Financial Modeling and Quantitative Analysis Bot

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Introduction:

The premise and purpose of this project to encompass advanced quantitative analysis techniques and seamless API integration. This project aims to deliver a fully automated trading solution while adhering to budget constraints. The project showcases a comprehensive array of features and methodologies, leveraging Python and relevant libraries to create a powerful and efficient trading system.

Data Extraction and Analysis:

The project incorporates robust data extraction mechanisms utilizing APIs and web scraping techniques to ensure the acquisition of accurate and up-to-date information. The Automated Trading Bot adeptly extracts both daily and intraday data from diverse sources. Additionally, the project seamlessly integrates with JSON data, a prevalent format for financial data exchange, facilitating smooth integration with the trading strategies.

There are several ways to extract financial stock data for analysis and trading purposes. One approach is to utilize libraries like yfinance, which provides a simple and convenient interface to access historical and real-time stock data directly within Python. Another option is to leverage APIs such as AlphaVantage, which offers a wide range of financial market data, including historical prices, technical indicators, and fundamental data. By integrating with the AlphaVantage API, users can programmatically retrieve the desired information. Additionally, web scraping techniques can be employed to extract data from financial websites and platforms. Through web scraping, relevant data points such as stock prices, company information, and financial statements can be retrieved and incorporated into trading systems or quantitative analysis. Each of these methods offers unique advantages, and their suitability depends on specific requirements and the availability of data from different sources.

Figure 1: Example data frame showing the output after asset data is queried, extracted, and locally stored to be further processed.

Visualization and Performance Measurement:

The project recognizes the significance of visualizing and measuring the performance of trading strategies. Advanced visualization techniques for time series data have been meticulously developed, enabling intuitive insights into market trends. Moreover, comprehensive metrics and evaluation methods have been incorporated to accurately assess the performance of the trading strategies. These are conducted in Python through core data analysis libraries Pandas, Numpy, and Matplotlib. For the scope of this project, all indicators and

investing strategies are based on the Dow Jones Industrial Average 30 of the most prominent stocks in the United States market as of early June 2023.
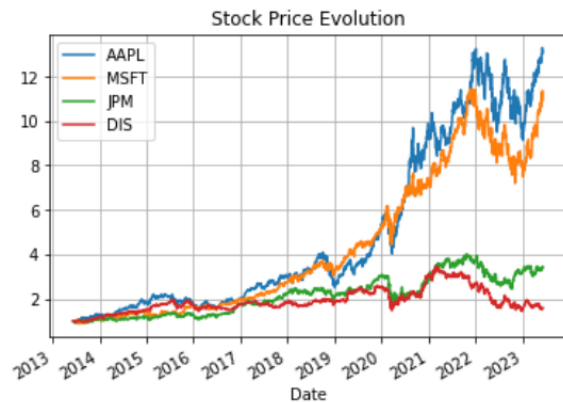

Figure 2: Four test stocks from the DOW 30 dataset are queried and plotted to show relative growth in value by a constant multiplier. Notice the dating of the stock and recognize the amount of information being queried and graphically optimized.
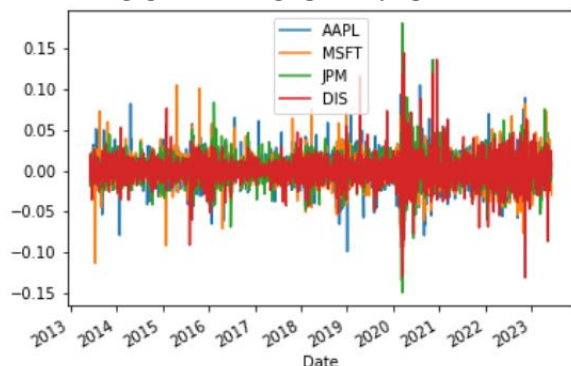

Figure 3: Four test stocks from the DOW 30 dataset are queried and plotted to show volatility as a decimal which can be translated to a percent increase or decrease. Recognize the need for both value and volatility data to conduct analysis further on.

Technical and Key Performance Indicators:

Advanced quantitative analysis techniques have been incorporated into the Automated Trading Bot to evaluate market conditions and make informed trading decisions. The project showcases the integration of an extensive range of technical indicators using Python, enabling the identification of trends, patterns, and signals to exploit potential trading opportunities. This sophisticated analysis framework serves as the cornerstone of the trading strategies. The compilation of key technical and key performance indicators utilized in this program are as follows.

Key Performance Indicators (KPIs) are essential metrics used in financial analysis to evaluate the performance and risk of investments. They provide valuable insights into various aspects of investment returns and volatility. Some important KPIs include Compound Annual Growth Rate (CAGR), which measures the average annual growth rate of an investment over a specific period, Max Drawdown and Calmar Ratio (Max_DD_Calmar), which assesses the maximum loss experienced and compares it to the average annual return, Sharpe-Sortino, which evaluates risk-adjusted returns, and Volatility, which quantifies the degree of variation or fluctuation in a stock or investment price. These KPIs play a crucial role in assessing the historical performance, risk, and potential returns of investment strategies, aiding in decision-making and portfolio management.

Technical indicators are tools used in financial analysis to interpret price trends, market conditions, and potential trading opportunities. They assist traders and investors in making informed decisions. Some widely used technical indicators include Average Directional Index (ADX), which measures the strength and direction of a trend, Average True Range (ATR), which assesses volatility, Bollinger Bands (BLNR_BND), used to identify potential price levels, Moving Average Convergence

Divergence (MACD), a trend-following momentum indicator, Renko charts, a charting technique based on fixed price movements, and Relative Strength Index (RSI), which indicates overbought or oversold conditions. These technical indicators provide valuable insights into market dynamics, price patterns, and potential entry or exit points, assisting traders in identifying favorable trading conditions and optimizing their investment strategies.

Fundamental Analysis and Value Investing:

In conjunction with technical analysis, the project implements a thorough quantitative analysis of fundamental data to assess the intrinsic value of financial assets and facilitate the implementation of value-investing strategies programmatically. By leveraging quantitative methods, the project ensures well-informed investment decisions, enhancing the performance and stability of the Automated Trading Bot.

Value investing is an investment philosophy that focuses on selecting undervalued stocks based on their solid financial and operational metrics. Value investors conduct rigorous analysis of a company's fundamentals and aim to buy stocks at a discounted price compared to their intrinsic value. This strategy emphasizes the concept that price is what you pay, while value is what you get. A popular approach within value investing is Joel Greenblatt's Magic Formula. It involves quantifying the "wonderful price" of stocks using the metric Return on Invested Capital (ROIC), excluding excess cash and interest-bearing assets. The formula ranks stocks based on their Earnings Yield and ROIC, and investors invest in the top-ranking 20-30 companies, excluding finance and insurance

sectors. The portfolio is rebalanced once a year, accumulating 2-3 positions per month over a 12-month period.

The Piotroski F-Score is a scoring system used to assess the financial strength of companies, ranging from 0 to 9 (9 being the best). This strategy focuses on specific criteria across different categories. For profitability, the company should have a positive return on assets, positive operating cash flow, an increase in return on assets compared to the previous year, and positive cash flow from operations divided by total assets. In terms of leverage, liquidity, and source of funds, lower long-term debt, a higher current ratio, and no new share issuances are favorable. Operating efficiency criteria include a higher gross margin and higher asset turnover ratio compared to the previous year. Stocks with scores of 8-9 are preferred, and the portfolio is rebalanced every 6 months to a year. This strategy has shown promising results, particularly in mid-cap and small-cap stocks.

Both value investing strategies aim to identify fundamentally strong companies trading at attractive prices. Greenblatt's Magic Formula strategy focuses on overall valuation, while the Piotroski F-Score strategy evaluates the financial strength and efficiency of companies. These strategies provide investors with systematic approaches to selecting stocks and can help in making informed investment decisions. In the implementation, we query the necessary information respective to each trading strategy and decipher the highest yield-producing asset based on presented data.

Strategy Backtesting and Automation:

To validate the effectiveness of the trading strategies, the project features a robust

backtesting framework. This facilitates simulating and evaluating the strategies' performance using historical data. Through meticulous backtesting, the project ensures the strategies' reliability and optimizes them for real-world trading scenarios. Additionally, the Automated Trading Bot is fully automated, seamlessly executing trading strategies based on predefined rules and signals.

The first strategy of portfolio rebalancing involves selecting a specific number of stocks based on their monthly returns within a defined universe, such as large cap, mid cap, small cap, industry-specific, or factor-specific stocks. These selected stocks form the core portfolio. Each month, the portfolio is rebalanced by removing the bottom-performing stocks and replacing them with the top-performing stocks from the same universe. The strategy is then backtested, and the resulting key performance indicators are compared with those of a simple buy-and-hold strategy corresponding to the relevant index. The algorithm found the most return maximization when comparing data at a month-to-month granularity.

Figure 4: Plotted Index Return vs. Strategy Return on the DOW 30 calculated by portfolio balancing. Notice more than twice returns as the time frame increases.

The next studied strategy known as resistance breakout is a technical trading approach that focuses on stocks breaching presumed resistance levels on price charts. For this strategy, high-volume and actively traded stocks are chosen. The breakout rule is defined as the price surpassing the 20-period rolling maximum or minimum price, accompanied by the volume exceeding the rolling maximum volume. Long or short positions are taken based on the signals generated. To manage risk, an exit or stop-loss signal is defined as the previous price plus or minus the 20-period Average True Range as the rolling stop-loss price. The strategy is backtested by calculating the cumulative return for each stock. The algorithm found the most return maximization when comparing data within an intraday granularity.
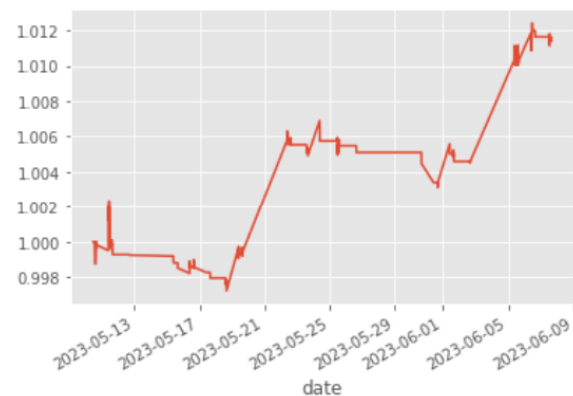

Figure 5: Plotted Strategy Return on the DOW 30 with strong uptrend maximizing return. Index strategy line forfeited as assumed to be linear for purpose of demonstration.

Furthermore, the Renko MACD strategy combines Renko charts with the Moving Average Convergence Divergence indicator. It is applied to high-volume and highly active stocks. The MACD indicator helps identify potential trend reversals and generate buy or sell signals. The strategy aims to capture short-term price movements

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based on Renko chart patterns and MACD signals. The algorithm found the most return maximization when comparing data within an intraday granularity.
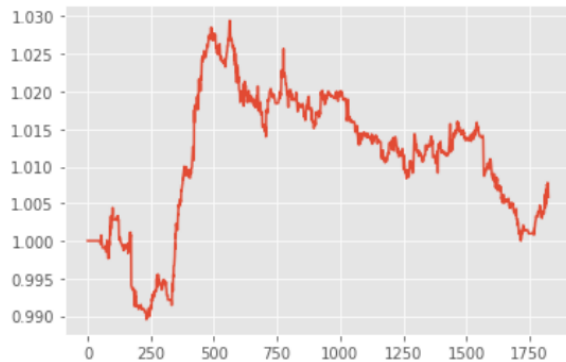

Figure 6: Plotted Strategy Return as a multiplier over the number of iterations. Somewhat unstable but still higher expected growth than the index strategy. Index strategy line forfeited as assumed to be linear for purpose of demonstration.

Lastly, the final backtesting strategy analyzed in this study known as the Renko OBV strategy involves selecting high-value and highly active stocks based on data extracted from Renko charts and the On-Balance Volume indicator. The OBV indicator indicates the buying or selling pressure preceding price movements. When the OBV line rises, it suggests increasing buying volume, while a fall indicates increasing selling volume. The OBV line is calculated by adding volume on days when the price closes higher and subtracting volume on days when the price closes lower.
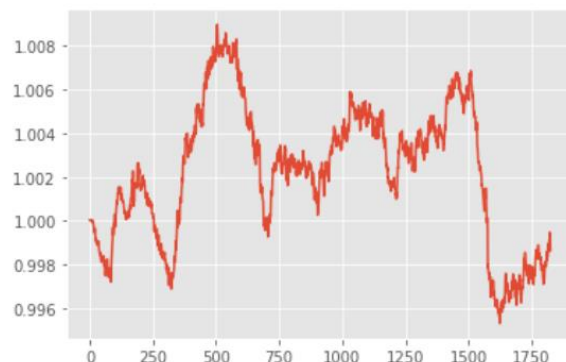

Figure 7: Plotted Strategy Return on the DOW 30 appears to be erratic and oscillating. Probable indication of a need for improvement. Index strategy line forfeited as assumed to be linear for purpose of demonstration.

API Integration and Seamless Trading Execution:

Integral to the project is the seamless integration of popular APIs such as the ones previously mentioned as well as FXCM and OANDA. This integration empowers direct connectivity between the trading script and these platforms, streamlining trade execution and providing real-time access to market data. The API integration capabilities contribute to the efficiency of the Automated Trading Bot, enabling hassle-free automation of trading strategies.

Sentiment Analysis for Enhanced Decision-making:

The project has room for growth in the form of sentiment analysis. Sentiment analysis techniques can theoretically gain insight into market sentiment and its potential impact on trading decisions. In order to incorporate this feature into the trading bot it would require an intricate machine learning and natural language processing subsystem. Although somewhat daunting, the possibility of this feature being developed and added to the bot solidifies its growth potential and possible capabilities. By analyzing and incorporating sentiment data into the strategies, we can expect to see this project maybe one day revolutionize decision-making capabilities and effectively capitalize on both market trends derived from presented data.

Conclusion:

The primary objective for this project was proven to be well accomplished and the

capabilities of this system with all of its respective moving parts and pieces can come together to develop a groundbreaking trading program. Further improvements are not only possible but likely imminent and despite the success of this bot, only merely scratches the surface of showcasing computational power regarding this real-world application.

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