Bollinger Bands strategy Backtest

Introduction

This Python program is designed to backtest a technical analysis based algorithmic trading strategy.

The strategy

The Bollinger Bands strategy is a technical analysis tool used to identify overbought and oversold conditions in the market. It involves calculating three lines: a simple moving average (SMA, 20 days in our example) of the stock price, an upper band set at 2 standard deviations above the SMA, and a lower band set at 2 standard deviations below. Signals are the following:

BUY when the price crosses the lower band from the top. Hold until it crosses the upper band from below. SELL when the price crosses the upper band from below. Hold until it crosses the lower band from the top.

This strategy leverages mean reversion, expecting prices to revert back to the mean (SMA) over time.

I. Libraries

In [ ]:
```
import warnings
warnings.filterwarnings('ignore')

# libraries
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import yfinance as yf
import pyfolio as pf
import datetime as dt
```

II Download OHLCV (Open High Low Close Volume) data

using Yahoo Finance python api

We are focusing on the Tesla stock between 2018 and 2023.

In [ ]:
```
# data downloading using yfinance
_start = dt.date(2018,1,1)
_end = dt.date(2023,12,30)
ticker = 'TSLA'
df = yf.download(ticker, start = _start, end = _end)
```

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

III. Calculate buy and hold returns

Our backtest compares our strategy returns with the buy and hold strategy. We introduce a column consisting of daily buy and hold returns for Tesla stocks.

In [ ]:
```
# introducing bnh strategy returns
df['buy and hold return'] = np.log(df['Adj Close']/df['Adj Close'].shift(1))
df.tail(5)
```

Out[ ]:

Date	Open	High	Low	Close	Adj Close	Volume	buy and hold return
2023-12-22	256.760010	258.220001	251.369995	252.539993	252.539993	93249800	-0.007731
2023-12-26	254.490005	257.970001	252.910004	256.609985	256.609985	86892400	0.015988
2023-12-27	258.350006	263.339996	257.519989	261.440002	261.440002	106494400	0.018647
2023-12-28	263.660004	265.130005	252.710007	253.179993	253.179993	113619900	-0.032104
2023-12-29	255.100006	255.190002	247.429993	248.479996	248.479996	100615300	-0.018738

IV. Create Bollinger Bands

We calculate the 20-day moving average, the standard deviation of the 20-day moving average, the upper band (ma+2sdev) and the lower band (ma-2sdev) of the standard deviation.

In [ ]:
```
# 20-day Moving Average
df['20d ma'] = df['Adj Close'].rolling(window=20).mean()
# 20-day Moving Average Standard Deviation
df['20d sdev'] = df['Adj Close'].rolling(window=20).std()
# Upper Band
df['upper band'] = df['20d ma'] + (2 * df['20d sdev'])
# Lower Band
df['lower band'] = df['20d ma'] - (2 * df['20d sdev'])
df.drop(['Open','High','Low'],axis=1,inplace=True,errors='ignore')
df.tail(5)
```

Out[ ]:

Date	Close	Adj Close	Volume	buy and hold return	20d ma	20d sdev	upper band	lower band
2023-12-22	252.539993	252.539993	93249800	-0.007731	244.503500	6.849882	258.203263	230.803736
2023-12-26	256.609985	256.609985	86892400	0.015988	245.529999	7.056294	259.642586	231.417411
2023-12-27	261.440002	261.440002	106494400	0.018647	246.265999	7.903738	262.073476	230.458522
2023-12-28	253.179993	253.179993	113619900	-0.032104	246.717999	8.033187	262.784373	230.651624

2023-12-29	248.479996	248.479996	100615300	-0.018738	247.137998	7.886109	262.910216	231.365780

V. Create strategy indicators

Buy and Sell condtions are defined according to the Bollinger Band strategy:

BUY when the price crosses the lower band from the top. Hold until it crosses the upper band from below. SELL when the price crosses the upper band from below. Hold until it crosses the lower band from the top.

The 'signal' column is forward filled to create long and short positions. Strategy returns are reported in the 'strat reurn' column.

In [ ]:
```
# defining the buy and sell conditions
buy_condition = (df['Adj Close'] < df['lower band']) & (df['Adj Close'].shift(1) >= df['lower band'])
sell_condition = (df['Adj Close'] > df['upper band']) & (df['Adj Close'].shift(1) <= df['upper band'])

# initializing 'signal' column, and setting buy and sell signals
df['signal'] = 0
df.loc[buy_condition, 'signal'] = 1
df.loc[sell_condition, 'signal'] = -1

# creating long and short positions by forward filling the 'signal' column
df['position'] = df['signal'].replace(to_replace=0, method='ffill')

# shifting by 1 to account for close price return calculations
df['position'] = df['position'].shift(1)

# calculating strategy returns
df['strat return'] = df['buy and hold return'] * (df['position'])

df.tail(5)
```

Out[ ]:

Date	Close	Adj Close	Volume	buy and hold return	20d ma	20d sdev	upper band	lower band	signal	position	strat return
2023-12-22	252.539993	252.539993	93249800	-0.007731	244.503500	6.849882	258.203263	230.803736	0	-1.0	0.007731
2023-12-26	256.609985	256.609985	86892400	0.015988	245.529999	7.056294	259.642586	231.417411	0	-1.0	-0.015988
2023-12-27	261.440002	261.440002	106494400	0.018647	246.265999	7.903738	262.073476	230.458522	0	-1.0	-0.018647
2023-12-28	253.179993	253.179993	113619900	-0.032104	246.717999	8.033187	262.784373	230.651624	0	-1.0	0.032104
2023-12-29	248.479996	248.479996	100615300	-0.018738	247.137998	7.886109	262.910216	231.365780	0	-1.0	0.018738

VI. Cumulative Returns

Long/short positions are combined with TSLA daily returns to generate strategy cumulative returns. Observing graph, we identify a possible negative correlation between buy and hold and strategy returns.

In [ ]:
```
# comparing buy & hold strategy / bollinger bands strategy returns
print("Buy and hold return:",df['buy and hold return'].cumsum()[-1])
print("Strategy return:",df['strat return'].cumsum()[-1])

# strategy historical performance plotting
df[['buy and hold return','strat return']] = df[['buy and hold return','strat return']].cumsum()
df[['buy and hold return','strat return']].plot(grid=True, figsize=(12, 8))
```

```
Buy and hold return: 2.4534366237874026
Strategy return: -1.3799988505227194
```

Out[ ]: <Axes: xlabel='Date'>

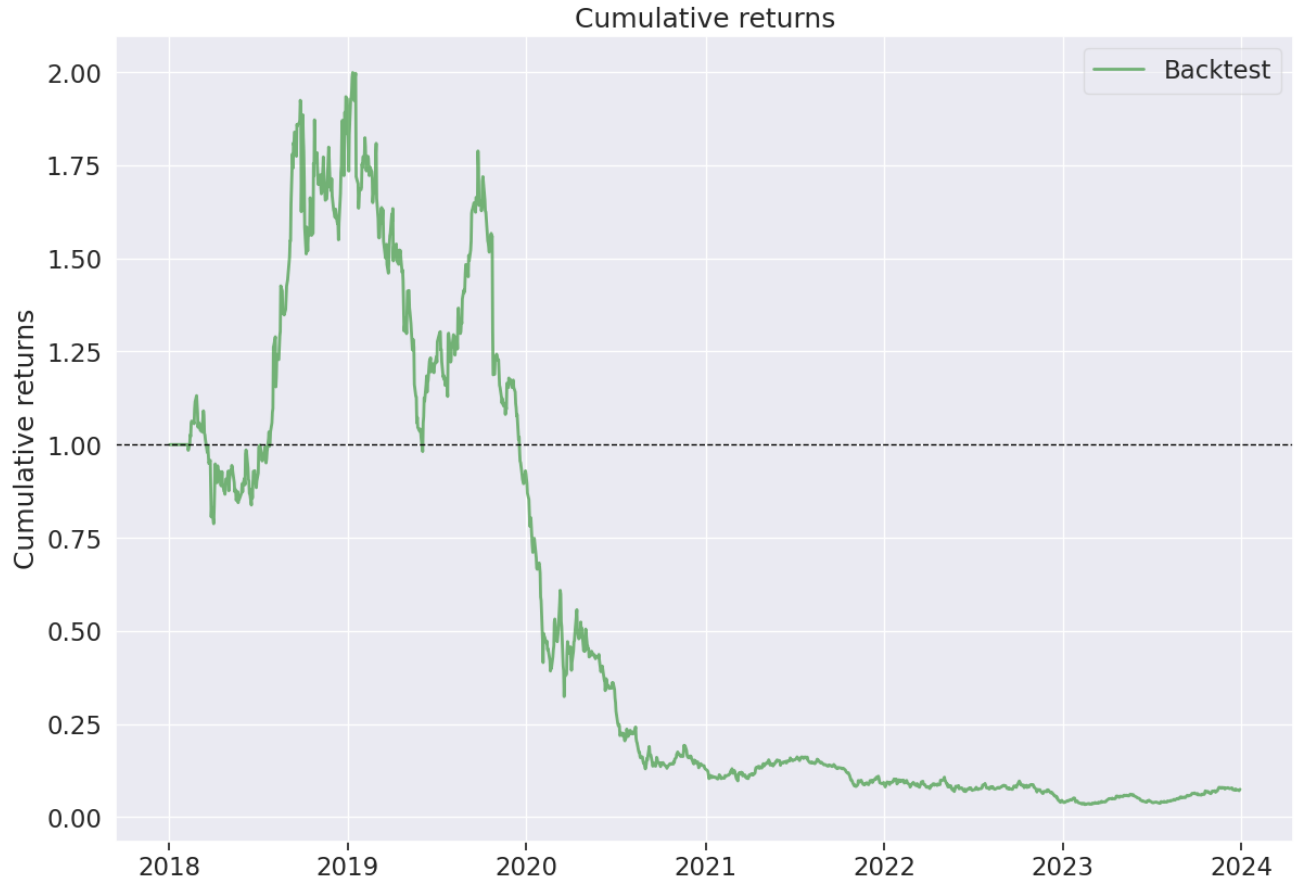
VII Analysis

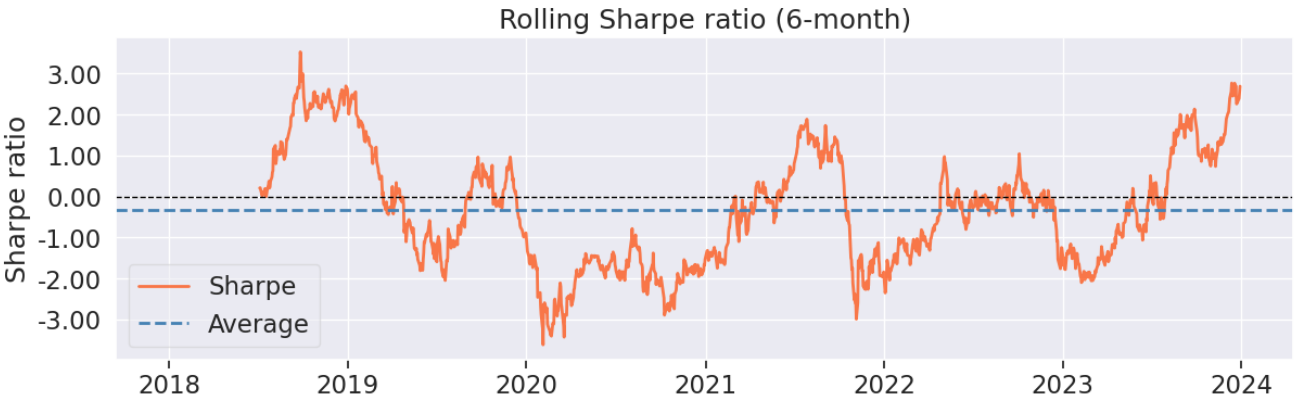
We use the pyfolio library for performance and risk analysis of the strategy returns.

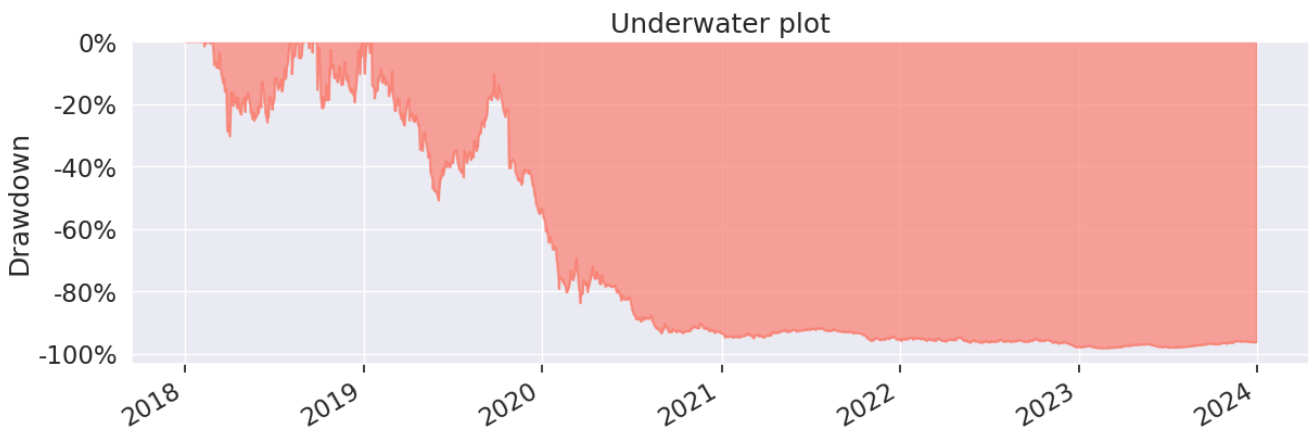
In [ ]:
```
pf.create_simple_tear_sheet(df['strat return'].diff())
```

Start date	2018-01-02
End date	2023-12-29
Total months	71

	Backtest
Annual return	-35.126%
Cumulative returns	-92.507%
Annual volatility	63.503%
Sharpe ratio	-0.36
Calmar ratio	-0.36
Stability	0.87
Max drawdown	-98.304%
Omega ratio	0.94
Sortino ratio	-0.51
Skew	NaN
Kurtosis	NaN
Tail ratio	0.91
Daily value at risk	-8.092%







Conclusion

On the long run, the Bollinger band strategy on the historical data underperformed the buy & hold strategy. It displayed extremely poor cumulative returns (-92.507%) with high annual volatility (63.503%), and a max drawdown of -98.304%. One possible explanation is that selling a stock when it appears to be 'overbought' is not a reliable strategy as it goingon a crazy surge like TSLA did from late 2019 to late 2021.

However, as the stock was struggling to generate positive returns between 2018 and late 2019, the strategy overperformed. A less volatile stock price seems to be a better environment to implement a Bollinger band strategy.