Backtesting tool comparison

Release 0.0.3

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Feb 22, 2022

CONTENTS:

Are you a newbie programmer or you are newbie trader ? This is your tutorial, where you can find some samples of code for downloading of historical data and for backtesting some samples of strategies.

And you may also find some interesting details in the **Comparison** and **Conclusion** sections.

CHAPTER

ONE

GETTING STARTED

These contents can help you to start with your **quantitative trading** (quant trading or QT) system: you can find some samples for the main steps.

There are

- many platforms can give you historical data
- a lot of program languages that you can use for implementing your strategies
- many trading systems that you can use for backtesting your system

Read the documentation on readthedocs for

- a sample of the main backtesting steps for a few of the main languages are used for statistical analysis, graphics representation and reporting
- comparison among languages and methods for **backtesting** your strategies
- the best practices for your **quant trading system**

1.1 Goals

These contents can be useful at the beginning, when you are newbie programmer.

And it can help you to evaluate which data, language or trading system you need.

1.2 Disclaimer

The strategies contained in this tutorial, are some simple samples for having an idea how to use the libraries: those strategies are for the educational purpose only. All investments and trading in the stock market involve risk: any decisions related to buying/selling of stocks or other financial instruments should only be made after a thorough research, backtesting, running in demo and seeking a professional assistance if required.

1.3 Contribution

The documentation for **R** and **Python** languages, it has been powered by Jupyter:

```
$ git clone https://github.com/bilardi/backtesting-tool-comparison
$ cd backtesting-tool-comparison/
$ pip install --upgrade -r requirements.txt
$ docker run --rm -p 8888:8888 -e JUPYTER_ENABLE_LAB=yes -v "$PWD":/home/jovyan/ jupyter/
↪datascience-notebook
```

The images are hosted on S3 and not in this repository:

- use a PR for sharing a new version without images, only the new url
- it will be our care to move them to S3 with all the others

For testing on your local client the documentation, see this README.md file.

1.4 License

CHAPTER

TWO

R

2.1 Prerequisites

For using the program language R, you have to install r.

For mac,

```
$ brew install r
```

There are a lot of guide for getting started with R: knowing the basics will be taken for granted. For installing some packages, you can use RStudio or directly console

```
$ r
# general tools
install.packages("httr")
install.packages("jsonlite")
install.packages("plotly")
install.packages("devtools")
# for downloading data
install.packages("quantmod") # for Yahoo finance historical data of stock market
install.packages("Quandl")
devtools::install_github("amrrs/coinmarketcapr") # for Crypto currencies
devtools::install_github("amrrs/coindeskr") # for Crypto currencies
# for processing the data: in addition to Quantmod also QuantStrat
devtools::install_github("braverock/blotter")
devtools::install_github("braverock/quantstrat")
```

If you want to use Jupyter, you can use directly the commands below

```
$ git clone https://github.com/bilardi/backtesting-tool-comparison
$ cd backtesting-tool-comparison/
$ docker run --rm -p 8888:8888 -e JUPYTER_ENABLE_LAB=yes -v "$PWD":/home/jovyan/ jupyter/
↪r-notebook
```

Jupyter is very easy for having a GUI virtual environment: knowing the basics will be taken for granted.

You can find all scripts descripted in this tutorial on GitHub:

- the .r files in src/r/ folder, the script that you can use on RStudio
- the .ipynb files in docs/sources/r/ folder, that you can use on Jupyter or browse on this tutorial

2.2 Getting started

R is a programming language and software environment for statistical analysis, graphics representation and reporting.

This is a summary of the r language syntax: you can find more details in cran documentation.

2.2.1 Basics

[1]:
```
# initialization of a variable
my_numeric_variable <- 1
my_string_variable <- "hello"
# print a variable
my_numeric_variable # and type enter
print(my_string_variable)
```

```
1
```

```
[1] "hello"
```

2.2.2 Vectors

[2]:
```
# initialization of a vector
my_numeric_vector <- c(1,2,3,4,5,6)
my_sequence <- 1:25
my_string_vector <- c("hello", "world", "!")
my_logic_vector <- c(TRUE, FALSE, T, F)
assign("my_vector", c(1:6))
my_random_vector <- sample(1:5000, 25) # Vector with 25 elements with random number from␣
↪1 to 5000
```

[3]:
```
# operations with vectors
sum(my_numeric_vector)
mean(my_numeric_vector)
median(my_numeric_vector)
```

```
21
```

```
3.5
```

```
3.5
```

[4]:
```
# multiplication 2 with each element of a vector
my_vector*2
# division 2 with each element of a vector
my_vector/2
```

```
2
```

```
4
```

```
6
```

```
8
```

```
10
```

```
12
```

0.5

1

1.5

2

2.5

3

[5]:
```
# sum each element of a vector with another vector by position
my_new_vector <- my_numeric_vector + my_vector # allow
my_new_vector <- my_numeric_vector + my_sequence # allow but with warning
my_new_vector <- my_numeric_vector + c(1:5) # allow but with warning
```

```
Warning message in my_numeric_vector + my_sequence:
“longer object length is not a multiple of shorter object length”
Warning message in my_numeric_vector + c(1:5):
“longer object length is not a multiple of shorter object length”
```

[6]:
```
# get element from a vector
my_string_vector[1] # print hello
my_string_vector[-2] # print hello!
my_string_vector[1:2] # print hello world
my_string_vector[c(1,3)] # print hello!
```

’hello’

’hello’

’!’

’hello’

’world’

’hello’

’!’

[7]:
```
# add labels to a vector
names(my_vector) <- c("one","two","three","four","five","six")
print(my_vector)
```

```
  one   two three  four  five   six
    1     2     3     4     5     6
```

[8]:
```
# get data type of a vector
class(my_vector) # print integer
typeof(my_string_vector) # print character
mode(my_vector) # print numeric
```

’integer’

’character’

’numeric’

[9]:
```
# convertion of each element of a vector
as.character(my_vector)
```

'1'

'2'

'3'

'4'

'5'

'6'

2.2.3 Matrixes

A matrix is a vector with more dimensions

[10]:
```
# matrix
my_matrix <- matrix(1:10, nrow = 2, ncol = 5) # creates a matrix bidimensional with 2␣
↪rows and 5 columns
my_matrix
my_matrix[2,2] # prints 4
my_matrix[1,] # prints row 1
my_matrix[,2] # prints column 2
```

A matrix: 2 × 5 of type int

1	3	5	7	9
2	4	6	8	10

4

1

3

5

7

9

3

4

[11]:
```
# merge of vectors
vector_one <- c("one", 0.1)
vector_two <- c("two", 1)
vector_three <- c("three", 10)
my_vectors <- matrix(c(vector_one, vector_two, vector_three), nrow = 3, ncol = 2, byrow␣
↪= 1)
colnames(my_vectors) <- c("vector number", "quantity")
rownames(my_vectors) <- c("yesterday", "today", "tomorrow")
```

[12]:
```
my_vectors
```

A matrix: 3 × 2 of type chr

	vector number	quantity
yesterday	one	0.1
today	two	1
tomorrow	three	10

2.2.4 Weighted average

[13]:
```
# performance
apple_performance <- 3
netflix_performance <- 7
amazon_performance <- 11
# weight
apple_weight <- .3
netflix_weight <- .4
amazon_weight <- .3
# portfolio performance
weighted_average <- apple_performance * apple_weight + netflix_performance * netflix_
↪weight + amazon_performance * amazon_weight
weighted_average
```

7

[14]:
```
# the same sample but with vectors
performance <- c(3,7,11)
weight <- c(.3,.4,.3)
company <- c('apple','netflix','amazon')
names(performance) <- company
names(weight) <- company
performance_weight <- performance * weight
performance_weight
weighted_average <- sum(performance_weight)
weighted_average
```

0.9

2.8

3.3

7

2.2.5 Functions

[15]:
```
# the weighted average but with a function
weighted_average_function <- function(performance, weight) {
    return(sum(performance * weight))
}
performance <- c(3,7,11)
weight <- c(.3,.4,.3)
weighted_average <- weighted_average_function(performance, weight)
weighted_average
```

7

2.3 Historical data

This page contains some samples for downloading historical data of your quant trading system.

2.3.1 Quantmod library

Stock markets from Yahoo finance by Quantmod library (doc)

[1]:
```
library(quantmod)
symbol <- "AMZN"
getSymbols(symbol) # or getSymbols(symbol, src = "yahoo")
```

```
Loading required package: xts

Loading required package: zoo


Attaching package: ‘zoo’


The following objects are masked from ‘package:base’:

    as.Date, as.Date.numeric


Loading required package: TTR

Registered S3 method overwritten by 'quantmod':
  method            from
  as.zoo.data.frame zoo

‘getSymbols’ currently uses auto.assign=TRUE by default, but will
use auto.assign=FALSE in 0.5-0. You will still be able to use
‘loadSymbols’ to automatically load data. getOption("getSymbols.env")
and getOption("getSymbols.auto.assign") will still be checked for
alternate defaults.

This message is shown once per session and may be disabled by setting
options("getSymbols.warning4.0"=FALSE). See ?getSymbols for details.
```

’AMZN’

[2]:
```
head(AMZN) # returns some data of AMZN vector
```

```
           AMZN.Open AMZN.High AMZN.Low AMZN.Close AMZN.Volume AMZN.Adjusted
2007-01-03     38.68     39.06    38.05      38.70    12405100         38.70
2007-01-04     38.59     39.14    38.26      38.90     6318400         38.90
2007-01-05     38.72     38.79    37.60      38.37     6619700         38.37
2007-01-08     38.22     38.31    37.17      37.50     6783000         37.50
2007-01-09     37.60     38.06    37.34      37.78     5703000         37.78
2007-01-10     37.49     37.70    37.07      37.15     6527500         37.15
```

[3]:
```
colnames(AMZN) # returns column names of AMZN vector
```

'AMZN.Open'

'AMZN.High'

'AMZN.Low'

'AMZN.Close'

'AMZN.Volume'

'AMZN.Adjusted'

[4]:
```
#Op(AMZN) # only column of open of all data
#Hi(AMZN) # only column of high of all data
#Lo(AMZN) # only column of low of all data
#Cl(AMZN) # only column of close of all data
#Vo(AMZN) # only column of volume of all data
#Ad(AMZN) # value adjusted of the close (of all data)
#OHLC(AMZN) # columns open, high, low and close of all data
```

Exchange rates (forex) from Yahoo finance

[5]:
```
library(quantmod)
cross_from <- c("EUR", "USD", "CAD")
cross_to <- c("USD", "JPY", "USD")
getQuote(paste0(cross_from, cross_to, "=X"))
```

A data.frame: 3 × 8

	Trade Time <dttm>	Last <dbl>	Change <dbl>	% Change <dbl>	Open <dbl>	High <dbl>	Low <dbl>
EURUSD=X	2021-01-11 12:21:43	1.2162491	-0.006693244	-0.5473087	1.2226434	1.2239902	1.2158055
USDJPY=X	2021-01-11 12:22:10	104.2400000	0.291000370	0.2799453	103.9490000	104.2490000	103.6870000
CADUSD=X	2021-01-11 12:22:10	0.7822278	-0.006048977	-0.7673632	0.7882768	0.7886435	0.7822095

Exchange rates (forex) from Oanda

[6]:
```
library(quantmod)
currency <- "EUR/GBP"
# the last 6 months
getSymbols(currency, src = "oanda")
head(EURGBP) # returns some data of EURGBP vector
```

'EUR/GBP'

```
           EUR.GBP
2020-07-16 0.907685
2020-07-17 0.909031
2020-07-18 0.909320
2020-07-19 0.909368
2020-07-20 0.907640
2020-07-21 0.903154
```

[7]:
```
# the last 60 days
getSymbols(currency, from = Sys.Date() - 60, to = Sys.Date(), src = "oanda")
head(EURGBP) # returns some data of EURGBP vector
```

'EUR/GBP'

```
           EUR.GBP
2020-11-12 0.895798
2020-11-13 0.898187
2020-11-14 0.896580
2020-11-15 0.896644
2020-11-16 0.897208
2020-11-17 0.896298
```

2.3.2 CoinMarketCap API

Crypto currencies by coinmarketcap (doc) and coindeskr (doc) Many libraries are not supported for a long period or it may no longer be supported because it has violated a policy:

- the library coindeskr has violated the CRAN's policy and it has archived on 2020-09-04
- its GitHub repository is already available, but it has not updated for a change of CoinMarketCap API

[8]:
```
library(coinmarketcapr)
library(coindeskr)
last_marketcap <- get_global_marketcap("EUR")
today_marketcap <- get_marketcap_ticker_all()
head(today_marketcap[,1:8])
last_month <- get_last31days_price() # default it is Bitcoin
current_price <- get_current_price() # default it is Bitcoin
```

```
 The old API is used when no 'apikey' is given.
```

```
Error: lexical error: invalid char in json text.
                                       <!DOCTYPE HTML> <html lang="en-
                     (right here) ------^

Traceback:

1. get_global_marketcap("EUR")
2. check_response(d)
3. stop(cat(crayon::red(cli::symbol$cross, "The request was not succesfull! \n",
 .     "Request URL:\n", req$url, "\n", "Response Content:\n", jsonlite::
↪prettify(rawToChar(req$content)),
 .     "\n")))
4. cat(crayon::red(cli::symbol$cross, "The request was not succesfull! \n",
 .     "Request URL:\n", req$url, "\n", "Response Content:\n", jsonlite::
↪prettify(rawToChar(req$content)),
 .     "\n"))
5. crayon::red(cli::symbol$cross, "The request was not succesfull! \n",
 .     "Request URL:\n", req$url, "\n", "Response Content:\n", jsonlite::
↪prettify(rawToChar(req$content)),
 .     "\n")
6. mypaste(...)
7. lapply(list(...), as.character)
```

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```
8. jsonlite::prettify(rawToChar(req$content))
9. reformat(txt, TRUE, indent_string = paste(rep(" ", as.integer(indent)),
 .     collapse = ""))
10. stop(out[[2]], call. = FALSE)
11. base::stop(..., call. = FALSE)
```

Below you can find a sample with sandbox API of CoinMarketCap.

[9]:
```
library(httr)
library(jsonlite)
base_url <- 'https://sandbox-api.coinmarketcap.com/'

get_coinmarketcap_data <- function(base_url, path, query) {
    response <- GET(url = base_url, path = paste('v1/', path, sep = ''), query = query)
    content <- content(response, 'text', encoding = 'utf-8')
    return(fromJSON(content, flatten = TRUE))
}

# returns all active cryptocurrencies
path <- 'cryptocurrency/map'
marketcap_map <- get_coinmarketcap_data(base_url, path, list())
head(marketcap_map$data)
```

A data.frame: 6 × 11

	id	name	symbol	slug	is_active	rank	platform.id	platform.name	platform.symbol	platform.slug
	<int>	<chr>	<chr>	<chr>	<int>	<int>	<int>	<chr>	<chr>	<chr>
1	1	Bitcoin	BTC	bitcoin	1	1	NA	NA	NA	NA
2	2	Litecoin	LTC	litecoin	1	5	NA	NA	NA	NA
3	3	Namecoin	NMC	namecoin	1	310	NA	NA	NA	NA
4	4	Terracoin	TRC	terracoin	1	926	NA	NA	NA	NA
5	5	Peercoin	PPC	peercoin	1	346	NA	NA	NA	NA
6	6	Novacoin	NVC	novacoin	1	842	NA	NA	NA	NA

[10]:
```
# returns last market data of all active cryptocurrencies
path <- 'cryptocurrency/listings/latest'
query <- list(convert = 'EUR')
last_marketcap <- get_coinmarketcap_data(base_url, path, query)
head(last_marketcap$data)
```

A data.frame: 6 × 24

	id	name	symbol	slug	num_market_pairs	date_added	tags	max_supply
	<int>	<chr>	<chr>	<chr>	<int>	<chr>	<list>	<dbl>
1	1	Bitcoin	BTC	bitcoin	7919	2013-04-28T00:00:00.000Z	mineable	2.1e+07
2	1027	Ethereum	ETH	ethereum	5629	2015-08-07T00:00:00.000Z	mineable	NA
3	52	XRP	XRP	ripple	449	2013-08-04T00:00:00.000Z		1.0e+11
4	1831	Bitcoin Cash	BCH	bitcoin-cash	378	2017-07-23T00:00:00.000Z	mineable	2.1e+07
5	2	Litecoin	LTC	litecoin	538	2013-04-28T00:00:00.000Z	mineable	8.4e+07
6	825	Tether	USDT	tether	3016	2015-02-25T00:00:00.000Z		NA

[11]:
```
# returns last market data of Bitcoin
path <- 'cryptocurrency/quotes/latest'
query <- list(id = 1, convert = 'EUR')
```

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```
last_bitcoin <- get_coinmarketcap_data(base_url, path, query)
last_bitcoin$data$`1`
last_bitcoin$data$`1`$`quote`$EUR
```

$id 1

$name 'Bitcoin'

$symbol 'BTC'

$slug 'bitcoin'

$num_market_pairs 7919

$date_added '2013-04-28T00:00:00.000Z'

$tags 'mineable'

$max_supply 21000000

$circulating_supply 17906012

$total_supply 17906012

$is_active 1

$is_market_cap_included_in_calc 1

$platform NULL

$cmc_rank 1

$is_fiat 0

$last_updated '2019-08-30T18:51:28.000Z'

$quote **$EUR** =

- **$price** 8708.44273026964
- **$volume_24h** 12507935648.1974
- **$percent_change_1h** NULL
- **$percent_change_24h** NULL
- **$percent_change_7d** NULL
- **$market_cap** 155933480029.521
- **$last_updated** '2019-08-30T18:51:01.000Z'

$price 8708.44273026964

$volume_24h 12507935648.1974

$percent_change_1h NULL

$percent_change_24h NULL

$percent_change_7d NULL

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$market_cap 155933480029.521

$last_updated '2019-08-30T18:51:01.000Z'

[12]:
```
# returns historical data from a time_start to a time_end
path <- 'cryptocurrency/quotes/historical'
query <- list(id = 1, convert = 'EUR', time_start = '2020-05-21T12:14', time_end = '2020-
↪05-21T12:44')
data <- get_coinmarketcap_data(base_url, path, query)
head(data$data)
```

$id 1

$name 'Bitcoin'

$symbol 'BTC'

$is_fiat 0

$quotes A data.frame: 6 × 2

	timestamp <chr>	quote.EUR.timestamp <chr>
1	2020-05-21T12:19:03.000Z	2020-05-21T12:19:03.000Z
2	2020-05-21T12:24:02.000Z	2020-05-21T12:24:02.000Z
3	2020-05-21T12:29:03.000Z	2020-05-21T12:29:03.000Z
4	2020-05-21T12:34:03.000Z	2020-05-21T12:34:03.000Z
5	2020-05-21T12:39:01.000Z	2020-05-21T12:39:01.000Z
6	2020-05-21T12:44:02.000Z	2020-05-21T12:44:02.000Z

2.3.3 Quandl library

OHLC (Open High Low Close) data by Quandl library (doc), for example crude oil

[13]:
```
library(Quandl)
oil_data <- Quandl(code = "CHRIS/CME_QM1")
head(oil_data) # returns all free columns names
```

A data.frame: 6 × 9

	Date <date>	Open <dbl>	High <dbl>	Low <dbl>	Last <dbl>	Change <dbl>	Settle <dbl>	Volume <dbl>	Previous Day Open Interest <dbl>
1	2021-01-08	50.925	52.750	50.825	52.750	1.41	52.24	10770	1833
2	2021-01-07	50.525	51.275	50.400	50.950	0.20	50.83	10814	1800
3	2021-01-06	49.825	50.925	49.475	50.525	0.70	50.63	16675	1908
4	2021-01-05	47.400	50.200	47.275	49.850	2.31	49.93	23473	1799
5	2021-01-04	48.400	49.850	47.200	47.350	-0.90	47.62	21845	1350
6	2020-12-31	48.325	48.575	47.775	48.450	0.12	48.52	6698	1446

[14]:
```
#getPrice(oil_data) # returns all free columns values
#getPrice(oil_data, symbol = "CHRIS/CME_QM1", prefer = "Open$") # returns open values of␣
↪a specific symbol
getPrice(oil_data, prefer = "Open$") # returns open values
```

50.925

50.525

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```
49.825
47.4
48.4
48.325
48.125
47.7
48.2
48.1
46.775
47.85
49.3
48.35
47.825
47.55
47.05
46.65
47
45.725
45.55
45.6
46.125
45.625
45
44.375
45.05
45.45
45.9
44.8
42.825
42.55
41.85
41.6
41.325
41.525
40.175
```

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40.9
41.425
41.8
39.825
37.325
38.5
39.1
38.15
37.025
35.325
36.1
37.475
38.95
38.625
39.75
40.6
40.025
41.25
40.95
40.9
40.875
41.15
40.225
39.525
40.45
41.325
39.975
39.875
39.375
37
38.525
39.85
39.225
40.575
40.125

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```
40.175
39.6
39.725
39.875
40.85
40.95
40.175
38.325
37.3
37.325
37.1
37.8
36.85
39.45
41.25
41.575
43.05
42.825
42.925
43
43.475
43.375
42.375
42.425
42.75
42.95
42.65
42.65
42.15
42.325
42.55
41.575
42
41.55
41.925
```

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42.225
41.525
40.775
40.375
40.4
41.325
41.1
41.675
41.325
41.1
41.925
41.55
40.8
40.45
40.75
40.95
40.55
39.625
40.375
39.6
40.825
40.45
40.6
40.375
39.775
39.825
39.625
37.95
39.075
38.05
39.975
40.65
39.05
38.875
37.625

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```
37.95
37.1
35.975
36.25
39.05
38.425
38.2
39.4
37.325
36.725
36.825
35.525
35.075
33.675
32.025
34.1
33.3
33.95
33.5
31.9
32.35
30
27.575
25.7
25.35
24.575
24.425
23.5
24
25.5
21.15
19.1
19.075
15.6
13.275
```

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```
13
16.875
16.825
14.3
13
21.3
17.75
20.025
20.125
20.7
22.4
24.55
26.25
24.25
26.35
26.5
24.8
21.225
20.1
20.25
21
23.3
24.15

56.1
55.375
55.325
57.25
59.225
63.35
63
65.525
66.725
67.4
67.6
```

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```
69.25
66.125
73.5
73.85
75.5
76.575
76.325
74.325
74.225
75.525
75.95
74.3
76.9
77.5
77.275
78.475
77.9
78.9
77.4
78.175
80.6
81
81.925
81.575
80.65
81.225
81.925
80.4
82.525
81.85
82.4
83.175
80.95
82.3
85.025
```

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85.3
84.4
87.7
88.45
90.5
89.75
91.35
90.725
91.375
94.3
93.3
92.525
92.9
91.65
90.7
91.625
91.95
94
94.725
92.75
92.125
93.05
91.7
92.775
93.15
93.45
94.525
95.1
93.225
95.875
94.575
93.725
93.875
93.35
93.375

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93.9
93.475
92.85
93.925
97.2
95.525
97.35
97.175
97.85
97.45
97.6
96.9
97.6
98.4
97.675
97.65
99.525
101
101.575
101.875
102.05
103.2
102
102.75
101.725
103.75
101.475
100.2
100.95
100.525
102.85
101.95
103.5
103.4
103.8

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104.275
105.225
105.55
105.775
105.65
106.7
106.025
106
106.9
106.075
105.7
106.625
106.575
106.9
106.825
104.5
104.325
104.5
102.7
102.425
102.375
102.775
102.45
102.875
103.45
103.075
104.15
104.375
103.75
103.825
102.925
102.1
101.6
101.575
102

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```
101.925
100.6
100.025
100.25
100.775
99.825
99.425
99.95
99.2
99.7
100.775
100.85
100.25
101.925
101.5
101.9
103.625
103.65
103.825
103.825
103.6
103.65
103.35
103.4
102.325
100.7
101
100.4
99.3
99.675
101.5
101.575
101.325
100.275
99.2
```

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```
99.425
99.45
98.675
99.15
98.575
98.025
99.35
98.2
98.1
99.5
100.925
101.9
101
103.325
```

2.4 Graphics

This is a sample for plotting with R.

[1]:
```
library(quantmod)
# initialization
symbols = c("AMZN", "FB", "NFLX", "MSFT")
start <- as.Date("2017-01-01")
end <- as.Date("2020-01-01")
getSymbols(Symbols = symbols, src = "yahoo", from = start, to = end)
# get only Close values of AMZN and MSFT symbols
stocks <- as.xts(data.frame(AMZN = AMZN[,"AMZN.Close"], MSFT = MSFT[,"MSFT.Close"]))
```

```
Loading required package: xts

Loading required package: zoo


Attaching package: ‘zoo’


The following objects are masked from ‘package:base’:

    as.Date, as.Date.numeric


Loading required package: TTR

Registered S3 method overwritten by 'quantmod':
```

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```
  method            from
  as.zoo.data.frame zoo

'getSymbols' currently uses auto.assign=TRUE by default, but will
use auto.assign=FALSE in 0.5-0. You will still be able to use
'loadSymbols' to automatically load data. getOption("getSymbols.env")
and getOption("getSymbols.auto.assign") will still be checked for
alternate defaults.

This message is shown once per session and may be disabled by setting
options("getSymbols.warning4.0"=FALSE). See ?getSymbols for details.
```

'AMZN'

'FB'

'NFLX'

'MSFT'

[2]:
```
# plotting
library(plotly)
plot(AMZN[,"AMZN.Close"], main = "AMZN") # prints linear graph
```

```
Loading required package: ggplot2


Attaching package: 'plotly'


The following object is masked from 'package:ggplot2':

    last_plot


The following object is masked from 'package:stats':

    filter


The following object is masked from 'package:graphics':

    layout
```

[3]:
```
# create a custom theme
my_theme <- chart_theme()
my_theme$col$up.col <- "darkgreen"
my_theme$col$up.border <- "black"
my_theme$col$dn.col <- "darkred"
my_theme$col$dn.border <- "black"
my_theme$rylab <- FALSE
my_theme$col$grid <- "lightgrey"
```

[4]:
```
# using the custom theme with a range
chart_Series(AMZN, subset = "2017-10::2018-09", theme = my_theme)
```

[5]:
```
# using the custom theme with a range of one month
chart_Series(AMZN, subset = "2018-09", theme = my_theme)
```

[6]:
```
# using the black theme of quantmod
barChart(AMZN, theme = chartTheme('black'))
```

[7]:
```
# using the candle theme of quantmod
candleChart(AMZN, up.col = "green", dn.col = "red", theme = "white")
```

[8]:
```
# zoom of graph on one month
zoomChart("2018-09")
```

[9]:
```
# zoom of graph on one year
zoomChart("2018")
```

[10]:
```
# add indicators
addSMA(n = c(20, 50, 200)) # adds simple moving averages
```

[11]:
```
addBBands(n = 20, sd = 2, ma = "SMA", draw = "bands", on = -1) # sd = standard deviation,
↪ ma = average
```

[12]:
```
AMZN_ema_21 <- EMA(Cl(AMZN), n=21) # exponencial moving average
addTA(AMZN_ema_21, on = 1, col = "red")
```

[13]:
```
AMZN_ema_50 <- EMA(Cl(AMZN), n=50) # exponencial moving average
addTA(AMZN_ema_50, on = 1, col = "blue")
```

[14]:
```
AMZN_ema_200 <- EMA(Cl(AMZN), n=200) # exponencial moving average
addTA(AMZN_ema_200, on = 1, col = "orange")
```

[15]:
```
addRSI(n = 14, maType = "EMA", wilder = TRUE) # relative strength index
```

2.5 Strategies

You can initilize a strategy by R language.

The main libraries are

- Quantmod (doc), for loading data and managing the strategy
- QuantStrat, for managing the strategy
- PerformanceAnalytics, for performance and risk analysis

2.5.1 How to load indicators on your strategy

[1]:
```
#install.packages("quantmod")
#require(devtools)
#devtools::install_github("braverock/blotter")
#devtools::install_github("braverock/quantstrat")
```

[2]:
```
library(quantmod)
# initialization
Sys.setenv(TZ="UTC")
symbol = as.character("AMZN")
start <- as.Date("2017-01-01")
```

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```
end <- as.Date("2020-01-01")
getSymbols(Symbols = symbol, src = "yahoo", from = start, to = end)
```

```
Loading required package: xts

Loading required package: zoo


Attaching package: ‘zoo’


The following objects are masked from ‘package:base’:

    as.Date, as.Date.numeric


Loading required package: TTR

Registered S3 method overwritten by 'quantmod':
  method            from
  as.zoo.data.frame zoo

‘getSymbols’ currently uses auto.assign=TRUE by default, but will
use auto.assign=FALSE in 0.5-0. You will still be able to use
‘loadSymbols’ to automatically load data. getOption("getSymbols.env")
and getOption("getSymbols.auto.assign") will still be checked for
alternate defaults.

This message is shown once per session and may be disabled by setting
options("getSymbols.warning4.0"=FALSE). See ?getSymbols for details.
```

```
’AMZN’
```

[3]:
```
AMZN <- na.omit(lag(AMZN))
# calculate indicators
sma20 <- SMA(Cl(AMZN), n = 20)
ema20 <- EMA(Cl(AMZN), n = 20)
```

[4]:
```
library(quantstrat)
# strategy initialization
currency("USD")
stock(symbol, currency = 'USD', multiplier = 1)
tradeSize <- 100000
initEquity <- 100000
account.st <- portfolio.st <- strategy.st <- "my strategy"
rm.strat("my strategy")
out <- initPortf(portfolio.st, symbols = symbol, initDate = start, currency = "USD")
out <- initAcct(account.st, portfolios = portfolio.st, initDate = start, currency = "USD
↪", initEq = initEquity)
initOrders(portfolio.st, initDate = start)
strategy(strategy.st, store = TRUE)
```

```
Loading required package: blotter

Loading required package: FinancialInstrument

Loading required package: PerformanceAnalytics


Attaching package: 'PerformanceAnalytics'


The following object is masked from 'package:graphics':

    legend


Loading required package: foreach
```

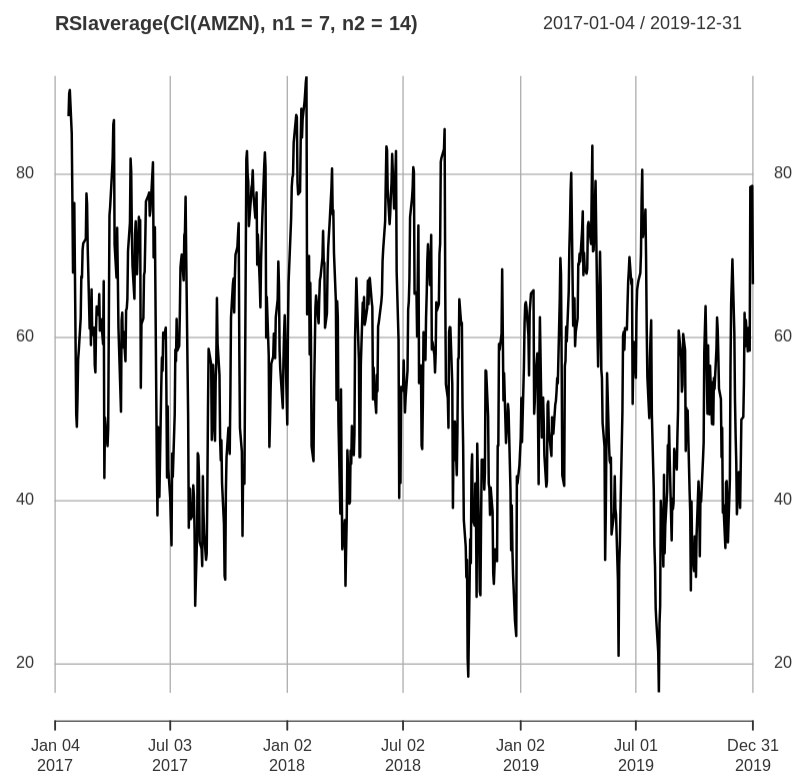
```
'USD'
```

```
'AMZN'
```

[5]:
```
# indicators with QuantStrat
out <- add.indicator(strategy.st, name = "SMA", arguments = list(x = quote(Cl(AMZN)), n␣
↪= 20, maType = "SMA"), label = "SMA20periods")
out <- add.indicator(strategy.st, name = "SMA", arguments = list(x = quote(Cl(AMZN)), n␣
↪= 50, maType = "SMA"), label = "SMA50periods")
out <- add.indicator(strategy.st, name = "EMA", arguments = list(x = quote(Cl(AMZN)), n␣
↪= 20, maType = "EMA"), label = "EMA20periods")
out <- add.indicator(strategy.st, name = "EMA", arguments = list(x = quote(Cl(AMZN)), n␣
↪= 50, maType = "EMA"), label = "EMA50periods")
out <- add.indicator(strategy.st, name = "RSI", arguments = list(price = quote(Cl(AMZN)),
↪ n = 7), label = "RSI720periods")
out <- add.indicator(strategy.st, name = "BBands", arguments = list(HLC =␣
↪quote(Cl(AMZN)), n = 20, maType = "SMA", sd = 2), label = "Bollinger Bands")
```

[6]:
```
# custom indicator
RSIaverage <- function(price, n1, n2) {
    RSI_1 <- RSI(price = price, n = n1)
    RSI_2 <- RSI(price = price, n = n2)
    calculatedAverage <- (RSI_1 + RSI_2) / 2
    colnames(calculatedAverage) <- "RSI_average"
    return(calculatedAverage)
}
out <- add.indicator(strategy.st, name = "RSIaverage", arguments = list(price =␣
↪quote(Cl(AMZN)), n1 = 7, n2 = 14), label = "RSIaverage")
```

[7]:
```
# first tests
plot(RSIaverage(Cl(AMZN), n1=7, n2=14)) # for graphing your function results
```



[8]:
```
# load all indicators on my data
test <- applyIndicators(strategy = strategy.st, mktdata = OHLC(AMZN))
subsetTest <- test["2018-01-01/2019-01-01"]
head(subsetTest)
```

```
           AMZN.Open AMZN.High AMZN.Low AMZN.Close SMA.SMA20periods
2018-01-02   1182.35   1184.00  1167.50    1169.47         1168.841
2018-01-03   1172.00   1190.00  1170.51    1189.01         1170.174
2018-01-04   1188.30   1205.49  1188.30    1204.20         1173.687
2018-01-05   1205.00   1215.87  1204.66    1209.59         1177.088
2018-01-08   1217.51   1229.14  1210.00    1229.14         1180.927
2018-01-09   1236.00   1253.08  1232.03    1246.87         1185.281
           SMA.SMA50periods EMA.EMA20periods EMA.EMA50periods rsi.RSI720periods
2018-01-02         1129.739         1168.779         1130.025          44.92805
2018-01-03         1133.787         1170.706         1132.338          60.65982
2018-01-04         1138.213         1173.896         1135.156          68.75469
2018-01-05         1143.078         1177.295         1138.075          71.20734
2018-01-08         1148.143         1182.233         1141.646          78.38659
2018-01-09         1153.622         1188.389         1145.773          82.89832
           dn.Bollinger.Bands mavg.Bollinger.Bands up.Bollinger.Bands
2018-01-02           1140.397             1168.841           1197.286
2018-01-03           1140.596             1170.174           1199.753
2018-01-04           1145.498             1173.687           1201.876
2018-01-05           1148.806             1177.088           1205.370
2018-01-08           1146.863             1180.927           1214.992
```

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```
2018-01-09           1142.097             1185.281           1228.466
           pctB.Bollinger.Bands RSI_average.RSIaverage
2018-01-02            0.5110476                49.34830
2018-01-03            0.8183989                60.54486
2018-01-04            1.0412143                66.72199
2018-01-05            1.0746036                68.64585
2018-01-08            1.2076629                74.50261
2018-01-09            1.2130873                78.45513
```

2.5.2 How to load signals on your strategy

The best practice is to prepare one column for each signal that you want to use on your strategy. The strategy below use the moving averages that they are SMA and EMA. You can use one or the other.

Disclaimer

The strategies below are some simple samples for having an idea how to use the libraries: those strategies are for the educational purpose only. All investments and trading in the stock market involve risk: any decisions related to buying/selling of stocks or other financial instruments should only be made after a thorough research, backtesting, running in demo and seeking a professional assistance if required.

Moving Average Crossover Strategy - Sample 1

- when the price value crosses the MA value from below, it will close any existing short position and go long (buy) one unit of the asset
- when the price value crosses the MA value from above, it will close any existing long position and go short (sell) one unit of the asset

Reference: https://www.learndatasci.com/tutorials/python-finance-part-3-moving-average-trading-strategy/

[9]:
```
# Moving Average Crossover Strategy - Sample 1
signalPosition <- function(price, ma) {
    # Taking the difference between the prices and the MA timeseries
    price_ma_diff <- price - ma
    price_ma_diff[is.na(price_ma_diff)] <- 0 # replace missing signals with no position
    # Taking the sign of the difference to determine whether the price or the MA is␣
↪greater
    position <- diff(price_ma_diff)
    position[is.na(position)] <- 0 # replace missing signals with no position
    colnames(position) <- "Signal_position"
    return(position)
}
```

[10]:
```
#out <- add.indicator(strategy.st, name = "signalPosition", arguments = list(price =␣
↪Cl(AMZN), ma = sma20), label = "signalPosition")
out <- add.indicator(strategy.st, name = "signalPosition", arguments = list(price =␣
↪Cl(AMZN), ma = ema20), label = "signalPosition1")
out <- add.signal(strategy.st, name = "sigThreshold", arguments = list(column = "Signal_
↪position", threshold = 2, relationship = "gte", cross = TRUE), label = "buy1")
```

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```
out <- add.signal(strategy.st, name = "sigThreshold", arguments = list(column = "Signal_
↪position", threshold = -2, relationship = "lte", cross = TRUE), label = "sell1")
#add.signal(strategy.st, name = "sigThreshold", arguments = list(data = position, column␣
↪= "AMZN.Close", threshold = 2, relationship = "gte", cross = TRUE), label = "buy1")
#add.signal(strategy.st, name = "sigThreshold", arguments = list(data = position, column␣
↪= "AMZN.Close", threshold = -2, relationship = "lte", cross = TRUE), label = "sell1")
# Creating rules
out <- add.rule(strategy.st, name = 'ruleSignal', arguments = list(sigcol = "buy1",␣
↪sigval = TRUE, orderqty = 100, ordertype = 'market', orderside = 'long'), type = 'enter
↪')
out <- add.rule(strategy.st, name = 'ruleSignal', arguments = list(sigcol = "sell1",␣
↪sigval = TRUE, orderqty = 'all', ordertype = 'market', orderside = 'long'), type =
↪'exit')
#out <- add.rule(strategy.st, name = 'ruleSignal', arguments = list(sigcol = "sell1",␣
↪sigval = TRUE, orderqty = -100, ordertype = 'market', orderside = 'short'), type = 'enter')
#out <- add.rule(strategy.st, name = 'ruleSignal', arguments = list(sigcol = "buy1",␣
↪sigval = TRUE, orderqty = 'all', ordertype = 'market', orderside = 'short'), type = 'exit')
```

[11]:
```
# backtesting
applyStrategy(strategy.st, portfolios=portfolio.st)
out <- updatePortf(portfolio.st)
dateRange <- time(getPortfolio(portfolio.st)$summary)[-1]
out <- updateAcct(portfolio.st, dateRange)
out <- updateEndEq(account.st)
chart.Posn(portfolio.st, Symbol=symbol, TA=c("add_SMA(n=20,col='red')"))
```

```
[1] "2017-02-02 00:00:00 AMZN 100 @ 832.349976"
[1] "2017-02-07 00:00:00 AMZN -100 @ 807.640015"
[1] "2017-02-09 00:00:00 AMZN 100 @ 819.710022"
[1] "2017-02-14 00:00:00 AMZN 100 @ 836.530029"
[1] "2017-02-17 00:00:00 AMZN 100 @ 844.140015"
[1] "2017-02-23 00:00:00 AMZN 100 @ 855.609985"
[1] "2017-02-24 00:00:00 AMZN -400 @ 852.190002"
[1] "2017-03-01 00:00:00 AMZN 100 @ 845.039978"
[1] "2017-03-02 00:00:00 AMZN -100 @ 853.080017"
[1] "2017-03-03 00:00:00 AMZN 100 @ 848.909973"
[1] "2017-03-06 00:00:00 AMZN -100 @ 849.880005"
[1] "2017-03-10 00:00:00 AMZN 100 @ 853"
[1] "2017-03-16 00:00:00 AMZN -100 @ 852.969971"
[1] "2017-03-22 00:00:00 AMZN 100 @ 843.200012"
[1] "2017-03-23 00:00:00 AMZN -100 @ 848.059998"
[1] "2017-03-24 00:00:00 AMZN 100 @ 847.380005"
[1] "2017-03-30 00:00:00 AMZN 100 @ 874.320007"
[1] "2017-04-04 00:00:00 AMZN 100 @ 891.51001"
[1] "2017-04-06 00:00:00 AMZN 100 @ 909.280029"
[1] "2017-04-10 00:00:00 AMZN -400 @ 894.880005"
[1] "2017-04-12 00:00:00 AMZN 100 @ 902.359985"
[1] "2017-04-13 00:00:00 AMZN -100 @ 896.22998"
[1] "2017-04-19 00:00:00 AMZN 100 @ 903.780029"
[1] "2017-04-21 00:00:00 AMZN -100 @ 902.059998"
[1] "2017-04-26 00:00:00 AMZN 100 @ 907.619995"
[1] "2017-05-01 00:00:00 AMZN 100 @ 924.98999"
```

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```
[1] "2017-05-04 00:00:00 AMZN -200 @ 941.030029"
[1] "2017-05-10 00:00:00 AMZN 100 @ 952.820007"
[1] "2017-05-12 00:00:00 AMZN -100 @ 947.619995"
[1] "2017-05-16 00:00:00 AMZN 100 @ 957.969971"
[1] "2017-05-17 00:00:00 AMZN -100 @ 966.070007"
[1] "2017-05-18 00:00:00 AMZN 100 @ 944.76001"
[1] "2017-05-19 00:00:00 AMZN -100 @ 958.48999"
[1] "2017-05-22 00:00:00 AMZN 100 @ 959.840027"
[1] "2017-05-24 00:00:00 AMZN 100 @ 971.539978"
[1] "2017-05-26 00:00:00 AMZN 100 @ 993.380005"
[1] "2017-06-01 00:00:00 AMZN -300 @ 994.619995"
[1] "2017-06-06 00:00:00 AMZN 100 @ 1011.340027"
[1] "2017-06-08 00:00:00 AMZN -100 @ 1010.070007"
[1] "2017-06-09 00:00:00 AMZN 100 @ 1010.27002"
[1] "2017-06-12 00:00:00 AMZN -100 @ 978.309998"
[1] "2017-06-15 00:00:00 AMZN 100 @ 976.469971"
[1] "2017-06-16 00:00:00 AMZN -100 @ 964.169983"
[1] "2017-06-20 00:00:00 AMZN 100 @ 995.169983"
[1] "2017-06-22 00:00:00 AMZN -100 @ 1002.22998"
[1] "2017-06-23 00:00:00 AMZN 100 @ 1001.299988"
[1] "2017-06-26 00:00:00 AMZN -100 @ 1003.73999"
[1] "2017-06-30 00:00:00 AMZN 100 @ 975.929993"
[1] "2017-07-03 00:00:00 AMZN -100 @ 968"
[1] "2017-07-07 00:00:00 AMZN 100 @ 965.140015"
[1] "2017-07-10 00:00:00 AMZN -100 @ 978.76001"
[1] "2017-07-11 00:00:00 AMZN 100 @ 996.469971"
[1] "2017-07-13 00:00:00 AMZN -100 @ 1006.51001"
[1] "2017-07-14 00:00:00 AMZN 100 @ 1000.630005"
[1] "2017-07-17 00:00:00 AMZN -100 @ 1001.809998"
[1] "2017-07-19 00:00:00 AMZN 100 @ 1024.449951"
[1] "2017-07-25 00:00:00 AMZN -100 @ 1038.949951"
[1] "2017-07-26 00:00:00 AMZN 100 @ 1039.869995"
[1] "2017-07-27 00:00:00 AMZN -100 @ 1052.800049"
[1] "2017-07-28 00:00:00 AMZN 100 @ 1046"
[1] "2017-07-31 00:00:00 AMZN -100 @ 1020.039978"
[1] "2017-08-03 00:00:00 AMZN 100 @ 995.890015"
[1] "2017-08-07 00:00:00 AMZN -100 @ 987.580017"
[1] "2017-08-08 00:00:00 AMZN 100 @ 992.27002"
[1] "2017-08-11 00:00:00 AMZN -100 @ 956.919983"
[1] "2017-08-15 00:00:00 AMZN 100 @ 983.299988"
[1] "2017-08-18 00:00:00 AMZN -100 @ 960.570007"
[1] "2017-08-24 00:00:00 AMZN 100 @ 958"
[1] "2017-08-25 00:00:00 AMZN -100 @ 952.450012"
[1] "2017-08-30 00:00:00 AMZN 100 @ 954.059998"
[1] "2017-09-06 00:00:00 AMZN -100 @ 965.27002"
[1] "2017-09-08 00:00:00 AMZN 100 @ 979.469971"
[1] "2017-09-12 00:00:00 AMZN -100 @ 977.960022"
[1] "2017-09-13 00:00:00 AMZN 100 @ 982.580017"
[1] "2017-09-18 00:00:00 AMZN -100 @ 986.789978"
[1] "2017-09-22 00:00:00 AMZN 100 @ 964.650024"
[1] "2017-09-25 00:00:00 AMZN -100 @ 955.099976"
[1] "2017-09-29 00:00:00 AMZN 100 @ 956.400024"
```

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[1] "2017-10-06 00:00:00 AMZN 100 @ 980.849976"
[1] "2017-10-12 00:00:00 AMZN -200 @ 995"
[1] "2017-10-13 00:00:00 AMZN 100 @ 1000.929993"
[1] "2017-10-20 00:00:00 AMZN -100 @ 986.609985"
[1] "2017-10-26 00:00:00 AMZN 100 @ 972.909973"
[1] "2017-10-27 00:00:00 AMZN -100 @ 972.429993"
[1] "2017-10-31 00:00:00 AMZN 100 @ 1110.849976"
[1] "2017-11-02 00:00:00 AMZN -100 @ 1103.680054"
[1] "2017-11-07 00:00:00 AMZN 100 @ 1120.660034"
[1] "2017-11-09 00:00:00 AMZN -100 @ 1132.880005"
[1] "2017-11-10 00:00:00 AMZN 100 @ 1129.130005"
[1] "2017-11-13 00:00:00 AMZN -100 @ 1125.349976"
[1] "2017-11-16 00:00:00 AMZN 100 @ 1126.689941"
[1] "2017-11-17 00:00:00 AMZN -100 @ 1137.290039"
[1] "2017-11-20 00:00:00 AMZN 100 @ 1129.880005"
[1] "2017-11-21 00:00:00 AMZN -100 @ 1126.310059"
[1] "2017-11-24 00:00:00 AMZN 100 @ 1156.160034"
[1] "2017-11-30 00:00:00 AMZN -100 @ 1161.27002"
[1] "2017-12-04 00:00:00 AMZN 100 @ 1162.349976"
[1] "2017-12-05 00:00:00 AMZN -100 @ 1133.949951"
[1] "2017-12-07 00:00:00 AMZN 100 @ 1152.349976"
[1] "2017-12-13 00:00:00 AMZN 100 @ 1165.079956"
[1] "2017-12-14 00:00:00 AMZN -200 @ 1164.130005"
[1] "2017-12-18 00:00:00 AMZN 100 @ 1179.140015"
[1] "2017-12-21 00:00:00 AMZN -100 @ 1177.619995"
[1] "2017-12-28 00:00:00 AMZN 100 @ 1182.26001"
[1] "2018-01-03 00:00:00 AMZN -100 @ 1189.01001"
[1] "2018-01-04 00:00:00 AMZN 100 @ 1204.199951"
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[1] "2018-01-12 00:00:00 AMZN -200 @ 1276.680054"
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[1] "2018-01-18 00:00:00 AMZN -100 @ 1295"
[1] "2018-01-24 00:00:00 AMZN 100 @ 1362.540039"
[1] "2018-01-26 00:00:00 AMZN -100 @ 1377.949951"
[1] "2018-01-29 00:00:00 AMZN 100 @ 1402.050049"
[1] "2018-02-05 00:00:00 AMZN -100 @ 1429.949951"
[1] "2018-02-06 00:00:00 AMZN 100 @ 1390"
[1] "2018-02-07 00:00:00 AMZN -100 @ 1442.839966"
[1] "2018-02-08 00:00:00 AMZN 100 @ 1416.780029"
[1] "2018-02-09 00:00:00 AMZN -100 @ 1350.5"
[1] "2018-02-14 00:00:00 AMZN 100 @ 1414.51001"
[1] "2018-02-21 00:00:00 AMZN -100 @ 1468.349976"
[1] "2018-02-22 00:00:00 AMZN 100 @ 1482.920044"
[1] "2018-02-26 00:00:00 AMZN -100 @ 1500"
[1] "2018-02-27 00:00:00 AMZN 100 @ 1521.949951"
[1] "2018-03-01 00:00:00 AMZN -100 @ 1512.449951"
[1] "2018-03-06 00:00:00 AMZN 100 @ 1523.609985"
[1] "2018-03-13 00:00:00 AMZN 100 @ 1598.390015"
[1] "2018-03-15 00:00:00 AMZN -200 @ 1591"
[1] "2018-03-22 00:00:00 AMZN 100 @ 1581.859985"
[1] "2018-03-23 00:00:00 AMZN -100 @ 1544.920044"
[1] "2018-03-28 00:00:00 AMZN 100 @ 1497.050049"
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[1] "2018-03-29 00:00:00 AMZN -100 @ 1431.420044"
[1] "2018-04-03 00:00:00 AMZN 100 @ 1371.98999"
[1] "2018-04-04 00:00:00 AMZN -100 @ 1392.050049"
[1] "2018-04-05 00:00:00 AMZN 100 @ 1410.569946"
[1] "2018-04-10 00:00:00 AMZN -100 @ 1406.079956"
[1] "2018-04-11 00:00:00 AMZN 100 @ 1436.219971"
[1] "2018-04-13 00:00:00 AMZN -100 @ 1448.5"
[1] "2018-04-16 00:00:00 AMZN 100 @ 1430.790039"
[1] "2018-04-17 00:00:00 AMZN -100 @ 1441.5"
[1] "2018-04-18 00:00:00 AMZN 100 @ 1503.829956"
[1] "2018-04-24 00:00:00 AMZN -100 @ 1517.859985"
[1] "2018-04-27 00:00:00 AMZN 100 @ 1517.959961"
[1] "2018-05-02 00:00:00 AMZN -100 @ 1582.26001"
[1] "2018-05-03 00:00:00 AMZN 100 @ 1569.680054"
[1] "2018-05-04 00:00:00 AMZN -100 @ 1572.079956"
[1] "2018-05-08 00:00:00 AMZN 100 @ 1600.140015"
[1] "2018-05-10 00:00:00 AMZN -100 @ 1608"
[1] "2018-05-11 00:00:00 AMZN 100 @ 1609.079956"
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[1] "2018-05-23 00:00:00 AMZN 100 @ 1581.400024"
[1] "2018-05-24 00:00:00 AMZN -100 @ 1601.859985"
[1] "2018-05-25 00:00:00 AMZN 100 @ 1603.069946"
[1] "2018-05-30 00:00:00 AMZN 100 @ 1612.869995"
[1] "2018-06-01 00:00:00 AMZN 100 @ 1629.619995"
[1] "2018-06-05 00:00:00 AMZN 100 @ 1665.27002"
[1] "2018-06-08 00:00:00 AMZN -400 @ 1689.300049"
[1] "2018-06-14 00:00:00 AMZN 100 @ 1704.859985"
[1] "2018-06-18 00:00:00 AMZN 100 @ 1715.969971"
[1] "2018-06-19 00:00:00 AMZN -200 @ 1723.790039"
[1] "2018-06-21 00:00:00 AMZN 100 @ 1750.079956"
[1] "2018-06-25 00:00:00 AMZN -100 @ 1715.670044"
[1] "2018-06-28 00:00:00 AMZN 100 @ 1660.51001"
[1] "2018-06-29 00:00:00 AMZN -100 @ 1701.449951"
[1] "2018-07-02 00:00:00 AMZN 100 @ 1699.800049"
[1] "2018-07-03 00:00:00 AMZN -100 @ 1713.780029"
[1] "2018-07-05 00:00:00 AMZN 100 @ 1693.959961"
[1] "2018-07-06 00:00:00 AMZN -100 @ 1699.72998"
[1] "2018-07-09 00:00:00 AMZN 100 @ 1710.630005"
[1] "2018-07-13 00:00:00 AMZN 100 @ 1796.619995"
[1] "2018-07-19 00:00:00 AMZN 100 @ 1842.920044"
[1] "2018-07-20 00:00:00 AMZN -300 @ 1812.969971"
[1] "2018-07-26 00:00:00 AMZN 100 @ 1863.609985"
[1] "2018-07-30 00:00:00 AMZN -100 @ 1817.27002"
[1] "2018-07-31 00:00:00 AMZN 100 @ 1779.219971"
[1] "2018-08-01 00:00:00 AMZN -100 @ 1777.439941"
[1] "2018-08-03 00:00:00 AMZN 100 @ 1834.329956"
[1] "2018-08-07 00:00:00 AMZN -100 @ 1847.75"
[1] "2018-08-08 00:00:00 AMZN 100 @ 1862.47998"
[1] "2018-08-14 00:00:00 AMZN -100 @ 1896.199951"
[1] "2018-08-15 00:00:00 AMZN 100 @ 1919.650024"
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[1] "2018-08-17 00:00:00 AMZN -100 @ 1886.52002"
[1] "2018-08-23 00:00:00 AMZN 100 @ 1904.900024"
[1] "2018-08-27 00:00:00 AMZN -100 @ 1905.390015"
[1] "2018-08-29 00:00:00 AMZN 100 @ 1932.819946"
[1] "2018-08-31 00:00:00 AMZN 100 @ 2002.380005"
[1] "2018-09-04 00:00:00 AMZN -200 @ 2012.709961"
[1] "2018-09-06 00:00:00 AMZN 100 @ 1994.819946"
[1] "2018-09-07 00:00:00 AMZN -100 @ 1958.310059"
[1] "2018-09-13 00:00:00 AMZN 100 @ 1990"
[1] "2018-09-17 00:00:00 AMZN -100 @ 1970.189941"
[1] "2018-09-20 00:00:00 AMZN 100 @ 1926.420044"
[1] "2018-09-21 00:00:00 AMZN -100 @ 1944.300049"
[1] "2018-09-24 00:00:00 AMZN 100 @ 1915.01001"
[1] "2018-09-25 00:00:00 AMZN -100 @ 1934.359985"
[1] "2018-09-26 00:00:00 AMZN 100 @ 1974.550049"
[1] "2018-09-28 00:00:00 AMZN -100 @ 2012.97998"
[1] "2018-10-01 00:00:00 AMZN 100 @ 2003"
[1] "2018-10-02 00:00:00 AMZN -100 @ 2004.359985"
[1] "2018-10-11 00:00:00 AMZN 100 @ 1755.25"
[1] "2018-10-12 00:00:00 AMZN -100 @ 1719.359985"
[1] "2018-10-16 00:00:00 AMZN 100 @ 1760.949951"
[1] "2018-10-17 00:00:00 AMZN -100 @ 1819.959961"
[1] "2018-10-18 00:00:00 AMZN 100 @ 1831.72998"
[1] "2018-10-22 00:00:00 AMZN -100 @ 1764.030029"
[1] "2018-10-23 00:00:00 AMZN 100 @ 1789.300049"
[1] "2018-10-25 00:00:00 AMZN -100 @ 1664.199951"
[1] "2018-10-29 00:00:00 AMZN 100 @ 1642.810059"
[1] "2018-10-30 00:00:00 AMZN -100 @ 1538.880005"
[1] "2018-11-01 00:00:00 AMZN 100 @ 1598.01001"
[1] "2018-11-07 00:00:00 AMZN -100 @ 1642.810059"
[1] "2018-11-08 00:00:00 AMZN 100 @ 1755.48999"
[1] "2018-11-12 00:00:00 AMZN -100 @ 1712.430054"
[1] "2018-11-19 00:00:00 AMZN 100 @ 1593.410034"
[1] "2018-11-20 00:00:00 AMZN -100 @ 1512.290039"
[1] "2018-11-26 00:00:00 AMZN 100 @ 1502.060059"
[1] "2018-11-27 00:00:00 AMZN -100 @ 1581.329956"
[1] "2018-11-28 00:00:00 AMZN 100 @ 1581.420044"
[1] "2018-12-03 00:00:00 AMZN -100 @ 1690.170044"
[1] "2018-12-04 00:00:00 AMZN 100 @ 1772.359985"
[1] "2018-12-07 00:00:00 AMZN -100 @ 1699.189941"
[1] "2018-12-10 00:00:00 AMZN 100 @ 1629.130005"
[1] "2018-12-11 00:00:00 AMZN -100 @ 1641.030029"
[1] "2018-12-12 00:00:00 AMZN 100 @ 1643.23999"
[1] "2018-12-17 00:00:00 AMZN -100 @ 1591.910034"
[1] "2018-12-20 00:00:00 AMZN 100 @ 1495.079956"
[1] "2018-12-21 00:00:00 AMZN -100 @ 1460.829956"
[1] "2018-12-28 00:00:00 AMZN 100 @ 1461.640015"
[1] "2019-01-02 00:00:00 AMZN 100 @ 1501.969971"
[1] "2019-01-07 00:00:00 AMZN -200 @ 1575.390015"
[1] "2019-01-08 00:00:00 AMZN 100 @ 1629.51001"
[1] "2019-01-11 00:00:00 AMZN -100 @ 1656.219971"
[1] "2019-01-17 00:00:00 AMZN 100 @ 1683.780029"
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[1] "2019-01-23 00:00:00 AMZN -100 @ 1632.170044"
[1] "2019-01-25 00:00:00 AMZN 100 @ 1654.930054"
[1] "2019-01-30 00:00:00 AMZN -100 @ 1593.880005"
[1] "2019-02-01 00:00:00 AMZN 100 @ 1718.72998"
[1] "2019-02-05 00:00:00 AMZN -100 @ 1633.310059"
[1] "2019-02-06 00:00:00 AMZN 100 @ 1658.810059"
[1] "2019-02-08 00:00:00 AMZN -100 @ 1614.369995"
[1] "2019-02-13 00:00:00 AMZN 100 @ 1638.01001"
[1] "2019-02-19 00:00:00 AMZN -100 @ 1607.949951"
[1] "2019-02-21 00:00:00 AMZN 100 @ 1622.099976"
[1] "2019-02-22 00:00:00 AMZN -100 @ 1619.439941"
[1] "2019-02-26 00:00:00 AMZN 100 @ 1633"
[1] "2019-02-28 00:00:00 AMZN 100 @ 1641.089966"
[1] "2019-03-04 00:00:00 AMZN -200 @ 1671.72998"
[1] "2019-03-05 00:00:00 AMZN 100 @ 1696.170044"
[1] "2019-03-07 00:00:00 AMZN -100 @ 1668.949951"
[1] "2019-03-13 00:00:00 AMZN 100 @ 1673.099976"
[1] "2019-03-15 00:00:00 AMZN 100 @ 1686.219971"
[1] "2019-03-18 00:00:00 AMZN -200 @ 1712.359985"
[1] "2019-03-19 00:00:00 AMZN 100 @ 1742.150024"
[1] "2019-03-26 00:00:00 AMZN -100 @ 1774.26001"
[1] "2019-03-27 00:00:00 AMZN 100 @ 1783.76001"
[1] "2019-03-29 00:00:00 AMZN -100 @ 1773.420044"
[1] "2019-04-01 00:00:00 AMZN 100 @ 1780.75"
[1] "2019-04-04 00:00:00 AMZN -100 @ 1820.699951"
[1] "2019-04-09 00:00:00 AMZN 100 @ 1849.859985"
[1] "2019-04-11 00:00:00 AMZN -100 @ 1847.329956"
[1] "2019-04-12 00:00:00 AMZN 100 @ 1844.069946"
[1] "2019-04-15 00:00:00 AMZN -100 @ 1843.060059"
[1] "2019-04-18 00:00:00 AMZN 100 @ 1864.819946"
[1] "2019-04-22 00:00:00 AMZN -100 @ 1861.689941"
[1] "2019-04-24 00:00:00 AMZN 100 @ 1923.77002"
[1] "2019-04-26 00:00:00 AMZN -100 @ 1902.25"
[1] "2019-04-30 00:00:00 AMZN 100 @ 1938.430054"
[1] "2019-05-01 00:00:00 AMZN -100 @ 1926.52002"
[1] "2019-05-07 00:00:00 AMZN 100 @ 1950.550049"
[1] "2019-05-08 00:00:00 AMZN -100 @ 1921"
[1] "2019-05-16 00:00:00 AMZN 100 @ 1871.150024"
[1] "2019-05-21 00:00:00 AMZN -100 @ 1858.969971"
[1] "2019-05-24 00:00:00 AMZN 100 @ 1815.47998"
[1] "2019-05-28 00:00:00 AMZN -100 @ 1823.280029"
[1] "2019-05-29 00:00:00 AMZN 100 @ 1836.430054"
[1] "2019-05-31 00:00:00 AMZN -100 @ 1816.319946"
[1] "2019-06-06 00:00:00 AMZN 100 @ 1738.5"
[1] "2019-06-14 00:00:00 AMZN -100 @ 1870.300049"
[1] "2019-06-17 00:00:00 AMZN 100 @ 1869.670044"
[1] "2019-06-18 00:00:00 AMZN -100 @ 1886.030029"
[1] "2019-06-19 00:00:00 AMZN 100 @ 1901.369995"
[1] "2019-06-24 00:00:00 AMZN 100 @ 1911.300049"
[1] "2019-06-25 00:00:00 AMZN -200 @ 1913.900024"
[1] "2019-06-28 00:00:00 AMZN 100 @ 1904.280029"
[1] "2019-07-02 00:00:00 AMZN -100 @ 1922.189941"
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[1] "2019-07-03 00:00:00 AMZN 100 @ 1934.310059"
[1] "2019-07-10 00:00:00 AMZN 100 @ 1988.300049"
[1] "2019-07-15 00:00:00 AMZN -200 @ 2011"
[1] "2019-07-24 00:00:00 AMZN 100 @ 1994.48999"
[1] "2019-07-29 00:00:00 AMZN -100 @ 1943.050049"
[1] "2019-08-08 00:00:00 AMZN 100 @ 1793.400024"
[1] "2019-08-13 00:00:00 AMZN -100 @ 1784.920044"
[1] "2019-08-15 00:00:00 AMZN 100 @ 1762.959961"
[1] "2019-08-16 00:00:00 AMZN -100 @ 1776.119995"
[1] "2019-08-19 00:00:00 AMZN 100 @ 1792.569946"
[1] "2019-08-22 00:00:00 AMZN -100 @ 1823.540039"
[1] "2019-08-23 00:00:00 AMZN 100 @ 1804.660034"
[1] "2019-08-26 00:00:00 AMZN -100 @ 1749.619995"
[1] "2019-08-28 00:00:00 AMZN 100 @ 1761.829956"
[1] "2019-08-30 00:00:00 AMZN 100 @ 1786.400024"
[1] "2019-09-04 00:00:00 AMZN -200 @ 1789.839966"
[1] "2019-09-05 00:00:00 AMZN 100 @ 1800.619995"
[1] "2019-09-10 00:00:00 AMZN -100 @ 1831.349976"
[1] "2019-09-16 00:00:00 AMZN 100 @ 1839.339966"
[1] "2019-09-17 00:00:00 AMZN -100 @ 1807.839966"
[1] "2019-09-19 00:00:00 AMZN 100 @ 1817.459961"
[1] "2019-09-20 00:00:00 AMZN -100 @ 1821.5"
[1] "2019-09-23 00:00:00 AMZN 100 @ 1794.160034"
[1] "2019-09-24 00:00:00 AMZN -100 @ 1785.300049"
[1] "2019-09-27 00:00:00 AMZN 100 @ 1739.839966"
[1] "2019-09-30 00:00:00 AMZN -100 @ 1725.449951"
[1] "2019-10-02 00:00:00 AMZN 100 @ 1735.650024"
[1] "2019-10-04 00:00:00 AMZN -100 @ 1724.420044"
[1] "2019-10-07 00:00:00 AMZN 100 @ 1739.650024"
[1] "2019-10-09 00:00:00 AMZN -100 @ 1705.51001"
[1] "2019-10-11 00:00:00 AMZN 100 @ 1720.26001"
[1] "2019-10-15 00:00:00 AMZN 100 @ 1736.430054"
[1] "2019-10-22 00:00:00 AMZN -200 @ 1785.660034"
[1] "2019-10-23 00:00:00 AMZN 100 @ 1765.72998"
[1] "2019-10-24 00:00:00 AMZN -100 @ 1762.170044"
[1] "2019-10-28 00:00:00 AMZN 100 @ 1761.329956"
[1] "2019-10-29 00:00:00 AMZN -100 @ 1777.079956"
[1] "2019-10-30 00:00:00 AMZN 100 @ 1762.709961"
[1] "2019-10-31 00:00:00 AMZN -100 @ 1779.98999"
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[1] "2019-11-04 00:00:00 AMZN -100 @ 1791.439941"
[1] "2019-11-05 00:00:00 AMZN 100 @ 1804.660034"
[1] "2019-11-07 00:00:00 AMZN -100 @ 1795.77002"
[1] "2019-11-14 00:00:00 AMZN 100 @ 1753.109985"
[1] "2019-11-15 00:00:00 AMZN -100 @ 1754.599976"
[1] "2019-11-18 00:00:00 AMZN 100 @ 1739.48999"
[1] "2019-11-19 00:00:00 AMZN -100 @ 1752.530029"
[1] "2019-11-20 00:00:00 AMZN 100 @ 1752.790039"
[1] "2019-11-22 00:00:00 AMZN -100 @ 1734.709961"
[1] "2019-11-26 00:00:00 AMZN 100 @ 1773.839966"
[1] "2019-12-03 00:00:00 AMZN -100 @ 1781.599976"
[1] "2019-12-10 00:00:00 AMZN 100 @ 1749.51001"
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[1] "2019-12-12 00:00:00 AMZN -100 @ 1748.719971"
[1] "2019-12-13 00:00:00 AMZN 100 @ 1760.329956"
[1] "2019-12-18 00:00:00 AMZN 100 @ 1790.660034"
[1] "2019-12-20 00:00:00 AMZN -200 @ 1792.280029"
[1] "2019-12-23 00:00:00 AMZN 100 @ 1786.5"
[1] "2019-12-24 00:00:00 AMZN -100 @ 1793"
[1] "2019-12-26 00:00:00 AMZN 100 @ 1789.209961"
[1] "2019-12-27 00:00:00 AMZN -100 @ 1868.77002"
[1] "2019-12-30 00:00:00 AMZN 100 @ 1869.800049"
[1] "2019-12-31 00:00:00 AMZN -100 @ 1846.890015"
```

[12]:
```
tstats <- tradeStats(portfolio.st, use="trades", inclZeroDays=FALSE)
data.frame(t(tstats))
```

A data.frame: 32 × 1

	AMZN
	<chr>
Portfolio	my strategy
Symbol	AMZN
Num.Txns	348
Num.Trades	160
Net.Trading.PL	103829
Avg.Trade.PL	648.9312
Med.Trade.PL	194.4946
Largest.Winner	24637.02
Largest.Loser	-12510.01
Gross.Profits	297592
Gross.Losses	-193763
Std.Dev.Trade.PL	4650.819
Std.Err.Trade.PL	367.6795
Percent.Positive	53.125
Percent.Negative	46.875
Profit.Factor	1.535856
Avg.Win.Trade	3501.083
Med.Win.Trade	1707.996
Avg.Losing.Trade	-2583.507
Med.Losing.Trade	-1808.008
Avg.Daily.PL	648.9312
Med.Daily.PL	194.4947
Std.Dev.Daily.PL	4650.819
Std.Err.Daily.PL	367.6795
Ann.Sharpe	2.214979
Max.Drawdown	-39630.02
Profit.To.Max.Draw	2.619958
Avg.WinLoss.Ratio	1.355167
Med.WinLoss.Ratio	0.9446838
Max.Equity	106120
Min.Equity	-2470.996
End.Equity	103829

[13]:
```
#install.packages("magrittr") # package installations are only needed the first time you␣
↪use it
#install.packages("dplyr")    # alternative installation of the %>%
library(magrittr) # needs to be run every time you start R and want to use %>%
library(dplyr)    # alternatively, this also loads %>%
trades <- tstats %>%
    mutate(Trades = Num.Trades,
        Win.Percent = Percent.Positive,
        Loss.Percent = Percent.Negative,
        WL.Ratio = Percent.Positive/Percent.Negative) %>%
    select(Trades, Win.Percent, Loss.Percent, WL.Ratio)
data.frame(t(trades))
```

```
Attaching package: ‘dplyr’


The following objects are masked from ‘package:xts’:
```

(continues on next page)

(continued from previous page)

```
    first, last


The following objects are masked from ‘package:stats’:

    filter, lag


The following objects are masked from ‘package:base’:

    intersect, setdiff, setequal, union
```

A data.frame: 4 × 1

	t.trades. <dbl>
Trades	160.000000
Win.Percent	53.125000
Loss.Percent	46.875000
WL.Ratio	1.133333

[14]:
```
a <- getAccount(account.st)
equity <- a$summary$End.Eq
plot(equity, main = "Equity Curve QQQ")
```

[15]:
```
portfolio <- getPortfolio(portfolio.st)
portfolioSummary <- portfolio$summary
colnames(portfolio$summary)
tail(portfolio$summary)
```

'Long.Value'

'Short.Value'

'Net.Value'

'Gross.Value'

'Period.Realized.PL'

'Period.Unrealized.PL'

'Gross.Trading.PL'

'Txn.Fees'

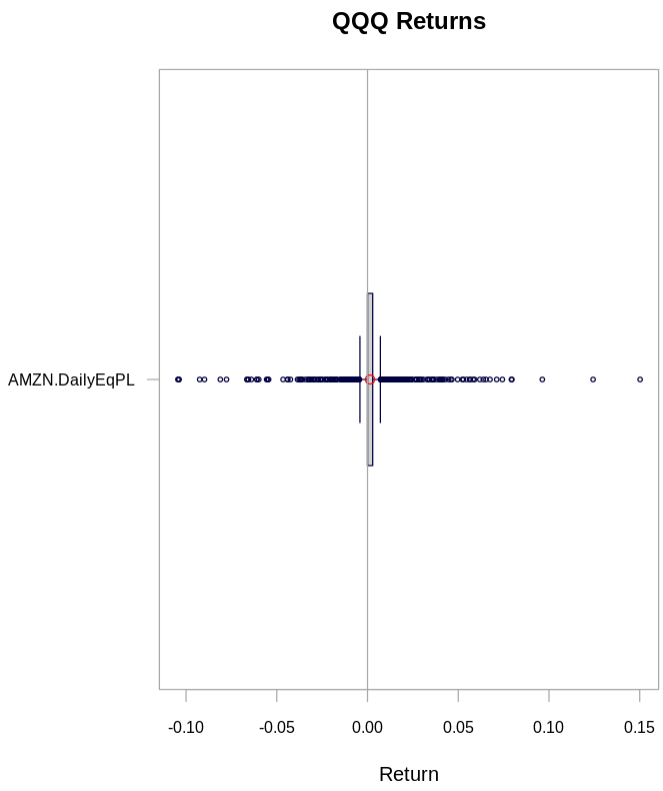
'Net.Trading.PL'

```
           Long.Value Short.Value Net.Value Gross.Value Period.Realized.PL
2019-12-23     178650           0    178650      178650              0.000
2019-12-24          0           0         0           0            650.000
2019-12-26     178921           0    178921      178921              0.000
2019-12-27          0           0         0           0           7956.006
2019-12-30     186980           0    186980      186980              0.000
2019-12-31          0           0         0           0          -2291.003
           Period.Unrealized.PL Gross.Trading.PL Txn.Fees Net.Trading.PL
2019-12-23                    0            0.000        0          0.000
2019-12-24                    0          650.000        0        650.000
2019-12-26                    0            0.000        0          0.000
2019-12-27                    0         7956.006        0       7956.006
2019-12-30                    0            0.000        0          0.000
2019-12-31                    0        -2291.003        0      -2291.003
```

[16]:
```
ret <- Return.calculate(equity, method = "log")
tail(ret)
charts.PerformanceSummary(ret, colorset = bluefocus, main = "Strategy Performance")
```

```
                End.Eq
2019-12-23  0.000000000
2019-12-24  0.003285503
2019-12-26  0.000000000
2019-12-27  0.039363582
2019-12-30  0.000000000
2019-12-31 -0.011177133
```

[17]:
```
rets <- PortfReturns(Account = account.st)
chart.Boxplot(rets, main = "QQQ Returns", colorset= rich10equal)
```



[18]:
```
table.Drawdowns(rets, top=10)
```

A data.frame: 10 × 7

From <date>	Trough <date>	To <date>	Depth <dbl>	Length <dbl>	To Trough <dbl>	Recovery <dbl>
2018-07-19	2019-02-22	2019-12-27	-0.3726	364	150	214
2018-03-14	2018-03-29	2018-05-10	-0.1135	41	12	29
2017-07-31	2017-09-11	2018-01-12	-0.0966	116	30	86
2017-04-07	2017-04-20	2017-05-23	-0.0671	32	9	23
2018-02-09	2018-02-09	2018-02-26	-0.0663	11	1	10
2018-02-02	2018-02-02	2018-02-07	-0.0609	4	1	3
2017-06-01	2017-06-21	2017-07-27	-0.0535	40	15	25
2018-06-07	2018-06-25	2018-06-29	-0.0362	17	13	4
2017-02-06	2017-02-07	2017-02-21	-0.0322	11	2	9
2019-12-31	2019-12-31	NA	-0.0229	2	1	NA

[19]:
```
table.CalendarReturns(rets)
```

A data.frame: 3 × 13

	Jan <dbl>	Feb <dbl>	Mar <dbl>	Apr <dbl>	May <dbl>	Jun <dbl>	Jul <dbl>	Aug <dbl>	Sep <dbl>	Oct <dbl>	Nov <dbl>	Dec <dbl>	AMZN.DailyEqP <dbl>
2017	0	0.0	0.4	0.9	0.3	0.0	-2.6	1.4	0.0	0.0	-3.2	0.4	-2.6
2018	2	-1.0	-6.6	5.5	2.4	4.1	0.0	0.4	3.8	0.0	-0.4	1.6	12.0
2019	0	0.5	0.8	0.0	-0.3	0.0	0.0	2.2	-1.4	1.7	2.2	-2.3	3.3

[20]:
```
table.DownsideRisk(rets)
```

	AMZN.DailyEqPL <dbl>
Semi Deviation	0.0143
Gain Deviation	0.0208
Loss Deviation	0.0225
Downside Deviation (MAR=210%)	0.0177
Downside Deviation (Rf=0%)	0.0138
Downside Deviation (0%)	0.0138
Maximum Drawdown	0.3726
Historical VaR (95%)	-0.0277
Historical ES (95%)	-0.0528
Modified VaR (95%)	-0.0264
Modified ES (95%)	-0.0264

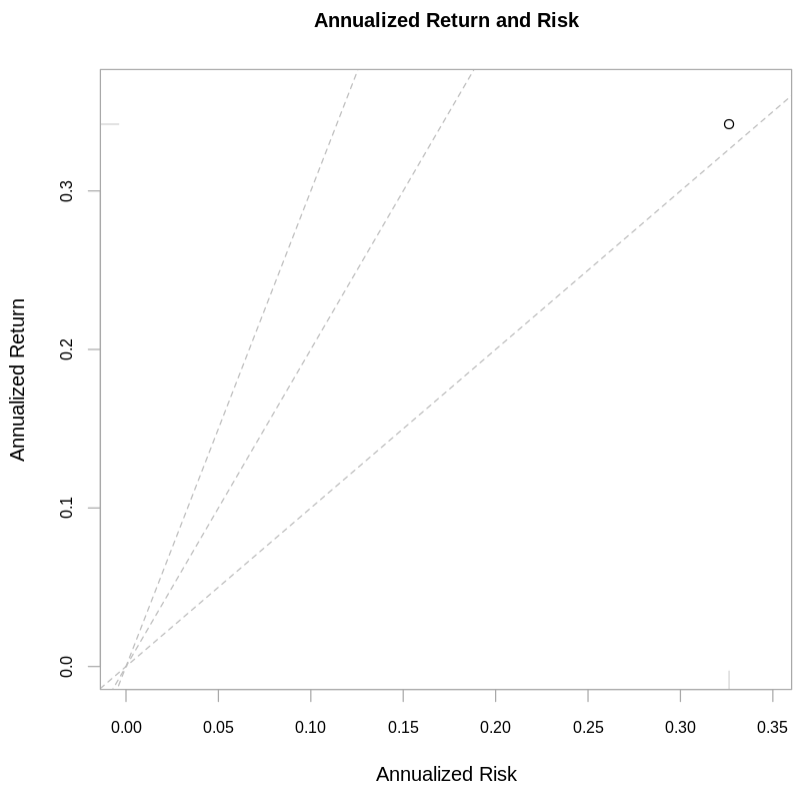
A data.frame: 11 × 1

[21]:
```
table.Stats(rets)
```

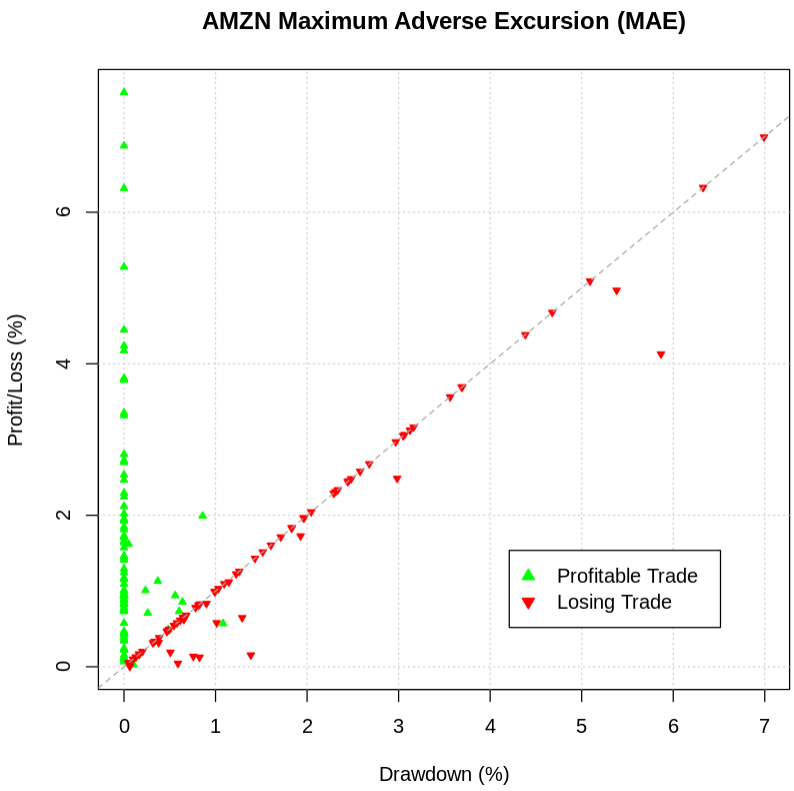
	AMZN.DailyEqPL <dbl>
Observations	753.0000
NAs	0.0000
Minimum	-0.1045
Quartile 1	0.0000
Median	0.0000
Arithmetic Mean	0.0014
Geometric Mean	0.0012
Quartile 3	0.0029
Maximum	0.1502
SE Mean	0.0007
LCL Mean (0.95)	-0.0001
UCL Mean (0.95)	0.0028
Variance	0.0004
Stdev	0.0206
Skewness	0.2160
Kurtosis	11.3408

A data.frame: 16 × 1

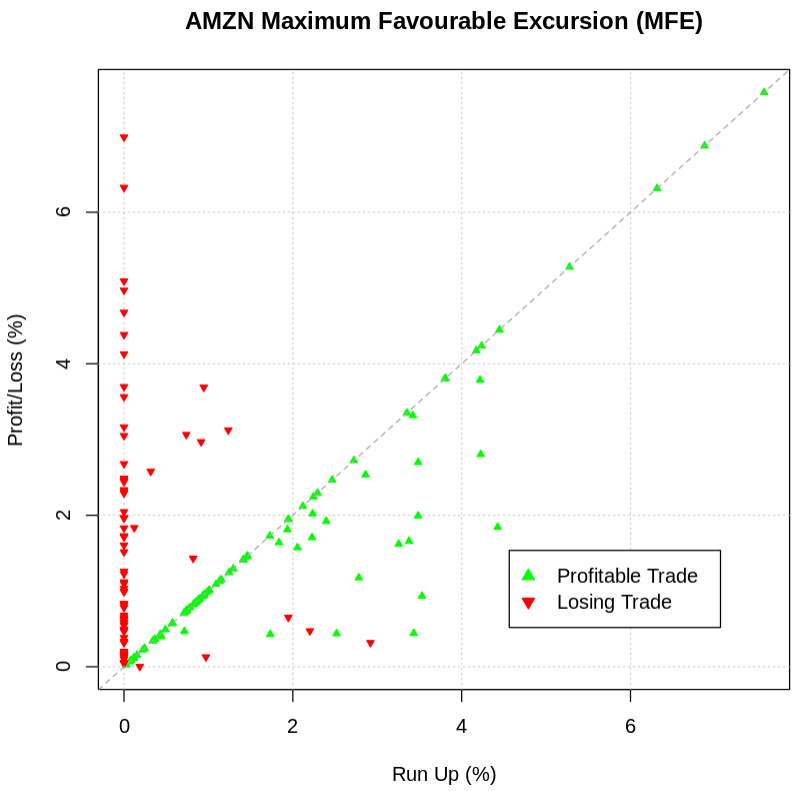
[22]:
```
chart.RiskReturnScatter(rets)
```



[23]:
```
chart.ME(Portfolio = portfolio.st, Symbol = symbol, type = "MAE", scale = "percent")
```



[24]:
```
chart.ME(Portfolio = portfolio.st, Symbol = symbol, type = "MFE", scale = "percent")
```



Moving Average Crossover Strategy - Sample 2

- when the short term moving average crosses above the long term moving average, this indicates a buy signal
- when the short term moving average crosses below the long term moving average, it may be a good moment to sell

Reference: https://towardsdatascience.com/making-a-trade-call-using-simple-moving-average-sma-crossover-strategy-python-impleme

[25]:
```
# Moving Average Crossover Strategy - Sample 2
# strategy resetting
rm.strat("my strategy")
out <- initPortf(portfolio.st, symbols = symbol, initDate = start, currency = "USD")
out <- initAcct(account.st, portfolios = portfolio.st, initDate = start, currency = "USD
↪", initEq = initEquity)
initOrders(portfolio.st, initDate = start)
strategy(strategy.st, store = TRUE)
# Indicators
out <- add.indicator(strategy.st, name = "SMA", arguments = list(x = quote(Cl(AMZN)), n␣
↪= 20, maType = "SMA"), label = "SMA20periods")
out <- add.indicator(strategy.st, name = "SMA", arguments = list(x = quote(Cl(AMZN)), n␣
↪= 50, maType = "SMA"), label = "SMA50periods")
out <- add.indicator(strategy.st, name = "EMA", arguments = list(x = quote(Cl(AMZN)), n␣
↪= 20, maType = "EMA"), label = "EMA20periods")
out <- add.indicator(strategy.st, name = "EMA", arguments = list(x = quote(Cl(AMZN)), n␣
↪= 50, maType = "EMA"), label = "EMA50periods")
```

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```
# Signals
#out <- add.signal(strategy.st, name = "sigCrossover", arguments = list(columns = c(
↪"SMA20periods", "SMA50periods"), relationship = "gte", cross = TRUE), label = "buy")
#out <- add.signal(strategy.st, name = "sigCrossover", arguments = list(columns = c(
↪"SMA20periods", "SMA50periods"), relationship = "lte", cross = TRUE), label = "sell")
out <- add.signal(strategy.st, name = "sigCrossover", arguments = list(columns = c(
↪"EMA20periods", "EMA50periods"), relationship = "gte", cross = TRUE), label = "buy2")
out <- add.signal(strategy.st, name = "sigCrossover", arguments = list(columns = c(
↪"EMA20periods", "EMA50periods"), relationship = "lte", cross = TRUE), label = "sell2")
# Rules
out <- add.rule(strategy.st, name = 'ruleSignal', arguments = list(sigcol = "buy2",␣
↪sigval = TRUE, orderqty = 100, ordertype = 'market', orderside = 'long'), type = 'enter
↪')
out <- add.rule(strategy.st, name = 'ruleSignal', arguments = list(sigcol = "sell2",␣
↪sigval = TRUE, orderqty = 'all', ordertype = 'market', orderside = 'long'), type =
↪'exit')
#out <- add.rule(strategy.st, name = 'ruleSignal', arguments = list(sigcol = "sell2",␣
↪sigval = TRUE, orderqty = -100, ordertype = 'market', orderside = 'short'), type = 'enter')
#out <- add.rule(strategy.st, name = 'ruleSignal', arguments = list(sigcol = "buy2",␣
↪sigval = TRUE, orderqty = 'all', ordertype = 'market', orderside = 'short'), type = 'exit')
```

[26]:
```
# backtesting
applyStrategy(strategy.st, portfolios=portfolio.st)
out <- updatePortf(portfolio.st)
dateRange <- time(getPortfolio(portfolio.st)$summary)[-1]
out <- updateAcct(portfolio.st, dateRange)
out <- updateEndEq(account.st)
chart.Posn(portfolio.st, Symbol=symbol) #, TA=c("add_SMA(n=20,col='red')"))
```

```
[1] "2017-10-16 00:00:00 AMZN 100 @ 1002.940002"
[1] "2018-10-16 00:00:00 AMZN -100 @ 1760.949951"
[1] "2019-02-01 00:00:00 AMZN 100 @ 1718.72998"
[1] "2019-02-13 00:00:00 AMZN -100 @ 1638.01001"
[1] "2019-03-04 00:00:00 AMZN 100 @ 1671.72998"
[1] "2019-06-06 00:00:00 AMZN -100 @ 1738.5"
[1] "2019-06-14 00:00:00 AMZN 100 @ 1870.300049"
[1] "2019-08-08 00:00:00 AMZN -100 @ 1793.400024"
[1] "2019-12-27 00:00:00 AMZN 100 @ 1868.77002"
```

[27]:
```
tstats <- tradeStats(portfolio.st, use="trades", inclZeroDays=FALSE)
data.frame(t(tstats))
```

A data.frame: 32 × 1

	AMZN
	<chr>
Portfolio	my strategy
Symbol	AMZN
Num.Txns	9
Num.Trades	5
Net.Trading.PL	64528
Avg.Trade.PL	12905.6
Med.Trade.PL	-2188
Largest.Winner	75800.99
Largest.Loser	-8071.997
Gross.Profits	82478
Gross.Losses	-17950
Std.Dev.Trade.PL	35660.49
Std.Err.Trade.PL	15947.85
Percent.Positive	40
Percent.Negative	60
Profit.Factor	4.594874
Avg.Win.Trade	41239
Med.Win.Trade	41239
Avg.Losing.Trade	-5983.333
Med.Losing.Trade	-7690.003
Avg.Daily.PL	16679
Med.Daily.PL	-506.5003
Std.Dev.Daily.PL	40007.96
Std.Err.Daily.PL	20003.98
Ann.Sharpe	6.617956
Max.Drawdown	-41021
Profit.To.Max.Draw	1.573048
Avg.WinLoss.Ratio	6.892312
Med.WinLoss.Ratio	5.362677
Max.Equity	103657
Min.Equity	-3664.001
End.Equity	64528

[28]:
```
#install.packages("magrittr") # package installations are only needed the first time you␣
↪use it
#install.packages("dplyr")    # alternative installation of the %>%
#library(magrittr) # needs to be run every time you start R and want to use %>%
#library(dplyr)    # alternatively, this also loads %>%
trades <- tstats %>%
    mutate(Trades = Num.Trades,
        Win.Percent = Percent.Positive,
        Loss.Percent = Percent.Negative,
        WL.Ratio = Percent.Positive/Percent.Negative) %>%
    select(Trades, Win.Percent, Loss.Percent, WL.Ratio)
data.frame(t(trades))
```

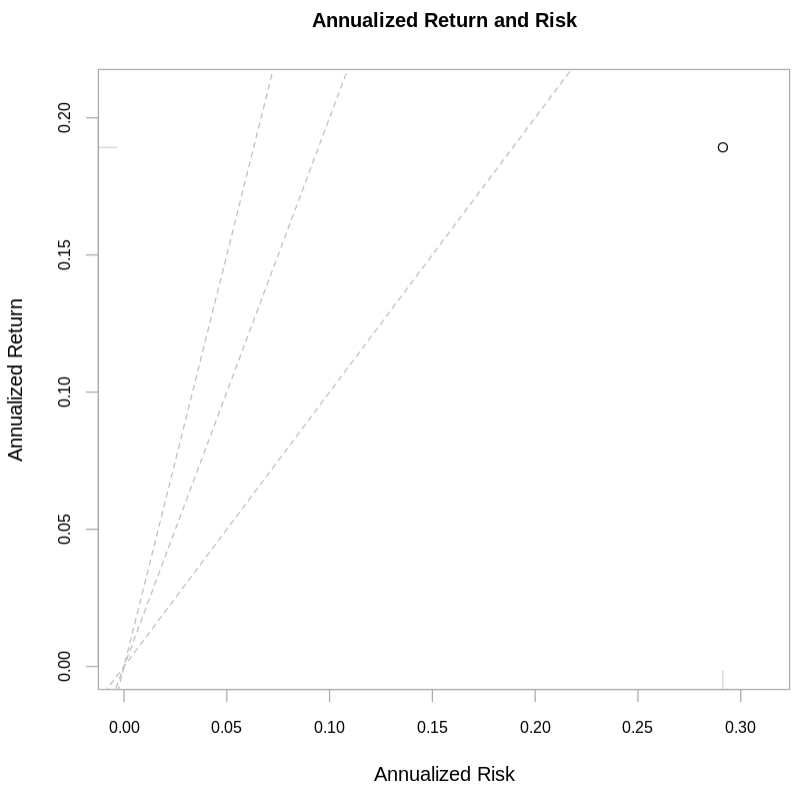
A data.frame: 4 × 1

	t.trades. <dbl>
Trades	5.0000000
Win.Percent	40.0000000
Loss.Percent	60.0000000
WL.Ratio	0.6666667

[29]:
```
a <- getAccount(account.st)
equity <- a$summary$End.Eq
plot(equity, main = "Equity Curve QQQ")
```

[30]:
```
ret <- Return.calculate(equity, method = "log")
charts.PerformanceSummary(ret, colorset = bluefocus, main = "Strategy Performance")
```

[31]:
```
rets <- PortfReturns(Account = account.st)
chart.RiskReturnScatter(rets)
```


Annualized Return and Risk
Annualized Return
0.00
0.05
0.10
0.15
0.20
Annualized Risk
0.00
0.05
0.10
0.15
0.20
0.25
0.30

CHAPTER

THREE

PYTHON

3.1 Prerequisites

For using the program language Python, you don't have to install nothing: Python is already installed.

There are a lot of guide for getting started with Python: knowing the basics will be taken for granted.

But you have to install some specific packages and it is a best practice to use a virtual environment. For unix,

```
$ git clone https://github.com/bilardi/backtesting-tool-comparison
$ cd backtesting-tool-comparison/
$ python3 -m venv .env # create virtual environment
$ source .env/bin/activate # enter in the virtual environment
$ pip install --upgrade -r requirements.txt # install your dependences
```

And when you want to delete all environment,

```
$ deactivate # exit when you will have finished the job
$ rm -rf .env # remove the virtual environment it is a best practice
```

A short description of each package that you have to import is below.

```
$ python
import yfinance # for Yahoo Finance historical data of stock market
import yahoo-fin # for Yahoo Finance historical data of stock market
import yahoofinancials # for Yahoo Finance historical data of stock market
import pandas_datareader # for historical data many sources
import datetime # for datetime management
import requests # for getting contents by url
import quandl # for Quandl historical data
import matplotlib # for plots
import mplfinance # for financial plots
import pandas # for data management
import numpy # for data management
import backtesting # for strategy management
```

If you want to use Jupyter, you can use directly the commands below

```
$ git clone https://github.com/bilardi/backtesting-tool-comparison
$ cd backtesting-tool-comparison/
$ pip install --upgrade -r requirements.txt
$ docker run --rm -p 8888:8888 -e JUPYTER_ENABLE_LAB=yes -v "$PWD":/home/jovyan/ jupyter/
↪scipy-notebook
```

Jupyter is very easy for having a GUI virtual environment: knowing the basics will be taken for granted.

You can find all scripts descripted in this tutorial on GitHub.

- the .py files in src/python/ folder, the you can use on shell
- the .ipynb files in docs/sources/python/ folder, that you can use on Jupyter or browse on this tutorial

3.2 Getting started

Python is a programming language and it has more libraries dedicated for statistical analysis, graphics representation and reporting.

This is a summary of the Python language syntax: you can find more details in python documentation.

3.2.1 Basics

[1]:
```
# initialization of a variable
my_numeric_variable = 1
my_string_variable = "hello"
```

[2]:
```
# print a variable directly
my_numeric_variable
```

[2]:
```
1
```

[3]:
```
# print method
print(my_string_variable)
```

```
hello
```

3.2.2 Vectors

[4]:
```
# initialization of a vector
my_numeric_vector = [1,2,3,4,5,6]
my_sequence = list(range(1,7))
my_string_vector = ["hello", "world", "!"]
my_logic_vector = [True, False]
import random
my_random_vector = random.sample(list(range(1,5000)), 25) # Vector with 25 elements with␣
↪random number from 1 to 5000
```

[5]:
```
my_numeric_vector
```

[5]:
```
[1, 2, 3, 4, 5, 6]
```

Operations with vectors

There are many libraries for statistics analysis, so you can use the same operations on different libraries.

[6]:
```
sum(my_numeric_vector) # sum
import statistics
print(statistics.mean(my_numeric_vector)) # mean
print(statistics.median(my_numeric_vector)) # median
import numpy
print(numpy.median(my_numeric_vector)) # median
```

```
3.5
3.5
3.5
```

[7]:
```
# multiplication 2 with each element of a vector
# each variable my_new_vector is the same
my_new_vector = [e * 2 for e in my_numeric_vector]
my_new_vector = list(map(lambda x: x * 2, my_numeric_vector))
import pandas
serie = pandas.Series(my_numeric_vector)
my_new_vector = (serie * 2).tolist()
import numpy
my_new_vector = list(numpy.array(my_numeric_vector) * 2)
my_new_vector
```

[7]:
```
[2, 4, 6, 8, 10, 12]
```

[8]:
```
# division 2 with each element of a vector
# each variable my_new_vector is the same
my_new_vector = [e / 2 for e in my_numeric_vector]
my_new_vector = list(map(lambda x: x / 2, my_numeric_vector))
serie = pandas.Series(my_numeric_vector)
my_new_vector = (serie / 2).tolist()
my_new_vector = list(numpy.array(my_numeric_vector) / 2)
my_new_vector
```

[8]:
```
[0.5, 1.0, 1.5, 2.0, 2.5, 3.0]
```

[9]:
```
# sum each element of a vector with another vector by position
# each variable my_new_vector is the same
my_new_vector = [sum(e) for e in zip(my_numeric_vector, my_sequence)]
my_new_vector = [x + y for x, y in zip(my_numeric_vector, my_sequence)]
import operator
my_new_vector = list(map(operator.add, my_numeric_vector, my_sequence))
import pandas
my_new_vector = list(pandas.Series(my_numeric_vector).add(pandas.Series(my_sequence)))
import numpy
my_new_vector = list(numpy.array(my_numeric_vector) + numpy.array(my_sequence))
my_new_vector
```

[9]:
```
[2, 4, 6, 8, 10, 12]
```

[10]:
```
# get element from a vector
print(my_string_vector[0]) # print hello
print(my_string_vector[::len(my_string_vector)-1]) # print hello!
print(my_string_vector[0:2]) # print hello world
```

```
hello
['hello', '!']
['hello', 'world']
```

[11]:
```
# add labels to a vector
import pandas
names = ["one","two","three","four","five","six"]
my_vector = pandas.DataFrame(my_numeric_vector, index=names).T
print(my_vector)
```

```
   one  two  three  four  five  six
0    1    2      3     4     5    6
```

[12]:
```
# get data type of a vector
import numpy
print(numpy.array(my_vector).dtype.type) # print numpy.int64
print(numpy.array(my_string_vector).dtype.type) # print numpy.str_
```

```
<class 'numpy.int64'>
<class 'numpy.str_'>
```

[13]:
```
# convertion of each element of a vector
# each variable my_new_string_vector is the same
my_new_string_vector = [str(e) for e in my_numeric_vector]
my_new_string_vector = list(map(str, my_numeric_vector))
my_new_string_vector
```

[13]:
```
['1', '2', '3', '4', '5', '6']
```

3.2.3 Matrixes

A matrix is a vector with more dimensions

[14]:
```
my_matrix = [[0] * 5 for e in range(2)] # creates a matrix bidimensional with 2 rows and␣
↪5 columns
my_matrix
```

[14]:
```
[[0, 0, 0, 0, 0], [0, 0, 0, 0, 0]]
```

[15]:
```
my_matrix = [list(range(1,6)) for e in range(2)] # creates a matrix bidimensional with 2␣
↪rows and 5 columns
my_matrix
```

[15]:
```
[[1, 2, 3, 4, 5], [1, 2, 3, 4, 5]]
```

[16]:
```
import numpy
my_matrix = numpy.arange(1,11).reshape(2, 5) # creates a matrix bidimensional with 2␣
↪rows and 5 columns
my_matrix
```

[16]:
```
array([[ 1,  2,  3,  4,  5],
       [ 6,  7,  8,  9, 10]])
```

[17]:
```
my_matrix = numpy.arange(1,11).reshape(5, 2).T # creates a matrix bidimensional with 2␣
↪rows and 5 columns like R language
my_matrix
```

[17]:
```
array([[ 1,  3,  5,  7,  9],
       [ 2,  4,  6,  8, 10]])
```

[18]:
```
print(my_matrix[1,1]) # prints 4
print(my_matrix[0,]) # prints row 1
print(my_matrix[:,1]) # prints column 2
```

```
4
[1 3 5 7 9]
[3 4]
```

[19]:
```
# merge of vectors
vector_one = ["one", 0.1]
vector_two = ["two", 1]
vector_three = ["three", 10]
my_vectors = [vector_one, vector_two, vector_three]
import pandas
colnames = ["vector number", "quantity"]
rownames = ["yesterday", "today", "tomorrow"]
pandas.DataFrame(my_vectors, index=rownames, columns=colnames)
```

[19]:

	vector number	quantity
yesterday	one	0.1
today	two	1.0
tomorrow	three	10.0

3.2.4 Weighted average

[20]:
```
# performance
apple_performance = 3
netflix_performance = 7
amazon_performance = 11
# weight
apple_weight = .3
netflix_weight = .4
amazon_weight = .3
```

[21]:
```
# portfolio performance
weighted_average = apple_performance * apple_weight + netflix_performance * netflix_
↪weight + amazon_performance * amazon_weight
weighted_average
```

[21]:
```
7.0
```

[22]:
```
# the same sample but with vectors
performance = [3,7,11]
weight = [.3,.4,.3]
company = ['apple','netflix','amazon']
import pandas
performance = pandas.DataFrame(performance, index=company).T
weight = pandas.DataFrame(weight, index=company).T
print(performance)
print(weight)
```

```
   apple  netflix  amazon
0      3        7      11
   apple  netflix  amazon
0    0.3      0.4     0.3
```

[23]:
```
# with headers
performance_weight = performance.multiply(weight)
print(performance_weight)
weighted_average = performance_weight.sum(axis=1)
print(weighted_average)
```

```
   apple  netflix  amazon
0    0.9      2.8     3.3
0    7.0
dtype: float64
```

[24]:
```
# without headers
import numpy
performance_weight = numpy.array(performance) * numpy.array(weight)
print(performance_weight)
weighted_average = numpy.sum(performance_weight)
print(weighted_average)
```

```
[[0.9 2.8 3.3]]
7.0
```

3.2.5 Functions

[25]:
```
import numpy
# the weighted average but with a function
def weighted_average_function(performance, weight):
    return numpy.sum(numpy.array(performance) * numpy.array(weight))
performance = [3,7,11]
weight = [.3,.4,.3]
weighted_average = weighted_average_function(performance, weight)
weighted_average
```

[25]:
```
7.0
```

3.3 Historical data

This page contains some samples for downloading historical data of your quant trading system.

3.3.1 Yahoo Finance API

There are many libraries for downloading historical data of stock markets from Yahoo finance, you can try some of them to discovery which you prefer:

- pandas_datareader (with a stable documentation and it works for many sources)
- yfinance (with a nice table of the arguments of the history method)
- yahoofinancials
- yahoo_fin

Exchange rates (forex) from Yahoo finance

[1]:
```
!pip install pandas_datareader
from pandas_datareader import data as pdr
cross_from = ['EUR', 'USD', 'CAD']
cross_to = ['USD', 'JPY', 'USD']
symbols = [x + y + '=X' for x, y in zip(cross_from, cross_to)]
data = pdr.DataReader(symbols, 'yahoo')
data
```

```
Requirement already satisfied: pandas_datareader in /opt/conda/lib/python3.8/site-
↪packages (0.9.0)
Requirement already satisfied: requests>=2.19.0 in /opt/conda/lib/python3.8/site-
↪packages (from pandas_datareader) (2.25.1)
Requirement already satisfied: lxml in /opt/conda/lib/python3.8/site-packages (from␣
↪pandas_datareader) (4.6.2)
Requirement already satisfied: pandas>=0.23 in /opt/conda/lib/python3.8/site-packages␣
↪(from pandas_datareader) (1.1.5)
Requirement already satisfied: python-dateutil>=2.7.3 in /opt/conda/lib/python3.8/site-
↪packages (from pandas>=0.23->pandas_datareader) (2.8.1)
Requirement already satisfied: pytz>=2017.2 in /opt/conda/lib/python3.8/site-packages␣
↪(from pandas>=0.23->pandas_datareader) (2020.5)
Requirement already satisfied: numpy>=1.15.4 in /opt/conda/lib/python3.8/site-packages␣
↪(from pandas>=0.23->pandas_datareader) (1.19.4)
Requirement already satisfied: six>=1.5 in /opt/conda/lib/python3.8/site-packages (from␣
↪python-dateutil>=2.7.3->pandas>=0.23->pandas_datareader) (1.15.0)
Requirement already satisfied: chardet<5,>=3.0.2 in /opt/conda/lib/python3.8/site-
↪packages (from requests>=2.19.0->pandas_datareader) (4.0.0)
Requirement already satisfied: certifi>=2017.4.17 in /opt/conda/lib/python3.8/site-
↪packages (from requests>=2.19.0->pandas_datareader) (2020.12.5)
Requirement already satisfied: idna<3,>=2.5 in /opt/conda/lib/python3.8/site-packages␣
↪(from requests>=2.19.0->pandas_datareader) (2.10)
Requirement already satisfied: urllib3<1.27,>=1.21.1 in /opt/conda/lib/python3.8/site-
↪packages (from requests>=2.19.0->pandas_datareader) (1.26.2)
```

[1]:
```
Attributes Adj Close                          Close                          \
Symbols     EURUSD=X    USDJPY=X  CADUSD=X  EURUSD=X    USDJPY=X  CADUSD=X
Date
2016-01-13  1.084399  117.830002  0.701508  1.084399  117.830002  0.701508
2016-01-14  1.088601  117.425003  0.696816  1.088601  117.425003  0.696816
2016-01-15  1.085894  118.203003  0.697126  1.085894  118.203003  0.697126
2016-01-18  1.092001  116.989998  0.685965  1.092001  116.989998  0.685965
2016-01-19  1.089503  117.384003  0.687545  1.089503  117.384003  0.687545
...              ...         ...       ...       ...         ...       ...
2021-01-05  1.225160  103.125000  0.782411  1.225160  103.125000  0.782411
2021-01-06  1.230027  102.678001  0.788973  1.230027  102.678001  0.788973
2021-01-07  1.234111  103.024002  0.789553  1.234111  103.024002  0.789553
2021-01-08  1.227144  103.790001  0.788407  1.227144  103.790001  0.788407
2021-01-11  1.216841  104.209999  0.782411  1.216841  104.209999  0.782411

Attributes      High                          Low                            \
Symbols     EURUSD=X    USDJPY=X  CADUSD=X  EURUSD=X    USDJPY=X  CADUSD=X
Date
2016-01-13  1.088400  118.362999  0.704871  1.080600  117.779999  0.700334
2016-01-14  1.095000  118.161003  0.697515  1.083999  117.309998  0.694734
2016-01-15  1.098200  118.255997  0.697253  1.085776  116.650002  0.687474
2016-01-18  1.092705  117.433998  0.690274  1.087600  116.931000  0.685857
2016-01-19  1.091000  118.099998  0.692953  1.086200  117.266998  0.687238
...              ...         ...       ...       ...         ...       ...
2021-01-05  1.229483  103.180000  0.787402  1.224995  102.671997  0.781959
2021-01-06  1.235025  103.431000  0.791766  1.226693  102.589996  0.786250
2021-01-07  1.234568  103.950996  0.789640  1.224665  102.956001  0.785379
2021-01-08  1.228215  104.078003  0.789952  1.221493  103.616997  0.786201
2021-01-11  1.223990  104.249001  0.788644  1.215806  103.686996  0.782142

Attributes      Open                          Volume
Symbols     EURUSD=X    USDJPY=X  CADUSD=X EURUSD=X USDJPY=X CADUSD=X
Date
2016-01-13  1.084399  117.831001  0.701459      0.0      0.0      0.0
2016-01-14  1.088803  117.400002  0.696811      0.0      0.0      0.0
2016-01-15  1.085776  118.223000  0.697204      0.0      0.0      0.0
2016-01-18  1.091906  117.010002  0.685857      0.0      0.0      0.0
2016-01-19  1.089503  117.397003  0.687564      0.0      0.0      0.0
...              ...         ...       ...      ...      ...      ...
2021-01-05  1.225295  103.141998  0.782473      0.0      0.0      0.0
2021-01-06  1.229861  102.699997  0.788868      0.0      0.0      0.0
2021-01-07  1.233776  103.028000  0.789472      0.0      0.0      0.0
2021-01-08  1.226873  103.794998  0.788308      0.0      0.0      0.0
2021-01-11  1.222643  103.948997  0.788277      0.0      0.0      0.0

[1281 rows x 18 columns]
```

Other asset classes from Yahoo finance

[2]:
```
symbol = 'AMZN'
start = '1997-05-15'
end = '2020-09-30'
period = 'daily'
```

[3]:
```
from pandas_datareader import data as pdr
data = pdr.DataReader(symbol, 'yahoo', start, end)
len(data) # 5884 # until 2020-09-30 included
#data.to_csv('pdr_data.csv')
data
```

[3]:
```
                  High          Low         Open        Close      Volume  \
Date
1997-05-15     2.500000     1.927083     2.437500     1.958333  72156000.0
1997-05-16     1.979167     1.708333     1.968750     1.729167  14700000.0
1997-05-19     1.770833     1.625000     1.760417     1.708333   6106800.0
1997-05-20     1.750000     1.635417     1.729167     1.635417   5467200.0
1997-05-21     1.645833     1.375000     1.635417     1.427083  18853200.0
...                 ...          ...          ...          ...         ...
2020-09-24  3069.300049  2965.000000  2977.790039  3019.790039   5529400.0
2020-09-25  3101.540039  2999.000000  3054.860107  3095.129883   4615200.0
2020-09-28  3175.040039  3117.169922  3148.850098  3174.050049   4224200.0
2020-09-29  3188.260010  3132.540039  3175.389893  3144.879883   3495800.0
2020-09-30  3212.879883  3133.989990  3141.139893  3148.729980   4896100.0

              Adj Close
Date
1997-05-15     1.958333
1997-05-16     1.729167
1997-05-19     1.708333
1997-05-20     1.635417
1997-05-21     1.427083
...                 ...
2020-09-24  3019.790039
2020-09-25  3095.129883
2020-09-28  3174.050049
2020-09-29  3144.879883
2020-09-30  3148.729980

[5884 rows x 6 columns]
```

[4]:
```
import pandas
!pip install yfinance
import yfinance
data = yfinance.Ticker(symbol)
data.info
df = pandas.DataFrame(data.history(period='max'))
len(df) # 5885 # until 2020-09-30 included + headline
#df.to_csv('yfinance_data.ticker.csv')
df
```

```
Requirement already satisfied: yfinance in /opt/conda/lib/python3.8/site-packages (0.1.
↪55)
Requirement already satisfied: multitasking>=0.0.7 in /opt/conda/lib/python3.8/site-
↪packages (from yfinance) (0.0.9)
Requirement already satisfied: lxml>=4.5.1 in /opt/conda/lib/python3.8/site-packages␣
↪(from yfinance) (4.6.2)
Requirement already satisfied: numpy>=1.15 in /opt/conda/lib/python3.8/site-packages␣
↪(from yfinance) (1.19.4)
Requirement already satisfied: requests>=2.20 in /opt/conda/lib/python3.8/site-packages␣
↪(from yfinance) (2.25.1)
Requirement already satisfied: pandas>=0.24 in /opt/conda/lib/python3.8/site-packages␣
↪(from yfinance) (1.1.5)
Requirement already satisfied: python-dateutil>=2.7.3 in /opt/conda/lib/python3.8/site-
↪packages (from pandas>=0.24->yfinance) (2.8.1)
Requirement already satisfied: pytz>=2017.2 in /opt/conda/lib/python3.8/site-packages␣
↪(from pandas>=0.24->yfinance) (2020.5)
Requirement already satisfied: six>=1.5 in /opt/conda/lib/python3.8/site-packages (from␣
↪python-dateutil>=2.7.3->pandas>=0.24->yfinance) (1.15.0)
Requirement already satisfied: urllib3<1.27,>=1.21.1 in /opt/conda/lib/python3.8/site-
↪packages (from requests>=2.20->yfinance) (1.26.2)
Requirement already satisfied: certifi>=2017.4.17 in /opt/conda/lib/python3.8/site-
↪packages (from requests>=2.20->yfinance) (2020.12.5)
Requirement already satisfied: chardet<5,>=3.0.2 in /opt/conda/lib/python3.8/site-
↪packages (from requests>=2.20->yfinance) (4.0.0)
Requirement already satisfied: idna<3,>=2.5 in /opt/conda/lib/python3.8/site-packages␣
↪(from requests>=2.20->yfinance) (2.10)
```

[4]:

Date	Open	High	Low	Close	Volume	\
1997-05-15	2.437500	2.500000	1.927083	1.958333	72156000	
1997-05-16	1.968750	1.979167	1.708333	1.729167	14700000	
1997-05-19	1.760417	1.770833	1.625000	1.708333	6106800	
1997-05-20	1.729167	1.750000	1.635417	1.635417	5467200	
1997-05-21	1.635417	1.645833	1.375000	1.427083	18853200	
...	...	...	...	...	...	
2021-01-04	3270.000000	3272.000000	3144.020020	3186.629883	4411400	
2021-01-05	3166.010010	3223.379883	3165.060059	3218.510010	2655500	
2021-01-06	3146.479980	3197.510010	3131.159912	3138.379883	4394800	
2021-01-07	3157.000000	3208.540039	3155.000000	3162.159912	3514500	
2021-01-08	3180.000000	3190.639893	3142.199951	3182.699951	3534300	

Date	Dividends	Stock Splits
1997-05-15	0	0.0
1997-05-16	0	0.0
1997-05-19	0	0.0
1997-05-20	0	0.0
1997-05-21	0	0.0
...	...	...
2021-01-04	0	0.0
2021-01-05	0	0.0
2021-01-06	0	0.0
2021-01-07	0	0.0

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```
2021-01-08          0           0.0

[5953 rows x 7 columns]
```

[5]:
```
data = yfinance.download(symbol, start=start, end=end, group_by='ticker')
len(data) # 5883 # until 2020-09-30 excluded
#data.to_csv('yfinance_data.download.csv')
data
```

```
[**********************100%**********************]  1 of 1 completed
```

[5]:
```
                  Open         High          Low        Close    Adj Close  \
Date
1997-05-15     2.437500     2.500000     1.927083     1.958333     1.958333
1997-05-16     1.968750     1.979167     1.708333     1.729167     1.729167
1997-05-19     1.760417     1.770833     1.625000     1.708333     1.708333
1997-05-20     1.729167     1.750000     1.635417     1.635417     1.635417
1997-05-21     1.635417     1.645833     1.375000     1.427083     1.427083
...                 ...          ...          ...          ...          ...
2020-09-23  3120.429932  3127.000000  2992.379883  2999.860107  2999.860107
2020-09-24  2977.790039  3069.300049  2965.000000  3019.790039  3019.790039
2020-09-25  3054.860107  3101.540039  2999.000000  3095.129883  3095.129883
2020-09-28  3148.850098  3175.040039  3117.169922  3174.050049  3174.050049
2020-09-29  3175.389893  3188.260010  3132.540039  3144.879883  3144.879883

              Volume
Date
1997-05-15  72156000
1997-05-16  14700000
1997-05-19   6106800
1997-05-20   5467200
1997-05-21  18853200
...              ...
2020-09-23   5652700
2020-09-24   5529400
2020-09-25   4615200
2020-09-28   4224200
2020-09-29   3495800

[5883 rows x 6 columns]
```

[6]:
```
yfinance.pdr_override()
data = pdr.get_data_yahoo(symbol, start=start, end=end)
len(data) # 5883 # until 2020-09-30 excluded
#data.to_csv('yfpdr_data.csv')
data
```

```
[**********************100%**********************]  1 of 1 completed
```

[6]:
```
                  Open         High          Low        Close    Adj Close  \
Date
1997-05-15     2.437500     2.500000     1.927083     1.958333     1.958333
1997-05-16     1.968750     1.979167     1.708333     1.729167     1.729167
```

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```
1997-05-19     1.760417     1.770833     1.625000     1.708333     1.708333
1997-05-20     1.729167     1.750000     1.635417     1.635417     1.635417
1997-05-21     1.635417     1.645833     1.375000     1.427083     1.427083
...                 ...          ...          ...          ...          ...
2020-09-23  3120.429932  3127.000000  2992.379883  2999.860107  2999.860107
2020-09-24  2977.790039  3069.300049  2965.000000  3019.790039  3019.790039
2020-09-25  3054.860107  3101.540039  2999.000000  3095.129883  3095.129883
2020-09-28  3148.850098  3175.040039  3117.169922  3174.050049  3174.050049
2020-09-29  3175.389893  3188.260010  3132.540039  3144.879883  3144.879883

              Volume
Date
1997-05-15  72156000
1997-05-16  14700000
1997-05-19   6106800
1997-05-20   5467200
1997-05-21  18853200
...              ...
2020-09-23   5652700
2020-09-24   5529400
2020-09-25   4615200
2020-09-28   4224200
2020-09-29   3495800

[5883 rows x 6 columns]
```

[7]:
```
!pip install yahoofinancials
from yahoofinancials import YahooFinancials
data = YahooFinancials(symbol)
json = data.get_historical_price_data(start_date=start, end_date=end, time_
↪interval=period)
df = pandas.DataFrame(json[symbol]['prices'])
len(df) # 5883 # until 2020-09-30 excluded and seconds instead of date
#df.to_csv('yahoofinancials_data.csv')
df
```

```
Requirement already satisfied: yahoofinancials in /opt/conda/lib/python3.8/site-packages␣
↪(1.6)
Requirement already satisfied: beautifulsoup4 in /opt/conda/lib/python3.8/site-packages␣
↪(from yahoofinancials) (4.9.3)
Requirement already satisfied: pytz in /opt/conda/lib/python3.8/site-packages (from␣
↪yahoofinancials) (2020.5)
Requirement already satisfied: soupsieve>1.2 in /opt/conda/lib/python3.8/site-packages␣
↪(from beautifulsoup4->yahoofinancials) (2.0.1)
```

[7]:
```
           date         high          low         open        close  \
0      863703000     2.500000     1.927083     2.437500     1.958333
1      863789400     1.979167     1.708333     1.968750     1.729167
2      864048600     1.770833     1.625000     1.760417     1.708333
3      864135000     1.750000     1.635417     1.729167     1.635417
4      864221400     1.645833     1.375000     1.635417     1.427083
...          ...          ...          ...          ...          ...
5878  1600867800  3127.000000  2992.379883  3120.429932  2999.860107
```

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```
5879  1600954200  3069.300049  2965.000000  2977.790039  3019.790039
5880  1601040600  3101.540039  2999.000000  3054.860107  3095.129883
5881  1601299800  3175.040039  3117.169922  3148.850098  3174.050049
5882  1601386200  3188.260010  3132.540039  3175.389893  3144.879883

        volume     adjclose formatted_date
0     72156000     1.958333     1997-05-15
1     14700000     1.729167     1997-05-16
2      6106800     1.708333     1997-05-19
3      5467200     1.635417     1997-05-20
4     18853200     1.427083     1997-05-21
...        ...          ...            ...
5878   5652700  2999.860107     2020-09-23
5879   5529400  3019.790039     2020-09-24
5880   4615200  3095.129883     2020-09-25
5881   4224200  3174.050049     2020-09-28
5882   3495800  3144.879883     2020-09-29

[5883 rows x 8 columns]
```

[8]:
```
!pip install yahoo_fin
from yahoo_fin import stock_info as si
data = si.get_data(symbol)
len(data) # 5885 # until 2020-09-30 included (+ headline)
#data.to_csv('yahoo_fin_data.csv')
data
```

```
Requirement already satisfied: yahoo_fin in /opt/conda/lib/python3.8/site-packages (0.8.
↪6)
Warning - Certain functionality
             requires requests_html, which is not installed.

             Install using:
             pip install requests_html

             After installation, you may have to restart your Python session.
```

[8]:
```
                  open         high          low        close     adjclose  \
1997-05-15     2.437500     2.500000     1.927083     1.958333     1.958333
1997-05-16     1.968750     1.979167     1.708333     1.729167     1.729167
1997-05-19     1.760417     1.770833     1.625000     1.708333     1.708333
1997-05-20     1.729167     1.750000     1.635417     1.635417     1.635417
1997-05-21     1.635417     1.645833     1.375000     1.427083     1.427083
...                 ...          ...          ...          ...          ...
2021-01-04  3270.000000  3272.000000  3144.020020  3186.629883  3186.629883
2021-01-05  3166.010010  3223.379883  3165.060059  3218.510010  3218.510010
2021-01-06  3146.479980  3197.510010  3131.159912  3138.379883  3138.379883
2021-01-07  3157.000000  3208.540039  3155.000000  3162.159912  3162.159912
2021-01-08  3180.000000  3190.639893  3142.199951  3182.699951  3182.699951

              volume ticker
1997-05-15  72156000   AMZN
1997-05-16  14700000   AMZN
```

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```
1997-05-19   6106800   AMZN
1997-05-20   5467200   AMZN
1997-05-21  18853200   AMZN
...              ...    ...
2021-01-04   4411400   AMZN
2021-01-05   2655500   AMZN
2021-01-06   4394800   AMZN
2021-01-07   3514500   AMZN
2021-01-08   3534300   AMZN

[5953 rows x 7 columns]
```

3.3.2 Exchange rates (forex) from Oanda

Oanda API allows to download the historical data with the API key of a free Oanda account: you can find the Oanda library or you can use many other backtesting libraries for this.

But this is a general tutorial, so you can find the data by oanda.URL that the getSymbols method of R quantmod library uses. When you use this method, you can only download the historical data of the last six months.

[9]:
```
import json
import pandas
import requests
from datetime import datetime, timedelta
base_url = 'https://www.oanda.com/fx-for-business/historical-rates/api/data/update/?&
↪source=OANDA&adjustment=0&base_currency={to_currency}&start_date={start_date}&end_date=
↪{end_date}&period={period}&price=mid&view=table&quote_currency_0={from_currency}'
today = datetime.strftime(datetime.now(), '%Y-%m-%d')
def get_oanda_currency_historical_rates(base_url, start, end, quote_currency, base_
↪currency, period):
    url = base_url.format(from_currency=quote_currency, to_currency=base_currency, start_
↪date=start, end_date=end, period=period)
    response = json.loads(requests.get(url).content.decode('utf-8'))
    return pandas.DataFrame(response['widget'][0]['data'])
# the last 6 months
df = get_oanda_currency_historical_rates(base_url, datetime.strftime(datetime.now() -␣
↪timedelta(180), '%Y-%m-%d'), today, 'EUR', 'USD', period)
df
```

[9]:
```
                0         1
0    1610236800000  0.818336
1    1610150400000  0.818270
2    1610064000000  0.816854
3    1609977600000  0.813786
4    1609891200000  0.812080
..             ...       ...
175  1595116800000  0.875000
176  1595030400000  0.875028
177  1594944000000  0.876130
178  1594857600000  0.877077
179  1594771200000  0.875957
```

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```
[180 rows x 2 columns]
```

[10]:
```
# the last 60 days
df = get_oanda_currency_historical_rates(base_url, datetime.strftime(datetime.now() -␣
↪timedelta(60), '%Y-%m-%d'), today, 'EUR', 'USD', period)
df.head()
```

[10]:
```
              0         1
0  1610236800000  0.818336
1  1610150400000  0.818270
2  1610064000000  0.816854
3  1609977600000  0.813786
4  1609891200000  0.812080
```

3.3.3 Crypto currencies from CoinMarketCap

CoinMarketCap API allows to download the historical data with the API key of a free CoinMarketCap account: you can find the CoinMarketCap library or you can use many other backtesting libraries for this.

Like for the all assets, there are many libraries that they implement Coinmarketcap API, but many are open source so the updates could be slowly:

- the CoinMarketCap library have the error message **JSONDecodeError('Expecting value: line 1 column 1 (char 0)')**
- the CCXT library uses an old version of CoinMarketCap API

Below you can find a sample with sandbox API of CoinMarketCap.

[11]:
```
import json
import pandas
import requests
base_url = 'https://sandbox-api.coinmarketcap.com/v1/'
def get_coinmarketcap_data(url):
    response = json.loads(requests.get(url).content.decode('utf-8'))
    return pandas.DataFrame(response['data'])

# returns all active cryptocurrencies
url = base_url + 'cryptocurrency/map'
marketcap_map = get_coinmarketcap_data(url)
marketcap_map
```

[11]:
```
        id              name symbol              slug  is_active  rank  \
0        1           Bitcoin    BTC           bitcoin          1     1
1        2          Litecoin    LTC          litecoin          1     5
2        3          Namecoin    NMC          namecoin          1   310
3        4         Terracoin    TRC         terracoin          1   926
4        5          Peercoin    PPC          peercoin          1   346
...    ...               ...    ...               ...        ...   ...
2322  4266           Monarch     MT           monarch          1  2059
2323  4268  NewYork Exchange    NYE  newyork-exchange          1  2012
2324  4273            Sessia  KICKS            sessia          1  2118
```

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```
2325  4275         Cocos-BCX  COCOS         cocos-bcx          1  1960
2326  4276              Defi   DEFI              defi          1  1965

                                                platform
0                                                   None
1                                                   None
2                                                   None
3                                                   None
4                                                   None
...                                                  ...
2322  {'id': 1027, 'name': 'Ethereum', 'symbol': 'ET...
2323                                                None
2324  {'id': 1027, 'name': 'Ethereum', 'symbol': 'ET...
2325  {'id': 1027, 'name': 'Ethereum', 'symbol': 'ET...
2326  {'id': 1027, 'name': 'Ethereum', 'symbol': 'ET...

[2327 rows x 7 columns]
```

[12]:
```
# returns last market data of all active cryptocurrencies
url = base_url + 'cryptocurrency/listings/latest?convert=EUR'
last_marketcap = get_coinmarketcap_data(url)
last_marketcap
```

[12]:
```
      id          name symbol          slug  num_market_pairs  \
0      1       Bitcoin    BTC       bitcoin              7919
1   1027      Ethereum    ETH      ethereum              5629
2     52           XRP    XRP        ripple               449
3   1831  Bitcoin Cash    BCH  bitcoin-cash               378
4      2      Litecoin    LTC      litecoin               538
..   ...           ...    ...           ...               ...
95  3709          Grin   GRIN          grin                53
96  2694          Nexo   NEXO          nexo                22
97  2900   Project Pai    PAI   project-pai                17
98  2137   Electroneum    ETN   electroneum                20
99  1681         PRIZM    PZM         prizm                 7

                  date_added        tags    max_supply  circulating_supply  \
0   2013-04-28T00:00:00.000Z  [mineable]  2.100000e+07        1.790601e+07
1   2015-08-07T00:00:00.000Z  [mineable]           NaN        1.075379e+08
2   2013-08-04T00:00:00.000Z          []  1.000000e+11        4.293287e+10
3   2017-07-23T00:00:00.000Z  [mineable]  2.100000e+07        1.797598e+07
4   2013-04-28T00:00:00.000Z  [mineable]  8.400000e+07        6.314712e+07
..                       ...         ...           ...                 ...
95  2019-01-27T00:00:00.000Z  [mineable]           NaN        1.954596e+07
96  2018-05-01T00:00:00.000Z          []           NaN        5.600000e+08
97  2018-07-05T00:00:00.000Z          []           NaN        1.451234e+09
98  2017-11-02T00:00:00.000Z  [mineable]  2.100000e+10        9.792946e+09
99  2017-05-19T00:00:00.000Z          []  6.000000e+09        9.820737e+07

    total_supply                                          platform  cmc_rank  \
0   1.790601e+07                                             None         1
1   1.075379e+08                                             None         2
```

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```
2   9.999137e+10                                                  None          3
3   1.797598e+07                                                  None          4
4   6.314712e+07                                                  None          5
..           ...                                                   ...        ...
95  1.954596e+07                                                  None         96
96  1.000000e+09  {'id': 1027, 'name': 'Ethereum', 'symbol': 'ET...         97
97  1.618050e+09                                                  None         98
98  9.792946e+09                                                  None         99
99  9.820737e+07                                                  None        100

                last_updated  \
0   2019-08-30T18:51:28.000Z
1   2019-08-30T18:51:21.000Z
2   2019-08-30T18:51:03.000Z
3   2019-08-30T18:51:08.000Z
4   2019-08-30T18:51:04.000Z
..                       ...
95  2019-08-30T18:51:18.000Z
96  2019-08-30T18:51:12.000Z
97  2019-08-30T18:51:14.000Z
98  2019-08-30T18:51:08.000Z
99  2019-08-30T18:51:05.000Z

                                                 quote
0   {'EUR': {'price': 8708.442730269642, 'volume_2...
1   {'EUR': {'price': 153.68597253794135, 'volume_...
2   {'EUR': {'price': 0.23181863120417767, 'volume...
3   {'EUR': {'price': 256.03512635975414, 'volume_...
4   {'EUR': {'price': 58.626074806105 76, 'volume_2...
..                                                ...
95  {'EUR': {'price': 1.7584409339670577, 'volume_...
96  {'EUR': {'price': 0.06125607986488225, 'volume...
97  {'EUR': {'price': 0.022456686270928363, 'volum...
98  {'EUR': {'price': 0.0032193992228962184, 'volu...
99  {'EUR': {'price': 0.3204834704804656, 'volume_...

[100 rows x 14 columns]
```

[13]:
```
# returns last market data of Bitcoin
url = base_url + 'cryptocurrency/quotes/latest?id=1&convert=EUR'
last_bitcoin = get_coinmarketcap_data(url)
last_bitcoin
```

[13]:
```
                                                                1
circulating_supply                                       17906012
cmc_rank                                                        1
date_added                                 2013-04-28T00:00:00.000Z
id                                                              1
is_active                                                       1
is_fiat                                                         0
is_market_cap_included_in_calc                                  1
last_updated                               2019-08-30T18:51:28.000Z
```

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```
max_supply                                                          21000000
name                                                                 Bitcoin
num_market_pairs                                                        7919
platform                                                                None
quote                          {'EUR': {'price': 8708.442730269642, 'volume_2...
slug                                                                 bitcoin
symbol                                                                   BTC
tags                                                              [mineable]
total_supply                                                        17906012
```

[14]:
```
# returns historical data from a time_start to a time_end
url = base_url + 'cryptocurrency/quotes/historical?id=1&convert=EUR&time_start=2020-05-
↪21T12:14&time_end=2020-05-21T12:44'
data = get_coinmarketcap_data(url)
data
```

[14]:
```
   id     name symbol  is_fiat  \
0   1  Bitcoin    BTC        0
1   1  Bitcoin    BTC        0
2   1  Bitcoin    BTC        0
3   1  Bitcoin    BTC        0
4   1  Bitcoin    BTC        0
5   1  Bitcoin    BTC        0

                                              quotes
0  {'timestamp': '2020-05-21T12:19:03.000Z', 'quo...
1  {'timestamp': '2020-05-21T12:24:02.000Z', 'quo...
2  {'timestamp': '2020-05-21T12:29:03.000Z', 'quo...
3  {'timestamp': '2020-05-21T12:34:03.000Z', 'quo...
4  {'timestamp': '2020-05-21T12:39:01.000Z', 'quo...
5  {'timestamp': '2020-05-21T12:44:02.000Z', 'quo...
```

3.3.4 Other asset classes from Quandl

You can see details of asset classes of Quandl, by its research, for example crude oil.

Quandl API allows to download the historical data with the API key of a free Quandl account: you can find the Quandl library (doc) or you can use many other backtesting libraries for this.

However, it is possible to execute 50 calls per day without API key.

[15]:
```
symbol = 'CHRIS/CME_QM1'

import pandas
from datetime import datetime
base_url = 'https://www.quandl.com/api/v3/datasets/{symbol}.csv?start_date={start_date}&
↪end_date={end_date}&collapse={period}'
today = datetime.strftime(datetime.now(), '%Y-%m-%d')
def get_quandl_financial_data(base_url, symbol, start, end, period):
    url = base_url.format(symbol=symbol, start_date=start, end_date=end, period=period)
    return pandas.read_csv(url)
# returns all free columns values
```

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```
df = get_quandl_financial_data(base_url, symbol, start, end, period)
df
```

[15]:

```
            Date     Open     High      Low     Last  Change  Settle   Volume  \
0     2020-09-30   39.225   40.375   38.675   39.850    0.93   40.22  10605.0
1     2020-09-29   40.575   40.700   38.425   39.075   -1.31   39.29  12589.0
2     2020-09-28   40.125   40.800   39.775   40.600    0.35   40.60   8194.0
3     2020-09-25   40.175   40.625   39.700   40.075   -0.06   40.25   7024.0
4     2020-09-24   39.600   40.350   39.125   40.200    0.38   40.31   8349.0
...          ...      ...      ...      ...      ...     ...     ...      ...
1646  2014-03-12   99.500   99.575   97.550   97.990    2.04   97.99   9437.0
1647  2014-03-11  100.925  101.500   99.350  100.030    1.09  100.03   7337.0
1648  2014-03-07  101.900  102.900  101.575  102.580    1.02  102.58   5304.0
1649  2014-03-06  101.000  102.050  100.150  101.560    0.11  101.56   6850.0
1650  2014-03-05  103.325  103.525  100.825  101.450    1.88  101.45   7459.0

      Previous Day Open Interest
0                         1252.0
1                          784.0
2                          787.0
3                          879.0
4                          869.0
...                          ...
1646                      2462.0
1647                      2300.0
1648                      2315.0
1649                      2383.0
1650                      2305.0

[1651 rows x 9 columns]
```

[16]:

```
# returns only open values
df['Open'] # or
df = get_quandl_financial_data(base_url + '&column_index=1', symbol, start, end, period)
df
```

[16]:

```
            Date     Open
0     2020-09-30   39.225
1     2020-09-29   40.575
2     2020-09-28   40.125
3     2020-09-25   40.175
4     2020-09-24   39.600
...          ...      ...
1646  2014-03-12   99.500
1647  2014-03-11  100.925
1648  2014-03-07  101.900
1649  2014-03-06  101.000
1650  2014-03-05  103.325

[1651 rows x 2 columns]
```

[17]:

```
!pip install quandl
```

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```
import quandl
# returns all free columns values
data = quandl.get(symbol)
data
```

```
Requirement already satisfied: quandl in /opt/conda/lib/python3.8/site-packages (3.5.3)
Requirement already satisfied: requests>=2.7.0 in /opt/conda/lib/python3.8/site-packages␣
↪(from quandl) (2.25.1)
Requirement already satisfied: six in /opt/conda/lib/python3.8/site-packages (from␣
↪quandl) (1.15.0)
Requirement already satisfied: python-dateutil in /opt/conda/lib/python3.8/site-packages␣
↪(from quandl) (2.8.1)
Requirement already satisfied: inflection>=0.3.1 in /opt/conda/lib/python3.8/site-
↪packages (from quandl) (0.5.1)
Requirement already satisfied: more-itertools in /opt/conda/lib/python3.8/site-packages␣
↪(from quandl) (8.6.0)
Requirement already satisfied: numpy>=1.8 in /opt/conda/lib/python3.8/site-packages␣
↪(from quandl) (1.19.4)
Requirement already satisfied: pandas>=0.14 in /opt/conda/lib/python3.8/site-packages␣
↪(from quandl) (1.1.5)
Requirement already satisfied: pytz>=2017.2 in /opt/conda/lib/python3.8/site-packages␣
↪(from pandas>=0.14->quandl) (2020.5)
Requirement already satisfied: certifi>=2017.4.17 in /opt/conda/lib/python3.8/site-
↪packages (from requests>=2.7.0->quandl) (2020.12.5)
Requirement already satisfied: urllib3<1.27,>=1.21.1 in /opt/conda/lib/python3.8/site-
↪packages (from requests>=2.7.0->quandl) (1.26.2)
Requirement already satisfied: chardet<5,>=3.0.2 in /opt/conda/lib/python3.8/site-
↪packages (from requests>=2.7.0->quandl) (4.0.0)
Requirement already satisfied: idna<3,>=2.5 in /opt/conda/lib/python3.8/site-packages␣
↪(from requests>=2.7.0->quandl) (2.10)
```

[17]:

Date	Open	High	Low	Last	Change	Settle	Volume	Previous Day Open Interest
2014-03-05	103.325	103.525	100.825	101.450	1.88	101.45	7459.0	2305.0
2014-03-06	101.000	102.050	100.150	101.560	0.11	101.56	6850.0	2383.0
2014-03-07	101.900	102.900	101.575	102.580	1.02	102.58	5304.0	2315.0
2014-03-11	100.925	101.500	99.350	100.030	1.09	100.03	7337.0	2300.0
2014-03-12	99.500	99.575	97.550	97.990	2.04	97.99	9437.0	2462.0
...	...	...	...	...	...	...	...	...
2021-01-04	48.400	49.850	47.200	47.350	-0.90	47.62	21845.0	
2021-01-05	47.400	50.200	47.275	49.850	2.31	49.93	23473.0	
2021-01-06	49.825	50.925	49.475	50.525	0.70	50.63	16675.0	
2021-01-07	50.525	51.275	50.400	50.950	0.20	50.83	10814.0	
2021-01-08	50.925	52.750	50.825	52.750	1.41	52.24	10770.0	

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```
2021-01-04                      1350.0
2021-01-05                      1799.0
2021-01-06                      1908.0
2021-01-07                      1800.0
2021-01-08                      1833.0

[1720 rows x 8 columns]
```

[18]:
```
# returns only open values
data['Open']
```

[18]:
```
Date
2014-03-05    103.325
2014-03-06    101.000
2014-03-07    101.900
2014-03-11    100.925
2014-03-12     99.500
               ...
2021-01-04     48.400
2021-01-05     47.400
2021-01-06     49.825
2021-01-07     50.525
2021-01-08     50.925
Name: Open, Length: 1720, dtype: float64
```

3.4 Graphics

This is a sample for plotting with Python. There are 2 principal libraries for plotting,

- the library matplotlib that it has many utilities like mplfinance for the visualization, and visual analysis, of financial data
- the library plotly that it is a very interesting tool makes interactive and publication-quality graphs

With **pandas_datareader** library you can download the historical data and with pandas library you can make the data range.

[1]:
```
# initialization
import pandas as pd
from pandas_datareader import data as pdr
start='2017-10-30'
end='2020-10-08'
amzn = pdr.DataReader('AMZN', 'yahoo', start, end)
# simple indicators
amzn['SMA25'] = amzn['Close'].rolling(25).mean()
amzn['EMA25'] = amzn['Close'].ewm(span=25, adjust=False).mean()
amzn['STD25'] = amzn['Close'].rolling(25).std()
amzn['Upper Band'] = amzn['SMA25'] + (amzn['STD25'] * 2)
amzn['Lower Band'] = amzn['SMA25'] - (amzn['STD25'] * 2)
# data ranges
all_bm = pd.date_range(start=start, end=end, freq='BM')
all_range = pd.date_range(start=start, end=end)
```

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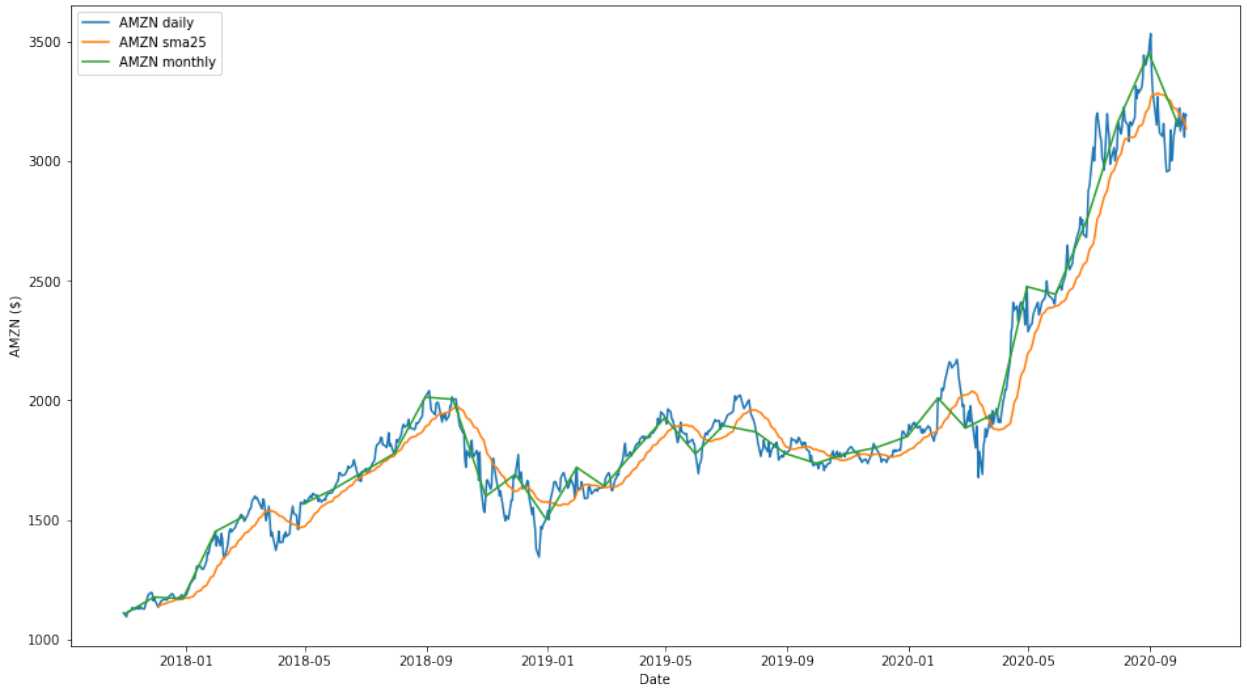
```
amzn_bm = amzn.reindex(all_bm)
amzn_bm_all = amzn_bm.reindex(all_range)
amzn_all = amzn.reindex(all_range)
piece_d = pd.date_range(start='2020-01-01', end='2020-10-01')
amzn_bm_piece_d = amzn_bm.reindex(piece_d)
amzn_piece_d = amzn.reindex(piece_d)
piece_bm = pd.date_range(start='2020-01-01', end='2020-10-01', freq='BM')
amzn_bm_piece_bm = amzn_bm.reindex(piece_bm)
```

Matplotlib is very powerful: you can add tracks with different date range.

[2]:
```
# plot with daily, monthly and sma 25
import matplotlib.pyplot as plt
fig, ax = plt.subplots(figsize=(16,9))
ax.plot(amzn['Close'].index, amzn['Close'], label='AMZN daily')
ax.plot(amzn['SMA25'].index, amzn['SMA25'], label='AMZN sma25')
ax.plot(amzn_bm['Close'].index, amzn_bm['Close'], label='AMZN monthly')
ax.set_xlabel('Date')
ax.set_ylabel('AMZN ($)')
ax.legend()
plt.show()
#plt.savefig('plot.with.daily.monthly.sma.25.png')
```



mplfinance contains the matplotlib finance API that makes it easier to create financial plots.

[3]:
```
# plot with candle daily and sma 25
!pip install mplfinance
import mplfinance as mpf
kwargs = dict(type='candle',mav=(25),volume=True,figratio=(16,9),figscale=1)
mpf.plot(amzn,**kwargs)
```

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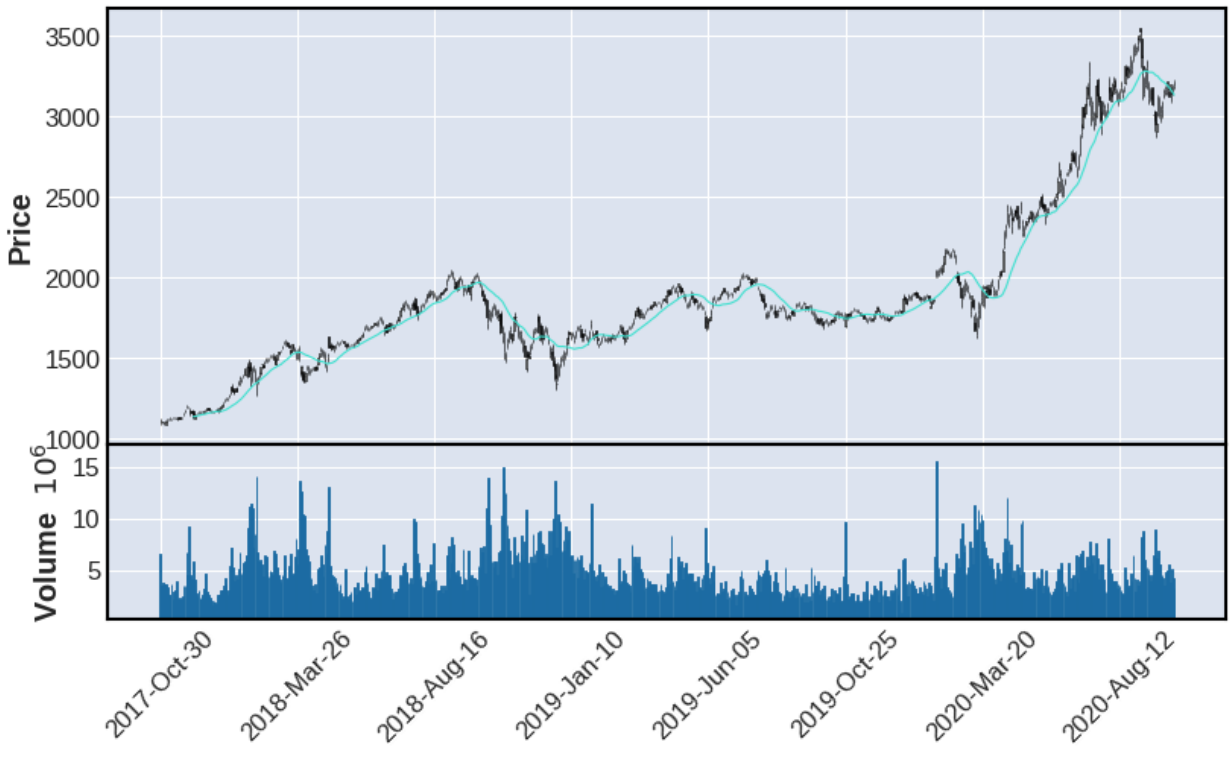
```
#plt.savefig('plot.with.candle.daily.sma.25.png')
```

```
Requirement already satisfied: mplfinance in /opt/conda/lib/python3.8/site-packages (0.
↪12.7a4)
Requirement already satisfied: pandas in /opt/conda/lib/python3.8/site-packages (from␣
↪mplfinance) (1.1.5)
Requirement already satisfied: matplotlib in /opt/conda/lib/python3.8/site-packages␣
↪(from mplfinance) (3.3.3)
Requirement already satisfied: kiwisolver>=1.0.1 in /opt/conda/lib/python3.8/site-
↪packages (from matplotlib->mplfinance) (1.3.1)
Requirement already satisfied: cycler>=0.10 in /opt/conda/lib/python3.8/site-packages␣
↪(from matplotlib->mplfinance) (0.10.0)
Requirement already satisfied: pillow>=6.2.0 in /opt/conda/lib/python3.8/site-packages␣
↪(from matplotlib->mplfinance) (8.0.1)
Requirement already satisfied: numpy>=1.15 in /opt/conda/lib/python3.8/site-packages␣
↪(from matplotlib->mplfinance) (1.19.4)
Requirement already satisfied: python-dateutil>=2.1 in /opt/conda/lib/python3.8/site-
↪packages (from matplotlib->mplfinance) (2.8.1)
Requirement already satisfied: pyparsing!=2.0.4,!=2.1.2,!=2.1.6,>=2.0.3 in /opt/conda/
↪lib/python3.8/site-packages (from matplotlib->mplfinance) (2.4.7)
Requirement already satisfied: six in /opt/conda/lib/python3.8/site-packages (from␣
↪cycler>=0.10->matplotlib->mplfinance) (1.15.0)
Requirement already satisfied: pytz>=2017.2 in /opt/conda/lib/python3.8/site-packages␣
↪(from pandas->mplfinance) (2020.5)
```



There are many styles to customize your graphs.

[4]:
```
# plot with candle daily, sma 25 and yahoo style
```

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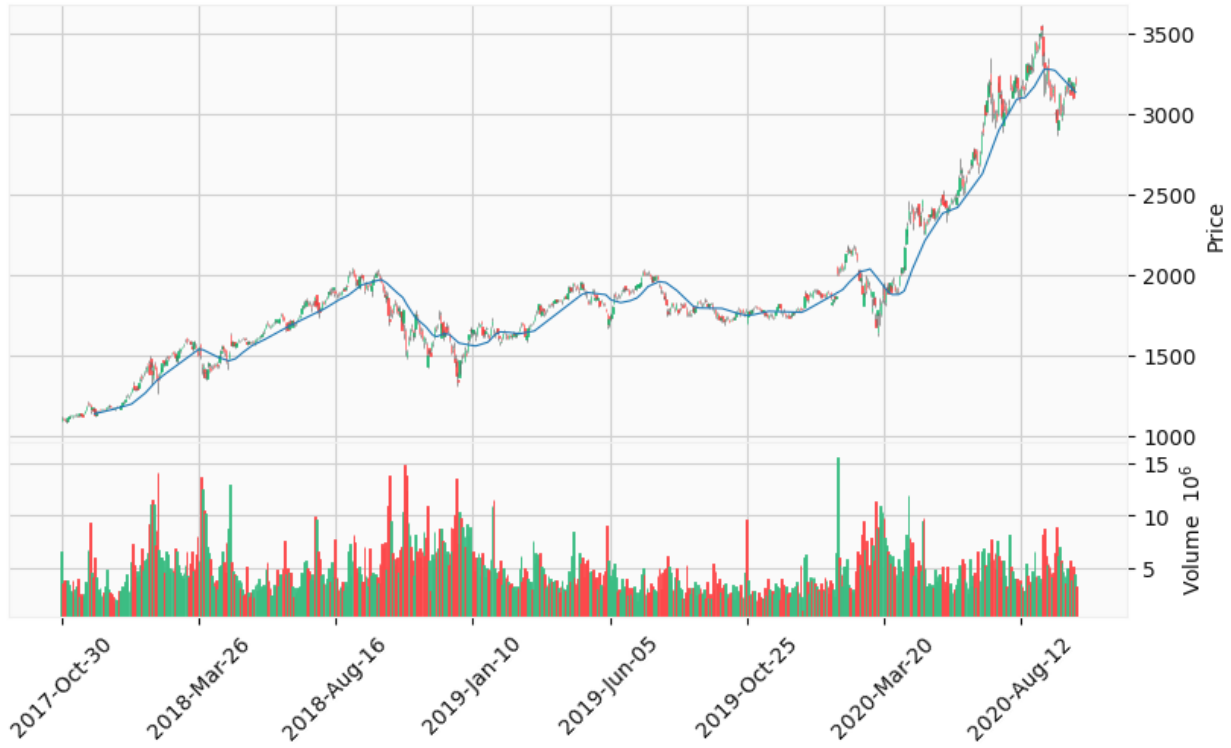
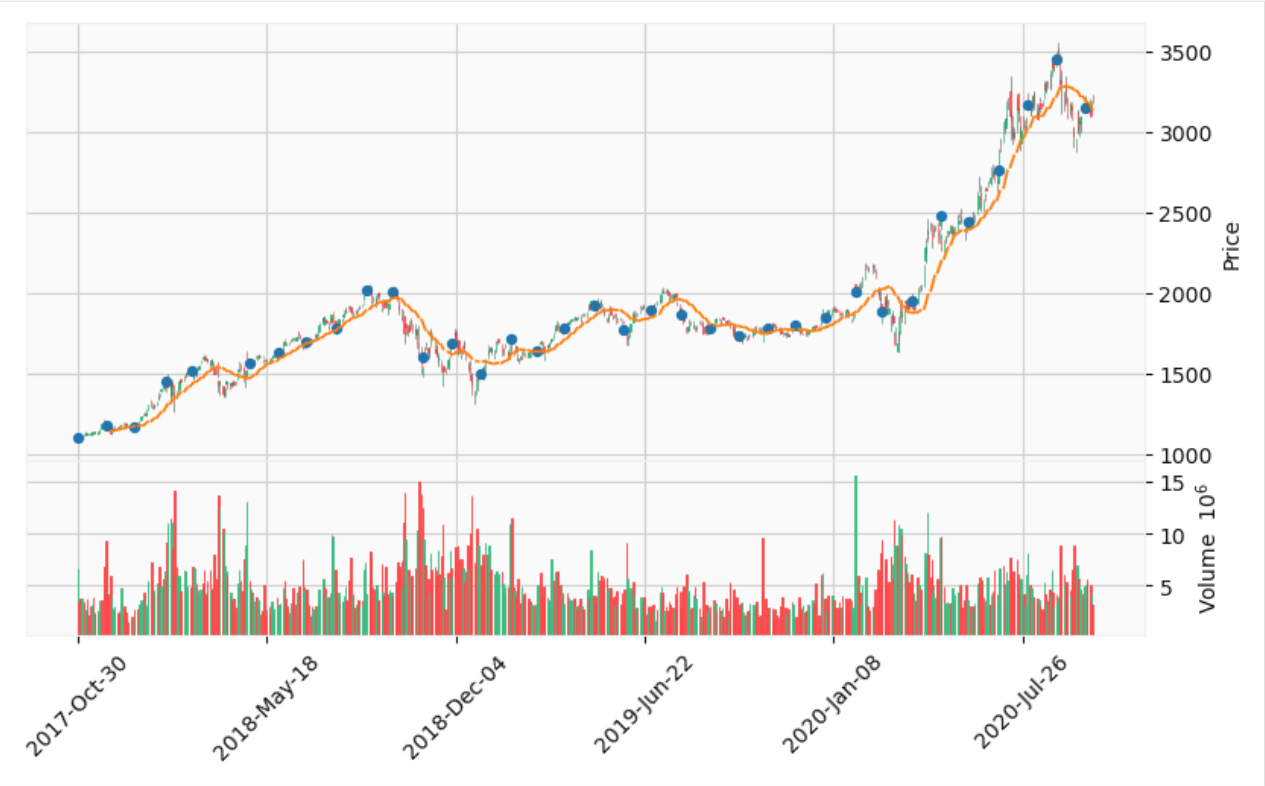
```
mpf.plot(amzn,**kwargs,style='yahoo')
#plt.savefig('plot.with.candle.daily.sma.25.yahoo.style.png')
```



You can add an array of plots that each has to be a dateframe.

[5]:
```
# plot with candle daily, monthly points, sma 25 and yahoo style
aps = [
    mpf.make_addplot(amzn_all['SMA25']),
    mpf.make_addplot(amzn_bm_all['Close'],type='scatter')
]
mpf.plot(amzn_all,**kwargs,style='yahoo',addplot=aps)
#plt.savefig('plot.with.candle.daily.monthly.points.sma.25.yahoo.style.png')
```



You can enlarge a window to observe that the weeks are not contiguous.

[6]:
```
# plot with candle daily, monthly points, sma 25 and yahoo style on a little date range
aps = [
    mpf.make_addplot(amzn_piece_d['SMA25']),
    mpf.make_addplot(amzn_bm_piece_d['Close'],type='scatter')
]
mpf.plot(amzn_piece_d,**kwargs,style='yahoo',addplot=aps)
#plt.savefig('plot.with.candle.daily.monthly.points.sma.25.yahoo.style.little.range.png')
```

You can add an array of simple lines date-value or other specific lines for trends, support, resistance, and trading.

[7]:
```
# plot with candle daily, monthly points and monthly line, sma 25 and yahoo style on a␣
↪little date range
subset = pd.DataFrame(amzn_bm_piece_bm['Close'])
amzn_bm_line = list(subset.itertuples(index=True, name=None))
aps = [
    mpf.make_addplot(amzn_piece_d['SMA25']),
    mpf.make_addplot(amzn_bm_piece_d['Close'],type='scatter',markersize=78)
]
mpf.plot(amzn_piece_d,**kwargs,style='yahoo',addplot=aps,alines=amzn_bm_line)
#plt.savefig('plot.with.candle.daily.monthly.points.monthly.line.sma.25.yahoo.style.
↪little.range.png')
```

You can also plot with matplotlib style for having more customization like legend.

[8]:
```
# the previous plot with matplotlib style plus old finance modules
import matplotlib.dates as mdates
from matplotlib.dates import MONDAY, DateFormatter, DayLocator, WeekdayLocator
from mplfinance.original_flavor import candlestick_ohlc

# configurations
fig, ax = plt.subplots(figsize=(16,9))

mondays = WeekdayLocator(MONDAY)        # major ticks on the mondays
alldays = DayLocator()              # minor ticks on the days
weekFormatter = DateFormatter('%b %d')  # e.g., Jan 12
dayFormatter = DateFormatter('%d')      # e.g., 12
ax.xaxis.set_major_locator(mondays)
#ax.xaxis.set_minor_locator(alldays)
ax.xaxis.set_major_formatter(weekFormatter)
#ax.xaxis.set_minor_formatter(dayFormatter)
plt.setp(plt.gca().get_xticklabels(), rotation=45, horizontalalignment='right')

# grid
plt.rc('axes', grid=True)

# the plots
candlestick_ohlc(ax, zip(mdates.date2num(amzn_piece_d.index.to_pydatetime()),
                 amzn_piece_d['Open'], amzn_piece_d['High'],amzn_piece_d['Low'], amzn_
↪piece_d['Close']),
                 colorup='g', colordown='r', width=0.6)
ax.plot(amzn_bm_piece_bm['Close'].index, amzn_bm_piece_bm['Close'], label='AMZN monthly')
```

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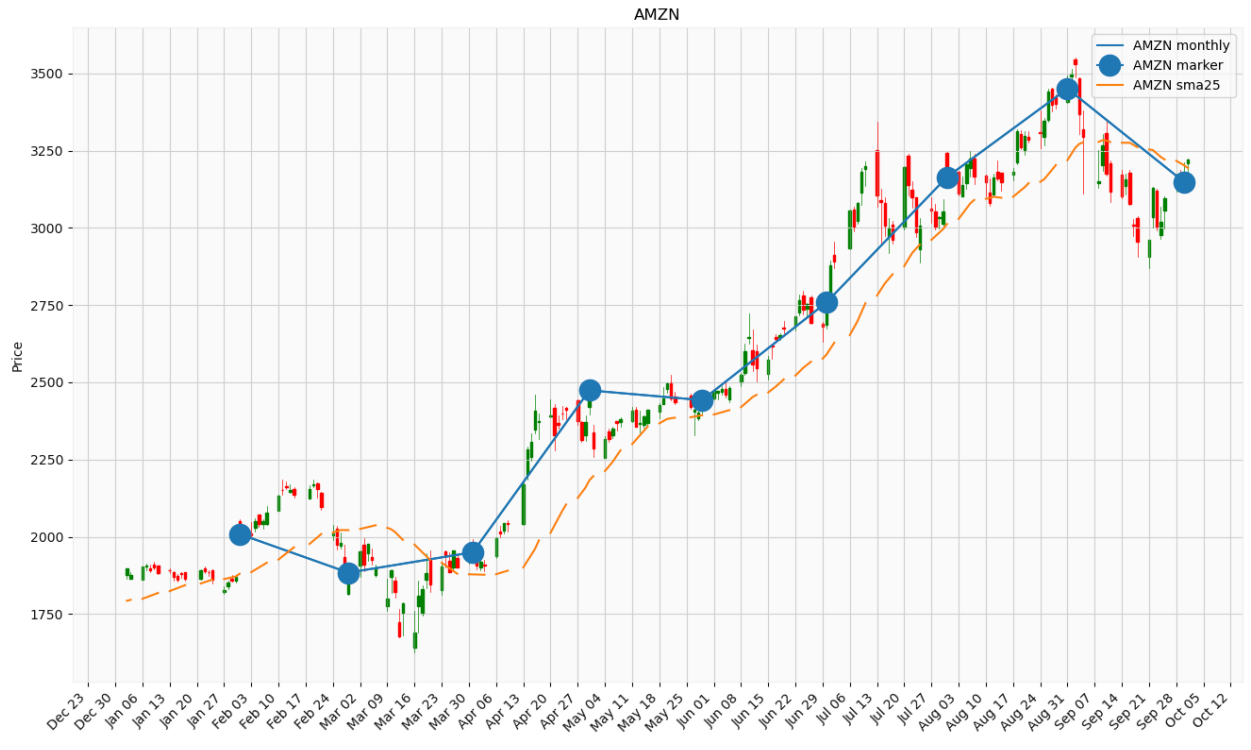
```
ax.plot(amzn_bm_piece_bm['Close'].index, amzn_bm_piece_bm['Close'], label='AMZN marker',␣
↪marker='o', markersize=16, color='C0')
ax.plot(amzn_piece_d['SMA25'].index, amzn_piece_d['SMA25'], label='AMZN sma25')

# other configurations
ax.set_title('AMZN')
#ax.set_xlabel('Date')
ax.set_ylabel('Price')
ax.legend()
plt.show()
#plt.savefig('plot.with.candle.daily.monthly.points.monthly.line.sma.25.matplotlib.style.
↪little.range.png')
```



Another customization could be to remove the gaps.

[9]:
```
# the previous plot with matplotlib style without gaps
import numpy as np

# configurations
fig, ax = plt.subplots(figsize=(16,9))

# remove the gaps
data = pd.DataFrame(amzn_piece_d.dropna())
# Preserve dates to be re-labelled later.
x_dates = data.index.to_pydatetime()
# Override data['date'] with a list of incrementatl integers.
#   This will not create gaps in the candle stick graph.
data_size = len(x_dates)
```

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```
data['Date'] = np.arange(start = 0, stop = data_size, step = 1, dtype='int')
# Re-arrange so that each line contains values of a day: 'date','open','high','low',
↪'close'.
quotes = [tuple(x) for x in data[['Date','Open','High','Low','Close']].values]

# Go through each x-tick label and rename it.
x_tick_labels = []
x_tick_positions = []
x_bm_line = []
for l_date in x_dates:
    date_str = ''
#    if l_date.strftime('%A') == 'Monday':
    if l_date.strftime('%A') == 'Tuesday':
        date_str = l_date.strftime('%b %d')
        x_tick_labels.append(date_str)
        x_tick_positions.append(list(x_dates).index(l_date))
    for date in amzn_bm_piece_bm.index:
        if l_date == date:
            x_bm_line.append(list(x_dates).index(l_date))
ax.set(xticks=x_tick_positions, xticklabels=x_tick_labels)
plt.setp(plt.gca().get_xticklabels(), rotation=45, horizontalalignment='right')

# grid
plt.rc('axes', grid=True)

# the plots
candlestick_ohlc(ax, quotes, colorup='g', colordown='r', width=0.6)
ax.plot(x_bm_line, amzn_bm_piece_bm['Close'], label='AMZN monthly')
ax.plot(x_bm_line, amzn_bm_piece_bm['Close'], label='AMZN marker', marker='o',␣
↪markersize=16, color='C0')
ax.plot(data['Date'], data['SMA25'], label='AMZN sma25')

# other configurations
ax.set_title('AMZN')
#ax.set_xlabel('Date')
ax.set_ylabel('Price')
ax.legend()
plt.show()
#plt.savefig('plot.with.candle.daily.monthly.points.monthly.line.sma.25.matplotlib.style.
↪little.range.without.gaps.png')
```

And to add the volume like bars.

[10]:
```
# the previous plot with matplotlib style without gaps plus volume

# configurations
fig, ax = plt.subplots(figsize=(16,9))
ax = plt.subplot2grid((3,3), (0,0), colspan=3, rowspan=2)
ax.yaxis.set_label_position('right')
ax.yaxis.tick_right()
ax2 = plt.subplot2grid((3,3), (2,0), colspan=3)
ax2.yaxis.set_label_position('right')
ax2.yaxis.tick_right()
#ax.axes.get_xaxis().set_visible(False)
fig.subplots_adjust(hspace=0)

# remove the gaps
data = pd.DataFrame(amzn_piece_d.dropna())
# Preserve dates to be re-labelled later.
x_dates = data.index.to_pydatetime()
# Override data['date'] with a list of incrementatl integers.
#   This will not create gaps in the candle stick graph.
data_size = len(x_dates)
data['Date'] = np.arange(start = 0, stop = data_size, step = 1, dtype='int')
# Re-arrange so that each line contains values of a day: 'date','open','high','low',
↪'close'.
quotes = [tuple(x) for x in data[['Date','Open','High','Low','Close']].values]

# Go through each x-tick label and rename it.
```

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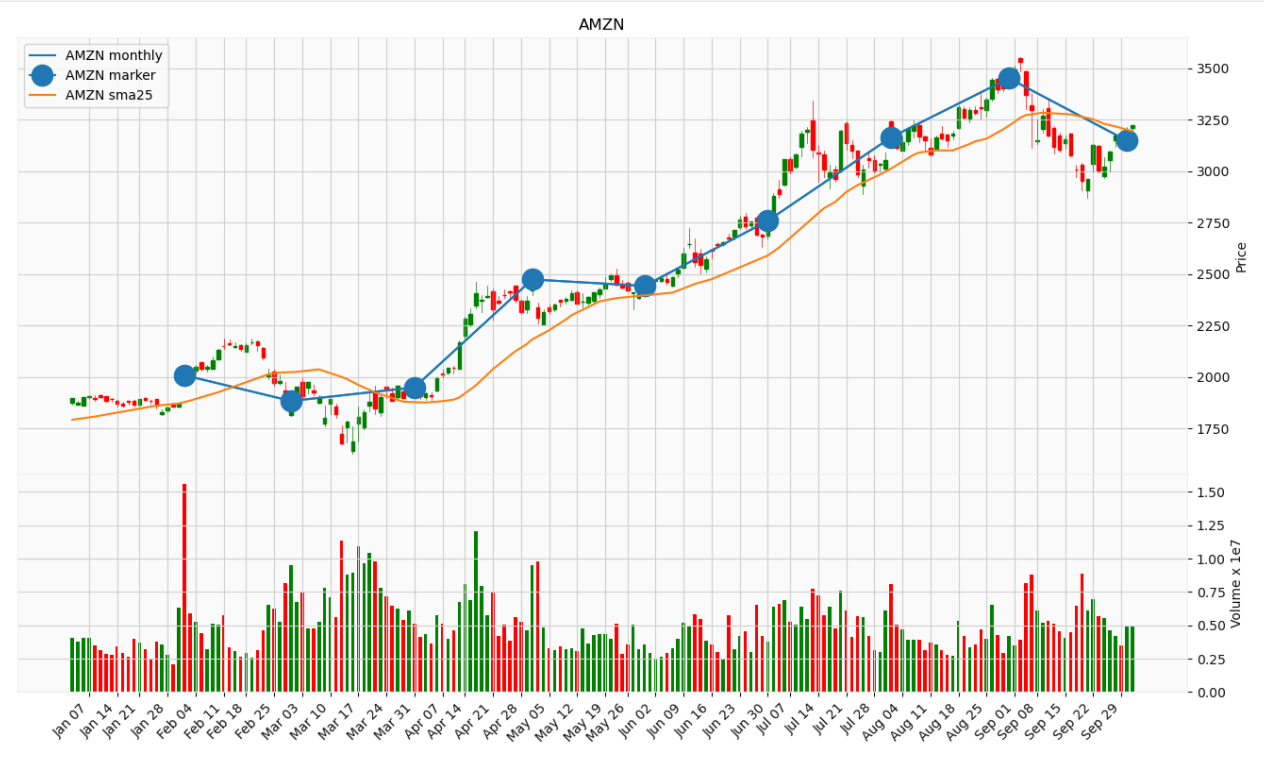
```
x_tick_labels_empty = []
x_tick_labels = []
x_tick_positions = []
x_bm_line = []
for l_date in x_dates:
    date_str = ''
#    if l_date.strftime('%A') == 'Monday':
    if l_date.strftime('%A') == 'Tuesday':
        date_str = l_date.strftime('%b %d')
        x_tick_labels.append(date_str)
        x_tick_labels_empty.append('')
        x_tick_positions.append(list(x_dates).index(l_date))
    for date in amzn_bm_piece_bm.index:
        if l_date == date:
            x_bm_line.append(list(x_dates).index(l_date))
#ax.set(xticks=x_tick_positions, xticklabels=x_tick_labels)
ax.set(xticks=x_tick_positions, xticklabels=x_tick_labels_empty)
ax2.set(xticks=x_tick_positions, xticklabels=x_tick_labels)
plt.setp(plt.gca().get_xticklabels(), rotation=45, horizontalalignment='right')

# grid
plt.rc('axes', grid=True)

# the plots
candlestick_ohlc(ax, quotes, colorup='g', colordown='r', width=0.6)
ax.plot(x_bm_line, amzn_bm_piece_bm['Close'], label='AMZN monthly')
ax.plot(x_bm_line, amzn_bm_piece_bm['Close'], label='AMZN marker', marker='o',␣
↪markersize=16, color='C0')
ax.plot(data['Date'], data['SMA25'], label='AMZN sma25')

# make bar plots and color differently depending on up/down for the day
pos = data['Open']-data['Close']<0
neg = data['Open']-data['Close']>0
ax2.bar(data['Date'][pos],data['Volume'][pos],color='green',width=0.6,align='center')
ax2.bar(data['Date'][neg],data['Volume'][neg],color='red',width=0.6,align='center')

# other configurations
ax.set_title('AMZN')
#ax2.set_xlabel('Date')
ax.set_ylabel('Price')
ax2.set_ylabel('Volume x 1e7')
# avoid scientific notation (1e7)
ax2.get_yaxis().get_offset_text().set_visible(False)
ax.legend()
plt.show()
#plt.savefig('plot.with.candle.daily.monthly.points.monthly.line.sma.25.matplotlib.style.
↪little.range.without.gaps.plus.volume.png')
```



Matplotlib is an advanced library for plotting everything you want, but maybe at the beginning, you need only to add the standard indicators.

It is simple to add **Simple Moving Averages** (SMA) with **mplfinance**, but this library contains only this indicator.

There are many libraries that they are a copy of TA-lib, an historical library of Technical Analisys.

- some libraries are a wrapper of the original **TA-lib**, like mrjbq7/ta-lib, and it needs the original TA-lib is installed
- some libraries are a wrapper of the **Matplotlib**, like ricequant/rqalpha
- many libraries create plots, calculate indicators and make backtesting starting from the previous ones: you only have to choose what you like best

[11]:
```
# plot with candle daily, sma 25, ema 25 and yahoo style without gaps
data = pd.DataFrame(amzn_piece_d.dropna())
aps = [
    mpf.make_addplot(data['SMA25'],color='C1'), # orange
    mpf.make_addplot(data['EMA25'],color='C3'), # red
    mpf.make_addplot(data['Upper Band'],linestyle='-.',color='g'),
    mpf.make_addplot(data['Lower Band'],linestyle='-.',color='g'),
]
mpf.plot(data,**kwargs,style='yahoo',addplot=aps,fill_between=dict(y1=data['Lower Band'].
↪values,y2=data['Upper Band'].values,alpha=0.1,color='g'))
#plt.savefig('plot.with.candle.daily.sma.25.ema.25.yahoo.style.without.gaps.png')
```

3.5 Strategies

You can initilize a strategy by Python language.

There are many libraries that you can use for defining your trading strategy: you only have to choose what you like best. In these samples, the library used for trading strategy is Backtesting.py.

3.5.1 How to load indicators on your strategy

The best practice is to prepare one column for each indicator that you want to use on your strategy.

[1]:
```
!pip install pandas_datareader
# initialization
import numpy as np
import pandas as pd
from pandas_datareader import data as pdr
start='2017-10-30'
end='2020-10-08'
amzn = pdr.DataReader('AMZN', 'yahoo', start, end)
# simple indicators
amzn['SMA20'] = amzn['Close'].rolling(20).mean()
amzn['SMA50'] = amzn['Close'].rolling(50).mean()
amzn['EMA20'] = amzn['Close'].ewm(span=20, adjust=False).mean()
amzn['EMA50'] = amzn['Close'].ewm(span=50, adjust=False).mean()
amzn['STD20'] = amzn['Close'].rolling(20).std()
amzn['Upper Band'] = amzn['SMA20'] + (amzn['STD20'] * 2)
```

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```
amzn['Lower Band'] = amzn['SMA20'] - (amzn['STD20'] * 2)
#amzn['Upper Band'] = amzn['EMA20'] + (amzn['STD20'] * 2)
#amzn['Lower Band'] = amzn['EMA20'] - (amzn['STD20'] * 2)
def RSI(data, time_window):
    diff = data.diff(1).dropna()
    up_chg = 0 * diff
    down_chg = 0 * diff
    up_chg[diff > 0] = diff[ diff>0 ]
    down_chg[diff < 0] = diff[ diff < 0 ]
    up_chg_avg   = up_chg.ewm(com=time_window-1 , min_periods=time_window).mean()
    down_chg_avg = down_chg.ewm(com=time_window-1 , min_periods=time_window).mean()
    rs = abs(up_chg_avg/down_chg_avg)
    rsi = 100 - 100/(1+rs)
    return rsi
amzn['RSI'] = RSI(amzn['Close'], 14)
amzn['RSI70'] = 70.0
amzn['RSI50'] = 50.0
# custom indicator
def RSIaverage(data, n1, n2):
    RSI_1 = RSI(data, n1)
    RSI_2 = RSI(data, n2)
    return (RSI_1 + RSI_2) / 2
amzn['RSIaverage'] = RSIaverage(amzn['Close'], 2, 14)
# data ranges
piece_d = pd.date_range(start='2017-10-30', end='2020-10-01')
#piece_d = pd.date_range(start='2020-01-01', end='2020-10-01')
amzn_piece_d = amzn.reindex(piece_d)
data = pd.DataFrame(amzn_piece_d.dropna())
# sample of divergence signal
divergence = [[('2020-07-22',3250),('2020-09-01',3550)]]
data['divergence'] = np.where((data.index == '2020-07-10') | (data.index == '2020-09-01
↪'), data['RSI'], None)
data['divergence'] = data['divergence'].dropna()
```

```
Requirement already satisfied: pandas_datareader in /opt/conda/lib/python3.8/site-
↪packages (0.9.0)
Requirement already satisfied: pandas>=0.23 in /opt/conda/lib/python3.8/site-packages␣
↪(from pandas_datareader) (1.1.5)
Requirement already satisfied: requests>=2.19.0 in /opt/conda/lib/python3.8/site-
↪packages (from pandas_datareader) (2.25.1)
Requirement already satisfied: lxml in /opt/conda/lib/python3.8/site-packages (from␣
↪pandas_datareader) (4.6.2)
Requirement already satisfied: python-dateutil>=2.7.3 in /opt/conda/lib/python3.8/site-
↪packages (from pandas>=0.23->pandas_datareader) (2.8.1)
Requirement already satisfied: pytz>=2017.2 in /opt/conda/lib/python3.8/site-packages␣
↪(from pandas>=0.23->pandas_datareader) (2020.5)
Requirement already satisfied: numpy>=1.15.4 in /opt/conda/lib/python3.8/site-packages␣
↪(from pandas>=0.23->pandas_datareader) (1.19.4)
Requirement already satisfied: six>=1.5 in /opt/conda/lib/python3.8/site-packages (from␣
↪python-dateutil>=2.7.3->pandas>=0.23->pandas_datareader) (1.15.0)
Requirement already satisfied: urllib3<1.27,>=1.21.1 in /opt/conda/lib/python3.8/site-
↪packages (from requests>=2.19.0->pandas_datareader) (1.26.2)
```

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```
Requirement already satisfied: certifi>=2017.4.17 in /opt/conda/lib/python3.8/site-
↪packages (from requests>=2.19.0->pandas_datareader) (2020.12.5)
Requirement already satisfied: idna<3,>=2.5 in /opt/conda/lib/python3.8/site-packages␣
↪(from requests>=2.19.0->pandas_datareader) (2.10)
Requirement already satisfied: chardet<5,>=3.0.2 in /opt/conda/lib/python3.8/site-
↪packages (from requests>=2.19.0->pandas_datareader) (4.0.0)
```

You can have to see your strategy and the plot is your solution. If you have not defined which indicators you want to use, you can see them all together.

[2]:
```
!pip install mplfinance
# plot with candle daily, sma 20, sma 50, bb, RSI and yahoo style
import mplfinance as mpf
kwargs = dict(type='candle',volume=True,figratio=(16,9),figscale=2)
aps = [
    mpf.make_addplot(data['SMA20'],color='C0'), # blue
    mpf.make_addplot(data['SMA50'],color='C1'), # orange
#    mpf.make_addplot(data['EMA20'],color='C0'), # blue
#    mpf.make_addplot(data['EMA50'],color='C1'), # orange
    mpf.make_addplot(data['Upper Band'],linestyle='-.',color='g'),
    mpf.make_addplot(data['Lower Band'],linestyle='-.',color='g'),
    mpf.make_addplot(data['RSI'],color='C4',panel=2,ylabel='RSI'),
    mpf.make_addplot(data['RSI70'],color='g',panel=2,type='line',linestyle='-.',alpha=0.
↪5),
    mpf.make_addplot(data['RSI50'],color='r',panel=2,type='line',linestyle='-.',alpha=0.
↪5),
    mpf.make_addplot(data['divergence'],color='C0',panel=2,type='scatter',markersize=78,
↪marker='o'),
    mpf.make_addplot(data['RSIaverage'],color='C2',panel=3,ylabel='RSIaverage'),
]
mpf.plot(data,**kwargs,style='yahoo',title='AMZN',addplot=aps,alines=divergence,fill_
↪between=dict(y1=data['Lower Band'].values,y2=data['Upper Band'].values,alpha=0.1,color=
↪'g'))
#mpf.plot(data,**kwargs,style='yahoo',title='AMZN',addplot=aps,alines=divergence,fill_
↪between=dict(y1=data['Lower Band'].values,y2=data['Upper Band'].values,alpha=0.1,color=
↪'g'),savefig=dict(fname='plot.with.candle.daily.sma.20.sma.50.bb.RSI.yahoo.style.png'))
```

```
Requirement already satisfied: mplfinance in /opt/conda/lib/python3.8/site-packages (0.
↪12.7a4)
Requirement already satisfied: matplotlib in /opt/conda/lib/python3.8/site-packages␣
↪(from mplfinance) (3.3.3)
Requirement already satisfied: pandas in /opt/conda/lib/python3.8/site-packages (from␣
↪mplfinance) (1.1.5)
Requirement already satisfied: pyparsing!=2.0.4,!=2.1.2,!=2.1.6,>=2.0.3 in /opt/conda/
↪lib/python3.8/site-packages (from matplotlib->mplfinance) (2.4.7)
Requirement already satisfied: pillow>=6.2.0 in /opt/conda/lib/python3.8/site-packages␣
↪(from matplotlib->mplfinance) (8.0.1)
Requirement already satisfied: numpy>=1.15 in /opt/conda/lib/python3.8/site-packages␣
↪(from matplotlib->mplfinance) (1.19.4)
Requirement already satisfied: python-dateutil>=2.1 in /opt/conda/lib/python3.8/site-
↪packages (from matplotlib->mplfinance) (2.8.1)
Requirement already satisfied: cycler>=0.10 in /opt/conda/lib/python3.8/site-packages␣
↪(from matplotlib->mplfinance) (0.10.0)
```

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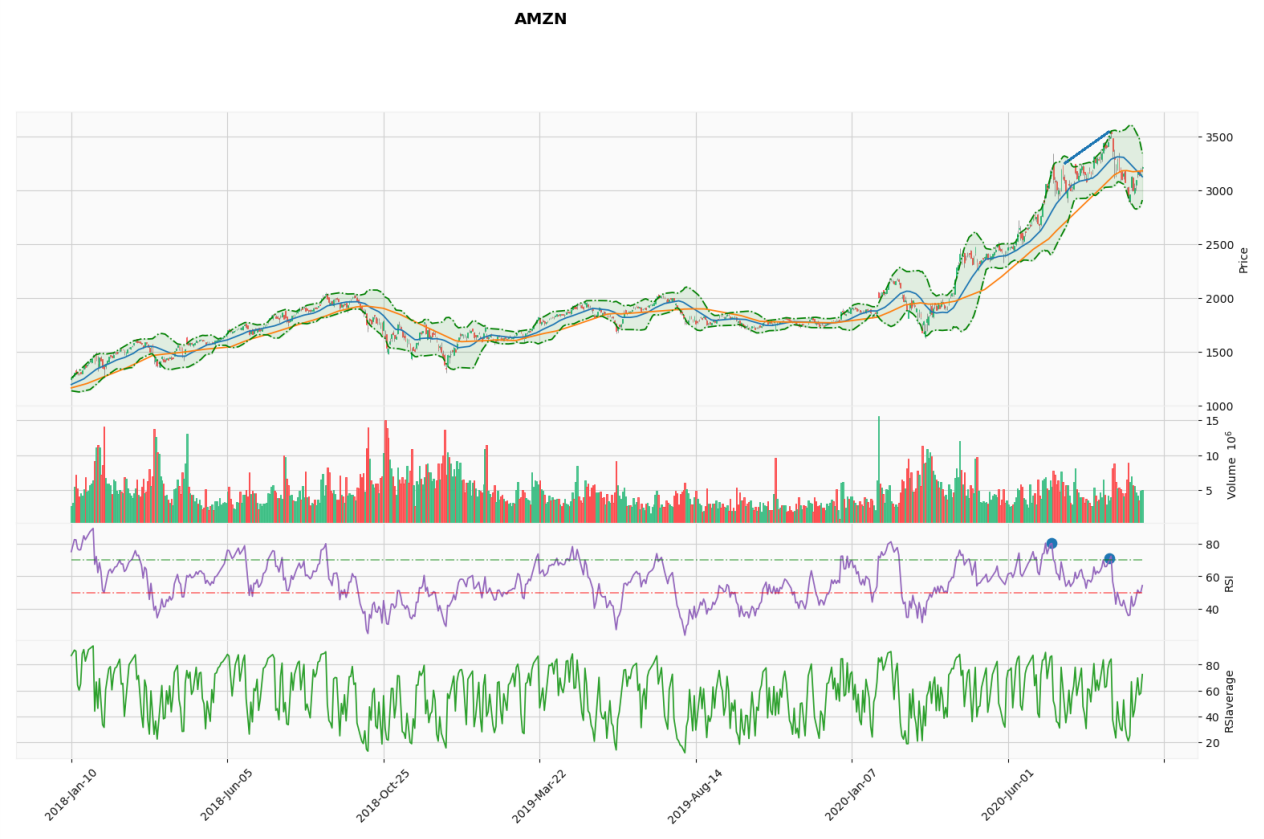
```
Requirement already satisfied: kiwisolver>=1.0.1 in /opt/conda/lib/python3.8/site-
↪packages (from matplotlib->mplfinance) (1.3.1)
Requirement already satisfied: six in /opt/conda/lib/python3.8/site-packages (from␣
↪cycler>=0.10->matplotlib->mplfinance) (1.15.0)
Requirement already satisfied: pytz>=2017.2 in /opt/conda/lib/python3.8/site-packages␣
↪(from pandas->mplfinance) (2020.5)
```



3.5.2 How to load signals on your strategy

The best practice is to prepare one column for each signal that you want to use on your strategy. The strategy below use the moving averages that they are SMA and EMA. You can use one or the other.

Disclaimer

The strategies below are some simple samples for having an idea how to use the libraries: those strategies are for the educational purpose only. All investments and trading in the stock market involve risk: any decisions related to buying/selling of stocks or other financial instruments should only be made after a thorough research, backtesting, running in demo and seeking a professional assistance if required.

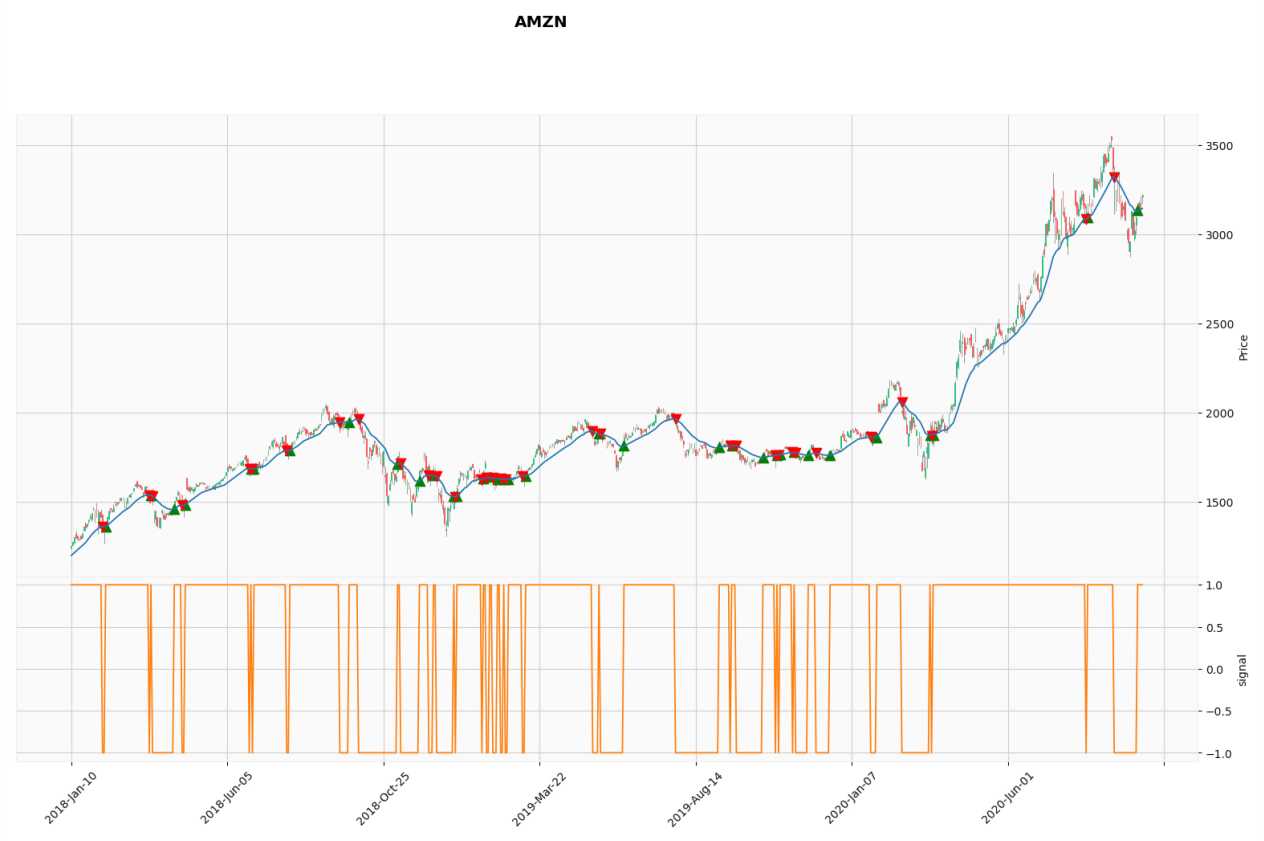
Moving Average Crossover Strategy - Sample 1

- when the price value crosses the MA value from below, it will close any existing short position and go long (buy) one unit of the asset
- when the price value crosses the MA value from above, it will close any existing long position and go short (sell) one unit of the asset

Reference: https://www.learndatasci.com/tutorials/python-finance-part-3-moving-average-trading-strategy/

[3]:
```
# Moving Average Crossover Strategy - Sample 1
#ma = 'SMA20'
ma = 'EMA20'
# Taking the difference between the prices and the MA timeseries
data['price_ma_diff'] = data['Close'] - data[ma]
# Taking the sign of the difference to determine whether the price or the EMA is greater
data['signal1'] = data['price_ma_diff'].apply(np.sign)
data['position1'] = data['signal1'].diff()
data['buy'] = np.where(data['position1'] == 2, data[ma], np.nan)
data['sell'] = np.where(data['position1'] == -2, data[ma], np.nan)
```

[4]:
```
# plot with candle daily, sma 20, signal and yahoo style
import mplfinance as mpf
kwargs = dict(type='candle',figratio=(16,9),figscale=2)
aps = [
    mpf.make_addplot(data[ma],color='C0'), # blue
    mpf.make_addplot(data['buy'],color='g',type='scatter',markersize=78,marker='^'),
    mpf.make_addplot(data['sell'],color='r',type='scatter',markersize=78,marker='v'),
    mpf.make_addplot(data['signal1'],color='C1',panel=1,ylabel='signal')
]
mpf.plot(data,**kwargs,style='yahoo',title='AMZN',addplot=aps)
#mpf.plot(data,**kwargs,style='yahoo',title='AMZN',addplot=aps,savefig=dict(fname='plot.
↪with.candle.daily.sma.20.signal.yahoo.style.png'))
```



[5]:
```
!pip install backtesting
from backtesting import Backtest, Strategy
from backtesting.lib import crossover
from backtesting.test import SMA
class PositionSign(Strategy):
    def init(self):
        self.close = self.data.Close
    def next(self):
        i = len(self.data.Close) - 1
        if self.data.position1[-1] == 2:
            self.position.close()
            self.buy()
        elif self.data.position1[-1] == -2:
            self.position.close()
            self.sell()
bt = Backtest(data, PositionSign, cash=10000, commission=.002, exclusive_orders=True)
bt.run()
```

```
Requirement already satisfied: backtesting in /opt/conda/lib/python3.8/site-packages (0.
↪3.0)
Requirement already satisfied: bokeh>=1.4.0 in /opt/conda/lib/python3.8/site-packages␣
↪(from backtesting) (2.2.3)
Requirement already satisfied: numpy in /opt/conda/lib/python3.8/site-packages (from␣
↪backtesting) (1.19.4)
Requirement already satisfied: pandas!=0.25.0,>=0.25.0 in /opt/conda/lib/python3.8/site-
↪packages (from backtesting) (1.1.5)
```

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```
Requirement already satisfied: python-dateutil>=2.1 in /opt/conda/lib/python3.8/site-
↪packages (from bokeh>=1.4.0->backtesting) (2.8.1)
Requirement already satisfied: Jinja2>=2.7 in /opt/conda/lib/python3.8/site-packages␣
↪(from bokeh>=1.4.0->backtesting) (2.11.2)
Requirement already satisfied: packaging>=16.8 in /opt/conda/lib/python3.8/site-packages␣
↪(from bokeh>=1.4.0->backtesting) (20.8)
Requirement already satisfied: pillow>=7.1.0 in /opt/conda/lib/python3.8/site-packages␣
↪(from bokeh>=1.4.0->backtesting) (8.0.1)
Requirement already satisfied: PyYAML>=3.10 in /opt/conda/lib/python3.8/site-packages␣
↪(from bokeh>=1.4.0->backtesting) (5.3.1)
Requirement already satisfied: typing-extensions>=3.7.4 in /opt/conda/lib/python3.8/site-
↪packages (from bokeh>=1.4.0->backtesting) (3.7.4.3)
Requirement already satisfied: tornado>=5.1 in /opt/conda/lib/python3.8/site-packages␣
↪(from bokeh>=1.4.0->backtesting) (6.1)
Requirement already satisfied: MarkupSafe>=0.23 in /opt/conda/lib/python3.8/site-
↪packages (from Jinja2>=2.7->bokeh>=1.4.0->backtesting) (1.1.1)
Requirement already satisfied: pyparsing>=2.0.2 in /opt/conda/lib/python3.8/site-
↪packages (from packaging>=16.8->bokeh>=1.4.0->backtesting) (2.4.7)
Requirement already satisfied: pytz>=2017.2 in /opt/conda/lib/python3.8/site-packages␣
↪(from pandas!=0.25.0,>=0.25.0->backtesting) (2020.5)
Requirement already satisfied: six>=1.5 in /opt/conda/lib/python3.8/site-packages (from␣
↪python-dateutil>=2.1->bokeh>=1.4.0->backtesting) (1.15.0)
```

```
/opt/conda/lib/python3.8/site-packages/backtesting/_plotting.py:45: UserWarning: Jupyter␣
↪Notebook detected. Setting Bokeh output to notebook. This may not work in Jupyter␣
↪clients without JavaScript support (e.g. PyCharm, Spyder IDE). Reset with `backtesting.
↪set_bokeh_output(notebook=False)`.
  warnings.warn('Jupyter Notebook detected. '
```

Data type cannot be displayed: application/javascript, application/vnd.bokehjs_load.v0+json

[5]:
```
Start                     2018-01-10 00:00:00
End                       2020-10-01 00:00:00
Duration                    995 days 00:00:00
Exposure Time [%]                   96.9432
Equity Final [$]                    6449.39
Equity Peak [$]                     11361.5
Return [%]                         -35.5061
Buy & Hold Return [%]               156.811
Return (Ann.) [%]                  -14.8609
Volatility (Ann.) [%]               25.1543
Sharpe Ratio                              0
Sortino Ratio                             0
Calmar Ratio                              0
Max. Drawdown [%]                  -62.3199
Avg. Drawdown [%]                  -17.0591
Max. Drawdown Duration      934 days 00:00:00
Avg. Drawdown Duration      238 days 00:00:00
# Trades                                 68
Win Rate [%]                              25
Best Trade [%]                      58.9442
```

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```
Worst Trade [%]                      -12.944
Avg. Trade [%]                     -0.750267
Max. Trade Duration         141 days 00:00:00
Avg. Trade Duration          15 days 00:00:00
Profit Factor                       0.790866
Expectancy [%]                     -0.473583
SQN                                 -1.05025
_strategy                     PositionSign
_equity_curve                          ...
_trades                      Size  EntryB...
dtype: object
```

[6]:
```
bt.plot()
```

Data type cannot be displayed: application/javascript, application/vnd.bokehjs_exec.v0+json

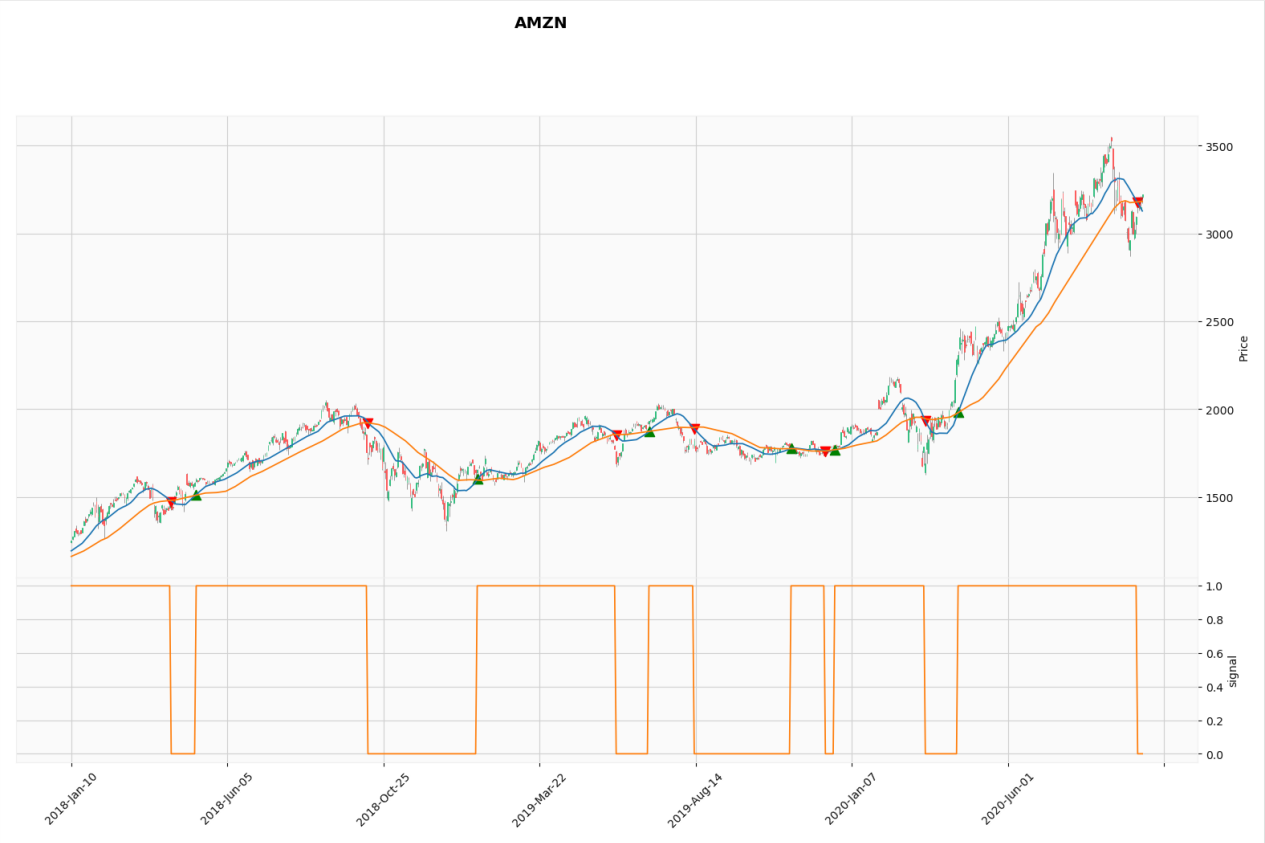
Moving Average Crossover Strategy - Sample 2

- when the short term moving average crosses above the long term moving average, this indicates a buy signal
- when the short term moving average crosses below the long term moving average, it may be a good moment to sell

Reference: https://towardsdatascience.com/making-a-trade-call-using-simple-moving-average-sma-crossover-strategy-python-impleme

[7]:
```
# Moving Average Crossover Strategy - Sample 2
ma20 = 'SMA20'
ma50 = 'SMA50'
#ma20 = 'EMA20'
#ma50 = 'EMA50'
data['signal2'] = 0.0
data['signal2'] = np.where(data[ma20] > data[ma50], 1.0, 0.0)
data['position2'] = data['signal2'].diff()
data['buy'] = np.where(data['position2'] == 1, data[ma20], np.nan)
data['sell'] = np.where(data['position2'] == -1, data[ma20], np.nan)
```

[8]:
```
# plot with candle daily, sma 20, sma 50, signal and yahoo style
import mplfinance as mpf
kwargs = dict(type='candle',figratio=(16,9),figscale=2)
aps = [
    mpf.make_addplot(data[ma20],color='C0'), # blue
    mpf.make_addplot(data[ma50],color='C1'), # orange
    mpf.make_addplot(data['buy'],color='g',type='scatter',markersize=78,marker='^'),
    mpf.make_addplot(data['sell'],color='r',type='scatter',markersize=78,marker='v'),
    mpf.make_addplot(data['signal2'],color='C1',panel=1,ylabel='signal')
]
mpf.plot(data,**kwargs,style='yahoo',title='AMZN',addplot=aps)
#mpf.plot(data,**kwargs,style='yahoo',title='AMZN',addplot=aps,savefig=dict(fname='plot.
↪with.candle.daily.sma.20.sma.50.signal.yahoo.style.png'))
```



[9]:
```
from backtesting import Backtest, Strategy
from backtesting.lib import crossover
from backtesting.test import SMA
class SmaCross(Strategy):
    n1 = 20
    n2 = 50
    def init(self):
        close = self.data.Close
        self.sma1 = self.I(SMA, close, self.n1)
        self.sma2 = self.I(SMA, close, self.n2)
    def next(self):
        if crossover(self.sma1, self.sma2):
            self.position.close()
            self.buy()
        elif crossover(self.sma2, self.sma1):
            self.position.close()
            self.sell()
bt = Backtest(data, SmaCross, cash=10000, commission=.002, exclusive_orders=True)
bt.run()
```

[9]:
```
Start                     2018-01-10 00:00:00
End                       2020-10-01 00:00:00
Duration                    995 days 00:00:00
Exposure Time [%]                     90.5386
Equity Final [$]                      7712.69
```

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```
Equity Peak [$]                      12532.8
Return [%]                          -22.8731
Buy & Hold Return [%]                156.811
Return (Ann.) [%]                   -9.08703
Volatility (Ann.) [%]                 24.431
Sharpe Ratio                               0
Sortino Ratio                              0
Calmar Ratio                               0
Max. Drawdown [%]                   -52.0307
Avg. Drawdown [%]                   -11.5153
Max. Drawdown Duration      517 days 00:00:00
Avg. Drawdown Duration       80 days 00:00:00
# Trades                                  13
Win Rate [%]                          38.4615
Best Trade [%]                        35.0832
Worst Trade [%]                     -32.3988
Avg. Trade [%]                      -2.23977
Max. Trade Duration         166 days 00:00:00
Avg. Trade Duration          70 days 00:00:00
Profit Factor                         0.79924
Expectancy [%]                      -1.11657
SQN                                -0.620588
_strategy                           SmaCross
_equity_curve                            ...
_trades                      Size  EntryB...
dtype: object
```

[10]:
```
bt.plot()
```

Data type cannot be displayed: application/javascript, application/vnd.bokehjs_exec.v0+json

CHAPTER

FOUR

PINE

4.1 Prerequisites

Tradingview is an analysis platform where you can,

- analyze your trades by indicators, your scripts and perform your backtesting
- share your analysis with other traders and investors, because it is a full-fledged social network
- view the analysis of other users
- monitor your trades by alerts

For implementing your indicators or your strategies, Tradingview has own script language: Pine.

For using Pine,

- just access the Chart section
- and click on the tab named **Pine Editor** on the bottom
- it is there that you can copy your Pine scripts

You can find all scripts descripted in this tutorial on GitHub in the folder src/pine/.

4.2 Getting started

Pine is a script language own of Tradingview for adding your indicators and backtesting your trades.

This is a summary of the pine language syntax: you can find,

- the methods description in pine script reference
- the complete documentation in pine script docs
- and many many samples in PineCoders

4.2.1 Basics

There are some methods to load your data

```
//@version=4
//study("My Simple Sample Script") // in a chart space dedicated
//study("My Simple Sample Script", max_labels_count = 500) // in a chart space dedicated␣
↪with a max label > 50, that it is the default
study("My Simple Sample Script", "", true) // in the main chart
```

It is important to remember that it is a script language:

- it has a few methods
- there are not matrixes or complex calculation, only the essential

Pine draws your indicators and data in the **Tradingview charts** and in the **Data Window**. So, it is important to understand which methods you have for debugging your code.

```
// initialization of a variable
my_numeric_variable = 1
my_string_variable = "H"

// where print something
plotchar(my_numeric_variable, "Numeric variable", "") // on the right, in Data Window
plotchar(bar_index, "Bar Index", "i", location = location.top) // on the right, in Data␣
↪Window and on the main panel, in the chart space
label.new(bar_index, high, my_string_variable) // on each bar
if barstate.islast
    label.new(bar_index, low, "L", style = label.style_label_up) // only on the last bar
```

It is not possible to use

- **plotchar** method on Data Window with a string value

- **plotchar** and **label.new** methods in a function
- **plotchar** method in a local scope like also a for loop

4.2.2 Arrays

Pine arrays are one-dimensional. All elements of an array are of the same type, which can be int, float, bool or color, always of series form.

```
// initialization of a vector
my_numeric_array = array.new_float(0)
for i = 1 to 6
    array.push(my_numeric_array, i)
if barstate.islast // print
    label.new(bar_index, high, "my_numeric_array:\n" + tostring(my_numeric_array), style␣
↪= label.style_label_down, size = size.large)

my_string_array = array.new_string(1, "hello")
array.concat(my_string_array, array.new_string(1, "world"))
array.concat(my_string_array, array.new_string(1, "!"))
if barstate.islast // print
    label.new(bar_index, low, "my_string_array: " + array.get(my_string_array, 0), style␣
↪= label.style_label_up, size = size.large)

my_logic_array = array.new_bool(0)
array.push(my_logic_array, 0)
array.push(my_logic_array, 1)

// operations with arrays
sum = array.sum(my_numeric_array)
mean = array.avg(my_numeric_array)
median = array.median(my_numeric_array)
plotchar(sum, "sum", "")
```

4.2.3 Weighted average

```
performance = array.new_float(0)
array.push(performance, 3)
array.push(performance, 7)
array.push(performance,11)
weight = array.new_float(0)
array.push(weight, .3)
array.push(weight, .4)
array.push(weight, .3)
weighted_average = array.get(performance, 0) * array.get(weight, 0) + array.
↪get(performance, 1) * array.get(weight, 1) + array.get(performance, 2) * array.
↪get(weight, 2)
plotchar(weighted_average, "weighted_average", "")
```

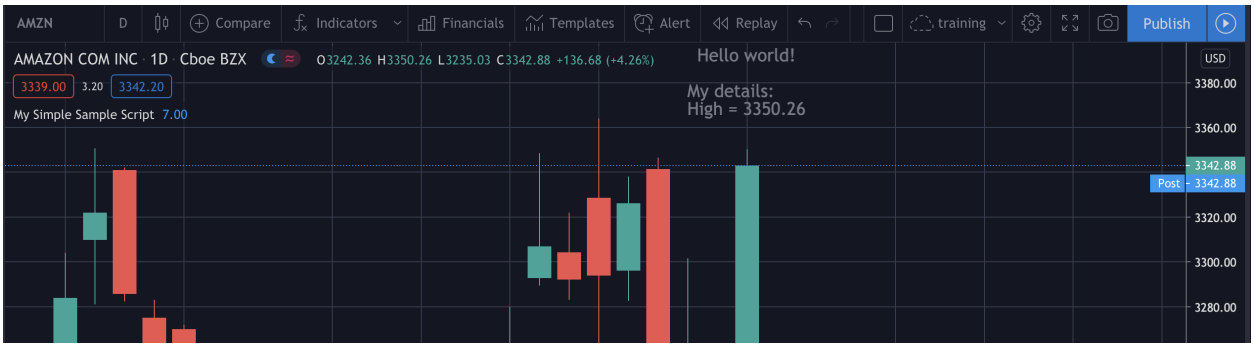

AMZN
Compare
Indicators
Financials
Templates
Alert
Replay
training
Publish
Data Window
AMAZON COM INC 1D Cboe BZX
O3242.36 H3350.26 L3235.03 C3342.88 +136.68 (+4.26%)
3339.00 3.88 3342.88
My Simple Sample Script 21.00
my_numeric_array: [1, 2, 3, 4, 5, 6]
my_st g_array: hello
Date 01 Feb '21
AMZN, 1D, Cboe BZX
Open 3242.36
High 3350.26
Low 3235.03
Close 3342.88
Change +136.68 (+4.26%)
My Simple Sample Script
sum 21.00


AMZN
Compare
Indicators
Financials
Templates
Alert
Replay
training
Publish
Data Window
AMAZON COM INC 1D Cboe BZX
O3242.36 H3350.26 L3235.03 C3342.88 +136.68 (+4.26%)
3240.00 102.20 3342.20
My Simple Sample Script 7.00
Date 01 Feb '21
AMZN, 1D, Cboe BZX
Open 3242.36
High 3350.26
Low 3235.03
Close 3342.88
Change +136.68 (+4.26%)
My Simple Sample Script
weighted_average 7.00

4.2.4 Functions

The functions could return something or not (see the docs for details). The first function named **f_print**, it returns nothing, only prints on the chart.

```
// prints on last bar, in the chart space
f_print(_text) =>
    // Create label on the first bar.
    var _label = label.new(bar_index, na, _text, xloc.bar_index, yloc.price, color(na),␣
↪label.style_none, color.gray, size.large, text.align_left)
    // On next bars, update the label's x and y position, and the text it displays.
    label.set_xy(_label, bar_index, highest(10)[1])
    label.set_text(_label, _text)
f_print("My details:\nHigh = " + tostring(high))
f_print(my_string_variable + "ello world!\n\n\n")
```



The second function named **multiply_performance_weight**, it returns an array.

```
// portfolio performance
company = array.new_string(1, "AAPL")
array.concat(company, array.new_string(1, "NFLX"))
array.concat(company, array.new_string(1, "AMZN"))
multiply_performance_weight(_performance, _weight) =>
    _performance_weight = array.new_float(0)
    for i = 0 to array.size(_performance) - 1
        _one_of_performance_weight = array.get(_performance, i) * array.get(_weight, i)
        array.push(_performance_weight, _one_of_performance_weight)
    _performance_weight // return the array
```

And inner a for loop is not possible to use **plotchar** method, but only **label.new** method.

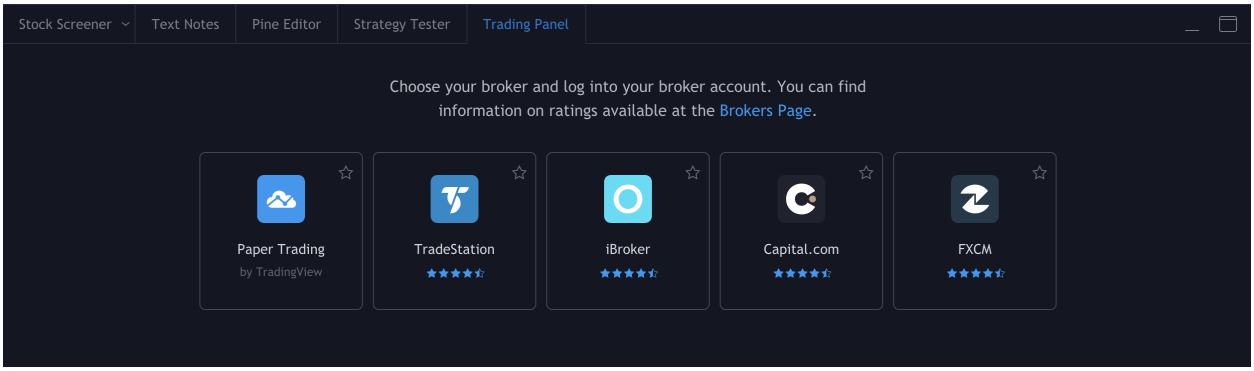
```
performance_weight = multiply_performance_weight(performance, weight)
weighted_average2 = array.sum(performance_weight)
for i = 0 to array.size(performance) - 1
    if barstate.islast // print
        label.new(bar_index, close, array.get(company, i) + ": " + tostring(array.
↪get(performance_weight, i)), style = label.style_label_up, size = size.large)
plotchar(weighted_average2, "portfolio", "") // Cannot use 'plotchar' in local scope.
```

4.3 Historical data

Tradingview displays directly the data in the main chart panel, and you can see the all data moving the main chart back.

So, this step is not necessary for using the Pine script language because it is already integrated.

The unique limit is that you can only use the assets present in Tradingview and its partners features.



4.4 Graphics

This is a sample for drawing objects with Pine. There are 2 principal methods for drawing, you can draw on

4.4.1 Lines

```
//@version=4
study("My Simple Sample Script", "", true) // the main chart
```

You can use the arrays pre loaded for you, like **close** (values of the closes), and modify them loading only the values that you want

```
// monthly points - the first Monday of each month
custom = array.new_float(1)
if dayofmonth <= 7 and dayofweek == dayofweek.monday
    array.set(custom, 0, close)
else
    array.set(custom, 0, na)
customPreviousClose = array.get(custom, 0)[1]
```

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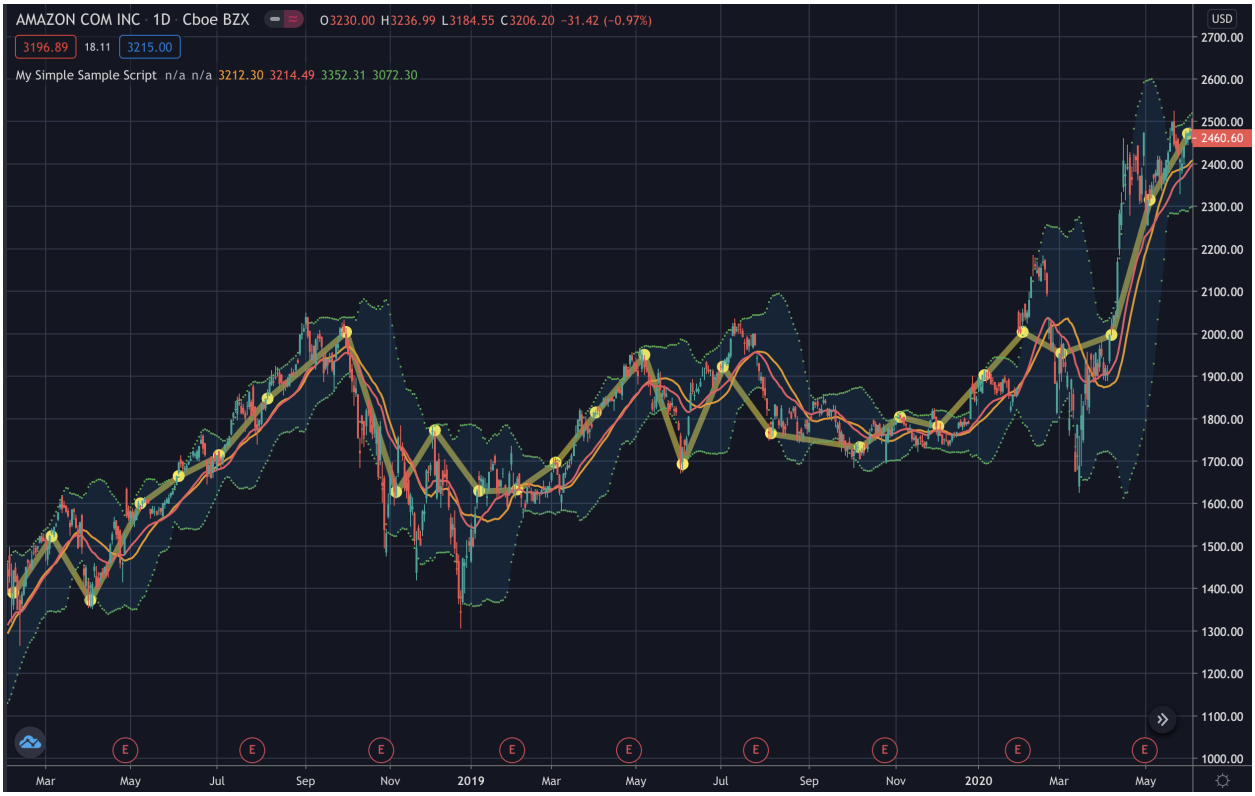
```
plot(customPreviousClose, "customPreviousClose", color.yellow, 6, plot.style_circles)
plot(customPreviousClose, "customPreviousClose", color.yellow, 6, plot.style_line,␣
↪transp = 50)
```

And you can add many many indicators in a few code lines

```
// moving average
sma25 = sma(close, 25)
ema25 = ema(close, 25)
plot(sma25, "sma 25", color.orange, 2)
plot(ema25, "ema 25", color.red, 2)

// bollinger bands
ma = sma25
dev = 2 * stdev(close, 25)
upper = ma + dev
lower = ma - dev
p1 = plot(upper, color=color.green, linewidth=1, style=plot.style_circles)
p2 = plot(lower, color=color.green, linewidth=1, style=plot.style_circles)
fill(p1, p2)
```



It is possible to draw line from one point to another point, by **bar_index** or **time**

```
// line by index
i = line.new(bar_index, high, bar_index[10], low[10], width = 4)
line.delete(i[1])
```

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```
// line by time
t = line.new(time, high, time[10], low[10], xloc.bar_time, width = 4)
line.delete(t[1])
```

4.4.2 Columns

It is possible to simulate **Volume indicator** on the main chart with specific parameters

- on the study method
- adding a workaround that it is the plot of high line

```
//@version=4
study("My Simple Volume Script", "", true, format.volume, 0, scale.none)

//Get volume for current bar and multiply with vwap
vInverse = volume * vwap
plot(series=vInverse, title="Volume", style=plot.style_columns, color=close >= open ?␣
↪color.green : color.red, transp=50)

//Plot high line to scale down the columns
highLine = input(1000, "High Line", minval = 2, step = 100)
limit = highest(vInverse, highLine)
scaleFactor = 100 / input(20, "% of vertical space used", step = 10, maxval = 100)
plot(limit * scaleFactor, "Historical High", color.black)
```

And you can also add **SMA indicator** over the **Volume indicator**

```
//Make the moving average user configurable
showMA = input(true)
plot(showMA ? sma(vInverse,20) : na, title="SMA", style=plot.style_area, color=color.
↪white, transp=80)
```

The second script has also some inputs that you can manage the values by **Settings** symbol > **Input**.

And you can change all colors by **Settings** symbol > **Style**.

4.4.3 Points

There are many ready-made methods for you like **pivot** points.

```
//@version=4
study("My Simple Pivot Script", "", true)
```

In that sample you can decide if which plots show by **input** methods.

```
legs = input(14)
showPivotHigh = input(true)
showPivotLow = input(true)
```

And it is used a function, for reusing the code in two points.


```
pivot_points(pi, legs) =>
    newPi = not na(pi)
    var float ci = na
    if newPi
        ci := close[legs]
    [pi, newPi, ci]

[pHi, newPHi, cHi] = pivot_points(pivothigh(close, legs, legs), legs)
plot(showPivotHigh ? cHi : na, "", newPHi ? na : color.fuchsia, offset = - legs)
plotchar(showPivotHigh ? pHi : na, "pHi", "", location.top, color.fuchsia, offset = -␣
↪legs)

[pLi, newPLi, cLi] = pivot_points(pivotlow(close, legs, legs), legs)
plot(showPivotLow ? cLi: na, "", newPLi ? na : color.orange, offset = - legs)
plotchar(showPivotLow ? pLi: na, "pLi", "", location.bottom, color.orange, offset = -␣
↪legs)
```

4.5 Strategies

You can initilize a strategy by Pine language.

Tradingview has a tab named **Strategy Tester** near the tab named **Pine Editor** that it has been created for backtesting your Pine scripts.

4.5.1 How to load indicators on your strategy

When you want to test your strategy on Tradingview, you have to start your Pine script with the method **strategy**.

```
//@version=4
strategy("My Simple Strategy Script", "", true) // in the main chart
```

And then, it is the same for loading your indicators.

A script runs either in **overlay=true** mode on the chart, in which case it cannot direct plots elsewhere, or in a separate pane when **overlay=false** (the default).

But there is a workaround for having some plots in the main chart and others in another chart. You can use **Settings > Style** for flagging who see where you want. So you can also add this code,

```
// initialization
legs = input(20)

// moving averages
sma20 = sma(close, legs)
```

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```
plot(sma20, "sma 20", color.blue, 2)
plot(sma(close, 50), "sma 50", color.orange, 2)

// bollinger bands
dev = 2 * stdev(close, legs)
upper = sma20 + dev
lower = sma20 - dev
p1 = plot(upper, title="BB upper", color=color.green, linewidth=1, style=plot.style_
↪circles)
p2 = plot(lower, title="BB lower", color=color.green, linewidth=1, style=plot.style_
↪circles)
fill(p1, p2)

// volume
plot(volume * vwap, title="Volume", style=plot.style_columns, color=close >= open ?␣
↪color.green : color.red, transp=50)

// rsi
plot(rsi(close, legs), title="RSI", color=color.purple)
h0 = hline(70)
h1 = hline(50)
fill(h0, h1, color=color.purple, transp=75)
```

Add the chart on the main chart with the header

```
//@version=4
strategy("My Simple Strategy Script", "", true) // in the main chart
```

Add the chart on another chart with the header

```
//@version=4
strategy("My Simple Strategy Script") // a chart space dedicated
```

And then you can use the **Settings** for splitting the plots between the main chart and others.

Instead, for the **line** method it is necessary to use an **input** and conditions for splitting the lines between the main chart and another. You can use **Settings** > **Input** for flagging who see where you want in order of the conditions.

In the code below is used the variable named **showLineRSI** for the visualization of the lines on RSI chart or the main chart.

```
// initialization
showLineRSI = input(true)

var bar_time1 = 0
var bar_time2 = 0
var float bar_high1 = 0
var float bar_high2 = 0
var float bar_rsi1 = 0
var float bar_rsi2 = 0
_rsi = rsi(close, 20)

if time == timestamp(2020, 04, 16, 09, 30)
    bar_high1 := high
```

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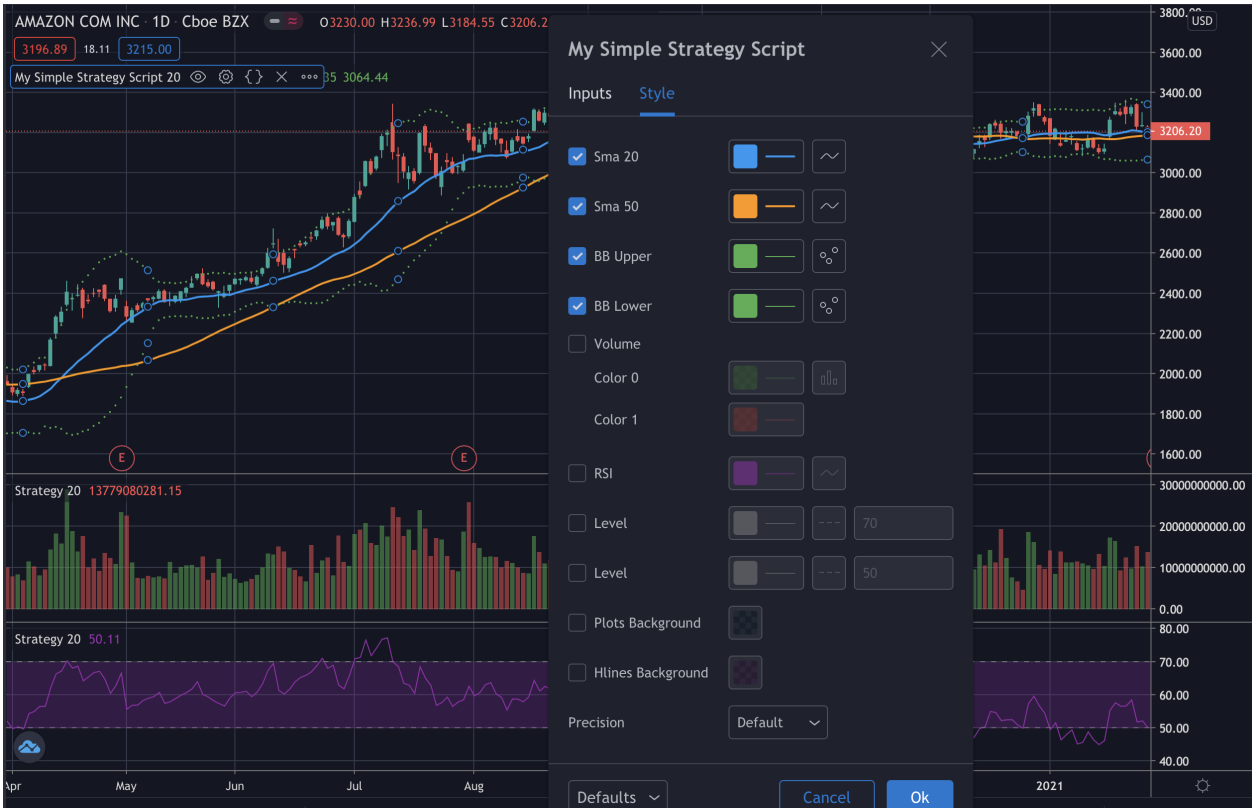

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```
    bar_time1 := time
    bar_rsi1 := _rsi

if time == timestamp(2020, 05, 21, 09, 30)
    bar_high2 := high
    bar_time2 := time
    bar_rsi2 := _rsi

// rsi line
plot(bar_rsi1 == 0 or bar_rsi2 != 0 ? na : _rsi, title="RSI of trend", color=color.
↪orange, linewidth=2)
plot(rsi(close, 20), title="RSI", color=color.purple)
h0 = hline(70)
h1 = hline(50)
fill(h0, h1, color=color.purple, transp=75)

// rsi trend line
if bar_rsi1 != 0 and bar_rsi2 != 0 and showLineRSI
    line.new(bar_time2, bar_rsi2, bar_time1, bar_rsi1, xloc.bar_time, width = 4)
    bar_rsi1 := 0
    bar_rsi2 := 0

// high line
plot(bar_high1 == 0 or bar_high2 != 0 ? na : high, title="High line", color=color.orange,
↪ linewidth=6)
```

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```
// high trend line
if bar_high1 != 0 and bar_high2 != 0 and showLineRSI != true
    line.new(bar_time2, bar_high2, bar_time1, bar_high1, xloc.bar_time, width = 4)
    bar_high1 := 0
    bar_high2 := 0
```

And then you can use the **Settings** and,

- **Style**, for splitting the plots between the main chart and others
- **Input**, for splitting the lines between the main chart and others

In the main chart, for selecting the plots, you can use **Settings** > **Style**

And **Settings** > **Input**, for showing the line on the main chart

Then, in the other chart, for selecting the plots, you can use **Settings** > **Style**


AMAZON COM INC · 1D · Cboe BZX
O2443.20 H2444.88 L2363.00 C2376.00 −34.22 (−1.42%)
3196.89
18.11
3215.00
My Simple Trend Line Script 20
My Simple Trend Line Script
Inputs
Style
Legs
20
ShowLineRSI
Defaults
Cancel
Ok
My Simple Trend Line Script 20 64.73 64.73 2444.88
USD
3554.08
3206.20
2020
Mar
27 Apr '20
Jul
Sep
Nov
2021
Mar


AMAZON COM INC · 1D · Cboe BZX
O2443.20 H2444.88 L2363.00 C2376.00 −34.22 (−1.42%)
3196.89
18.11
3215.00
My Simple Trend Line Script 20
My Simple Trend Line Script
Inputs
Style
Legs
20
ShowLineRSI
Defaults
Cancel
Ok
My Simple Trend Line Script 20 64.73 64.73 2444.88
USD
3549.22
3206.20
2020
Mar
27 Apr '20
Jul
Sep
Nov
2021
Mar

4.5.2 How to load signals on your strategy

The best practice is to prepare one variable for each signal that you want to use on your strategy. The strategy below use the moving averages that they are SMA and EMA. You can use one or the other.

Disclaimer

The strategies below are some simple samples for having an idea how to use the libraries: those strategies are for the educational purpose only. All investments and trading in the stock market involve risk: any decisions related to buying/selling of stocks or other financial instruments should only be made after a thorough research, backtesting, running in demo and seeking a professional assistance if required.

Moving Average Crossover Strategy - Sample 1

- when the price value crosses the MA value from below, it will close any existing short position and go long (buy) one unit of the asset
- when the price value crosses the MA value from above, it will close any existing long position and go short (sell) one unit of the asset

Reference: https://www.learndatasci.com/tutorials/python-finance-part-3-moving-average-trading-strategy/

```
//@version=4
//strategy("My Simple Strategy Script - sample 1") // a chart space dedicated
strategy("My Simple Strategy Script - sample 1", "", true) // in the main chart
```

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```
legs = input(20)
//ma = sma(close, legs)
ma = ema(close, legs)
plot(ma, "Ma", color.orange, 2)
dev = 2 * stdev(close, legs)
upper = ma + dev
lower = ma - dev
p1 = plot(upper, title="BB upper", color=color.green, linewidth=1, style=plot.style_
↪circles)
p2 = plot(lower, title="BB lower", color=color.green, linewidth=1, style=plot.style_
↪circles)
fill(p1, p2)

// Taking the difference between the prices and the MA timeseries
price_ma_diff = close - ma

// Taking the sign of the difference to determine whether the price or the EMA is greater
position = price_ma_diff - price_ma_diff[1]
buyEntry = position >= 2 ? price_ma_diff : na
sellEntry = position <= -2 ? price_ma_diff : na

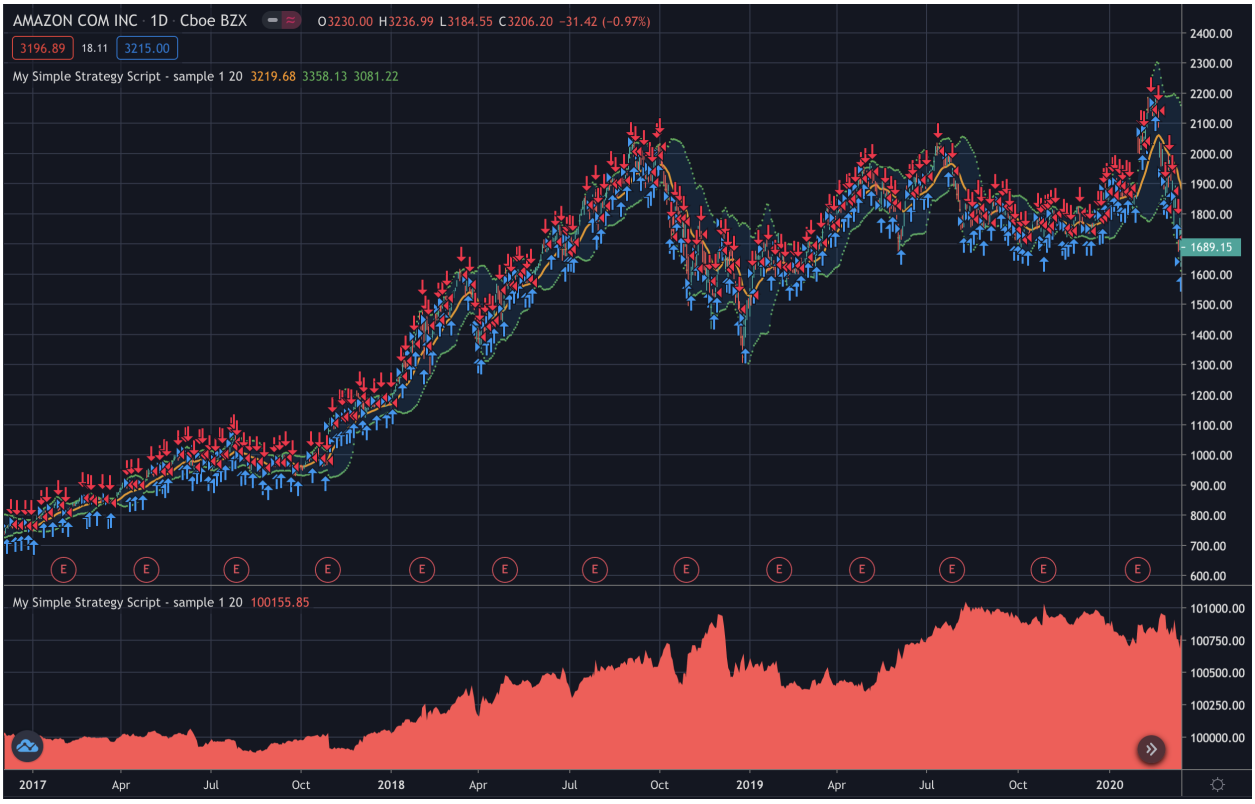
if (buyEntry)
//    strategy.entry("MaLE", strategy.long, stop=lower, oca_name="Ma", oca_type=strategy.
↪oca.cancel, comment="MaLE")
    strategy.entry("MaLE", strategy.long, oca_name="Ma", oca_type=strategy.oca.cancel,␣
↪comment="MaLE")
else
    strategy.cancel(id="MaLE")

if (sellEntry)
//    strategy.entry("MaSE", strategy.short, stop=upper, oca_name="Ma", oca_
↪type=strategy.oca.cancel, comment="MaSE")
    strategy.entry("MaSE", strategy.short, oca_name="Ma", oca_type=strategy.oca.cancel,␣
↪comment="MaSE")
else
    strategy.cancel(id="MaSE")

plot(strategy.equity, title="Equity", color=color.red, linewidth=2, style=plot.style_
↪areabr)
```

When you **Add to Chart** your strategy, the **Strategy Tester** tab will contain the results of your backtesting:

- an **Overview** of the main parameters like **Net Profit** and **Drawdown**
- the **Performance Summary** with all important parameters for defining if your backtesting is good or not
- the **List of Trades** with the details of each trade like **Date**, **Price** and **Profit**


AMAZON COM INC · 1D · Cboe BZX
O3230.00 H3236.99 L3184.55 C3206.20 −31.42 (−0.97%)
3196.89
18.11
3215.00
My Simple Strategy Script - sample 1 20 3219.68 3358.13 3081.22
My Simple Strategy Script - sample 1 20 100155.85
2017
Apr
Jul
Oct
2018
Apr
Jul
Oct
2019
Apr
Jul
Oct
2020


Stock Screener
Text Notes
Pine Editor
Strategy Tester
Trading Panel
My Simple Strategy Script - sample 1
Overview
Performance Summary
List of Trades
$ 179.65
0.18 %
Net Profit
1347
Total Closed Trades
42.09 %
Percent Profitable
1.016
Profit Factor
$ 1172.53
1.16 %
Max Drawdown
$ 0.13
0 %
Avg Trade
5
Avg # Bars in Trades
Drawdown
Equity
Buy & Hold Equity
Absolute

My Simple Strategy Script - sample 1 — Overview | Performance Summary | List of Trades

	All	Long	Short
Net Profit	$ 179.65 0.18 %	$ 1695.50 1.7 %	$ 1515.85 1.52 %
Gross Profit	$ 11395.76 11.4 %	$ 6714.50 6.71 %	$ 4681.26 4.68 %
Gross Loss	$ 11216.11 11.22 %	$ 5019.00 5.02 %	$ 6197.11 6.2 %
Max Drawdown	$ 1172.53 1.16 %		
Buy & Hold Return	$ 17091420.91 17091.42 %		
Sharpe Ratio	2.744		
Profit Factor	1.016	1.338	0.755
Max Contracts Held	1	1	1
Open PL	$ 23.80 0.02 %		
Commission Paid	$ 0	$ 0	$ 0
Total Closed Trades	1347	673	674
Total Open Trades	1	1	0

My Simple Strategy Script - sample 1 — Overview | Performance Summary | List of Trades

Trade #	Type	Signal	Date	Price	Contracts	Profit	Cum. Profit	Run-up	Drawdown
1	Entry Short	MaSE	1998-07-08	18.65	1	$ 4.22 22.63 %	$ 4.22 0 %	$ 2.94 15.77 %	$ 4.70 25.22 %
	Exit Short	MaLE	1998-07-21	22.87					
2	Entry Long	MaLE	1998-07-21	22.87	1	$ 10.18 44.51 %	$ 14.40 0.01 %	$ 1.63 7.13 %	$ 10.18 44.51 %
	Exit Long	MaSE	1998-09-01	12.69					
3	Entry Short	MaSE	1998-09-01	12.69	1	$ 0.72 5.67 %	$ 15.12 0 %	$ 1.86 14.63 %	$ 3.31 26.08 %
	Exit Short	MaLE	1998-09-17	13.41					
4	Entry Long	MaLE	1998-09-17	13.41	1	$ 0.40 2.98 %	$ 14.72 0 %	$ 6.59 49.14 %	$ 0.74 5.54 %
	Exit Long	MaSE	1998-10-08	13.81					
5	Entry Short	MaSE	1998-10-08	13.81	1	$ 11.46 82.98 %	$ 26.18 0.01 %	$ 0.48 3.45 %	$ 11.90 86.16 %
	Exit Short	MaLE	1998-11-18	25.27					
6	Entry Long	MaLE	1998-11-18	25.27	1	$ 3.90 15.43 %	$ 22.28 0 %	$ 3.98 15.75 %	$ 0.02 0.08 %
	Exit Long	MaSE	1998-11-20	29.17					
7	Entry Short	MaSE	1998-11-20	29.17	1	$ 2.64 9.05 %	$ 24.92 0 %	$ 1.67 5.73 %	$ 2.64 9.05 %
	Exit Short	MaLE	1998-11-23	31.81					

Moving Average Crossover Strategy - Sample 2

- when the short term moving average crosses above the long term moving average, this indicates a buy signal
- when the short term moving average crosses below the long term moving average, it may be a good moment to sell

Reference: https://towardsdatascience.com/making-a-trade-call-using-simple-moving-average-sma-crossover-strategy-python-impleme

```
//@version=4
//strategy("My Simple Strategy Script - sample 2") // a chart space dedicated
strategy("My Simple Strategy Script - sample 2", "", true) // in the main chart

ma20 = sma(close, 20)
ma50 = sma(close, 50)
//ma20 = ema(close, 20)
//ma50 = ema(close, 50)
plot(ma20, "Ma20", color.blue, 2)
plot(ma50, "Ma50", color.orange, 2)

buyEntry = crossover(ma20, ma50)
sellEntry = crossunder(ma20, ma50)

if (buyEntry)
    strategy.entry("MaLE", strategy.long, oca_name="Ma", oca_type=strategy.oca.cancel,␣
↪comment="MaLE")
else
    strategy.cancel(id="MaLE")

if (sellEntry)
    strategy.entry("MaSE", strategy.short, oca_name="Ma", oca_type=strategy.oca.cancel,␣
↪comment="MaSE")
else
    strategy.cancel(id="MaSE")

plot(strategy.equity, title="Equity", color=color.red, linewidth=2, style=plot.style_
↪areabr)
```

When you **Add to Chart** your strategy, the **Strategy Tester** tab will contain the results of your backtesting:

- Overview
- Performance Summary
- List of Trades


AMAZON COM INC · 1D · Cboe BZX
O3230.00 H3236.99 L3184.55 C3206.20 −31.42 (−0.97%)
3196.89
18.11
3215.00
My Simple Strategy Script - sample 2 3202.89 3187.48
My Simple Strategy Script - sample 2 100486.84
2017
Apr
Jul
Oct
2018
Apr
Jul
Oct
2019
Apr
Jul
Oct
2020


My Simple Strategy Script - sample 2
Overview
Performance Summary
List of Trades
$ 474.54
0.47 %
Net Profit
125
Total Closed Trades
35.2 %
Percent Profitable
1.207
Profit Factor
$ 1036.82
1.03 %
Max Drawdown
$ 3.80
0 %
Avg Trade
47
Avg # Bars in Trades
Drawdown
Equity
Buy & Hold Equity
Absolute

My Simple Strategy Script - sample 2

Overview | Performance Summary | List of Trades

	All	Long	Short
Net Profit	$ 474.54 0.47 %	$ 1832.02 1.83 %	$ 1357.48 1.36 %
Gross Profit	$ 2770.29 2.77 %	$ 2441.40 2.44 %	$ 328.89 0.33 %
Gross Loss	$ 2295.75 2.3 %	$ 609.38 0.61 %	$ 1686.37 1.69 %
Max Drawdown	$ 1036.82 1.03 %		
Buy & Hold Return	$ 72768181.82 72768.18 %		
Sharpe Ratio	2.23		
Profit Factor	1.207	4.006	0.195
Max Contracts Held	1	1	1
Open PL	$ 12.30 0.01 %		
Commission Paid	$ 0	$ 0	$ 0
Total Closed Trades	125	62	63
Total Open Trades	1	1	0

My Simple Strategy Script - sample 2

Overview | Performance Summary | List of Trades

Trade #	Type	Signal	Date	Price	Contracts	Profit	Cum. Profit	Run-up	Drawdown
1	Entry Short	MaSE	1997-12-04	4.40	1	$ 0.25 5.68 %	$ 0.25 0 %	$ 0.05 1.04 %	$ 0.43 9.85 %
	Exit Short	MaLE	1997-12-12	4.65					
2	Entry Long	MaLE	1997-12-12	4.65	1	$ 2.62 56.34 %	$ 2.37 0 %	$ 3.68 79.21 %	$ 0.50 10.84 %
	Exit Long	MaSE	1998-06-02	7.27					
3	Entry Short	MaSE	1998-06-02	7.27	1	$ 2.65 36.45 %	$ 0.28 0 %	$ 0.40 5.43 %	$ 3.31 45.57 %
	Exit Short	MaLE	1998-06-15	9.92					
4	Entry Long	MaLE	1998-06-15	9.92	1	$ 5.00 50.4 %	$ 4.72 0.01 %	$ 14.58 146.97 %	$ 0.07 0.66 %
	Exit Long	MaSE	1998-09-09	14.92					
5	Entry Short	MaSE	1998-09-09	14.92	1	$ 3.02 20.24 %	$ 1.70 0 %	$ 3.19 21.39 %	$ 5.08 34.05 %
	Exit Short	MaLE	1998-10-22	17.94					
6	Entry Long	MaLE	1998-10-22	17.94	1	$ 29.25 163.04 %	$ 30.95 0.03 %	$ 81.62 454.97 %	$ 0.04 0.25 %
	Exit Long	MaSE	1999-02-19	47.19					
7	Entry Short	MaSE	1999-02-19	47.19	1	$ 23.75 50.33 %	$ 7.20 0.02 %	$ 1.69 3.58 %	$ 24.19 51.25 %
	Exit Short	MaLE	1999-03-19	70.94					

CHAPTER

FIVE

COMPARISON

The comparison is for evaluating which language or system you could use based on:

- maintenance of packages
- learning curve / costs
- performance
- monitoring

In this tutorial, there have been used some languages and systems:

- R
- Python
- Pine
- MQL4

You could know another language or system that it is perfect for your needs. This is only a discussion to highlight key points, bottlenecks and risks.

5.1 Maintenance of packages

5.2 Learning curve / costs

5.3 Performance

5.4 Monitoring

CHAPTER

SIX

CONCLUSION

6.1 Historical data

The samples that you find in this tutorial they use the same **data reader**: Yahoo Finance API.

This is a tutorial, so it is for educational purpose, and it is not important the results. Each historical data contains some differences among others, so it is very important understanding when using which source.

At the beginning, when you test your code, or learn your instruments, you can also use free historical data. In a perfect system, when your QT system will become your demo and your business, you have to use paid historical data of the trading platform where you will do your demo and your business.

Why do you have to use the same historical data of the trading platform where you will do your demo and your business ?

- for avoiding the closing differences or other, that they would completely change the backtesting results
- for being prepared for any issue related to those data that will be used for your business (see the Comparison section for details)

6.2 Analysis

You cannot make backtesting without defining your trading strategy. And you may not use your trading strategy live without analyze the financial historical data by backtesting.

You can use existing indicators and yours for defining **resistence points** and **signals**.

Coming soon.

6.3 Best practice

You can use the command line, an IDE or a (Jupyter) notebook for your favorite language or directly a trading platform console, but the rules below do not change: you have to

- evaluate your data source and to check (*) that your driver is working properly
- test your code by TDD every time that you change it
- check (*) your algorithm and its parameters by your backtesting system
- evaluate the hosting where you run your QT system and to check (*) that your QT system did not reach its limits
- define when your QT system does not have to work

(*) it would be great if each check can run to warn you with a channel you follow about

- information of the next release of your driver, your hosting, .. or your trading platform
- your algorithm performance

At the beginning, the checks can be executed with a wide cadence, until you find how often each check should be performed according to your expectations. In a perfect system, when your QT system will become your business, the checks will be executed continuously or with a tight cadence.

Coming soon # mql4/index