Indian Institute of Technology, Bombay

EE338

Digital Signal Processing

Application Assignment

Autumn 2020

Digital Signal Processing in Quantitative Trading

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1 Abstract

1.1 Background

The financial landscape across the world is constantly changing. While the use of computerized trade execution techniques is becoming more and more popular, traditional trading techniques like news flow, analyst rating, and guru opinion are harshly failing as deriving a positive gain expectancy and making consistent money is extremely hard. Over the years, after the digital revolution speed and computational advantages that computers have over human traders have exponentially increased. To capitalize on this chance a new type of trading was developed which is known as quantitative trading. In this type of trading digital signal processing techniques are used in order to generate accurate buy/sell signals.

1.2 Methodology

In order to make the right trading decisions, first, we need to sample the stock price signal at an appropriate frequency. Further, we will compile the following popular algorithms to form strategies and use the collective decision of all the strategies to generate accurate buy/sell signals.

1. Simple Moving Average
2. Momentum
3. Moving Average Convergence Divergence (MACD)
4. Bollinger Band standard Deviation
5. Linear Regression
6. Ichimoku Cloud
7. Intraday momentum index
8. Donchian Channel
9. Average true range

1.3 Towards Atmanirbhar Bharat

Applying complicated digital signal processing techniques and representing the output in a graphical view is the main feature due to which quantitative trading is gaining popularity. But the complexity in understanding these techniques is massive and due to learning difficulties, the use of quantitative trading is not democratized. In this project, we aim to compile a set of signal processing algorithms that can deliver precise buy/sell signals so that common people from India without a technical understanding of the trading process or someone relatively new to this field can aid their trading decisions.

2 Project Description

The financial landscape across the world is constantly changing. Hence the adaptation of Quantitative trading over traditional trading techniques is constantly increasing. But there are many hurdles for a novice trader or someone who don't have the technical background to adapt to quantitative trading:

- **Substantial time and energy:** Understanding market strategy, back testing, future event analysis takes considerable time.
- **Good technical knowledge:** Understanding how a strategy works require strong logic and mathematical understanding. Over that there are technical terms like Short entry, Long entry, Volatility, Breakout, Resistance which are not at all intuitive.
- **Complex:** There are too many algorithms to choose from hence choosing the optimum strategy is a very difficult task.

To overcome all these hurdles is the main objective of this project, We are going to achieve the following things:

- Develop our own trading strategies by extensive back testing.
- List all the profitable strategies with predefined sampling rate.
- Filter the strategy which gives maximum profit.
- Accurately generate buy/sell signals.

3 Principle

To conduct the study, 5 companies of different category of valuations (very ranging from Rs. 1980 crores to Rs. 2,01,485 crores are selected. Accordingly their stock prices are varying from Rs. 176 to Rs. 7228. The main understanding is the randomness in stock signal is inversely proportional to the valuation of the company. This was the main reason for selecting a variable set of stock prices, as the strategies can be further generalized for all the stocks in the market. The sampling rate is chosen according to the volatility of the stock in the given period, if the stock is more volatile then the sampling rate selected is high in order to not miss good trading opportunities. We have used MACD, EMA, SMA, AROON, PSAR and Stochastic MTM algorithms, details of which are discussed further ahead in the report.
Coming to the flow of this project, there are three important aspects to carry out this application.

- To determine the Sampling Rate
- To download properly sampled data.
- To run the strategy using a mathematical engine.

3.1 Determining the sampling rate

The timeframe or sampling rate is purely selected on the volatility of the stock. Volatility can be understood as the volume of stock that is being traded. If a large number of stocks are traded in a short amount of time then the volatility of the stock is high. In case of high volatility the upward trend of the market lasts for a very short time. In order to execute profitable trades we have to capture as many trades as possible hence the sampling rate should be very high. In case of low volatility the opposite happens. The upward trends that exists for a very short time are considered as false breakout. If you try to ride a short trend in a low volatility stock, most of the time the price drops quickly and you can face a massive loss. To avoid such false breakouts the sampling rate of stocks having low volatility is kept low. The typical range of sampling period is 10 minutes to 2 hours

3.2 Downloading of properly sampled data

We have used Alpha vintage API to download the stock market data. Alpha vintage is an open source free API which enables us to download stock data of intervals as low as 1 min. After entering the API KEY, adding the stock ticker, entering the period and assigning a sampling rate the data gets downloaded automatically as we run the script.

3.3 Running the strategy using a mathematical engine

We have used pyfolio as our broker. Pyfolio is a high level python library which has all the stock market analysis algorithms. Pyfolio has a broker known as backtrader which is used for backtesting the strategies. We just have to specify the path of data file and code the Entry and Exit strategy. Backtrader execute the trades whenever a trigger event happens and displays all the details at the end of the computation.

4 Technical details

4.1 Important Terminologies

Some of the terminologies used ahead are explained here:

1. **Stop Loss :** A stop-loss order is an order placed with a broker to buy or sell a specific stock once the stock reaches a certain price. A stop-loss is designed to limit an investor's loss on a security position. For example, setting a stop-loss order for 10% below the price at which you bought the stock will limit your loss to 10%.
2. **Uptrend :** An uptrend describes the price movement of a financial asset when the overall direction is upward.
3. **Downtrend :** A downtrend refers to the price action of a security that moves lower in price as it fluctuates over time.
4. **Support :** Support is a price level where a downtrend can be expected to pause due to a concentration of demand or buying interest.
5. **Resistance :** Resistance is a price level where a uptrend can be expected to pause due to a concentration of demand or buying interest.

4.2 Strategies Used

We consider a total of 5 strategies for 5 different types of firms :

4.2.1 MACD Bullish Crossover

The MACD is calculated by subtracting the 26-period Exponential Moving Average (EMA) from the 12-period EMA. The result of that calculation is called as the MACD line. A 9-day EMA of the MACD called the "signal line," is then plotted on top of the MACD line, which can function as a trigger for buy and sell signals.
The formula for MACD is given as :

$$MACD[n] = EMA_{12}[n] - EMA_{26}[n]$$

Where,

$$EMA_d[n] = x[n]\left(\frac{s}{1+d}\right) + EMA_d[n-1]\left(1 - \frac{s}{1+d}\right)$$

$$s = smoothing\ factor, \quad d = Period$$

Taking Z transform of the above MACD equation,

$$MACD(z) = X(z)\left[\frac{14s(1-z^{-1})}{(27-s)(13-s)(\frac{27}{27-s} - z^{-1})(\frac{13}{13-s} - z^{-1})}\right]$$

where $X(z)$ is the Z-transform of the signal $x[n]$
Generally, the smoothing factor while calculating the EMA is taken to be 2.
Hence, we get :

$$MACD(z) = X(z)\left[\frac{0.1019(1-z^{-1})}{(1.08 - z^{-1})(1.189 - z^{-1})}\right]$$

Now, we calculate 9-day EMA of this MACD series to get another sequence called as the "signal line" :

$$EMA_9[n] = MACD[n] * 0.2 + EMA_9[n-1] * 0.8$$

Taking Z transform :

$$EMA_9(z) = MACD(z) * 0.2 + 0.8 * z^{-1} EMA_9(z)$$

$$EMA_9(z) = \frac{0.2 * MACD(z)}{1 - 0.8 * z^{-1}} = \frac{0.25 * MACD(z)}{(1.25 - z^{-1})} = X(z) \left[\frac{0.0254(1 - z^{-1})}{(1.25 - z^{-1})(1.08 - z^{-1})(1.189 - z^{-1})} \right]$$

1. **Entry level Strategy**
   BUY 100 shares when MACD line crosses above MACD signal line. Enter trade between 09:00 to 17:00

2. **Exit level Strategy**
   SELL 100 shares at stop loss of 1% or target profit of 2%

4.2.2 SMA Short Band

The general formula for calculating SMA is given by :

$$SMA_N[n] = \frac{\sum_{i=0}^{N-1} x[n-i]}{N}$$

Taking Z transform :

$$SMA_N(z) = \frac{X(z)}{N}[1 + z^{-1} + z^{-2} + ... + z^{-(N-1)}]$$

The general formula for calculating Closing price series is given by :

$$Close[n] = x[n+1]$$

1. **Entry level Strategy**
   For this strategy we require to calculate the following series :

   - 35 SMA series

   $$H_{SMA_{35}}(z) = \frac{SMA_{35}(z)}{X(z)} = \left[\frac{1 + z^{-1} + ... + z^{-34}}{35} \right]$$

   - 5 SMA series

   $$H_{SMA_5}(z) = \frac{SMA_5(z)}{X(z)} = \left[\frac{1 + z^{-1} + ... + z^{-4}}{5} \right]$$

   - Closing price series

   $$H_{Close}(z) = \frac{Close(z)}{X(z)} = z$$

   SELL 100 shares when closing price series crosses below 35 SMA line and closing price series is lower than 5 SMA. Enter trade between 09:00 to 23:59.

2. **Exit level Strategy**
   For this strategy we require to calculate the following series :

   - 150 SMA series

   $$H_{SMA_{150}}(z) = \frac{SMA_{150}(z)}{X(z)} = \left[\frac{1 + z^{-1} + ... + z^{-149}}{150} \right]$$

   - 350 SMA series

   $$H_{SMA_{350}}(z) = \frac{SMA_{350}(z)}{X(z)} = \left[\frac{1 + z^{-1} + ... + z^{-349}}{350} \right]$$

- Closing price series

$$H_{Close}(z) = \frac{Close(z)}{X(z)} = z$$

BUY 100 shares when Close lower than 150 SMA and Close crosses below 350 SMA or at stop loss of 5% or target profit of 10%

4.2.3 Long EMA Resistance Breakout

In this strategy, we require to calculate 5 period EMA line of the data which is given as follows :

$$EMA_5[n] = x[n] * 0.334 + EMA_5[n-1] * 0.667$$

$$H_{EMA_5}(z) = \frac{EMA_5(z)}{X(z)} = \frac{0.334}{1 - 0.667z^{-1}}$$

Along with we need to calculate a signal know as the "Pivot point" which is given by the formula :

$$Pivot[n] = \frac{2}{3}\left(high[n] + close[n] - \frac{low[n]}{2}\right)$$

where,

- $high[n]$ is the maximum price in the interval between n and n+1
- $low[n]$ is the minimum price in the interval between n and n+1
- $close[n] = x[n+1]$

1. **Entry Level Strategy**
   BUY 100 shares when 5 EMA crosses above Pivot line at 5 minutes candle interval using candlestick chart. Enter trade between 09:00 to 23:59
2. **Exit Level Strategy**
   SELL 100 shares at stop loss of 1.5% or target profit of 5% at 5 minutes candle interval using candlestick chart.

4.2.4 Bearish AROON with PSAR

For this strategy implementation, we need to calculate the Parabolic SAR (PSAR) and Aroon Indicator:

$$PSAR = Prior_{PSAR} + Prior_{AF} * (Prior_{EP} - Prior_{PSAR})$$

where,

1. $Prior_{PSAR}$ = lowest value among $x[n-1], x[n-2], ..., x[n-N]$, where $N \geq 5$
2. AF = Acceleration Factor, it starts at 0.02 and increases by 0.02, up to a maximum of 0.2, each time the extreme point(EP) makes a new high
3. EP = Extreme Point, the highest high in the current uptrend(rising SAR)
4. $Prior_{PSAR}$ = the lowest low of those N periods

Method to calculate Aroon UP and Aroon Down Indicators :

1. **Aroon UP**
   Track the highs (maximas) for the last $N(N = 14\ in\ our\ case)$ periods on an asset. Calculate the number of periods since the last high (N_{high}).

$$Aroon_{UP} = \frac{N - N_{high}}{N} * 100 = \frac{14 - N_{high}}{14} * 100$$

2. **Aroon Down**
   Track the lows (minimas) for the last $N(N = 14 in our case)$ periods on an asset. Calculate the number of periods since the last low (N_{low}).

$$Aroon_{DOWN} = \frac{N - N_{low}}{N} * 100 = \frac{14 - N_{low}}{14} * 100$$

1. **Entry level Strategy**
   - SELL 500 shares when Parabolic SAR(0.02,0.2) higher than high and 14 Aroon-Up lower than 14 Aroon-Down. Enter trade between 09:15 to 15:30.
2. **Exit level Strategy**
   - BUY 500 shares at stop loss of 1.5% or target profit of 5%.

4.2.5 MFI Stochastic Short

For this strategy implementation, we need to calculate the Money flow index(MFI) and Stochastic Momemtum Index.

1. **Stochastic Momentum Index (SMI)**

   (a) First we select N previos periods

   (b) We calculate the mid-price which is given by:

$$Mid\,price[n] = \frac{High + Low}{2}$$

   $High$ = The maximum price among $x[n], x[n-1], ..., x[n-(N-1)]$
   Low = The minimum price among $x[n], x[n-1], ..., x[n-(N-1)]$

   (c) We then calculate the difference of bar's closing price from the midpoint of the range

$$D[n] = Close[n] - Mid\,price[n] = x[n+1] - Mid\,price[n]$$

   (d) Thereafter, we calculate double exponential moving average of $D[n]$

$$Ds[n] = EMA_N[EMA_N(D[n])]$$

   (e) Henceforth, double EMA is applied to the difference between highest high and lowest low in the selected period

$$Dhl[n] = EMA_N[EMA_N((High[n] - Low[n])$$

   (f)

$$Stochastic\,Momentum\,Index = SMI[n] = \frac{Ds[n]}{Dhl[n]} * 100$$

2. **Money Flow Index (MFI)**
   Money Flow Index (MFI) is calculated by using the following formula :

$$MFI = 100 - \frac{100}{1 + Money\,flow\,Ratio\,(MFR)}$$

   where,

$$MFR = \frac{14 Period Positive Money Flow}{14 Period Negative Money Flow}$$

3. **Supertrend**

(a) Supertrend indicator takes 2 parameters that are period and multiplier

(b) The supertrend indicator calculation goes as follows:-

(c)
$$Up = \frac{High + Low}{2} + Multiplier(ATR)$$

(d)
$$Down = \frac{High + Low}{2} - Multiplier(ATR)$$

(e) Calculation of average true range -

(f)
$$ATR = \frac{(PriorATR)13 + CurrentTR}{period}$$

1. **Entry level Strategy**
   - SELL 100 shares when 20 mfi lower than 80 and stochastic mtm(%k,10,3,3,10,ema) crosses below stochastic mtm(%d,10,3,3,10,ema) and close lower than Supertrend(10,2,0). Enter trade between 09:00 to 23:59
2. **Exit level Strategy**
   - BUY 100 shares at stop loss of 1% or target profit of 2.5%.

4.3 Functioning of the selected Trading Strategies

Following is the reasoning of every strategy

1. MACD Bullish Crossover
   (a) MACD is known as Moving Average Convergence Divergence.
   (b) The MACD is calculated by subtracting the 26-period Exponential Moving Average (EMA) from the 12-period EMA.
   (c) A nine-day EMA of the MACD called the "signal line," is then plotted on top of the MACD line, which can function as a trigger for buy and sell signals.
   (d) If the MACD line crosses above the signal line, then we can simply conclude that the value of current MACD is greater that the average of the previous 9 values of MACD.
   (e) This further signifies that the there is a strong uptrend in the stock incoming so this is the perfect time to buy the stocks.
   (f) After that appropriate exit conditions are applied like specifying stop loss and profit.
2. SMA Short Band
   (a) SMA is known as simple moving average which is nothing but standard average of the previous values.
   (b) Close is the closing value of a stock according to the given sampling rate.
   (c) If the close value is lower then the 35 SMA then it signifies that the value of stock has fallen lower than it has been in the last 35 samples.
   (d) This further tells us that the downtrend is coming, and if the value of 5 SMA is greater than the close value then it double validates that the downtrend is real.
   (e) So in this situation we sell the stock as the price is going to be dropped.
   (f) Usually the downtrend lasts for 100-300 samples and if the close is crossing below the 350 SMA then it tells us that the downtrend has lasted long enough that it is going to be uptrend soon.
   (g) Hence at this point we buy the stock as the price of the stock is going to increase.
   (h) To not rely completely on trigger events we also set stop loss and profit parameters in our exit strategy.
3. Long EMA Resistance Breakout
   (a) EMA is known as exponential moving average which adds weight to the values which are closer to the current time.
   (b) Pivot point acts as a resistance line that means it is a support and the value will not fall below the support as long as the trend is real.
   (c) Here 5 EMA just smooths the stock signal in order to eliminate the unnecessary randomness.
   (d) If the 5 EMA crosses above the Resistance line then it is considered as a positive breakout hence now the stock is going to follow an uptrend.
   (e) Hence at this breakout we should buy the stock.
   (f) To sell we hardcode the stop loss and profit values.
4. Bearish AROON with PSAR
   (a) The parabolic SAR indicator, developed by J. Wells Wilder, is used by traders to determine trend direction and potential reversals in price.
   (b) The indicator uses a trailing stop and reverse method called "SAR," or stop and reverse, to identify suitable exit and entry points.

(c) The parabolic SAR indicator appears on a chart as a series of dots, either above or below an asset's price, depending on the direction the price is moving.

(d) A dot is placed below the price when it is trending upward, and above the price when it is trending downward.

(e) So when the PSAR is higher than high we can conclude that a downtrend is coming so we short all the securities.

(f) The Aroon algorithm is used to identify trend changes in the price of an asset, as well as the strength of that trend.

(g) In essence, the indicator measures the time between highs and the time between lows over a time period.

(h) The idea is that strong uptrends will regularly see new highs, and strong downtrends will regularly see new lows.

(i) When AROON Down is higher than AROON Up this validates that there is a downtrend and hence the securities should be shorted.

(j) To exit we hardcode the stop loss and profit values.

5. MFI Stochastic short

(a) When the direction of money flow index is in the opposite of the direction of price then it is sign of trend reversal

(b) For example, if money flow index starts to fall below 80 while the price keeps climbing up, this signifies that a strong downtrend is coming and hence we should sell our securities.

(c) If the close is lower than the supertrend then it is a strong representation that a downtrend is happening

(d) In Stochastic oscillator when %k falls below %d then it shows that security market is declining and hence it is a strong indication of SELL.

(e) To exit we have hard coded the profit and stop loss parameters.

4.4 Estimated Profits using above strategies for various stocks

1. **MACD Bullish Crossover:**
   (a) **Sampling Rate :** 1 Hour
   (b) **Period :** 7 Nov 2019 to 23 Oct 2020
   (c) **Results :**
      i. **MARUTI (7800 Rs.):** Profit :- 30817(+4.23%)
      ii. **ZEEL (206 Rs.):** Loss :- -1343 (-4.58%)
2. **SMA Short Band**
   (a) **Sampling Rate :** 1 Hour
   (b) **Period :** 13 Nov 2019 to 15 Oct 2020
   (c) **Results :**
      i. **HDFC (2245 Rs.):** Profit :- 49460 (+22.28%)
      ii. **ZEEL (206 Rs.):** Profit :- 1308 (+4.49%)
      iii. **MARUTI (7800 Rs.):** Profit :- 8421 (+1.13 %)
3. **Long EMA Resistance Breakout**
   (a) **Sampling Rate :** 1 Hour
   (b) **Period :** 13 Nov 2019 to 15 Oct 2020
   (c) **Results :**
      i. **INDUSINDBK (916 Rs.):** Profit :- 10411 (+19.96%)
      ii. **ZEEL (206 Rs.):** Profit :- 1232 (+8.81 %)
      iii. **MARUTI (7800 Rs.):** Profit :- 2431 (+0.34 %)
4. **Bearish AROON with PSAR**
   (a) **Sampling Rate :** 10 Mins
   (b) **Period :** 28 July 2020 - 23 Oct 2020
   (c) **Results :**
      i. **DEEPAKFERT (152 Rs.):** Profit :- 21005 (+28.51 %)
      ii. **ZEEL (206 Rs.):** Profit :- 18535 (+19.94 %)
      iii. **MARUTI (7800 Rs.):** Loss :- -10955 (-0.32 %)
5. **MFI Stochastic short**
   (a) **Sampling Rate :** 5 mins
   (b) **Period :** 26 Jul 2020 to 25 Oct 2020
   (c) **Results :**
      i. **ZEEL (206 Rs.):** Profit :- 5766 (+39.14%)
      ii. **MARUTI (7800 Rs.):** Loss :- -1739 (-0.26 %)

4.5 Comparison of Profits using various Trading Strategies

MARUTI		
Trading Strategy	PROFIT/LOSS	PERCENTAGE INCREMENT
MACD Bullish Crossover	30817	+4.23%
SMA Short Band	8421	+1.13%
Long EMA Resistance Breakout	2431	+0.34%
Bearish AROON with PSAR	-10955	-0.32%
MFI Stochastic Short	-1739	-0.26%

ZEEL		
Trading Strategy	PROFIT/LOSS	PERCENTAGE INCREMENT
MACD Bullish Crossover	-1343	-4.58%
SMA Short Band	1308	+4.49%
Long EMA Resistance Breakout	1232	+8.81%
Bearish AROON with PSAR	18535	+19.94%
MFI Stochastic Short	5766	+39.14%

- Here the stock price of MARUTI is 7800 Rs. and stock price of ZEEL is 206 Rs.
- As the price of stocks are different we can see that same strategies don't work for both.
- This is primarily because difference in valuation results in difference in volatility hence randomness of 2 stocks are not same.
- It can be seen that the **MACD Bullish Crossover** generates maximum profits in case of **Maruti** whereas in case of **Zeel**, Bearish AROON with PSAR is the maximum profit strategy.

5 Demonstration

The step by step demonstration of how to execute the scripts is given below:

1. **Downloading the sampled data:**
   We are using the below python script to carry out this step:

```
import pandas as pd
from alpha_vantage.timeseries import TimeSeries
import time

api_key = '9LBH4ZXAHKDUFSO4'

ts = TimeSeries(key=api_key, output_format='pandas')
data, meta_data = ts.get_intraday(symbol='MSFT', interval = '1min',
outputsize = 'full')

data.to_excel("output.xlsx")
```

   - By going to Alpha Vintage website you can generate your own API Key.
   - Enter the API key, Symbol of the stock and time interval or sampling rate of which you want the stock data.
   - After running the script the output will be saved in an Excel file

	A	B	C	D	E	F
1	**date**	**1. open**	**2. high**	**3. low**	**4. close**	**5. volume**
2	**2020-11-27 17:00:00**	215.01	215.24	215.01	215.24	376
3	**2020-11-27 16:59:00**	215.06	215.06	215.05	215.05	1089
4	**2020-11-27 16:58:00**	215.23	215.23	215.23	215.23	100
5	**2020-11-27 16:53:00**	215.23	215.23	215.23	215.23	300
6	**2020-11-27 16:49:00**	215.17	215.17	215.17	215.17	260
7	**2020-11-27 16:42:00**	215.2	215.2	215.2	215.2	1010
8	**2020-11-27 16:29:00**	215.23	215.23	215.23	215.23	411
9	**2020-11-27 16:17:00**	215.12	215.12	215.12	215.12	1017
10	**2020-11-27 16:15:00**	215.12	215.12	215.12	215.12	500
11	**2020-11-27 13:01:00**	215.35	215.35	215.23	215.23	1480168
12	**2020-11-27 13:00:00**	215.01	215.31	214.95	215.29	181027
13	**2020-11-27 12:59:00**	215.07	215.08	214.99	215.02	79589
14	**2020-11-27 12:58:00**	214.99	215.1	214.99	215.07	71633
15	**2020-11-27 12:57:00**	214.94	214.99	214.87	214.99	72706
16	**2020-11-27 12:56:00**	214.98	215.045	214.92	214.95	64534
17	**2020-11-27 12:55:00**	215.1	215.11	214.97	214.98	59813
18	**2020-11-27 12:54:00**	215.04	215.1024	214.99	215.099	39248
19	**2020-11-27 12:53:00**	215.02	215.105	215.02	215.0448	47637

2. **Executing the strategy:**
   Following script is used to generate results using a particular coding strategy and the data.

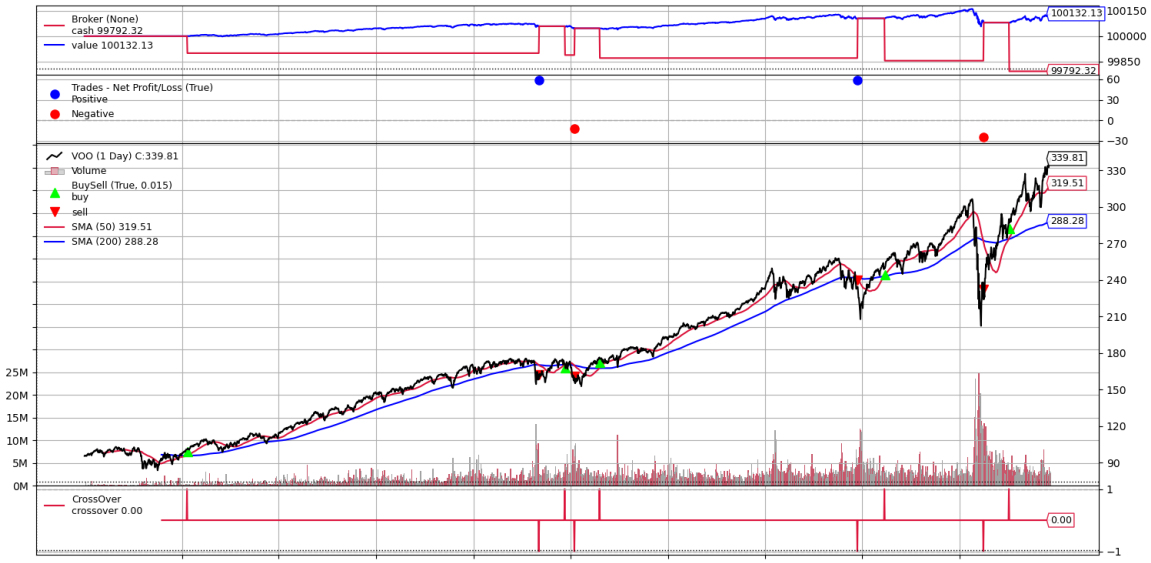
```
import sys
import pandas as pd
```

```
import numpy as np
import backtrader as bt
import pyfolio as pf


def backtesting_engine(symbol, strategy, fromdate, todate, args=None):
    """
        Primary function for backtesting, not entirely parameterized
    """

    # Backtesting Engine
    cerebro = bt.Cerebro()


    # Add a Strategy if no Data Required for the model
    cerebro.addstrategy(SmaCross)
    """
    if args is None:
        cerebro.addstrategy(strategy)
    # If the Strategy requires a Model and therefore data
    elif args is not None:
        cerebro.addstrategy(strategy, args)
"""
    # You can add your own Datafile here
    data = bt.feeds.YahooFinanceData(
        dataname=symbol,
        fromdate=fromdate,  # datetime.date(2015, 1, 1)
        todate=todate  # datetime.datetime(2016, 1, 1)

    )

    # Add Data to Backtesting Engine
    cerebro.adddata(data)

    # Set Initial Portfolio Value
    cerebro.broker.setcash(100000.0)

    # Add Analysis Tools
    cerebro.addanalyzer(bt.analyzers.SharpeRatio, _name='sharpe')
    cerebro.addanalyzer(bt.analyzers.Returns, _name='returns')
    cerebro.addanalyzer(bt.analyzers.SQN, _name='sqn')
    cerebro.addanalyzer(bt.analyzers.DrawDown, _name='drawdown')
    cerebro.addanalyzer(bt.analyzers.PositionsValue, _name='posval')
    cerebro.addanalyzer(bt.analyzers.PyFolio, _name='pyfolio')

    # Starting Portfolio Value
    print('Starting Portfolio Value: %.2f' % cerebro.broker.getvalue())

    # Run the Backtesting Engine
    backtest = cerebro.run()
    cerebro.plot()

    # Print Analysis and Final Portfolio Value
    print(
```

```
        'Final Portfolio Value: %.2f' % cerebro.broker.getvalue()
        )
    print(
        'Return: ', backtest[0].analyzers.returns.get_analysis()
        )
    print(
        'Sharpe Ratio: ', backtest[0].analyzers.sharpe.get_analysis()
        )
    print(
        'System Quality Number: ', backtest[0].analyzers.sqn.get_analysis()
        )
    print(
        'Drawdown: ', backtest[0].analyzers.drawdown.get_analysis()
        )
    print(
        'Active Position Value: ', backtest[0].analyzers.posval.get_analysis()
    )
    print(
        'Pyfolio: ', backtest[0].analyzers.pyfolio.get_analysis()
    )

    # Print Analysis and Final Portfolio Value
    pyfoliozer = backtest[0].analyzers.getbyname('pyfolio')
    returns, positions, transactions, gross_lev = pyfoliozer.get_pf_items()

    # See if we can add regular FB data to compare against returns of algo
    pf.create_full_tear_sheet(
        returns, positions=positions, transactions=transactions
        )


# TODO: Create pipeline: Optimization -> Testing essentially
class BacktestingPipeline:
    """
        Pipeline for in sample optimization and out of sample testing
    """
    pass

###############################################################################


from datetime import datetime
class SmaCross(bt.SignalStrategy):
    def __init__(self):
        sma1, sma2 = bt.ind.SMA(period=50), bt.ind.SMA(period=200)
        crossover = bt.ind.CrossOver(sma1, sma2)
        self.signal_add(bt.SIGNAL_LONG, crossover)

"""
    Script for backtesting strategies
"""

if __name__ == '__main__':
    # Run backtesting engine
```

```
backtesting_engine(
    'VOO', SmaCross,
    fromdate=datetime(2011, 1, 1), todate=datetime(2022, 12, 31)
)
```

- Enter the data path of the data that you are using.
- Code the strategy that you want to execute, refer to official documentation of pyfolio for the syntax.
- After running the script all the results will be displayed in a graphical format.



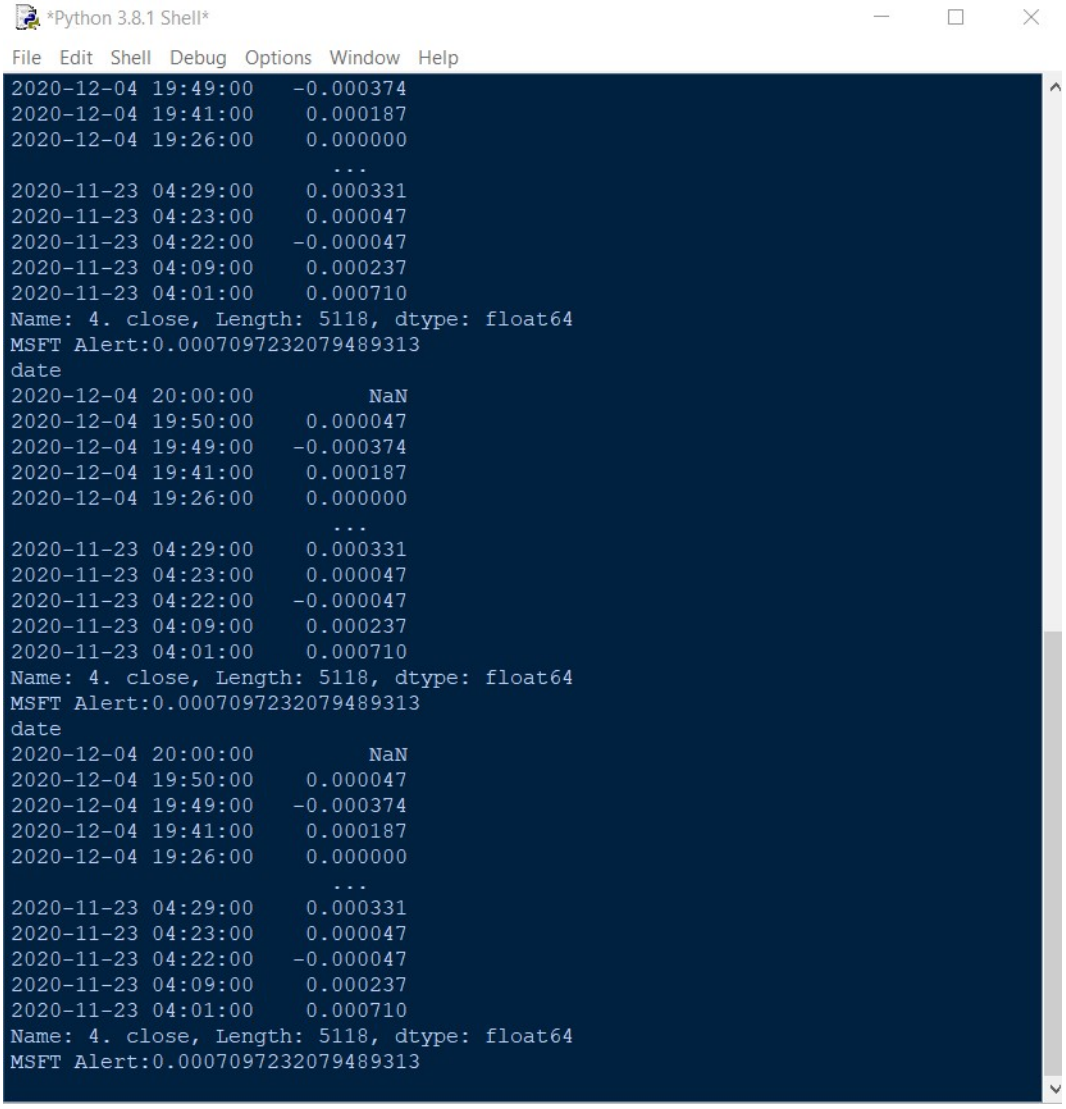
- Here the green dots represent the entry trigger event and red dots represent the exit trigger event.
- On the rightmost corner we can see the total valuation so from that we can calculate the profit.

3. **Generating live signals:** After doing extensive back testing we can go to live trading where we can get notifications of buy/sell signals in the real time using following python script.

```
import pandas as pd
from alpha_vantage.timeseries import TimeSeries
import time

api_key = 'RNZPXZ6Q9FEFMEHM'

ts = TimeSeries(key=api_key, output_format='pandas')
data, meta_data = ts.get_intraday(symbol='MSFT', interval = '1min',...
                                  outputsize = 'full')
print(data)

i = 1
while i==1:
    data, meta_data = ts.get_intraday(symbol='MSFT', interval = '1min',...
                                      outputsize = 'full')
    data.to_excel("output.xlsx")
    close_data = data['4. close']
```

```
percentage_change = close_data.pct_change()

print(percentage_change)

last_change = percentage_change[-1]

if abs(last_change) > 0.0004:
    print("MSFT Alert:" + str(last_change))
time.sleep(60)
```

- By entering strategy, Symbol and interval, live signals can be generated.
- The example alert is shown in the figure below.



6 Further Improvements

- We can stream live coding signals by just inserting the code in a while loop.
- Different sampling rates can be used to determine the best possible sampling rate for a particular stock.
- Combining multiple strategies to have strong validation and more accurate trades is also possible.
- Apart from the above used algorithms, other signal processing algorithms can also be tested to form a good strategy.
- Our results and python scripts can be generalized for the back-testing of any stock.
- Development of a web interface is easily possible so that the development and execution of trading strategies will be more efficient than it was ever before.
- Using this as back-end coupled with an intuitive User Interface can be used to scale the use of Digital Signal Processing algorithms in trading.

7 Conclusions

1. This project is a baseline for the use of Digital Signal Processing Algorithms in trading.
2. To select the best sampling rate we have to analyse the volatility of the stock and the sampling rate increases as the volatility of the stock increases.
3. There is a high probability that if a particular strategy is profitable for one company then the same strategy will be profitable for the companies having somewhat same valuation.
4. There is a high probability that if a particular strategy is profitable for one company then the same strategy will not be profitable for the companies having a large difference in valuation.
5. DSP offers a powerful set of algorithms that can provide reliable up trends and downtrends.
6. Before using any strategy in practice, thorough back testing should be done to curtail the risk.
7. Using digital signal processing algorithms for trading is much more efficient than traditional trading methods.

8 References

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