loss: 4.3446e-04 -
val_loss: 2.8220e-04
Epoch 8/50
178/178 [==============================] - 6s 32ms/step - loss: 3.9332e-04 -
val_loss: 2.0411e-04
Epoch 9/50
178/178 [==============================] - 6s 32ms/step - loss: 3.4700e-04 -
val_loss: 8.1840e-05
Epoch 10/50
178/178 [==============================] - 6s 31ms/step - loss: 3.1097e-04 -
val_loss: 1.0283e-04
```

```
Epoch 11/50
178/178 [==============================] - 6s 31ms/step - loss: 2.6432e-04 -
val_loss: 3.3485e-04
Epoch 12/50
178/178 [==============================] - 6s 31ms/step - loss: 2.3694e-04 -
val_loss: 4.5100e-04
Epoch 13/50
178/178 [==============================] - 6s 33ms/step - loss: 2.1160e-04 -
val_loss: 2.9730e-04
Epoch 14/50
178/178 [==============================] - 6s 33ms/step - loss: 1.9145e-04 -
val_loss: 1.2025e-04
Epoch 15/50
178/178 [==============================] - 6s 33ms/step - loss: 1.6249e-04 -
val_loss: 7.9187e-05
Epoch 16/50
178/178 [==============================] - 6s 33ms/step - loss: 1.5389e-04 -
val_loss: 1.5905e-04
Epoch 17/50
178/178 [==============================] - 6s 32ms/step - loss: 1.4801e-04 -
val_loss: 6.7272e-05
Epoch 18/50
178/178 [==============================] - 6s 31ms/step - loss: 1.3777e-04 -
val_loss: 2.1031e-04
Epoch 19/50
178/178 [==============================] - 6s 31ms/step - loss: 1.3018e-04 -
val_loss: 1.9101e-04
Epoch 20/50
178/178 [==============================] - 6s 32ms/step - loss: 1.3026e-04 -
val_loss: 5.6308e-05
Epoch 21/50
178/178 [==============================] - 6s 31ms/step - loss: 1.3083e-04 -
val_loss: 1.0275e-04
Epoch 22/50
178/178 [==============================] - 6s 31ms/step - loss: 1.1945e-04 -
val_loss: 7.3819e-05
Epoch 23/50
178/178 [==============================] - 6s 32ms/step - loss: 1.1876e-04 -
val_loss: 5.3316e-05
Epoch 24/50
178/178 [==============================] - 6s 31ms/step - loss: 1.1321e-04 -
val_loss: 7.2847e-05
Epoch 25/50
178/178 [==============================] - 6s 33ms/step - loss: 1.1379e-04 -
val_loss: 1.9193e-04
Epoch 26/50
178/178 [==============================] - 6s 33ms/step - loss: 1.0913e-04 -
val_loss: 5.8016e-05
```

```
Epoch 27/50
178/178 [==============================] - 6s 32ms/step - loss: 1.1329e-04 -
val_loss: 2.9341e-04
Epoch 28/50
178/178 [==============================] - 6s 33ms/step - loss: 1.1809e-04 -
val_loss: 9.9973e-05
Epoch 29/50
178/178 [==============================] - 6s 33ms/step - loss: 1.1838e-04 -
val_loss: 9.6906e-05
Epoch 30/50
178/178 [==============================] - 6s 32ms/step - loss: 1.1411e-04 -
val_loss: 5.1586e-05
Epoch 31/50
178/178 [==============================] - 6s 32ms/step - loss: 1.1226e-04 -
val_loss: 4.6670e-05
Epoch 32/50
178/178 [==============================] - 6s 32ms/step - loss: 1.0264e-04 -
val_loss: 6.3160e-05
Epoch 33/50
178/178 [==============================] - 6s 32ms/step - loss: 1.0502e-04 -
val_loss: 7.6875e-05
Epoch 34/50
178/178 [==============================] - 6s 32ms/step - loss: 1.1307e-04 -
val_loss: 9.7018e-05
Epoch 35/50
178/178 [==============================] - 6s 32ms/step - loss: 1.0657e-04 -
val_loss: 1.3218e-04
Epoch 36/50
178/178 [==============================] - 6s 32ms/step - loss: 1.0168e-04 -
val_loss: 2.5959e-04
Epoch 37/50
178/178 [==============================] - 6s 31ms/step - loss: 1.0760e-04 -
val_loss: 9.0648e-05
Epoch 38/50
178/178 [==============================] - 6s 31ms/step - loss: 1.0874e-04 -
val_loss: 4.8204e-05
Epoch 39/50
178/178 [==============================] - 6s 31ms/step - loss: 9.8711e-05 -
val_loss: 3.6766e-04
Epoch 40/50
178/178 [==============================] - 6s 31ms/step - loss: 1.1701e-04 -
val_loss: 4.3219e-05
Epoch 41/50
178/178 [==============================] - 6s 32ms/step - loss: 1.1273e-04 -
val_loss: 1.7114e-04
Epoch 42/50
178/178 [==============================] - 6s 31ms/step - loss: 1.0346e-04 -
val_loss: 1.0875e-04
```

```
Epoch 43/50
178/178 [==============================] - 6s 31ms/step - loss: 9.1268e-05 -
val_loss: 3.4208e-05
Epoch 44/50
178/178 [==============================] - 6s 32ms/step - loss: 1.1551e-04 -
val_loss: 9.1323e-05
Epoch 45/50
178/178 [==============================] - 5s 31ms/step - loss: 1.0399e-04 -
val_loss: 3.2151e-04
Epoch 46/50
178/178 [==============================] - 6s 31ms/step - loss: 1.0522e-04 -
val_loss: 8.4018e-05
Epoch 47/50
178/178 [==============================] - 6s 32ms/step - loss: 9.5427e-05 -
val_loss: 1.2586e-04
Epoch 48/50
178/178 [==============================] - 5s 31ms/step - loss: 1.0524e-04 -
val_loss: 9.4939e-05
Epoch 49/50
178/178 [==============================] - 6s 32ms/step - loss: 1.0543e-04 -
val_loss: 2.9855e-05
Epoch 50/50
178/178 [==============================] - 6s 32ms/step - loss: 1.0243e-04 -
val_loss: 6.3389e-05
```

[34]:
```
<tensorflow.python.keras.callbacks.History at 0x7f82fab01e50>
```

[35]:
```
#Model evaluation
evaluation = model.evaluate([ohlcv_test, tech_ind_test], y_test)
print(evaluation)
```

```
22/22 [==============================] - 0s 9ms/step - loss: 4.1959e-04
0.0004195899819023907
```

[36]:
```
print(ohlcv_test.shape)
print(tech_ind_test.shape)
```

```
(703, 50, 5)
(703, 2)
```

[37]:
```
#Predict and check model performance
y_test_predicted = model.predict([ohlcv_test, tech_ind_test])
y_predicted = model.predict([ohlcv_histories_normalised, technical_indicators])
```

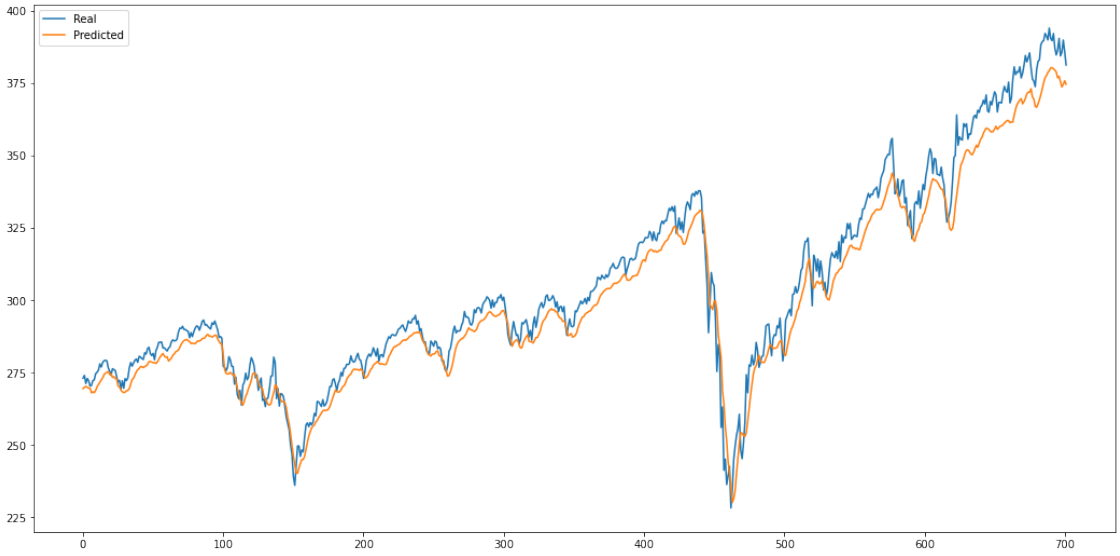
[38]:
```
#Denomaization or scaler inverse
y_test_predicted = y_normaliser.inverse_transform(y_test_predicted)
y_predicted = y_normaliser.inverse_transform(y_predicted)
```

[39]:
```
assert unscaled_y_test.shape == y_test_predicted.shape, "data shapes are␣
↪inconsistent"
```

[40]:
```
#Calculate Root Mean Square Error performance
rmse = np.mean(np.square(unscaled_y_test - y_test_predicted))
scaled_mse = rmse / (np.max(unscaled_y_test) - np.min(unscaled_y_test)) * 100
print(scaled_mse)
```

```
31.115932817299914
```

[41]:
```
import matplotlib.pyplot as plt
#Plot
plt.gcf().set_size_inches(18, 9, forward=True)
real = plt.plot(unscaled_y_test[0:-1], label='real')
#Shift test predictions for plotting
pred = plt.plot(y_test_predicted[0:-1], label='predicted')
#Plot baseline and prediction
plt.legend(['Real', 'Predicted'])
plt.show()
```



[42]:
```
#Save model for trade program
model.save(f'time_series_model.h5')
```