

User Manual

GM FinTech

Getting Started



Actual GM Stock Price Trend as of 12/1/19

Document Version History

Version	Date	Author	Reviewer	Approved by	Description
0.1	11/12/2019	Abdul Ahmad	N/A	N/A	Created the new document, formatted, wrote starter text
0.2	11/15/2019	Abdul Ahmad	N/A	N/A	Formatted sections
0.3	11/23/2019	Aalem Singh	Abdul Ahmad	Abdul Ahmad	Appendix E, Algorithm explanation
0.4	11/26/2019	Abdul Ahmad	N/A	N/A	Front page, graphics, TOC, section 1 , 1.1
0.5	11/27/2019	Abdul Ahmad	N/A	N/A	Added section 2, TOC, created section headings
0.6	11/28/2019	Mohamad Saab	Abdul Ahmad	Abdul Ahmad	Updated section 1, graphics
0.7	11/29/2019	Abdul Ahmad	N/A	N/A	Section 2, 2.1, added section 3, screenshots of each step
0.8	11/30/2019	Abdul Ahmad	N/A	N/A	Section 2.2, 3.3, 3.9
0.9	12/1/2019	Abdul Ahmad	N/A	N/A	Section 1, 1.2, 1.3, 1.4, 2.4, 3.2, 3.3, 3.4, 3.5, appendix D, headings
0.10	12/2/2019	John Gettel	N/A	N/A	Section 3.3 , Appendix B
0.11	12/3/2019	Abdul Ahmad	N/A	N/A	Appendix A, section 4, 4.1, 4.2
0.12	12/4/2019	Abdul Ahmad	N/A	N/A	Section 4.2 completed
0.13	12/5/2019	Abdul Ahmad; John Gettel;	N/A	N/A	Appendix C, D, TOC, hyperlinks, section E5, proofread
1.0	12/6/2019	Abdul Ahmad	N/A	N/A	Proofread, headings, edited, hyperlinks, release v1.0
1.0	12/10/2019	Abdul Ahmad	N/A	John Gettel; Aalem Singh; Mohamad Saab;	Proofread, section 1.3 edited, appendix B, C, E edited, front page, footer

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1 Welcome to GM FinTech

GM FinTech is a stock price analysis application that trends, forecasts and simulate stock prices using five algorithms and five strategies on five different stock symbols. This application is designed as part of Capstone project by senior undergraduate students in the department of Computer Science at Wayne State University under the advising of Dr. Seyed Ziae Mousavi Mojab and Mr. Joshua Feinstein Lead in the Global Data, Artificial Intelligence & Analytics Services department at General Motors Corporation in Detroit, Michigan. With GM FinTech application an experienced stock data analyst can make decisions to buy, sell or hold stocks, monitor stock prices, observe the simulated trading strategies performance and view the stock forecasts based on different algorithms.

1.1 What You Will Learn

The following chapters will give you a tour of the GM FinTech application and a tutorial on how to update the database. You will learn to do the following:

- Run the data files
- Load data to database
- Use the Tableau front end
- Manage the instrument master table

1.2 Before You Begin

All software must be installed as described in the product design specification document. Following is the list for your reference:

- MySQL 8.0 or later (Workbench), Username: **root** – Password : **password**
- PyCharm Professional Edition 2019.2 or later(with all required packages)
- Python 3.7
- PIP 19.3.1 or later (PyPA recommended tool for installing Python packages)
- Tableau Desktop Professional Edition 2019.3.0 or later
- Microsoft Windows 10 PC with Intel 10th generation processor and 16GB memory, minimum screen resolution of 1366 x 768
- Download all the source code from <https://gitlab.com/jwgettel/gmfintechf2019>

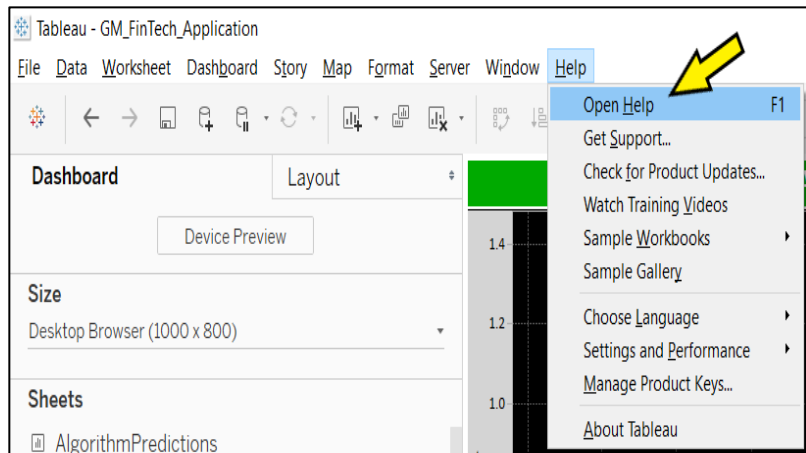
1.3 What You Need to Get Started

A Microsoft Windows Personal Computer with all the required software as listed in section 1.2 above and in the product design specification document, source code and, a working Internet connection. All software must be installed using the README file.

1.4 Where to Go for Help

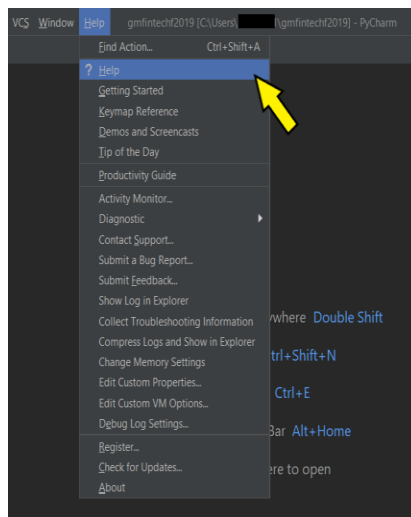
There is no custom onscreen help available in the GM FinTech application. Tooltips on each graph and measure will provide information regarding the calculations.

You can use Tableau help and support by clicking on the built-in **Help** menu as shown on the right.

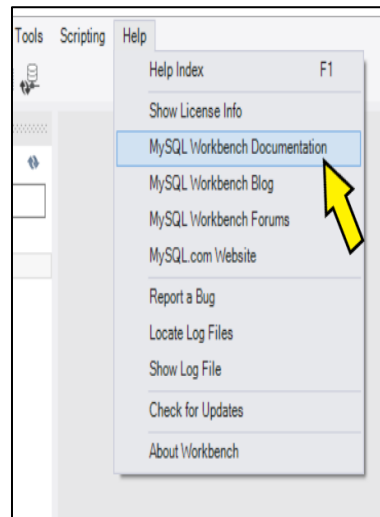


1.4a Tableau Help Menu

You can use PyCharm and MySQL help and support by clicking on the built-in **Help** menu as shown on the right.



1.4b PyCharm Help Menu



1.4c MySQL Help Menu

Following are few other help resources available online for Tableau, PyCharm and MySQL help:

<https://www.tableau.com/support/help>

<https://community.tableau.com/welcome>

<https://www.jetbrains.com/help/pycharm/getting-help.html>

<https://www.python.org/doc/>

<https://pypi.org/project/pip/>

<https://dev.mysql.com/doc/>

2 Getting Started

This chapter provides detailed instructions on how to get started with the GM FinTech application, including running the back-end data, operating the Tableau front-end and understanding the financial information.

2.1 Start PyCharm

Start PyCharm IDE(Interactive Development Environment)

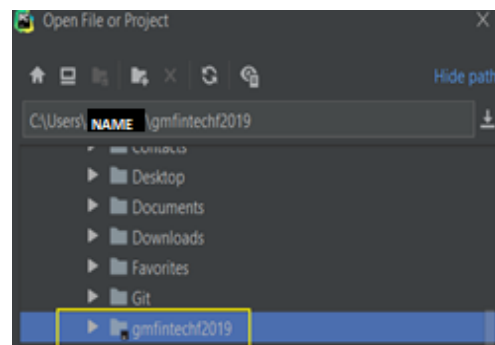
2.2 Locate Project Folder

Go to File → Open

Go to → C:\Users\your_name\gmfintechf2019

Click on the folder named '**gmfintechf2019**'
(do not double click)

Click the OK button



2.2 Project Folder

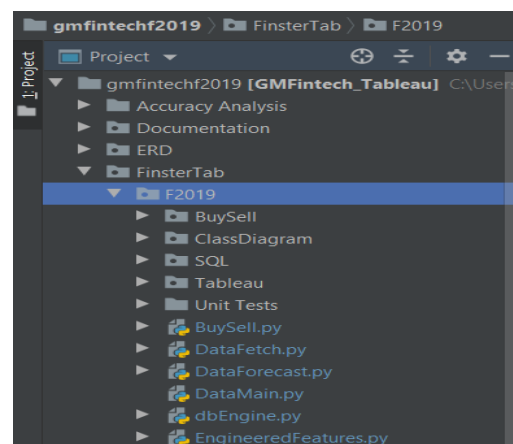
2.3 Run DataMain

Browse to FinsterTab → F2019



2.3a Folder Path

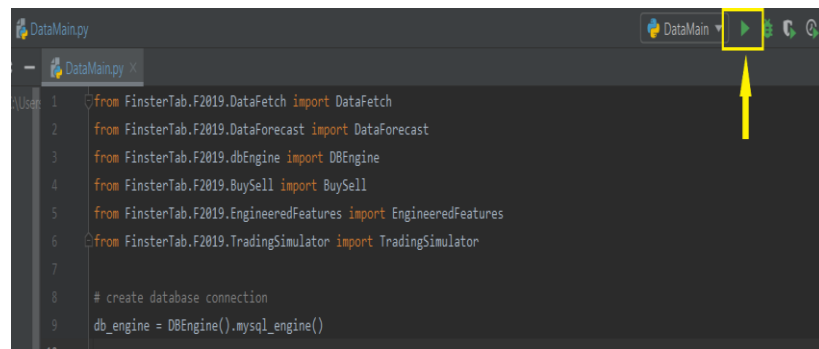
Open '**DataMain.py**'



2.3b Open DataMain.py

Click the Run button as shown on the right

You can also right click and click the Run 'DataMain'

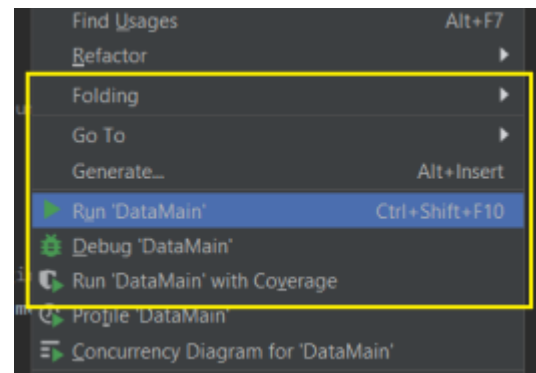


2.3c Run DataMain.py

2.4 Data Load

All the data is now being fetched, calculations are being performed and loading into the MySQL database. All these steps will take 50 seconds or less.

Above runtime is dependent upon your internet connection and YAHOO data exchange's availability.



2.4 Data Load

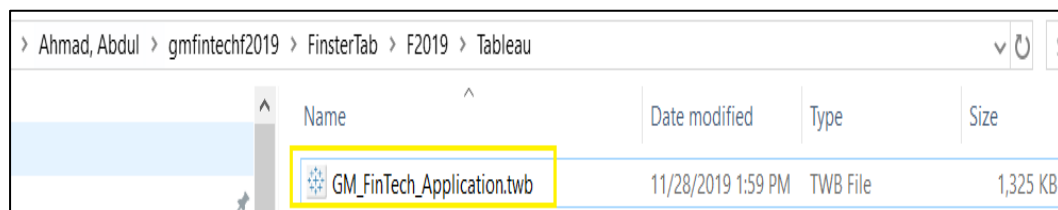
3 Tableau

3.1 Start Tableau Application

Go to the folder location → C:\Users\your_name\gmfintechf2019\FinsterTab\F2019\Tableau\

Start the application by double clicking on the 'GM_FinTech_Application.twb' file

.twb is the Tableau file extension

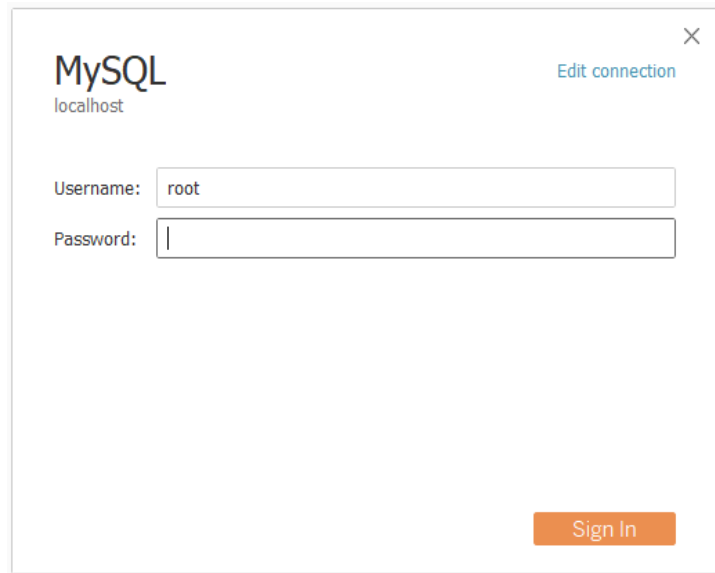


3.2 Login

After starting the application, you will be asked to enter a username and password. This is not for Tableau but rather for the MySQL database that the GM FinTech application is connected to.

The username is **'root'** which will be automatically populated. If it's not populated you can enter it.

In the Password field enter the word **'password'** or the password value that was configured during the setup of MySQL local database instance.



3.2 Tableau MySQL Login Screen

3.3 Data Refresh

For the back-end of this project Tableau extract server was not used. An extract(file) server is required to publish data files which can then be refreshed via command line as shown in the figure on the right.

The application does not have capability to automatically update all the data sources at once in Tableau.

```
Microsoft Windows [Version 10.0.17134.1069]
(c) 2018 Microsoft Corporation. All rights reserved.

C:\Windows>cd..

C:\>cd C:\Program Files\Tableau\Tableau 2019.3\bin

C:\Program Files\Tableau\Tableau 2019.3\bin>tableau refreshextract
Please specify the server where the extract is published.

C:\Program Files\Tableau\Tableau 2019.3\bin>
```

3.9 Tableau automated refresh command

Tableau data models in GM FinTech application are based on **'live connection'**. Live connection allows a single dataset to be updated at a time. You can update data for each data model rather than overloading the system with full extract update. Drawback of this strategy is that the user will have to individually refresh each dataset connected to the tab they are looking at.

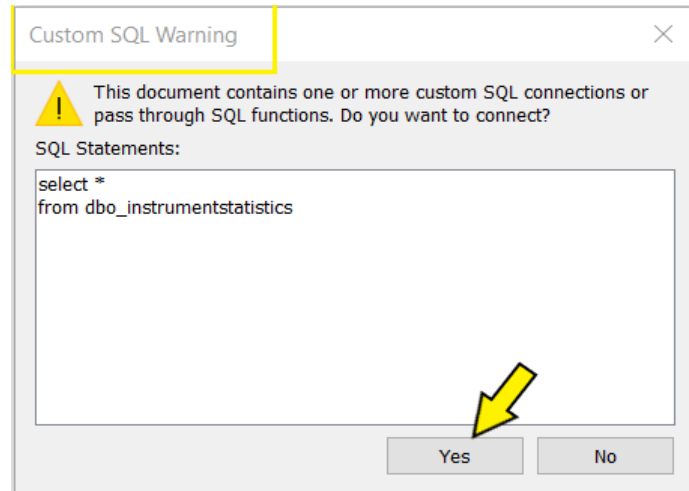
Similar to many business intelligence tools there should be ability to update all ‘live connections’ in a Tableau application with a single refresh but it’s currently an open issue with Tableau. Following are few community and help threads regarding the issue:

<https://community.tableau.com/ideas/7086>

https://help.tableau.com/current/pro/desktop/en-us/extracting_TDE.htm

You might also get a pop-up asking permission to run custom SQL.

Please Press → **Yes**

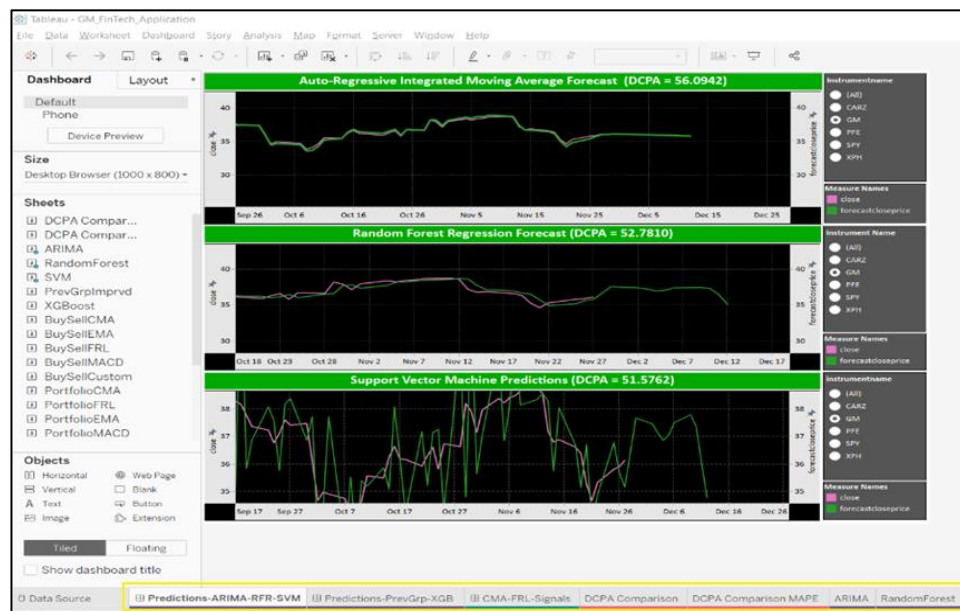


This warning can’t be suppressed. Following is a Tableau community discussion regarding the issue:

https://community.tableau.com/thread/150951?_ga=2.17993273.148115256.1575306322-904304250.1567360993&_gac=1.116629876.1573414684.CjwKCAiAh5_uBRA5EiwASW3IarLcCF7yf5d743QsKJfCantOwAV3fAxKW36sb5jMggXlek2W3Y74BoCw5YQAvD_BwE

3.4 Tabs

You will now land at a tab in Tableau. There are several tabs across the bottom of the application. Each tab is designed to show a different type of measure and view.

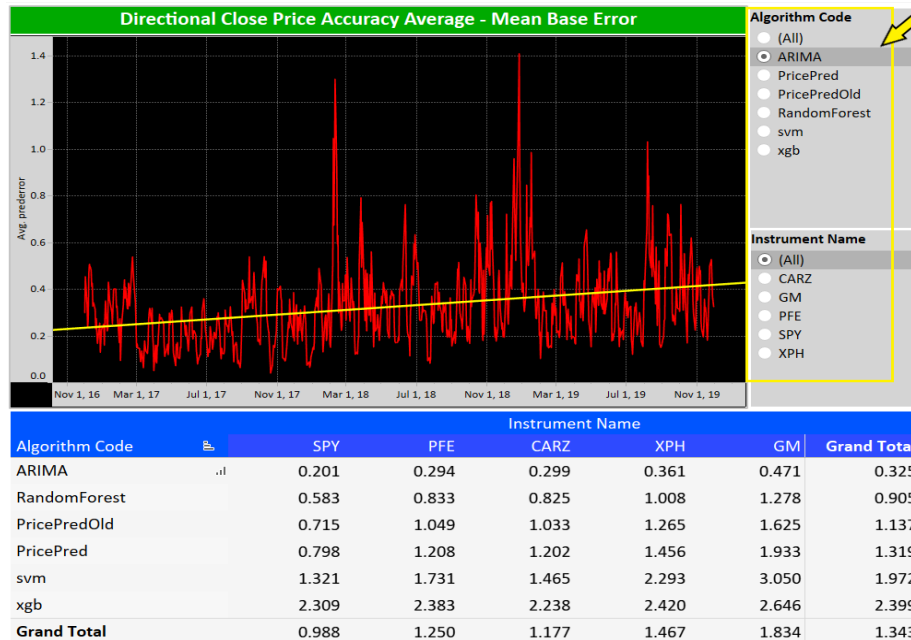


3.3 Tableau Tabs/Views

3.5 Radio Buttons

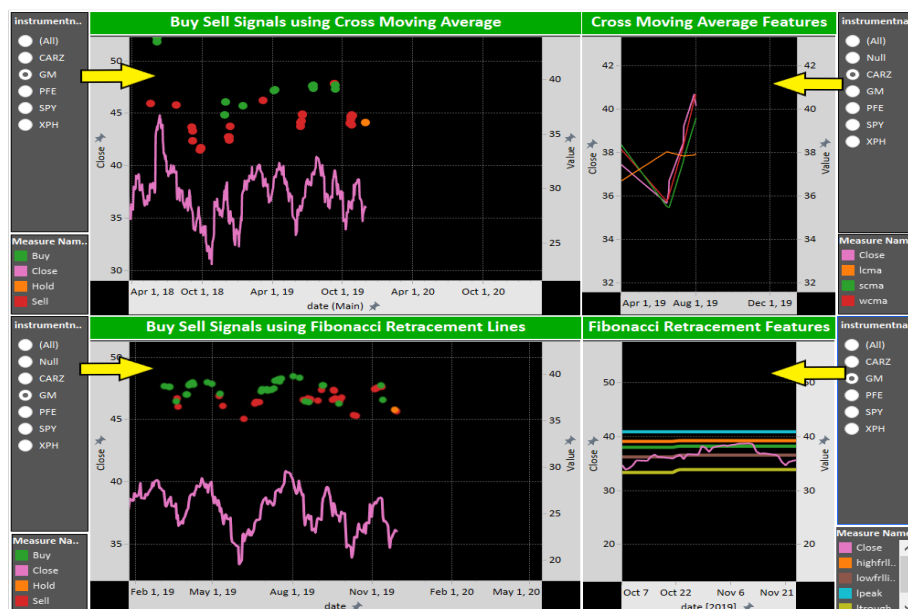
Graphs and metrics have radio buttons to the right or left of the screen. These buttons can be used to make selections according to your requirement.

Most of the buttons throughout the application are stacked on the right side.



3.4a Radio Buttons

Buttons on the 'CMA-FRL-Signals' tab are stacked to the right and left. Each visual has its own set of buttons associated with it as shown in the figure on the right.



3.4b Radio Buttons on the Left and Right

4 Database

GM FinTech application's backend is built using a MySQL database. A local instance is created with the username 'root' and password 'password'. MySQL is a free database solution.

4.1 MySQL Workbench

As mentioned in section 1.2, MySQL Workbench is needed to execute any SQL script.

4.2 Add/Remove Instruments

Add an Instrument

Start MySQL Workbench

Go to → C:\Users\yourname\gmfintechf2019\FinsterTab\F2019\SQL\SQL CREATE TABLE SCRIPTS MYSQL\

Open script file → INSERT_INTO_INSTRUMENT_MASTER_MYSQL.sql

If you would like to add an instrument.

Make a copy of the last line, first value is an identifier, 2nd value should be the exact trading symbol name that you would to add, the name must be same as its traded on the stock market. 3rd and 4th value can be kept the same.

After editing the code click the Run button or press Ctrl + Shift + Enter

```
insert into dbo_instrumentmaster
values (1 , 'GM' , 'Equity' , 'YAHOO'),
      (2 , 'PFE' , 'Equity' , 'YAHOO'),
      (3 , 'SPY' , 'Equity' , 'YAHOO'),
      (4 , 'XPH' , 'Equity' , 'YAHOO'),
      (5 , 'CARZ' , 'Equity' , 'YAHOO')
;
```

Remove and Instrument

Open script file → REMOVE_FROM_INSTRUMENT_MASTER_MYSQL.sql

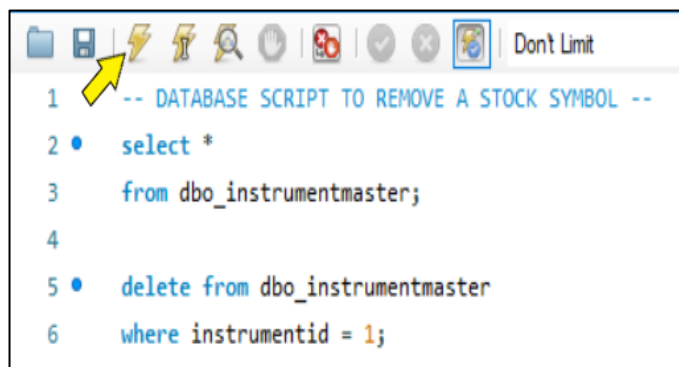
Highlight line 2 and 3 in MySQL, run it. Note the 'instrumentid' of the symbol you would like to delete.

select *

from dbo_instrumentmaster;

On line 6, change the 'instrumentid' value, highlighted below as well. Highlight line 5 and 6 in MySQL, run it.

delete from dbo_instrumentmaster
where instrumentid = 1;



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APPENDIX

APPENDIX A : Financial Base Data

These are the data elements extracted from the YAHOO! Finance data exchange API. This data is loaded into 'dbo_instrumentstatistics' table in the database.

Date	Trading date
High	Highest price reached on the trading date
Low	Lowest price reached on the trading date
Open	Price at which the stock opened trading on the trading date, please note that this is not necessarily the closing price of yesterday.
Close	Closing price of a single unit/share of stock at the end of the trading day. This is the most talked about and important number in this application. Trading closes at 4:00pm Eastern Time.
Volume	Number of shares bought and sold during the trading day.
Adj Close	The adjusted close price analyzes the stock's dividends, stock splits and new stock offerings to determine an adjusted value. The adjusted closing price reflects the change in stock value caused by new offerings from the corporation

APPENDIX B : Strategy Formulae

B1 CMA (Cross Moving Average)

The CMA strategy is based on the comparison of moving averages of varying lengths. In short, when the averages are close together a reversal is more likely to be occurring. When the averages are farther apart, an upward or downward trend is more likely to be developing.

$wcma = 7\text{-day moving average}$
 $scma = 20\text{-day moving average}$
 $lcma = 100\text{-day moving average}$
 $5\text{-day average} = 5\text{ day simple moving average}$
 $BuyWeekApproach = previous\ day's\ wcma / lcma$
 $week_long = wcma / lcma$
 $SellWeekApproach = previous\ day's\ wcma / scma$
 $week_short = wcma / scma$
 $momentumA = price / price\ 5\ days\ ago$

BUY WHEN:

- BuyWeekApproach is between 0.977 and 1.025
- week_long is greater than 1.018
- momentumA is greater than 1

SELL WHEN:

- SellWeekApproach* is greater than 1
- week_short* is greater than 0.93
- wmca* from 3 days ago is greater than *wmca* today

HOLD: In all other situations

B2 FRL (Fibonacci Retracement Lines)

Fibonacci Retracement Lines are common trading indicators that can be used in a variety of ways. Signals are generated based on the recent price behavior when the price is close to one of the retracement levels. In this strategy five different levels are used in addition to other momentum calculations.

lpeak = maximum price in the past 100 days

highfrllinelong = $0.764 * lpeak$

medfrllinelong = $0.618 * lpeak$

lowfrllinelong = $0.382 * lpeak$

ltrough = minimum price in the past 100 days

ActualChange = today's price / yesterday's price

momentumA = price / price 5 days ago

BUY WHEN:

- close price is between 1.25% and 2.25% above *highfrllinelong*, *medfrllinelong*, or *lowfrllinelong*
- momentumA* is less than 0.99

SELL WHEN:

- close price is between 2.5% and 1.5% below *highfrllinelong*, *medfrllinelong*, or *lowfrllinelong*
- momentumA* is greater than 0.99
- ActualChange* yesterday minus *ActualChange* today is less than 0.1

HOLD: In all other situations

B3 EMA (Exponential Moving Average)

The EMA strategy is similar to the CMA strategy but replaces the simple moving average calculation with a weighted average that places exponentially more weight on prices as they move closer and closer to today.

sema = 20-day moving average
mema = 50-day moving average
lema = 100-day moving average
5-day avg = 5-day simple moving average
sigMid = sema / mema
sigLong = sema / lema
momentumA = price / 5-day avg

BUY WHEN:

-*sigLong* is less than 1
-*momentumA* is greater than 0.97

SELL WHEN:

-*sigMid* is between 0.983 and 1.004
-*momentumA* is less than 1.012

HOLD: In all other situations

B4 MACD (Moving Average Convergence Divergence)

The moving average convergence/divergence (MACD) is another commonly used technical indicator.

macd = difference between the 12-day exponential moving average and the 26-day exponential moving average
macds = 9-day exponential moving average of macd

BUY WHEN:

-yesterday's *macd* < yesterday's *macds*
-today's *macd* > today's *macds*

SELL WHEN:

-yesterday's *macd* > yesterday's *macds*
-today's *macd* < today's *macds*

HOLD: In all other situations

B5 Algorithm Forecast

This signaling strategy is based on the next day directional prices forecasts generated by the program. It uses the price prediction model and the ARIMA model to generate signals.

BUY WHEN:

- price prediction model generates a 'buy' signal
- ARIMA model generates a 'buy' signal

SELL WHEN:

- price prediction model generates a 'sell' signal
- ARIMA model generates a 'sell' signal

HOLD: In all other situations

B6 Custom Combined

The combination strategy takes into consideration each of the signals generated by the previous five strategies. A 'buy' signal is assigned a value of 1, a 'sell' signal is assigned a value of -1, and a 'hold' is assigned a value of 0. The five individual signals generated for each day are then summed together to produce a *signalsum* value. This value will be greater than or equal to -5 but less than or equal to 5.

BUY WHEN:

- signalsum* is greater than 0

SELL WHEN:

- signalsum* is less than 0

HOLD WHEN:

- signalsum* equals 0

B7 Buy and Hold

The buy and hold strategy can be considered a baseline against which the performance of all other algorithms can be measured. Beginning on the first day pricing data is available as many shares as possible are bought. No further action is taken after this. The change in the value of the asset will be reflected directly in the change in the value of the portfolio.

BUY WHEN:

- first day pricing data is available, or when you initiate your portfolio

SELL WHEN:

- never

HOLD: Always hold, no trading activity should occur

APPENDIX C: Engineered Features/Technical Indicators

Simple Moving Average (SMA): An unweighted mean of each of the previous ' n ' data points.

Exponential Moving Average (EMA): A weighted mean of each of the previous n data points. Weighting factors that decrease exponentially are applied to each older data point.

Relative Strength Index (RSI): An oscillating indicator that measures the degree to which a price is overbought or oversold compared to recent prices. The average of 'up' price closes is divided by the average of 'down' price closes. This ratio is then converted to a value between 0 and 100. Traditionally, a measure above 70 is considered over bought and a measure below 30 is considered oversold.

Fibonacci Retracement Lines (FRL): A tool used to calculate potential areas of support and resistance in the price range of a stock. The highest and lowest price in the past n days are taken as the peak and trough, respectively. Additional levels are then calculated at 23.6%, 38.2%, and 61.8% between the trough and peak. In combination with another indicator that signals direction, these levels can be used to initiate trades when prices approach one of these levels

Moving Average Convergence/Divergence (MACD): A momentum indicator that shows the difference between a short period exponential moving average and a long period moving average. This is known as the *MACD line*. Another exponential moving average is then calculated from the MACD line and is called the *signal line*. Once these two measures are calculated the daily difference is then plotted as a histogram. A positive and increasing histogram is a sign of a trend moving upwards. A negative and decreasing histogram is a sign of a trend moving downwards.

Bollinger Bands: A range based around an ' n ' period simple moving average. A certain number of standard deviations – usually two – is then calculated above and below the average to form the outer 'bands' of the range. The closer it moves to the upper or lower band is a signal of how over-bought or over-sold the market is.

APPENDIX D : Custom Trading Simulation Algorithm

Our custom trading simulation strategy uses ARIMA + Previous group's improved prediction + FRL + CMA + EMA + MACD predictions for next day

Signal Values

- If the price is predicted to go up each of the above algorithms or strategies will generate a value of 1
- if the price is predicted to go down each of the above algorithms or strategies will generate a value of -1
- If the price is predicated to stay the same, each of the above algorithms or strategies will generate a value of 0

ActionSignals' table strategycode = algo (BuySell Custom) Definition

Date	Instrument	ARIMA	PrevGroupCorr	AlgoSignal
11/11/2019	GM	Up	Up	1
11/12/2019	GM	Down	Up	0
11/13/2019	GM	Down	Down	-1

Hold = 0

Sell = -1

Buy = 1

Up = next day's prediction is higher than today's close

Down = next day's prediction is lower than today's close

StatisticalReturn' Strategy Code 'COMB' Definition (Simulator)

Date	Instrument	FRL	CMA	EMA	MACD	AlgoSignal	FinalSignal
11/11/2019	GM	1	-1	1	-1	1	1
11/12/2019	GM	1	1	-1	1	0	2
11/13/2019	GM	0	1	-1	0	-1	-1

Hold = 0

Sell < 0

Buy > 1

APPENDIX E : Algorithms Detail

E1 ARIMA

- **What is ARIMA:**

- ARIMA Stands for Auto Regressive Integrated Moving Average
- It can be broken down into its various representative parts:
 - AR: Stands for Auto-Regression, it means that it's modeling a dependent relationship between an observation and previous observations

$$X_t = c + \sum_{i=1}^p \varphi_i X_{t-i} + \varepsilon_t$$

- I: Stands for Integrated. Simply calculating the differences of observations to create a stationary time series
- MA: Stands for Moving Average. This part of the model uses a dependency between observations, and the residual error from this moving average model applied to previous observations

- **There are 3 main parameters included in ARIMA:**

- P = the number of lag observations, also known as the lag order
- d = the number of times that the observations are differenced, this is known as the degree of differencing
- q = the size of the window calculating the moving average

- **What is differencing:**

- As mentioned previously, d is known as the degree of differencing.
- Differencing is a statistics principle that exists in time series data, where transformation is applied to the time series data in order to make it stationary. This makes it so that properties of the observations to not depend on the TIME of the observation. In other words, this eliminates factors like trend and seasonality in time series data.

$$\begin{aligned} y_t^* &= y_t' - y_{t-1}' \\ &= (y_t - y_{t-1}) - (y_{t-1} - y_{t-2}) \\ &= y_t - 2y_{t-1} + y_{t-2} \end{aligned}$$

E2 Extreme Gradient Boosting XGB

What is XGBoost:

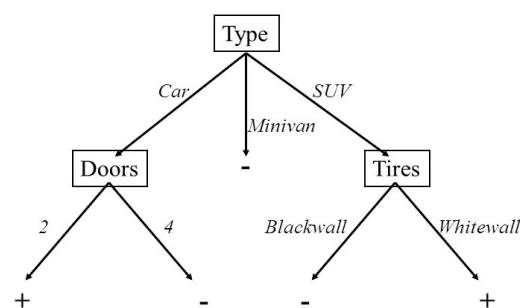
- XGBoost stands for extreme gradient boosting.
- XGBoost is a progression of the Gradient Boosting algorithm, which will be explained in just a moment.
- The engineering of this algorithm was designed for overall efficiency in computational time, and usage of memory resource
- XGBoost uses the gradient boosting decision tree algorithm
- The idea this follows is that new models are created in order to correct the errors made by already existing models
- These new models are then added together to create an informed prediction

What is the Gradient Boosting Algorithm:

- The Gradient Boosting Algorithm Follows 3 main Steps:
 - Optimize the loss function
 - Use a weak learner to make predictions
 - Implement an additive model to add weak learners to minimize loss function
- The loss function must be differentiable
- Decision trees are used as the weak learner in the gradient boosting algorithm
- For the additive model, trees are added one by one, and the existing trees remain unmodified



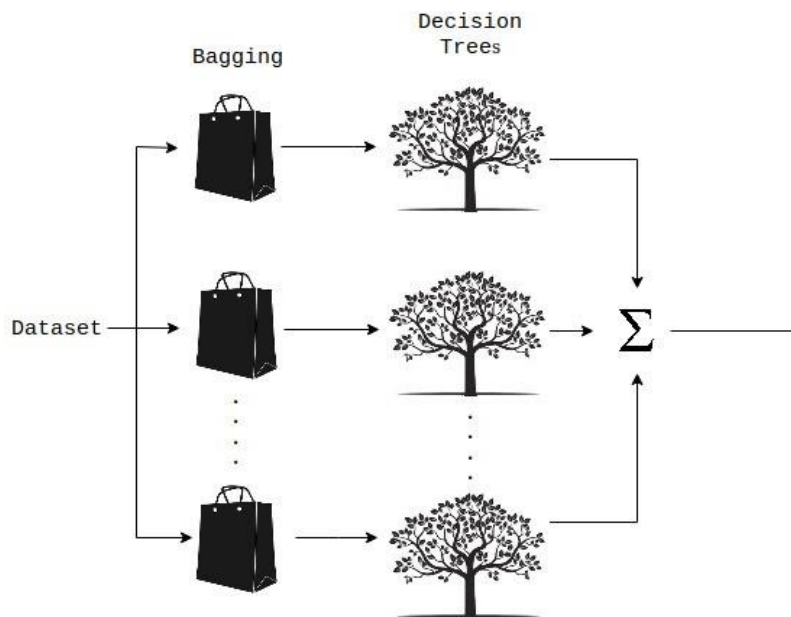
A Decision Tree



E3 Random Forest

What is Random Forest Regressor:

- Random forest is an algorithm that uses two techniques: classification and regression. It performs these using a technique called Bootstrap Aggregation, also known as bagging
- Bagging: Uses a technique of training each “decision tree”, on different data sample, using a subset from the original data sample



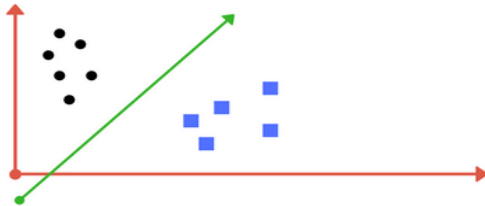
Understanding the Programming Methodology:

- First, we pass in 'X' and 'Y' variables, in the case of stock data, we are using **close** data. The Sklearn library that we see in the code uses these parameters to make determinations on how to split the data
- Next, we split our data into training and test data
- Then we specify the various parameters for our trees. In the case of our data, we are only specifying the number of estimators per bag, or the subsets of training data
- Finally, we calculate the accuracy of our model. This is done by creating a directional score and absolute mean base error based on the predicted data from the algorithm.
- Accuracy calculations details are available in the 'Analyses and Support Files' directory on the Git repository.

E4 Support Vector Machine

What is SVM:

- Support Vector Machine, or SVM, is an algorithm that works using the concept of separation of classes. In other words, it classifies training data based on its characteristics.

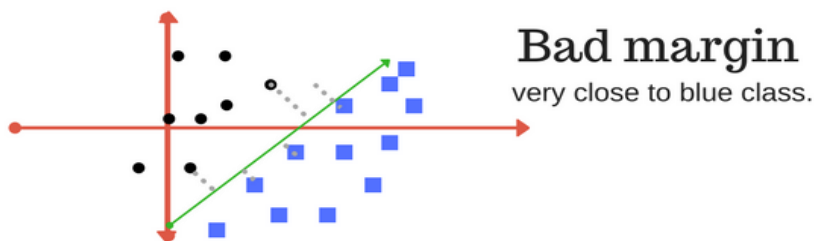
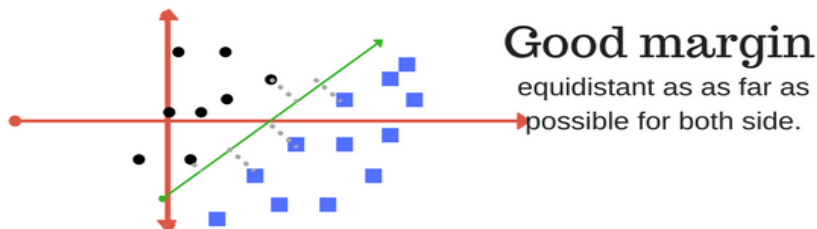


- For linear kernel the equation for prediction for a new input using the dot product between the input (x) and each support vector (x_i) is calculated as follows:
- $f(x) = B(0) + \sum(a_i * (x, x_i))$

The Regularization parameter (often termed as C parameter in python's sklearn library) tells the SVM optimization how much you want to avoid misclassifying each training example.

A margin is a separation of line to the closest class points.

A good margin is one where this separation is larger for both the classes.



E5 Custom Algorithm BuySell

ARIMA + Previous group's improved predictions to generate a composite BuySell signal.

ActionSignals' table strategycode = algo (BuySell Custom) Definition				
Date	Instrument	ARIMA	PrevGroupCorr	AlgoSignal
11/11/2019	GM	Up	Up	1
11/12/2019	GM	Down	Up	0
11/13/2019	GM	Down	Down	-1
<i>Hold = 0</i>				
<i>Sell = -1</i>				
<i>Buy = 1</i>				
<i>Up = next day's prediction is higher than today's close</i>				
<i>Down = next day's prediction is lower than today's close</i>				

E6 Fibonacci Retracement Lines(FRL)

FRL is based on the key numbers identified by mathematician Leonardo Fibonacci in the 13th century. Fibonacci's sequence of numbers is not as important as the mathematical relationships, expressed as ratios, between the numbers in the series.

In technical analysis, a Fibonacci retracement is created by taking two extreme points (usually a major peak and trough) on a stock chart and dividing the vertical distance by the key Fibonacci ratios of 23.6%, 38.2%, 50%, 61.8%, and 100%. Once these levels are identified, horizontal lines are drawn and used to identify possible support and resistance levels.

- A Fibonacci retracement is a popular tool that traders can use to identify support and resistance levels, and place stop-loss orders or target prices
- A Fibonacci retracement is created by taking two extreme points on a stock chart and dividing the vertical distance by the key Fibonacci ratios of 23.6%, 38.2%, 50%, 61.8%, and 100%
- Fibonacci retracements suffer from the same drawbacks as other universal trading tools, so they are best used in conjunction with other indicators

Fibonacci Retracement

Before we can understand why these ratios were chosen, let's review the Fibonacci number series. The Fibonacci sequence of numbers is as follows: 0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, etc. Each term in this sequence is simply the sum of the two preceding terms, and the sequence continues infinitely. One of the remarkable characteristics of this numerical sequence is that each number is approximately 1.618 times greater than the preceding number. This common relationship between every number in the series is the foundation of the common ratios used in retracement studies. The key Fibonacci ratio of 61.8% is found by dividing one number in the series by the number that follows

it. For example, 21 divided by 34 equals 0.6176 and 55 divided by 89 equals 0.6179. The 38.2% ratio is found by dividing one number in the series by the number that is found two places to the right. For example, 55 divided by 144 equals 0.3819. The 23.6% ratio is found by dividing one number in the series by the number that is three places to the right. For example, 8 divided by 34 equals 0.2352.

Fibonacci Retracement and Predicting Stock Prices

For reasons that are unclear, these Fibonacci ratios seem to play an important role in the stock market, just as they do in nature, and can be used to determine critical points that cause an asset's price to reverse. Fibonacci retracements are the most widely used of all the Fibonacci trading tools. This is partially due to their relative simplicity and partially due to their applicability to almost any trading instrument. They can be used to identify and confirm support and resistance levels, place stop-loss orders or target prices, and even act as a primary mechanism in a countertrend trading strategy.

Fibonacci retracement levels use horizontal lines to indicate where *possible* support and resistance levels are. Each level is associated with one of the above ratios or percentages, indicating the percentage is how much of a prior move the price has retraced. The direction of the prior trend is likely to continue once the price of the asset has retraced to one of the ratios listed above.

The following chart illustrates how a Fibonacci retracement appears. Most modern trading platforms contain a tool that automatically draws in the horizontal lines. Notice how the price changes direction as it approaches the support/resistance levels.

In addition to the ratios described above, many traders also like using the 50% level.

The 50% retracement level is not really a Fibonacci ratio, but traders often like it because of the overwhelming tendency for an asset to continue in a certain direction once it completes a 50% retracement.



Chart by Metastock

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<https://www.investopedia.com/ask/answers/05/fibonacciretracement.asp>