

# TIME-SERIES FORECASTING

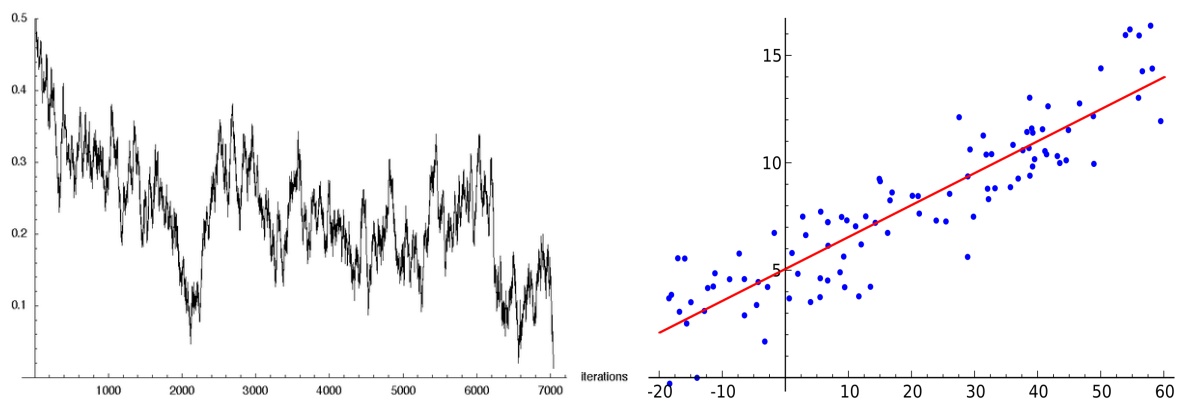
COMPUTER SCIENCE PROJECT

**XII-B**

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## Introduction

A time-series is a type of series where the data points are graphed in time order (value vs time graph) at equal successions of time. Now because it is in time order, the values are discrete and there generally isn't a pattern or equation for the entirety of the graph. This is the main reason why techniques like linear regression won't be able to forecast the data and give accurate predictions. So for analyzing a time-series, we need a specific type of model that will be able to give accurate predictions.



## The ARIMA Model

The Auto-Regressive Integrated Moving Average (ARIMA) model is one such model that can give accurate predictions while analyzing a time-series. It comprises of three main parts which are :

- Auto-Regression (AR)
- Differencing (D) / Integrated (I)
- Moving Average (MA)

Using the aforementioned processes, we would be able to get a 'future' value of the time-series based on its own past values. Now let us understand each process individually.

### 1. Auto Regression (AR)

Auto-regression is a time series model that uses observations from previous time steps as input to a regression equation to predict the value at the next time step.

It can only be used for linear (stationary graphs) and cannot be directly used in a time-series.

$$Y_t = \alpha + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \dots + \beta_p Y_{t-p} + \epsilon_1$$

*Sample Equation for Auto-Regression*

## **2. Integrated (I) / Differenced (D)**

As the series needs to be stationary (linear) for Auto-Regression to work, we subtract the (n-1)th values from the nth values. This is known as First-Order Differenced Data which will make the graph stationary.

## **3. Moving Average (MA)**

The moving average (MA) is a simple technical analysis tool that smooths out price data by creating a constantly updated average price. The average is taken over a specific period of time. The Moving Average in the ARIMA model depends on the forecast errors of the Auto-Regressive Model.

$$Y_t = \alpha + \epsilon_t + \phi_1 \epsilon_{t-1} + \phi_2 \epsilon_{t-2} + \dots + \phi_q \epsilon_{t-q}$$

*Sample Equation for Moving Average*

## **How the ARIMA Model Works?**

An ARIMA model is characterized by 3 terms: p, d, q where,

- p is the order of the AR term
- q is the order of the MA term
- d is the number of differencing required to make the time series stationary

The ARIMA model takes different values of (p,d,q) to give out accurate results for a time-series.

$$y'_t = c + \underbrace{\varphi_1 y'_{t-1} + \dots + \varphi_p y'_{t-p}}_{\text{lagged values}} + \underbrace{\theta_1 \varepsilon_{t-1} + \dots + \theta_q \varepsilon_{t-q}}_{\text{lagged errors}} + \varepsilon_t$$

intercept

differenced time series

*The ARIMA Equation (a combination of three processes)*

## What we used:

### Pandas Module

Pandas is an open-source library in python that specializes in Data Analysis. It allows importing data from various file formats such as CSV, JSON, SQL, Microsoft Excel. Pandas also allows various data manipulation operations such as merging, reshaping, selecting, as well as data cleaning, and data wrangling features.



### Pandas Functions and Methods Used in The Project:

- `panda.read_csv(file)` - reads a comma-separated values (csv) file into DataFrame
- `pandas.plotting.lag_plot(series,lag)` - plots a lag plot for time series

- `pandas.DataFrame(data)` - converts data into a two-dimensional, size-mutable form that is tabular and can have arithmetic operations
- `pandas.DataFrame.diff(period=1)` - calculates the difference of a Dataframe element compared with another element in the Dataframe (default is element in previous row)
- `pandas.DataFrame.to_numpy()` - converts the DataFrame to a NumPy array

## **Matplotlib and PyPlot Module**

Matplotlib is a plotting library for Python and its numerical mathematics extension NumPy. It provides an object-oriented API for embedding plots into applications using general-purpose GUI toolkits like Tkinter, wxPython and Qt.

PyPlot is a state-based interface to Matplotlib. It provides a MATLAB-like way of plotting. PyPlot is mainly intended for interactive plots and simple cases of programmatic plot generation



## **Matplotlib and PyPlot Functions Used in The Project:**

- `matplotlib.pyplot` - module that is mainly intended for interactive plots and simple cases of programmatic plot generation
- `pyplot.figure()` - creates a new figure/graph
- `pyplot.plot(data)` - plots data into the figure
- `pyplot.show()` - displays an existing graph
- `pyplot.xticks([ticks,data])` - sets the current tick values and labels for the x-axis

## **Statsmodels Module**

Statsmodels is a Python module that provides classes and functions for the estimation of many different statistical models, as well as for conducting statistical tests, and statistical data exploration. The results are tested against existing statistical packages to ensure that they are correct.



The ARIMA Statistical Model used in the project was a standard class from the statsmodels library.

`statsmodels.tsa.arima_model.ARIMA(data,[p,d,q])` - gives the module for the ARIMA model

`ARIMA.fit()` - used to estimate different parameters for the model

`ARIMA.fit.forecast()` - used to predict values for the model



**YFinance Module**

Ever since Yahoo! finance decommissioned their historical data API yfinance aims to solve this problem by offering a reliable, threaded, and Pythonic way to download historical market data from Yahoo! Finance.

YFinance Functions and Methods Used:

- `yfinance.Ticker(<stock name on Yahoo! finance>)` - creates a ticker object for the particular stock from the yahoo finance page so data can be extracted
- `<yfinance.Ticker.ticker>.history(<start date>, <end date>)` - getting the stock data for the particular dates

## KIVY

Kivy is a free and open source Python framework for developing mobile apps and other multitouch application software with a natural user interface. Using this module we were able to create an app for our project.

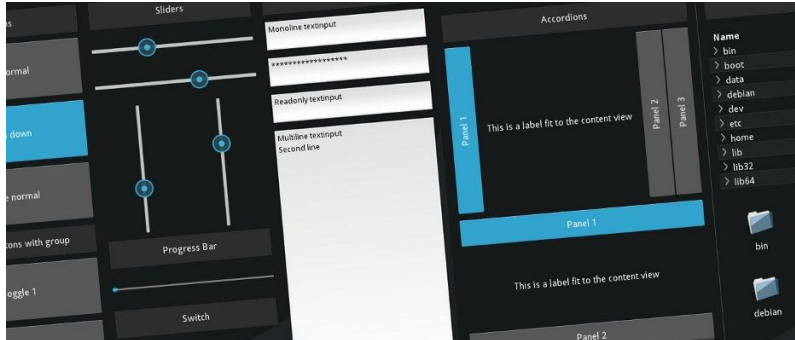


## Classes Used in The Project:

- Class `MainWindow(Screen)` - used to create and add all values in the main window of the app
- Class `SecondWindow(Screen)` - used to create and add all values in the second window of the app
- `WindowManager(ScreenManager)` - used to arrange and take care of the transition between the two screens
- Class `MyMainApp(App)` - used to run the whole program

## The Kv Language

The Kv language is a language dedicated to describing user interface and interactions in Kivy framework. As with other interface markup languages, it is possible to easily create a whole UI and attach interaction.

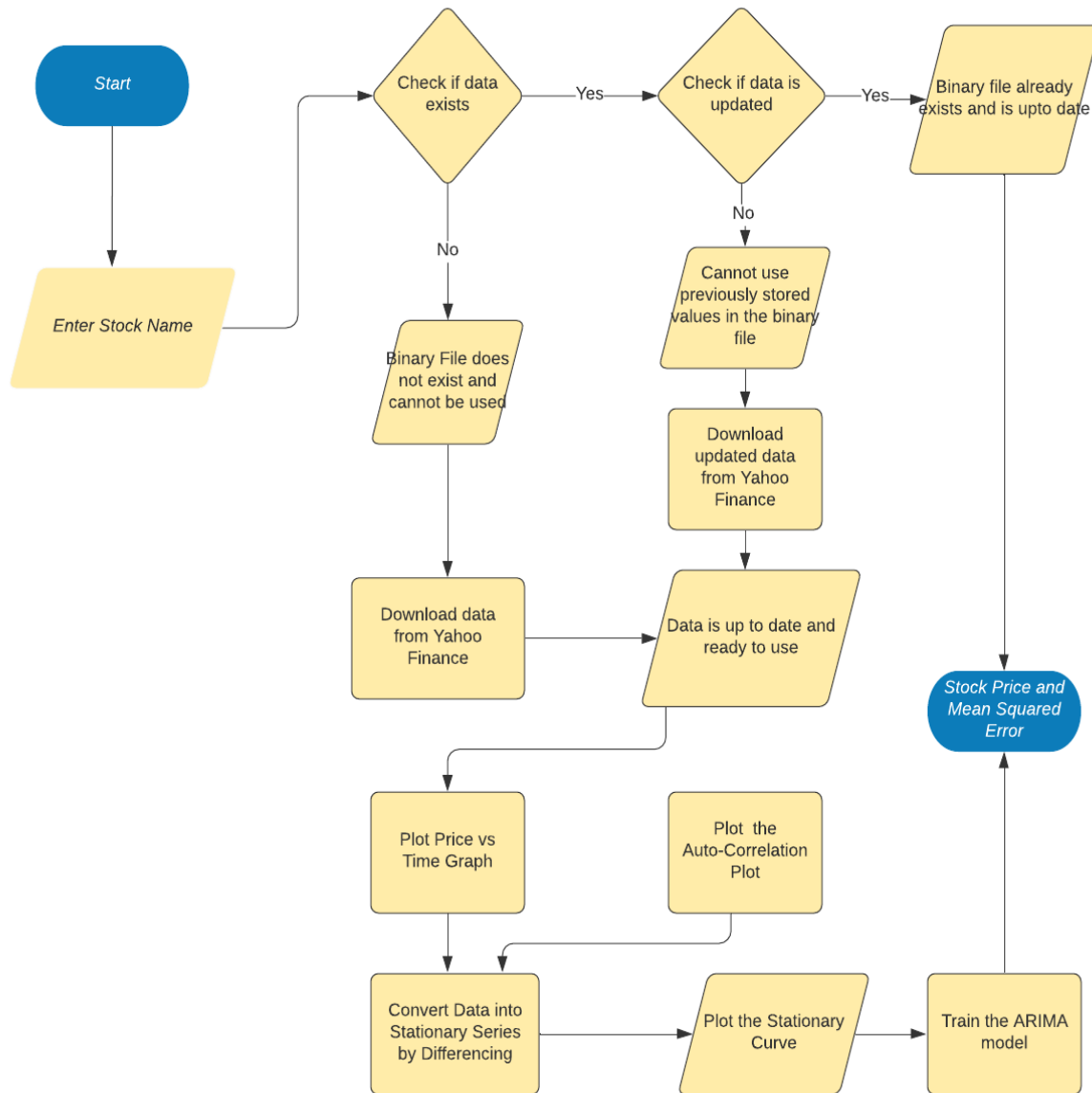


## Kv Language Commands Used in The Project:

- `root.press()` - executes the function if widget is pressed
- `app.root.current` - sets the app to move to the desired screen
- `Root.manager.transition.direction` - makes a basic animation/transition in the mentioned direction
- `root.clear()` - clears the screen



## The Flow of Data:



# Our Project

We used the ARIMA Model to try and predict the Future Price of a company's stock using historical data that was available on Yahoo Finance.

## The Code:

```
main.py x
main.py > MainWindow > press

32 try:
33
34     global train_model
35
36     df = pandas.read_csv("C:\\Users\\kaust\\{}.csv".format(stock_name)) # if data for the stock is already present we check
37     print('File exists. Checking if it is updated...') # if it is updated
38     for x in df['Date'][::-1]: # getting latest date on existing csv
39         last_on_csv = x
40         break
41     today = datetime.date.today() # getting today's date
42     hist = stock.history(start=last_on_csv, end=today)
43     if len(hist) > 2: # to check if there is newer data
44         hist = stock.history(period='max')
45         hist.to_csv("C:\\Users\\kaust\\{}.csv".format(stock_name)) # updating data
46         df = pandas.read_csv("C:\\Users\\kaust\\{}.csv".format(stock_name)) # redefining DataFrame object
47         print('Database updated')
48         train_model = True
49     else:
50         print('Database already up to date')
51         train_model = False
52 except:
53     hist = stock.history(period = 'max')
54     hist.to_csv("C:\\Users\\kaust\\{}.csv".format(stock_name))
55     train_model = True
56
57 df = pandas.read_csv("C:\\Users\\kaust\\{}.csv".format(stock_name)) # loading in the data
58
59 matplotlib.pyplot.figure()
60
61 pandas.plotting.lag_plot(df['Close'], lag=3) # plot of stock prices plotted with itself in the past with certain
62 matplotlib.pyplot.show() # eg June 14 on y axis, June 11 on x axis
63
64 matplotlib.pyplot.plot(df["Date"], df["Close"]) # plotting price v time
65 matplotlib.pyplot.xticks(numpy.arange(0,len(df), len(df)//3), df['Date'][0:len(df):len(df)//3])
66 matplotlib.pyplot.show()
67
68 train_data, test_data = df[0:int(len(df)*0.75)], df[int(len(df)*0.75):] # 75% of data used for training and 25% for testing
69 training = train_data['Close'].values
70 testing = test_data['Close'].values
71
72 frame = pandas.DataFrame(training) # creating a dataframe object
```

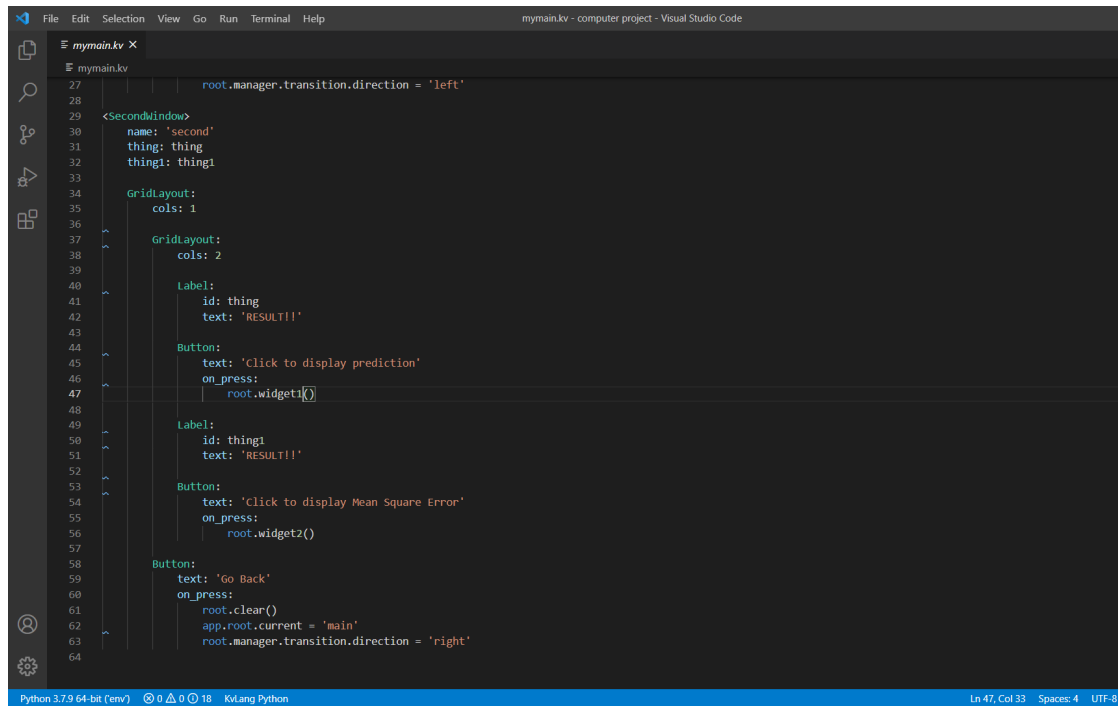
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main.py X
main.py > MainWindow > press
71
72 frame = pandas.DataFrame(training)                                # creating a dataframe object
73 training = frame.diff(periods = 1, axis = 0)                       # differencing the training
74 training = training.to_numpy()                                     #periods = 1 for first order differencing and axis = 0 since we're dif
75
76
77 matplotlib.pyplot.plot(training)                                   # data has been made into a stationary series
78 matplotlib.pyplot.show()
79
80 t = training[1:len(training)+1]
81
82 history = [x for x in t]
83 model_predictions = []
84 N_test_observations = len(test_data)
85 progress_count = 0
86
87 if train_model:
88     print('Training model...')
89     for time_point in range(N_test_observations):
90         model = ARIMA(history, order=(4,1,0))
91         model_fit = model.fit(disp=0)
92         output = model_fit.forecast()
93         yhat = output[0]
94         model_predictions.append(yhat)
95         true_test_value = testing[time_point]
96         history.append(true_test_value)
97         progress_count += 1
98         print(progress_count, 'out of', N_test_observations, 'complete.')
99
100 MSE_error = mean_squared_error(testing, model_predictions)
101 print('Testing Mean Squared Error is', MSE_error)
102 print('The predicted value is :', model_predictions[-1][0])
103
104 global mse_1
105 mse_1 = str(MSE_error)
106
107 global preval_1
108 preval_1 = str(model_predictions[-1][0])
109
```

```
main.py X
main.py > MainWindow > press
110 test_set_range = df[int(len(df)*0.75):].index
111 matplotlib.pyplot.plot(test_set_range, model_predictions, color = 'blue', linestyle = 'dashed', label = 'Predicted Price', marker = '.', ms = 4)
112 matplotlib.pyplot.plot(test_set_range, testing, color='red', label='Actual Price')
113 matplotlib.pyplot.show()
114
115 print('Saving values...')
116 file = open("c:\\Users\\Kaust\\{}_values.dat".format(stock_name), 'wb')
117 pickle.dump(model_predictions, file)
118 pickle.dump(MSE_error, file)
119 file.close()
120 print('Saved')
121
122 else:
123     print('Model already trained.')
124     file = open("c:\\Users\\Kaust\\{}_values.dat".format(stock_name), 'rb')
125     try:
126         while True:
127             x = pickle.load(file)
128             if type(x) == type([]):
129                 print('The predicted value is :', round(x[-1][0], 4))
130
131                 global preval_2
132                 preval_2 = str(round(x[-1][0], 4))
133
134             else:
135                 print('Testing Mean Squared Error is', round(x, 4))
136
137                 global mse_2
138                 mse_2 = str(round(x, 4))
139
140     except:
141         file.close()
142
143 class Secondwindow(Screen):                                # for building second screen
144     def widget1(self):
145         if train_model:
146             self.ids.thing.text = preval_1
147         else:
148             self.ids.thing.text = preval_2
149
```

```
148
149     def widget2(self):
150         if train_model:
151             self.ids.thing1.text = mse_1
152         else:
153             self.ids.thing1.text = mse_2
154
155     def clear(self):
156         self.ids.thing.text = self.ids.thing1.text = 'RESULT!!'
157
158 class WindowManager(ScreenManager):
159     pass
160
161 kv = Builder.load_file('mymain.kv') # calling the kivy file and building app
162
163 class MyMainApp(App):
164     def build(self):
165         return kv
166
167 if __name__ == '__main__': # running app
168     MyMainApp().run()
169
```

Python 3.7.9 64-bit (env) 0 0 Kivy Python Ln 17, Col 97 Spaces: 4 UTF-8 C

```
File Edit Selection View Go Run Terminal Help mymain.kv - computer project - Visual Studio Code
mymain.kv X
1 WindowManager:
2     MainWindow:
3     SecondWindow:
4
5 <MainWindow>
6     name: 'main'
7     stock: stock
8
9     GridLayout:
10         cols: 1
11
12         GridLayout:
13             cols: 2
14
15             Label:
16                 text: 'Stock: '
17
18             TextInput:
19                 id: stock
20                 multiline: False
21
22             Button:
23                 text: 'Submit'
24                 on_press:
25                     root.press()
26                     app.root.current = 'second'
27                     root.manager.transition.direction = 'left'
```



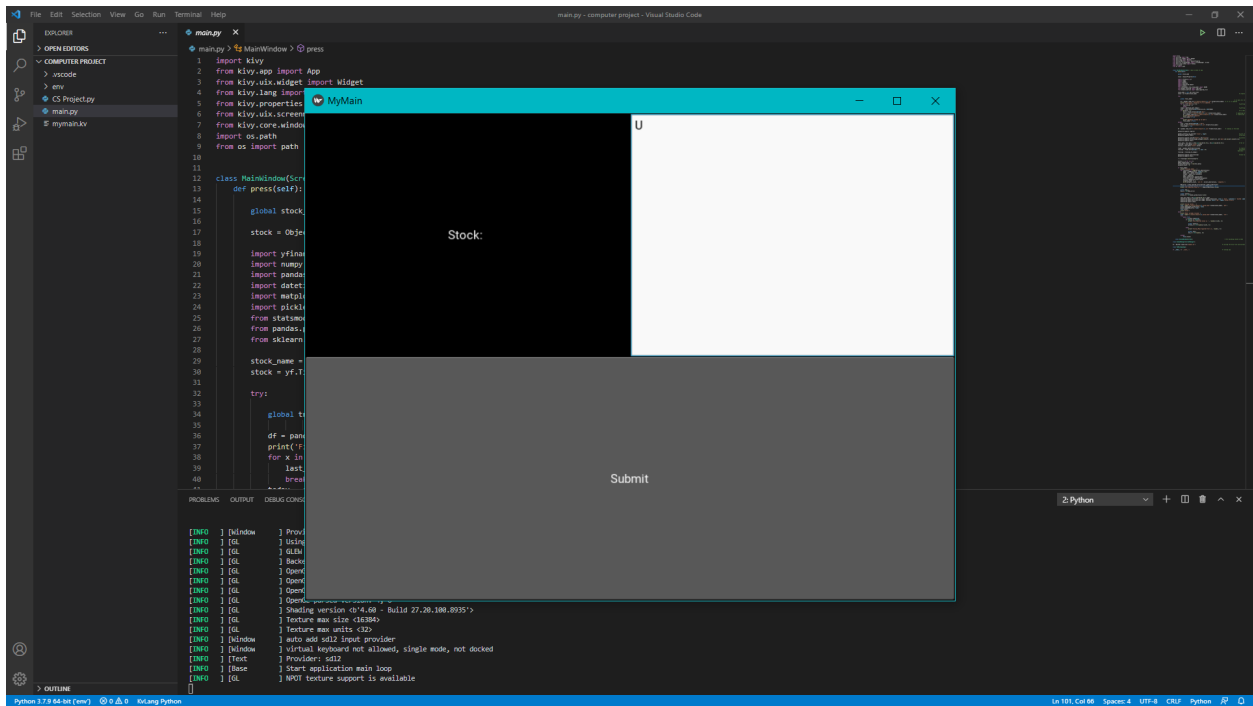
```
27 root.manager.transition.direction = 'left'
28
29 <SecondWindow>
30     name: 'second'
31     thing: thing
32     thing1: thing1
33
34     GridLayout:
35         cols: 1
36
37         GridLayout:
38             cols: 2
39
40             Label:
41                 id: thing
42                 text: 'RESULT!!'
43
44             Button:
45                 text: 'Click to display prediction'
46                 on_press:
47                     root.widget1()
48
49             Label:
50                 id: thing1
51                 text: 'RESULT!!'
52
53             Button:
54                 text: 'Click to display Mean Square Error'
55                 on_press:
56                     root.widget2()
57
58         Button:
59             text: 'Go Back'
60             on_press:
61                 root.clear()
62                 app.root.current = 'main'
63                 root.manager.transition.direction = 'right'
64
```

## The Output:

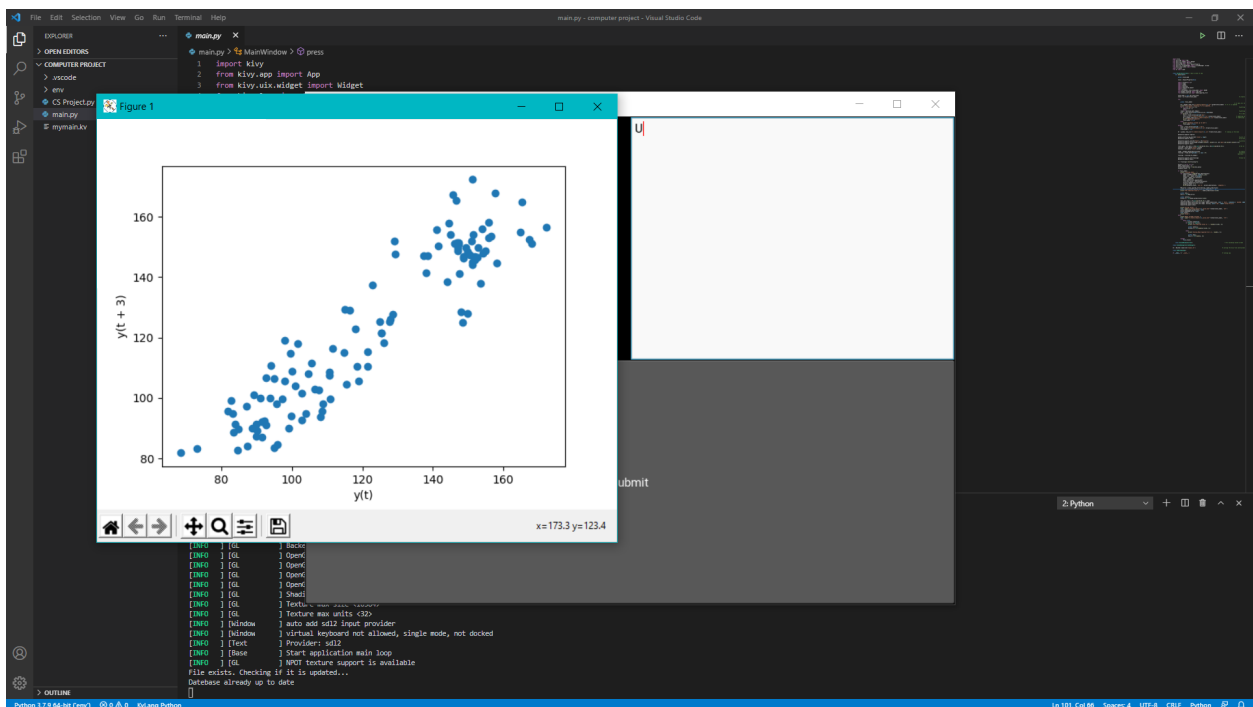
We have taken five different Stocks with different case-scenarios and have attached them below.

## Case 1 - Unity:

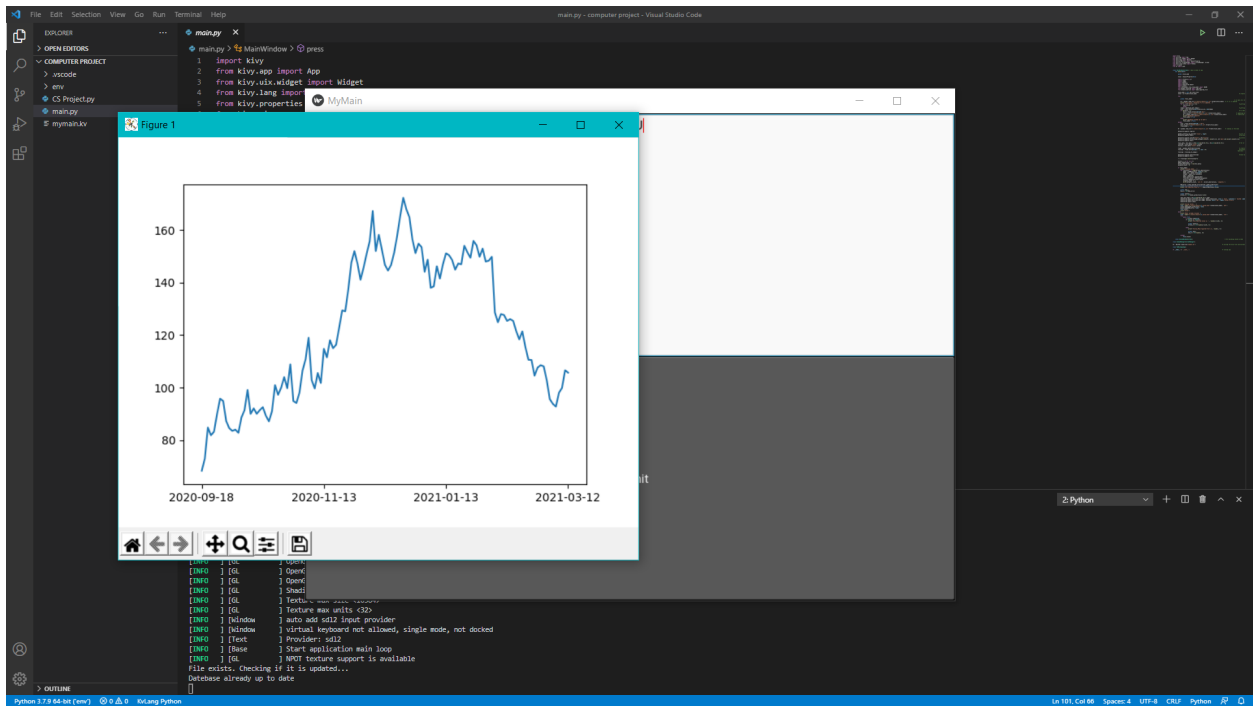
NYSE Stock Name - U



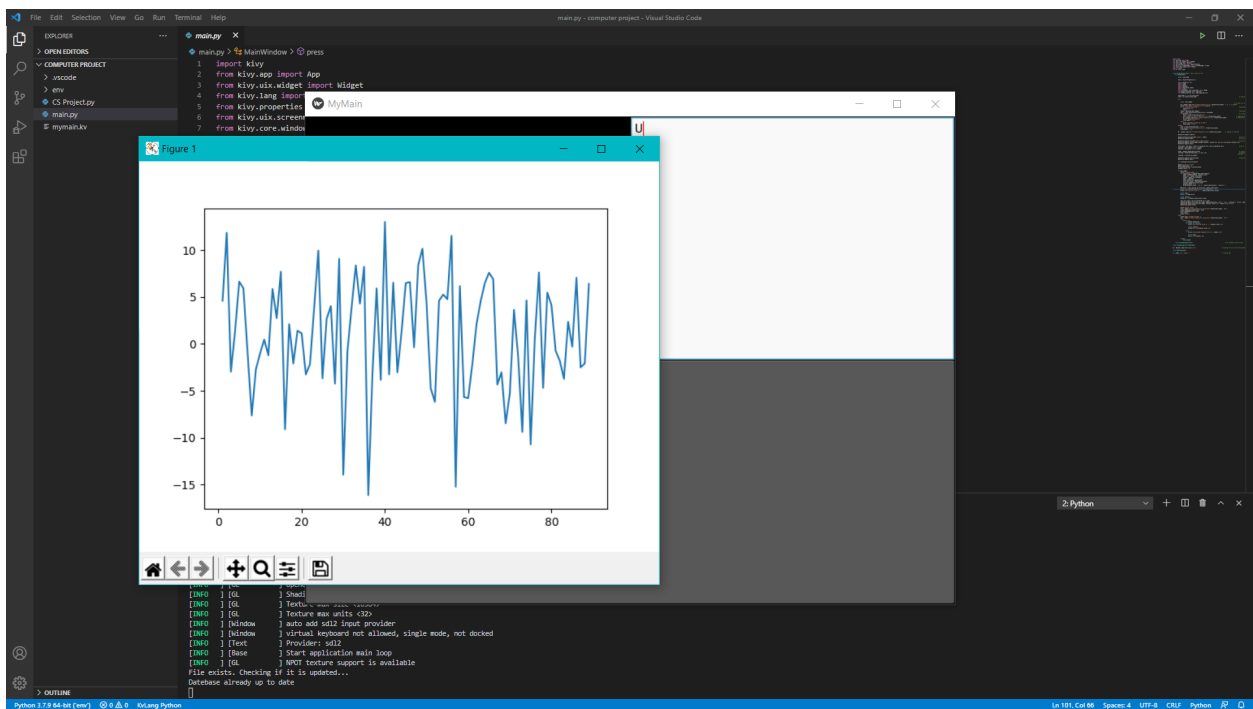
Start/Input Window



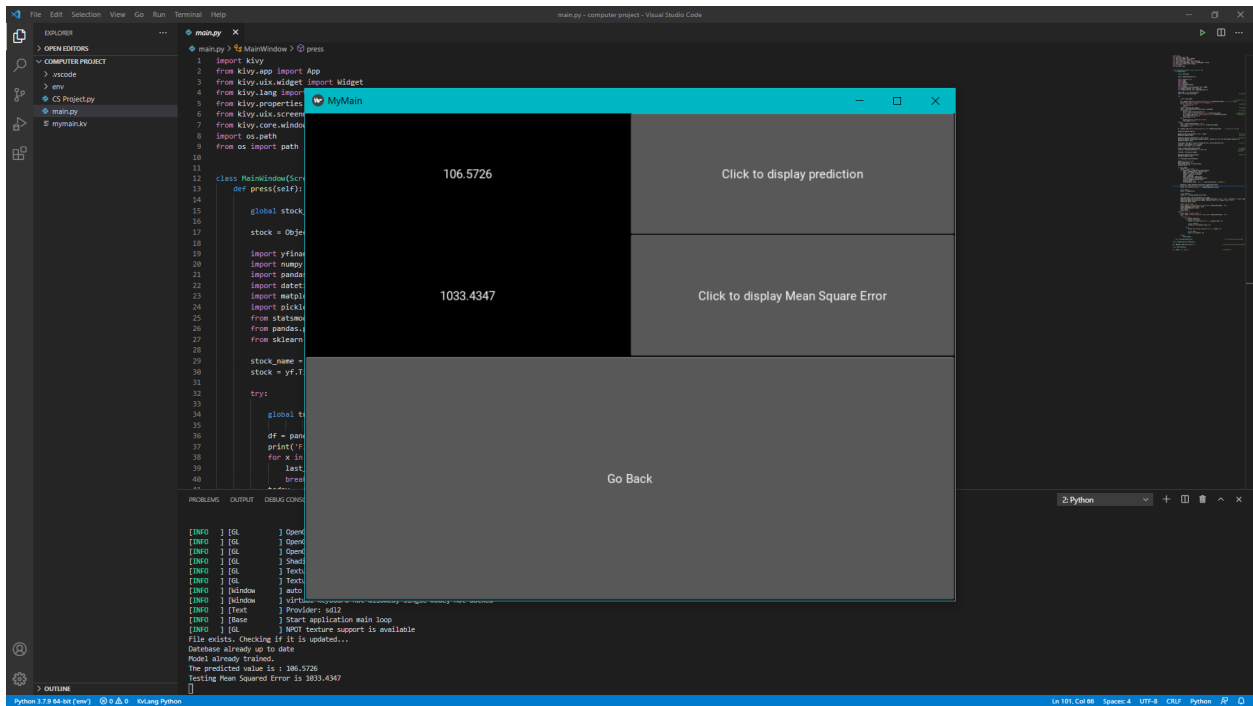
Auto-Correlation Graph



Price vs Time Graph

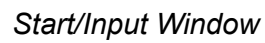


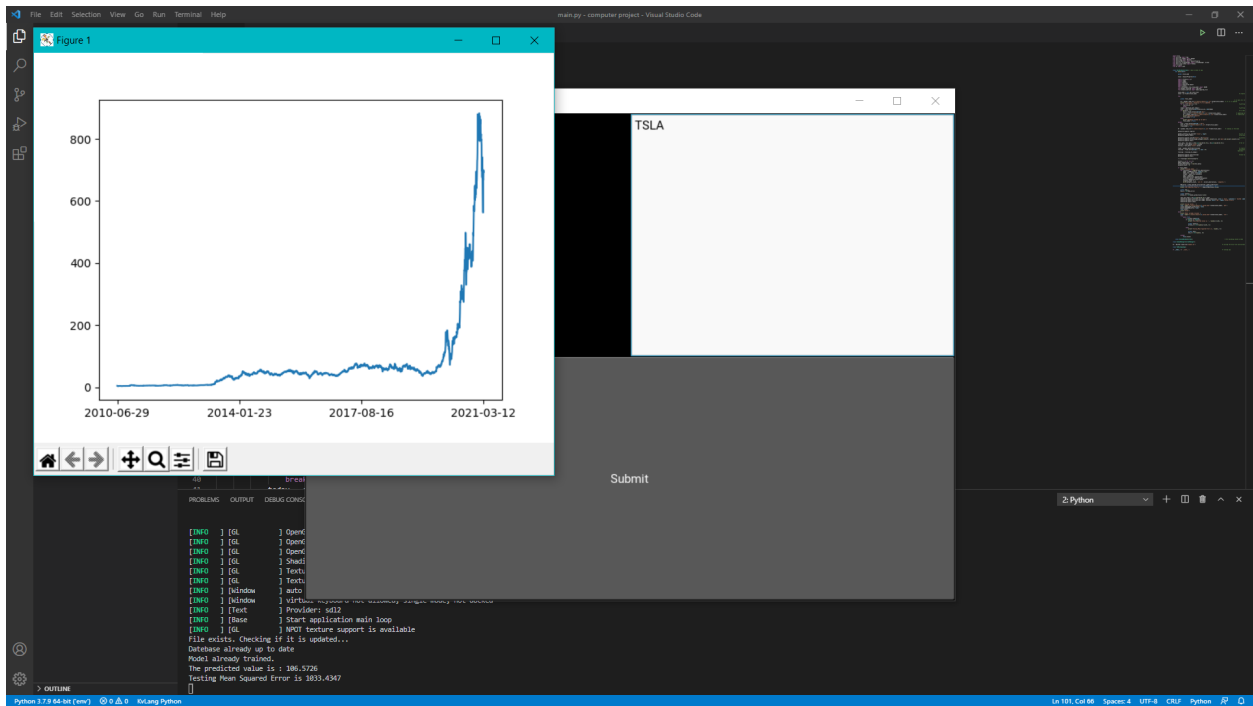
Stationary Curve Graph



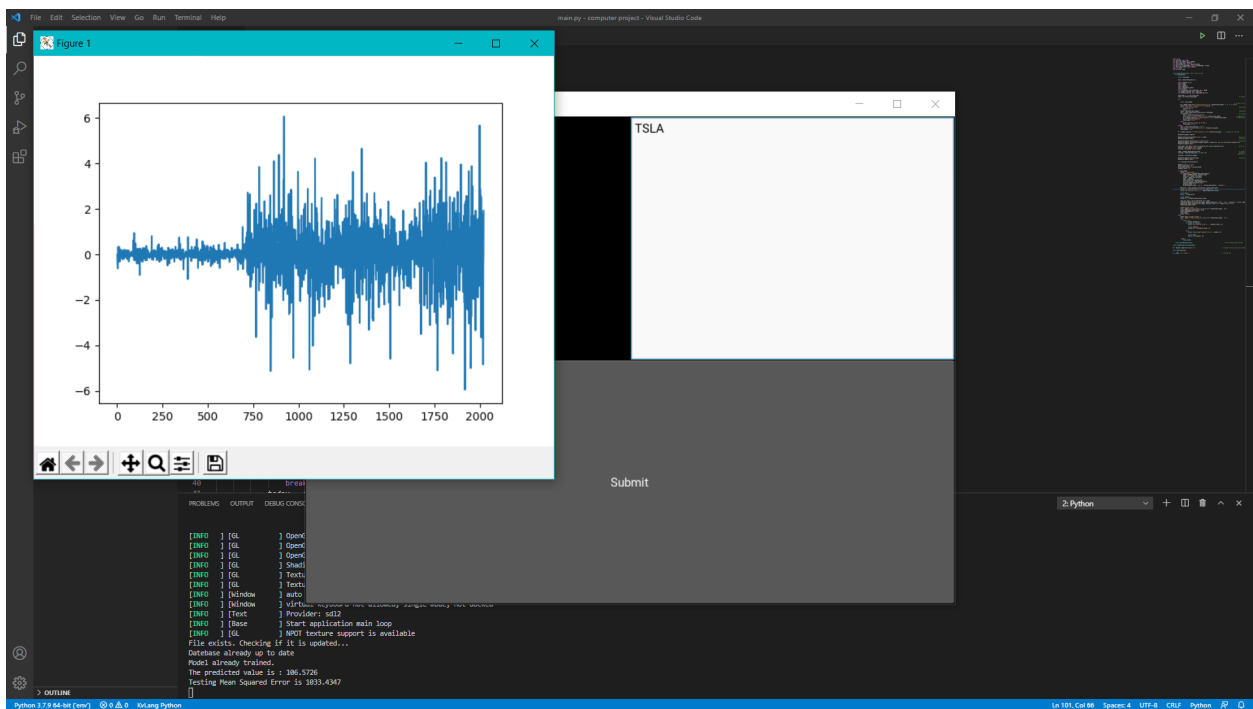
## Case 2 - Tesla:







Price vs Time Graph

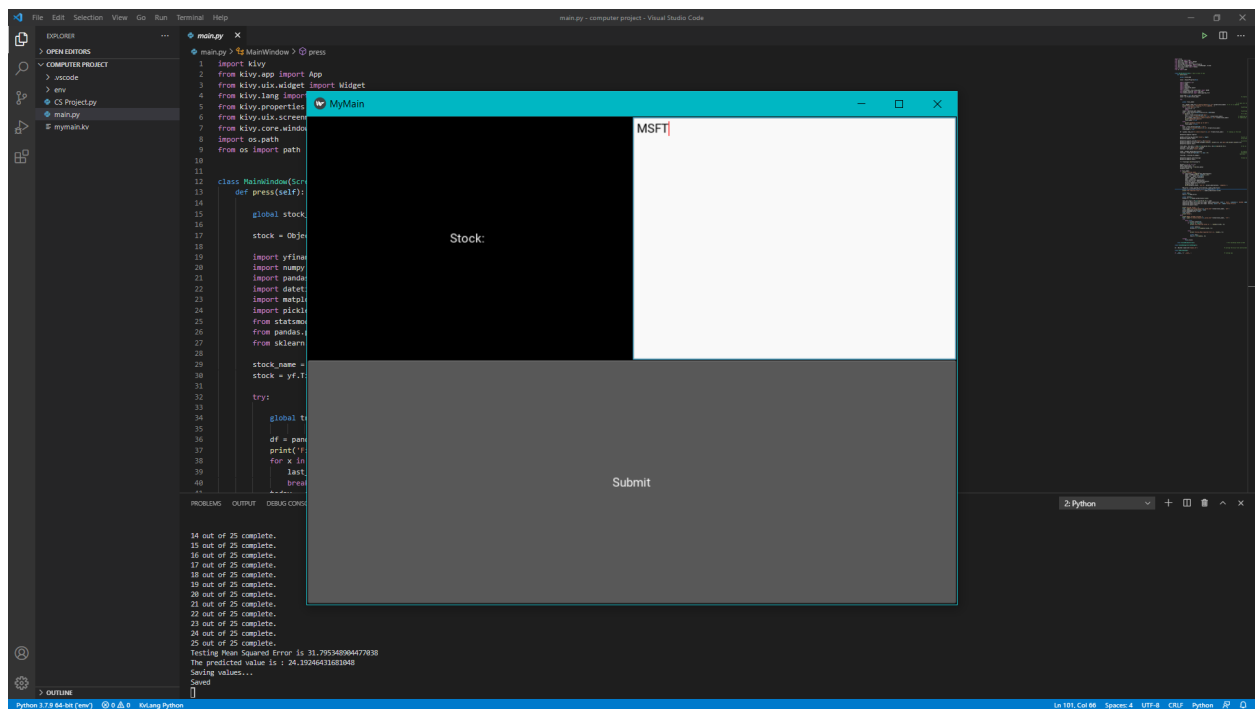


Stationary Curve Graph

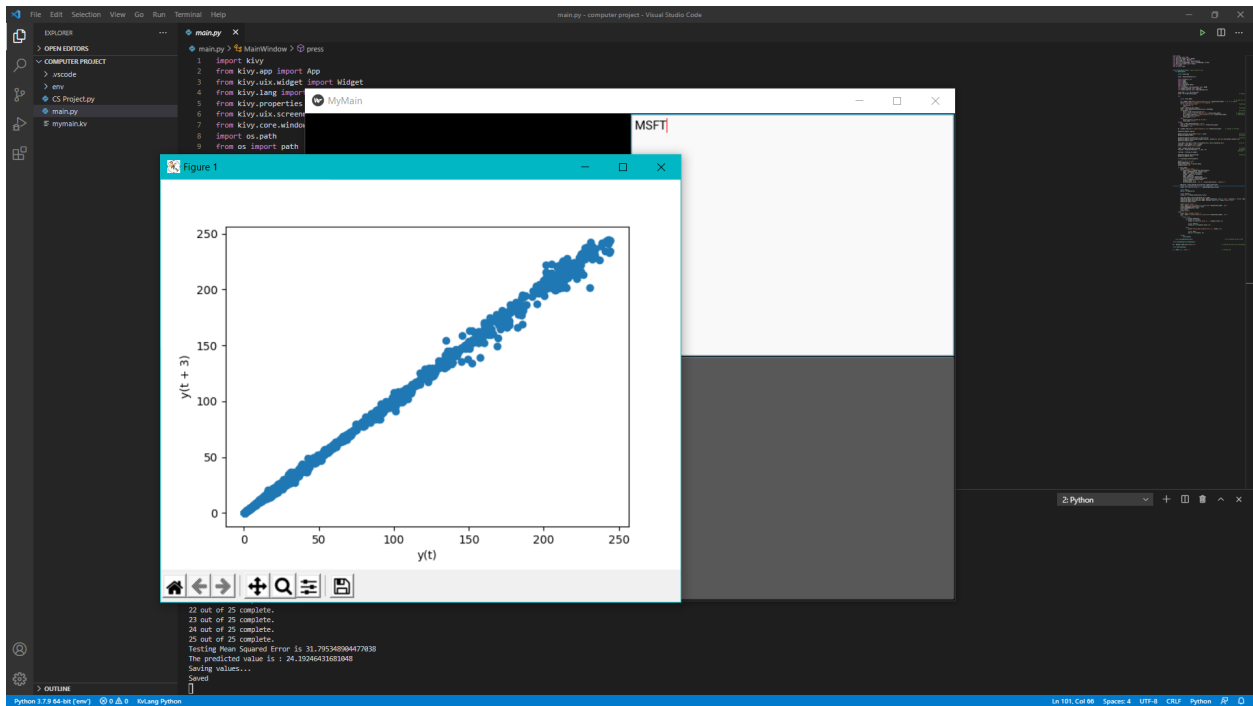


## Case 3 - Microsoft:

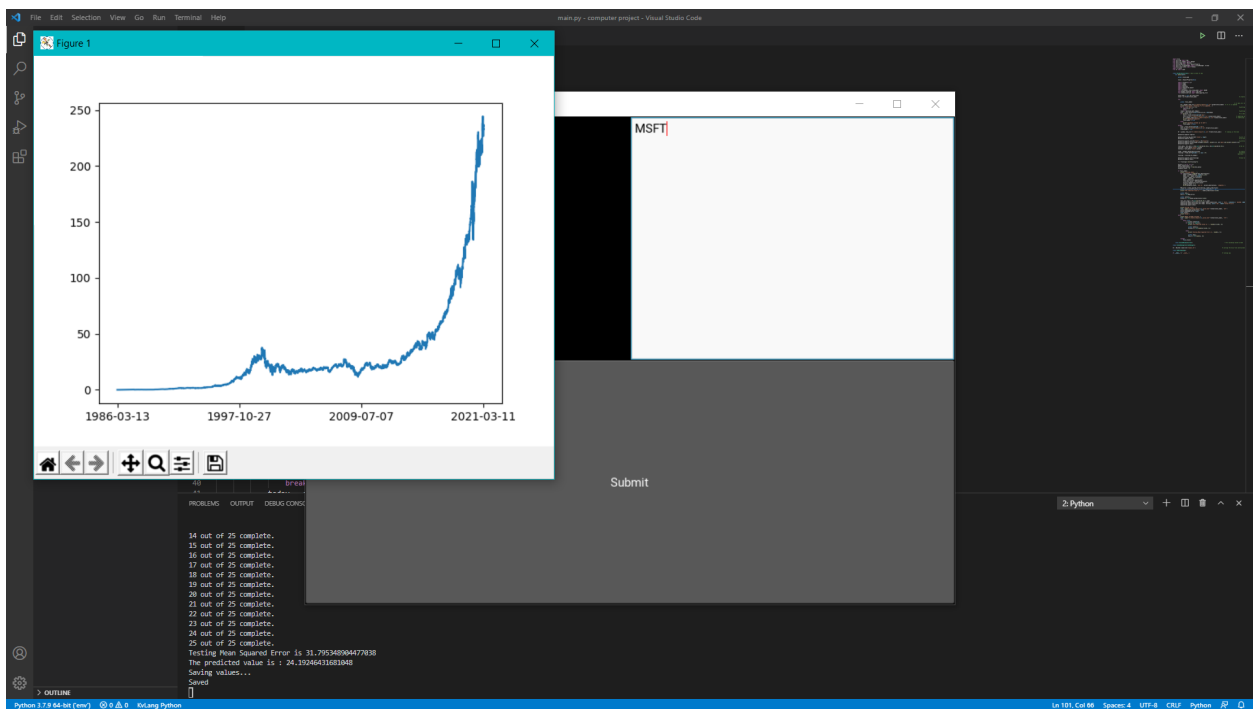
NYSE Stock Name - MSFT



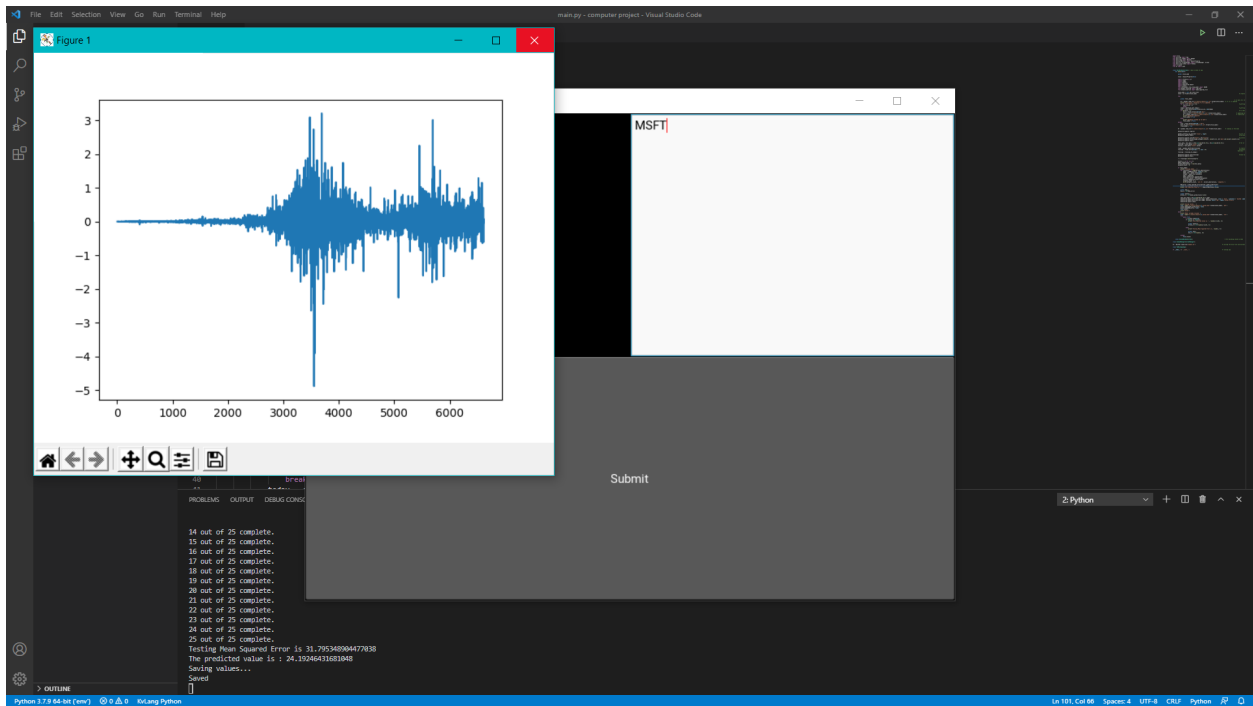
*Start/Input Window*



Auto-Correlation Graph

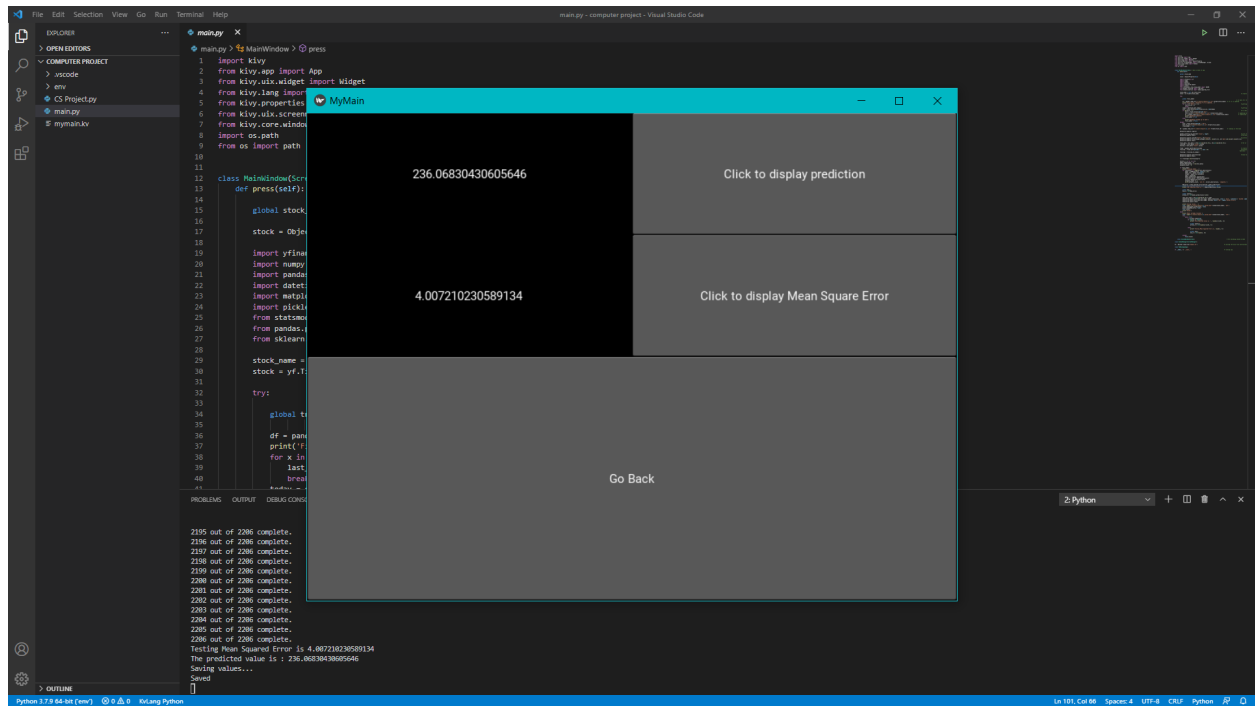


Price vs Time Graph



Stationary Curve Graph

```
1 import kivy
2 from kivy.app import App
3 from kivy.uix.widget import Widget
4 from kivy.lang import Builder
5 from kivy.properties import ObjectProperty
6 from kivy.uix.screenmanager import ScreenManager, Screen
7 from kivy.core.window import Window
8 import os.path
9 from os import path
10
11
12 class MainScreen(Screen): # main screen of app
13     def press(self):
14
15         global stock_name
16
17         stock = ObjectProperty(None)
18
19         import yfinance as yf
20         import numpy
21         import pandas
22         import datetime
23         import matplotlib.pyplot
24         import pickle
25         from statsmodels.tsa.arima_model import ARIMA
26         from pandas.plotting import lag_plot
27         from sklearn.metrics import mean_squared_error
28
29         stock_name = self.ids.stock.text
30         stock = yf.Ticker(stock_name) # creating an object for the stock
31
32         try:
33             global train_model
34
35             # If data for the stock is already present we check
36             df = pandas.read_csv("C:\\Users\\koust\\1.csv".format(stock_name)) # if it is updated
37             print("File exists. Checking if it is updated...")
38             for x in df["date"][(i-1)]: # getting latest date on existing csv
39                 last_on_csv = x
40             break
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