Algorithmic Trading: Winning or Losing

I collect returns data for test assets (which Miscrosoft "MSFT") for the calendar year 2022 to develop algorithmic trading system. I have developed 3 different trading systems such as Bollinger bands strategy, Day-trading strategy, and MACD strategy and then backtested these trading programs on my test data.

Initially, I created a data frame presenting daily trading fundamentals such as open, high, low, close, adjusted close, and volume for MSFT and calculated buy-hold returns on a daily basis for the whole calendar year 2022. A snapshot of the findings is presented below –

Date	Open	High	Low	Close	Adj Close	Volume	bnh_returns
2022-01-03	500.000000	502.899994	493.049988	502.279999	495.928772	3033600	NaN
2022-01-04	503.200012	503.750000	490.880005	490.899994	484.692657	3908100	-0.022917
2022-01-05	494.769989	497.000000	489.690002	489.690002	483.497986	3921100	-0.025385
2022-01-06	480.000000	484.140015	463.119995	469.649994	463.711365	6555200	-0.067170
2022-01-07	467.690002	467.970001	455.549988	458.600006	452.801086	5494200	-0.090979
...	...	...	...	...	...	...	...
2022-12-23	524.099976	531.309998	522.900024	531.309998	531.309998	1292300	0.068913
2022-12-27	533.929993	535.840027	529.849976	531.989990	531.989990	1596700	0.070192
2022-12-28	535.070007	538.150024	527.729980	528.450012	528.450012	1694200	0.063516
2022-12-29	532.539978	533.679993	528.859985	529.880005	529.880005	1379700	0.066218
2022-12-30	530.000000	530.500000	524.840027	530.179993	530.179993	1849300	0.066784

Algorithmic trading system 1: Bollinger band strategy

Then, I calculated a 20-day moving average, standard deviation of daily returns, upper band, and lower band to generate buy-and-sell signal, buy-and-sell positions, and Bollinger band strategy returns. A snapshot of the updated data frame for last 5 trading days is shown below –

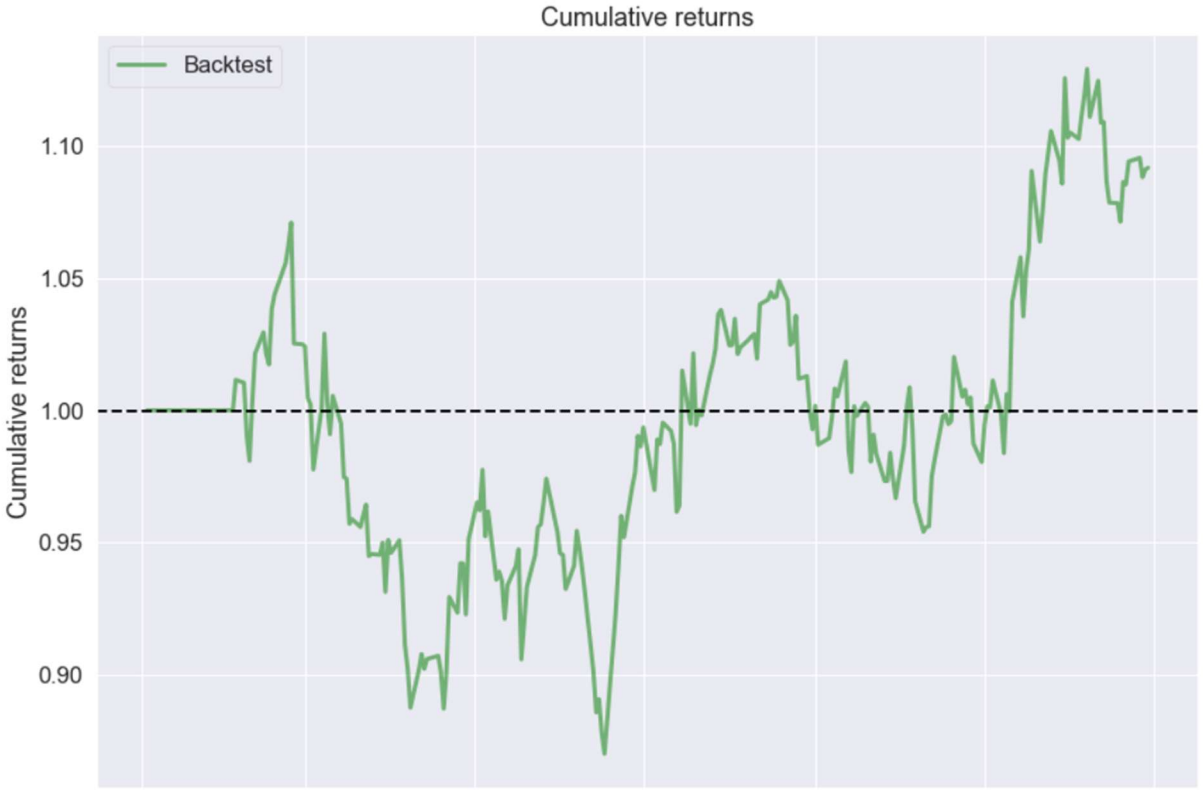
Date	Open	High	Low	Close	Adj Close	Volume	bnh_returns	ma20	std	upper_band	lower_band
2022-12-23	524.099976	531.309998	522.900024	531.309998	531.309998	1292300	0.007974	534.123407	8.173620	550.470646	517.776168
2022-12-27	533.929993	535.840027	529.849976	531.989990	531.989990	1596700	0.001279	534.191193	8.148744	550.488681	517.893704
2022-12-28	535.070007	538.150024	527.729980	528.450012	528.450012	1694200	-0.006676	534.294824	8.056803	550.408429	518.181219
2022-12-29	532.539978	533.679993	528.859985	529.880005	529.880005	1379700	0.002702	533.484991	7.611942	548.708876	518.261107
2022-12-30	530.000000	530.500000	524.840027	530.179993	530.179993	1849300	0.000566	533.230994	7.634320	548.499633	517.962354

Bollinger Bands Strategy Returns: Cumulative returns, Rolling Sharpe Ratio, Underwater Plot

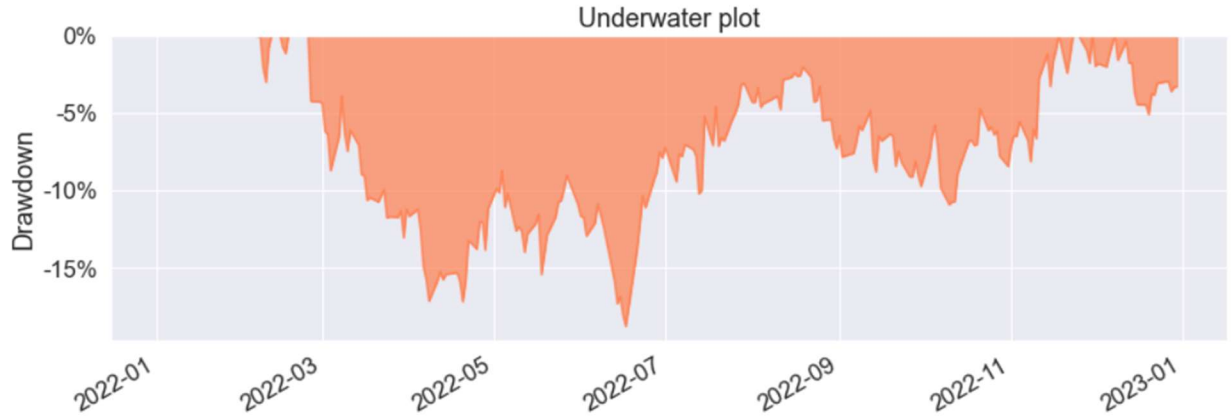
Start date	2022-01-03
End date	2022-12-30
Total months	11
	Backtest
Annual return	9.2%
Cumulative returns	9.2%
Annual volatility	23.3%
Sharpe ratio	0.50
Calmar ratio	0.49
Stability	0.24
Max drawdown	-18.7%
Omega ratio	1.09
Sortino ratio	0.73
Skew	NaN
Kurtosis	NaN
Tail ratio	0.95
Daily value at risk	-2.9%

I observe that it takes nearly 3-5 seconds to compute a buy/sell decision under this strategy. Let's summarize the findings from backtesting the Bollinger bands strategy returns –

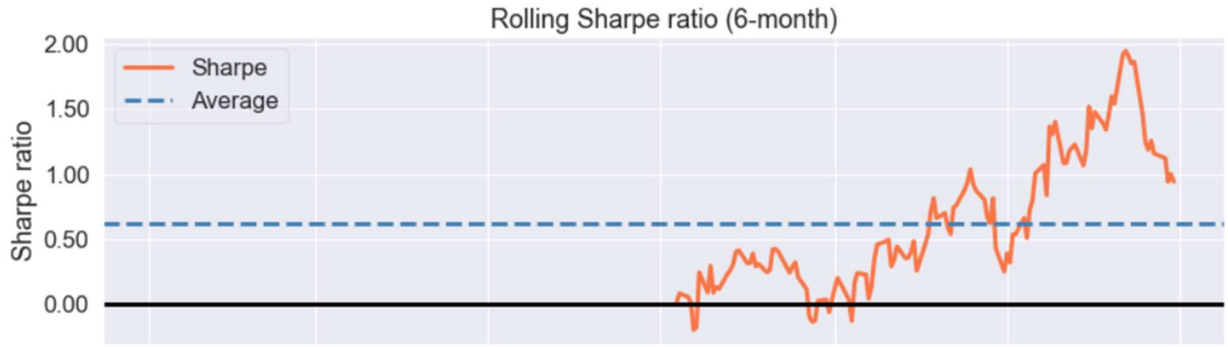
Cumulative returns: The cumulative returns for this strategy is actually the annual return as we observe the returns for the calendar year 2022. The cumulative return of this strategy is 9.2%.



Monthly returns: On average, this strategy generates 0.77% return in each month. Therefore, this trading strategy yields a return that is significantly different from 0.



Maximum drawdown: A maximum drawdown (MDD) is the maximum observed loss from a peak to a trough of a portfolio, before a new peak is attained. For this strategy, the maximum drawdown is 18.7%.



Sharpe ratio: The Sharpe ratio determines the total-risk adjusted excess return ratio. This strategy has a Sharpe ratio of 0.5. Therefore, the strategy generates 0.5 unit of excess return for each unit of total risk.

Algorithmic trading system 2: Day-trading strategy

I updated the data frame by generating buy-and-sell signal, buy-and-sell positions, and strategy returns for day-trading strategy. A snapshot of the updated data frame for last 5 trading days is shown below –

Date	Open	High	Low	Close	Adj Close	Volume	bnh_returns	ma20	std	upper_band	lower_band
2022-12-23	524.099976	531.309998	522.900024	531.309998	531.309998	1292300	0.007974	534.123407	8.173620	550.470646	517.776168
2022-12-27	533.929993	535.840027	529.849976	531.989990	531.989990	1596700	0.001279	534.191193	8.148744	550.488681	517.893704
2022-12-28	535.070007	538.150024	527.729980	528.450012	528.450012	1694200	-0.006676	534.294824	8.056803	550.408429	518.181219
2022-12-29	532.539978	533.679993	528.859985	529.880005	529.880005	1379700	0.002702	533.484991	7.611942	548.708876	518.261107
2022-12-30	530.000000	530.500000	524.840027	530.179993	530.179993	1849300	0.000566	533.230994	7.634320	548.499633	517.962354

Volume	bnh_returns	ma20	std	upper_band	lower_band	bb_signal	bb_position	bb_strategy_returns	dt_signal	dt_position	dt_strategy_returns
1292300	0.007974	534.123407	8.173620	550.470646	517.776168	0	1.0	0.007974	0	-1.0	-0.007974
1596700	0.001279	534.191193	8.148744	550.488681	517.893704	0	1.0	0.001279	0	-1.0	-0.001279
1694200	-0.006676	534.294824	8.056803	550.408429	518.181219	0	1.0	-0.006676	0	-1.0	0.006676
1379700	0.002702	533.484991	7.611942	548.708876	518.261107	0	1.0	0.002702	0	-1.0	-0.002702
1849300	0.000566	533.230994	7.634320	548.499633	517.962354	0	1.0	0.000566	0	-1.0	-0.000566

Day-trading Strategy Returns: Cumulative returns, Rolling Sharpe Ratio, Underwater Plot

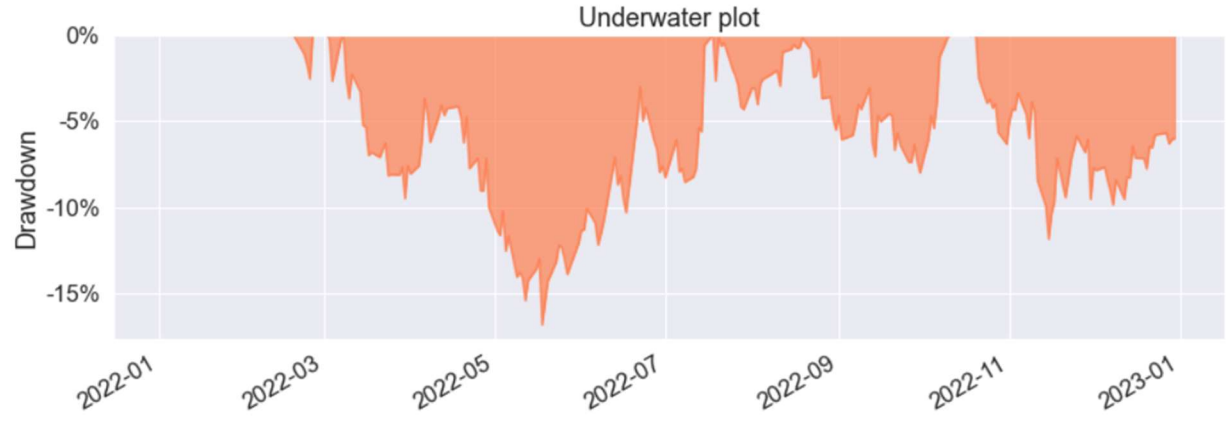
Start date	2022-01-03
End date	2022-12-30
Total months	11

	Backtest
Annual return	5.9%
Cumulative returns	5.9%
Annual volatility	22.9%
Sharpe ratio	0.37
Calmar ratio	0.35
Stability	0.27
Max drawdown	-16.8%
Omega ratio	1.07
Sortino ratio	0.54
Skew	NaN
Kurtosis	NaN
Tail ratio	0.98
Daily value at risk	-2.9%

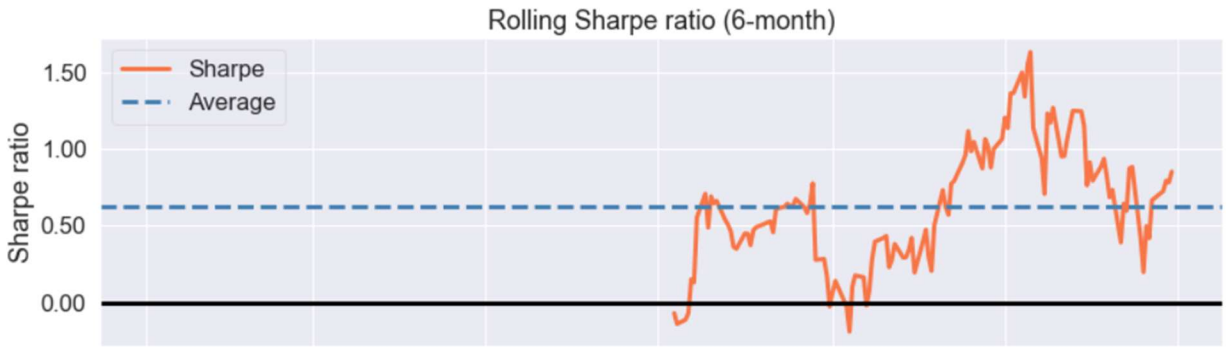
I observe that it takes nearly 3-5 seconds to compute a buy/sell decision under this strategy. Let's summarize the findings from backtesting the day-trading strategy returns –

Cumulative returns: The cumulative returns for this strategy is actually the annual return as we observe the returns for the calendar year 2022. The cumulative return of this strategy is 5.9%.

Monthly returns: On average, this strategy generates 0.49% return in each month. Therefore, this trading strategy yields a return that is significantly different from 0.



Maximum drawdown: A maximum drawdown (MDD) is the maximum observed loss from a peak to a trough of a portfolio, before a new peak is attained. For this strategy, the maximum drawdown is 16.8%.



Sharpe ratio: The Sharpe ratio determines the total-risk adjusted excess return ratio. This strategy has a Sharpe ratio of 0.37. Therefore, the strategy generates 0.37 unit of excess return for each unit of total risk.

Algorithmic trading system 3: Moving-average Convergence Divergence (MACD) strategy

I updated the data frame by generating buy-and-sell signal, buy-and-sell positions, and strategy returns for day-trading strategy. A snapshot of the updated data frame for last 5 trading days is shown below –

Date	Open	High	Low	Close	Adj Close	Volume	bnh_returns	ma20	std	upper_band	lower_band
2022-12-23	524.099976	531.309998	522.900024	531.309998	531.309998	1292300	0.007974	534.123407	8.173620	550.470646	517.776168
2022-12-27	533.929993	535.840027	529.849976	531.989990	531.989990	1596700	0.001279	534.191193	8.148744	550.488681	517.893704
2022-12-28	535.070007	538.150024	527.729980	528.450012	528.450012	1694200	-0.006676	534.294824	8.056803	550.408429	518.181219
2022-12-29	532.539978	533.679993	528.859985	529.880005	529.880005	1379700	0.002702	533.484991	7.611942	548.708876	518.261107
2022-12-30	530.000000	530.500000	524.840027	530.179993	530.179993	1849300	0.000566	533.230994	7.634320	548.499633	517.962354

r_band	lower_band	bb_signal	bb_position	bb_strategy_returns	dt_signal	dt_position	dt_strategy_returns	macd_signal	macd_position	macd_strategy_returns
470646	517.776168	0	1.0	0.007974	0	-1.0	-0.007974	1	1.0	0.007974
488681	517.893704	0	1.0	0.001279	0	-1.0	-0.001279	1	1.0	0.001279
408429	518.181219	0	1.0	-0.006676	0	-1.0	0.006676	1	1.0	-0.006676
708876	518.261107	0	1.0	0.002702	0	-1.0	-0.002702	1	1.0	0.002702
499633	517.962354	0	1.0	0.000566	0	-1.0	-0.000566	1	1.0	0.000566

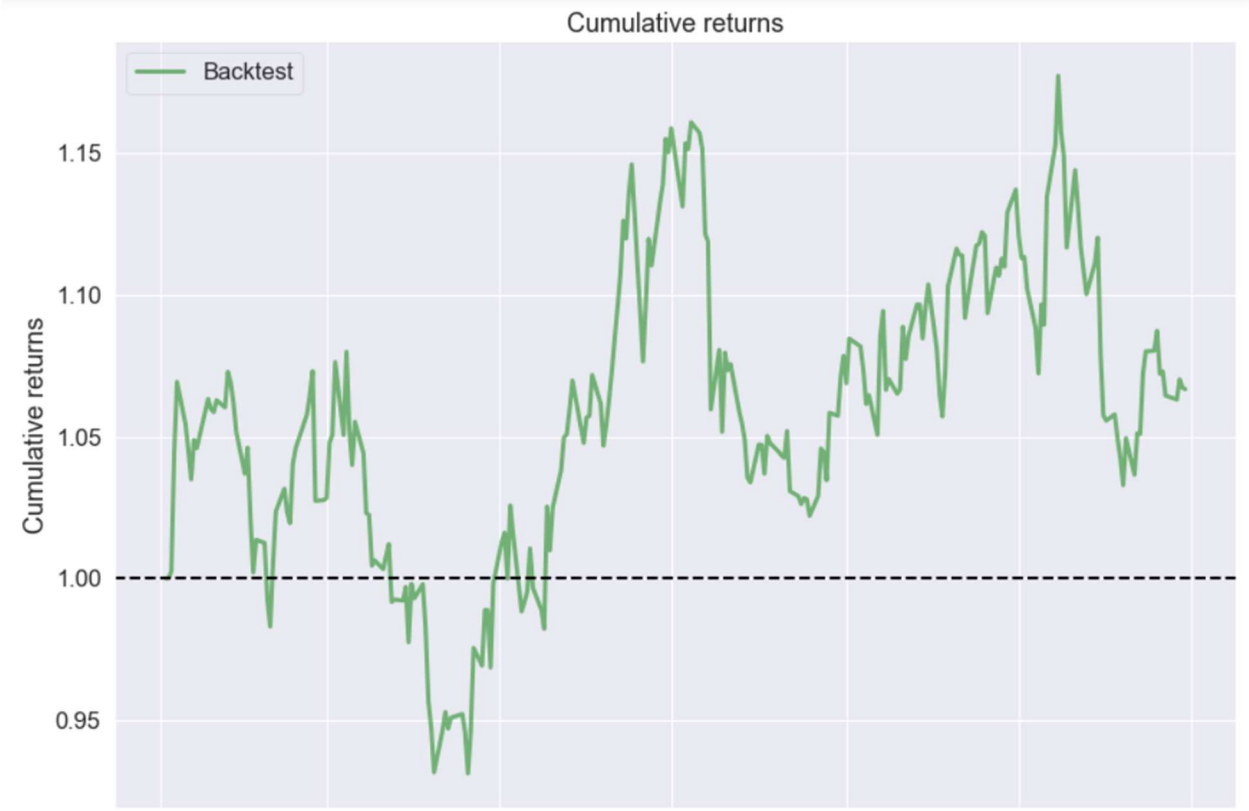
MACD Strategy Returns: Cumulative returns, Rolling Sharpe Ratio, Underwater Plot

Start date	2022-01-03
End date	2022-12-30
Total months	11

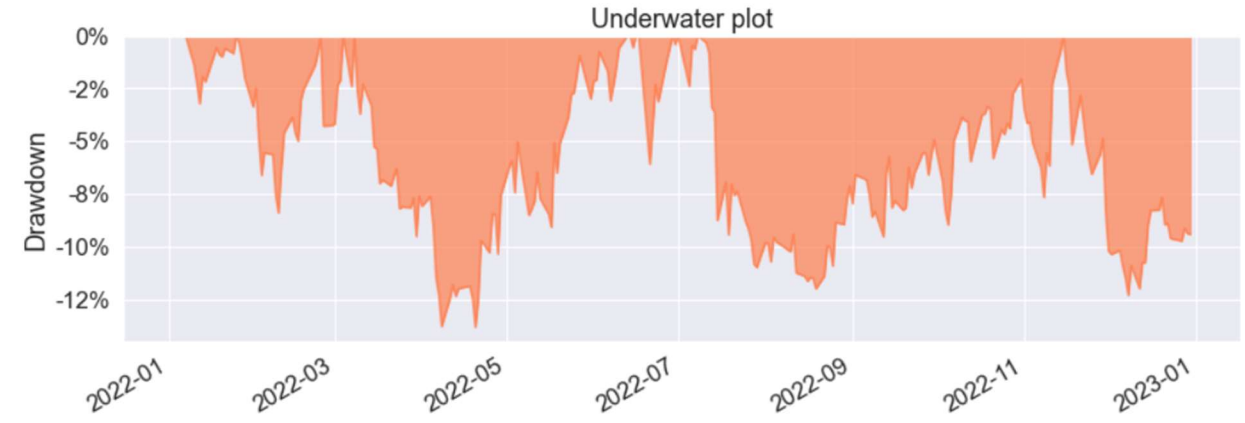
	Backtest
Annual return	6.7%
Cumulative returns	6.7%
Annual volatility	24.3%
Sharpe ratio	0.39
Calmar ratio	0.49
Stability	0.27
Max drawdown	-13.8%
Omega ratio	1.07
Sortino ratio	0.55
Skew	NaN
Kurtosis	NaN
Tail ratio	1.01
Daily value at risk	-3.0%

I observe that it takes nearly 3-5 seconds to compute a buy/sell decision under this strategy. Let's summarize the findings from backtesting the MACD strategy returns –

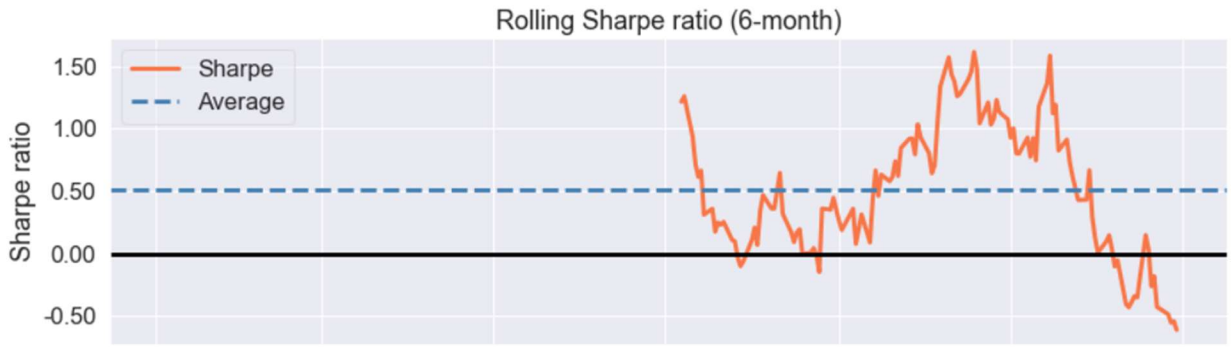
Cumulative returns: The cumulative returns for this strategy is actually the annual return as we observe the returns for the calendar year 2022. The cumulative return of this strategy is 6.7%.



Monthly returns: On average, this strategy generates 0.56% return in each month. Therefore, this trading strategy yields a return that is significantly different from 0.



Maximum drawdown: A maximum drawdown (MDD) is the maximum observed loss from a peak to a trough of a portfolio, before a new peak is attained. For this strategy, the maximum drawdown is 13.8%.



Sharpe ratio: The Sharpe ratio determines the total-risk adjusted excess return ratio. This strategy has a Sharpe ratio of 0.39. Therefore, the strategy generates 0.39 unit of excess return for each unit of total risk.

Do the strategies outperform the buy-and-hold strategy?

To answer this question, let's compare the cumulative returns of respective strategies -

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Buy and hold returns: 6.7 %
Bollinger bands strategy returns: 11.4 %
Day-trading strategy returns: 9.4 %
MACD strategy returns: 8.3 %
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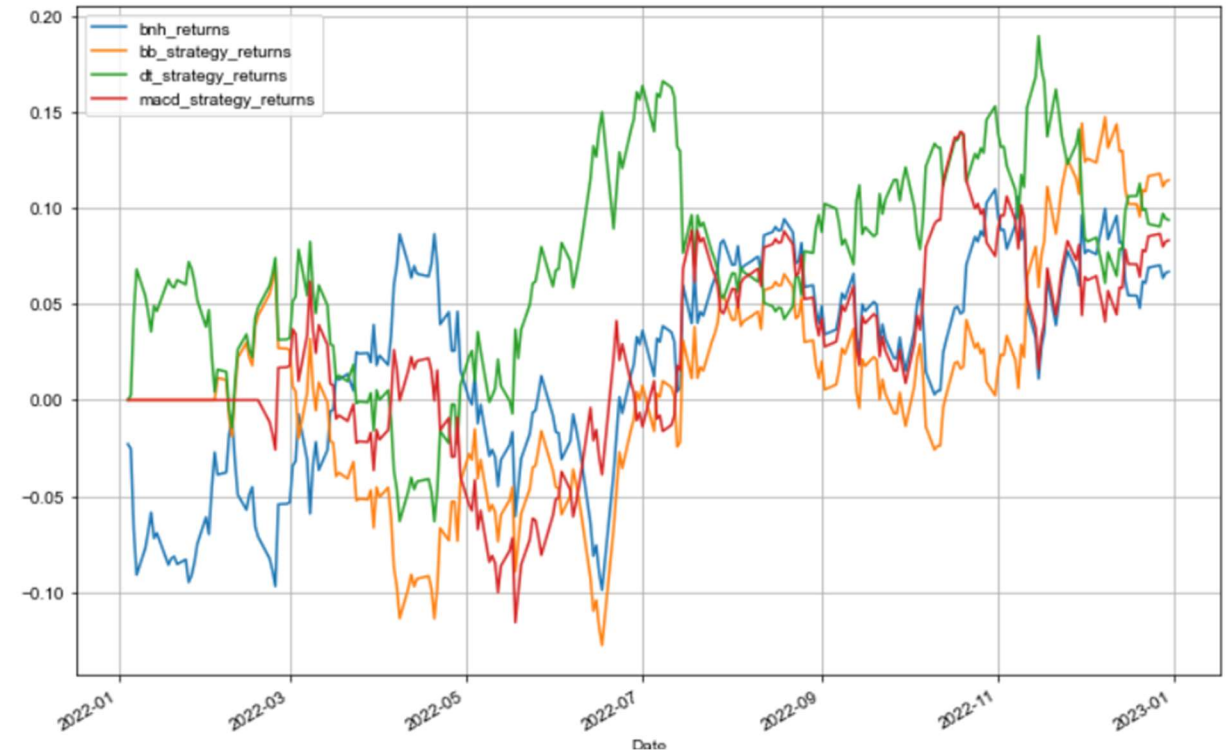

I observe that all three algorithm trading strategies outperform the buy-and-hold strategy that generates 6.7% returns, while the Bollinger-bands strategies generates 11.4%, the day-traders generate 9.4%, and the MACD strategists generate 8.3%.