

# Full stack Artificial Intelligence Trading Robot Application with Data Visualization of Strategy Backtesting \*

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## Abstract

In recent years, there has been a shift to an automated response due to the volatility and uncertain shifts in the stock market. This is owing to the aid of algorithms being able to determine correct decisions without hindrance from emotion using mathematical and statistical methods. With corporations tackling stock market problems in this way, clear data visualisation of these algorithms on the stock market is a necessity. A full stack web application is being developed that allows users to use different algorithms to predict the stock market and view results for such algorithms over a previous time frame. The core aim of this project is to allow users to execute buy/sell orders in real time, view the strategy they are using and display the outcome of the strategy in different timelines of the market.

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\*Stefan Court: *I certify that all material in this dissertation which is not my own work has been identified.*

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# 1 Introduction and Motivation

The stock market is a component of a free-market economy, which allows companies to raise money by offering stock shares to investors to gain equity in the company and raise money through the dividends that they own. The companies' reputation is also closely linked to the price of the stock and the current trend as seen in [1] with higher annual rankings of reputations of companies leading to on average 4% returns. This means that reputation can either draw investors in or push them away. There are many ways of investing on the stock market ranging and not limited to Common Stocks, Preferred Stocks, Blue-Chip Stocks, Dividend Stocks and many more [2]. All of these types of stocks share the same principle, being buying a share of the company and if the company generates returns so will the investor.

Predicting the stock market is an ongoing challenge that has never truly been solved since its inception in Amsterdam in 1602 [3], however, as it is true that the stock market has been changing, so has the way people approach predicting it, from paper-based physical shared certificates, to being controlled almost completely electronically. Machine learning models such as, Artificial Neural Networks (ANNs) [4] and the Support Vector Regression (SVR) system [5] were implemented to try to become profitable and even some have tried incorporating social media into their software, using platforms such as Twitter [6] and Facebook [7]; however with ever-changing market conditions more is needed than technical analysis to predict the future price of assets [8].

With artificial intelligence becoming so main stream, humans must adapt to be able to use this power advantageously. With algorithms such as mean reversion and VWAP [9] becoming automated and corporations using these algorithms to profit off certain market conditions. It is important that knowledge of how to create and use these algorithms is shared with a wider audience. For this reason, an algorithmic trading bot with advanced strategy backtesting will be developed to enhance knowledge on how advantageous artificial intelligence strategies have been used in the past and today.

# 2 Aims and Objectives

The aim of this project is to provide users with an engaging interface for a trading platform that displays strategy backtesting, news, finance, and an option to commit manual and automatic trades. This must be done in an efficient and clear manner to ensure retention of users. Due to the nature of the project, the users will be able to trade without emotional intervention and will have risk management completed automatically; this is beneficial as proved in [10] where heart rate changes could be detrimental to earnings. As the program is being created, a lot will be learned about the market itself and the algorithms surrounding it, creating a better understanding of what strategies are best in certain scenarios. This in turn allows more information to be input onto the website to enhance the viewers' knowledge on the market and different strategies.

To be able to satisfy the final goal of the project, there is a need to create a responsive front-end, detailed back-end and visually stunning data visualisation. This will be done at different points along the project timeline, with most of the front-end completed first, then focusing on the back-end and finally the data visualization. This is shown in the Gantt chart below, where:

yellow = front-end development,

blue = back-end development,

green = data visualization.

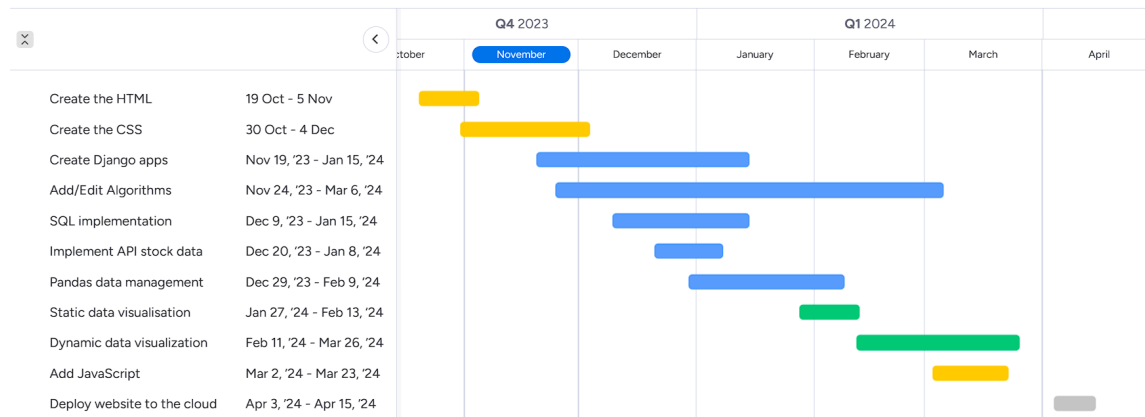


Figure 1: Gantt chart shows timeline for start and completion date of each task

To see why each language and library is used to facilitate the aim of the project, see [\(4. Design and Implementation\)](#)

## 3 Trading strategies

### 3.1 Arbitrage

This trading strategy tries to capitalize on the liquidity of the markets. It is done by capitalizing on the fundamental relationship between price and liquidity and trying to profit due to the perceived miss-pricing of an asset compared to the expected value [11]. Some different ways of creating arbitrage bots include:

- Cross-Exchange Arbitrage
- Spatial Arbitrage
- Triangular Arbitrage

Some advantages to using an arbitrage bot are the low-risk profits and safe and swift trades, however some disadvantages of this trading strategy are the low returns and the complexity of programming these bots. Overall, this strategy is a good choice for people that have high level programming skills and understand market inefficiencies that are not willing to risk much capital.

### 3.2 Mean Reversion

Mean reversion is a financial theory that suggests that the “price of a stock will eventually return to its long-term mean or average” [12]. This concept is grounded in the belief that asset prices and historical returns will return to a long-term average over time. Knowing this, some traders have decided to try to benefit and capitalize on stock prices that have deviated significantly from the historical mean. Some technical indicators that can help this strategy are:

- Bollinger Bands
- Moving Average Crossover [13]
- Fibonacci Retracement

Some benefits of using a mean reversion strategy include simplicity, historical evidence, clear entry and exit points and exploiting market inefficiencies. However, some detriments of this strategy are a possible-prolonged deviation from the mean, difficulty in identifying the mean and that the strategy requires patience. These combined mean that it would be a good strategy for long term holders and new traders.

### 3.3 Volume weighted average price (VWAP)

This is a strategy which analyses the stock specific historical volume profile and trades in parts of order quantity with the objective to keep the average traded price close to the VWAP [14][15]. The main equation used in VWAP calculations is:

$$VWAP = \frac{\Sigma(Price \times Volume)}{\Sigma Volume} \quad (1)$$

In this equation, the numerator represents the total value of all trades for the given period, while the denominator represents the total trading volume for the period. There are various variations of VWAP one of these being anchored VWAP which allows trades to at a specific starting point which allows for more control over the time frame and can help identify support and resistance levels.

### 3.4 Momentum

Momentum is a trading strategy whereby an algorithm purchases assets that have been showing an uptrend or selling assets that are in a downtrend. The reasoning behind this strategy is that if a trend is well established, then it is likely to continue. Momentum strategies often use very similar technical indicators to mean reversion being, Moving Average, Relative Strength Index (RSI) and the Average Directional Index (ADX). Some of these mathematical methods can be seen in [16]. There are two main types of momentum strategies being:

- Relative Momentum
- Absolute Momentum

Some advantages to momentum trading include generating high returns in a short period of time, and it can be used in multiple different markets. Some disadvantages to this strategy are the higher risk associated with the strategy, and that entry and exit points are hard to identify precisely. This strategy is perfect for those that want to take trades in the short term, such as day traders and swing traders that are willing to risk higher amounts of capital to gain more.

## 4 Design and Implementation

### 4.1 Front-End

The application in development will use **HTML**, **CSS** and **JavaScript** to meet contemporary standards for front-end development. The application will be designed to have various pages, including pages for trade placing, automated trading, backtesting visualisation and statistics. One notable feature of the website will be an optional dark mode to limit eye strain [17] for the user. To streamline navigation and facilitate user interaction, a navigation sidebar will be implemented to seamlessly link all the pages together, as this was shown to make a library website more interactive [18]. User experience will be benefited from multiple layouts for the pages so that the app can be viewed via desktop, tablet or mobile device with general guidelines for font, headings, and menus being adhered to [19]. The JavaScript for the pages will contribute to them having responsive buttons and adding animations by affecting the Document Object Model (DOM) of a website [20]. In the event of early project completion, Consideration will be given to implementing a JavaScript framework such as Vue or React to enhance user engagement and functionality.(5. Further Plans). See below to view a plan of the layout of the websites.

## Front-end Plan

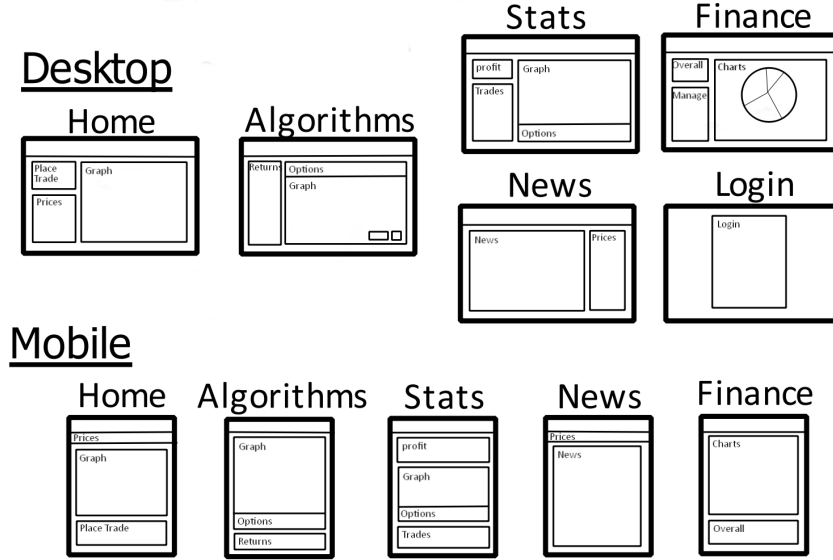


Figure 2: Planned layout of webpages

## 4.2 Back-End

To construct the back-end of the website, **Django** framework, **Pandas** library, **Python**, and **SQL** will be utilised. The Django framework will be used because of its advantages in versatility, security, and scalability [21] over other frameworks. This is because of the ease of creating new apps or otherwise expanding old ones and the option of adding security options to admin controls and sensitive data. Python will be the main language of choice due to its large community and plethora of viable libraries for data cleaning and visualising. For the extrapolating and managing of data, Pandas (see documentation [22]) will be used to input this data into a dataframe (table). SQL will be used to communicate data between the server and the client using a client-server model, this database management system underpins the storage and retrieval of data for users and is used by many professions as seen in table 5 [23]. to maintain a real-time dynamic experience, the web page will continuously be updated with data from the **Yahoo Finance API** [24]. this API serves as a constant stream of data from the markets and contains historical information about the markets to be used for the backtesting of algorithms.

### 4.3 Data Visualisation

To accomplish the project’s primary aim effectively, the website’s graphical representation must be precise and offer visual appeal to users. For this **Matplotlib** will be employed to create both static and live graphs, this is due to Matplotlib having a huge library of graphs to chose from including pie-charts, histograms and more seen in [25]. Matplotlib will serve two crucial functions, being for both creating dynamically changing live graphs and static graphs that are used for backtesting. There is a slew of different ways that you can place these graphs onto the HTML page for the website, the decision will be made on which is best going further into the project, a possible option is to save the graph as an image, use mlpd3 [26] or plotly [26]. However, one of the requirements will be that the graphs must update every second without refreshing the page. This is to ensure that the website is responsive and kept up to a modern standard, as according to figure 2 in [27] the number of publications on dynamic graph visualisation has increased over the years.

## 5 Risk Management

### 5.1 The program

One problem that could arise is bad data quality, this could be due to using an API that has incorrect information or because data has been lost in transmission. This could lead to buying/selling a stock at an incorrect price [28], meaning, although the algorithm may be working as intended, the amount profited may be incorrect. To ensure this does not happen, the validity of each API and piece of data will need to be scrutinized by looking for breaking changes as seen in [29] and compare actual data from the exchange to the API’s data, if there is a difference the API in use will need to be changed.

Another problem that could arise is the use of bad algorithms. bad algorithms in turn will mean less profitable or even unprofitable trades, as seen by [30] where Knight Capital lost \$440 million in a 45-minute period. A way around this is to complete enough backtesting and to ensure that there is relevant unit testing for the algorithms to ensure that the algorithms have worked in past market conditions and will work under different constraints. To ensure this is done, a test driven development (TDD) [31] will be used.

Time constraints could cause issues, with high latency being a very common issue among trading bots as they are required to make precise decisions without falter, however this is not always possible, due to possible network delays, hardware limitations or software inefficiencies. One example of this is figure 1 in [32] for the millisecond environment, where the two graphs show when agency algorithms check market conditions. (5. Further Plans)

### 5.2 The Market

Market crashes such as the 1987 and 2010 flash crash, where federal reserves had to be used [33], if the “Dow Jones Industrial Average plunges about 9%” [34] this could result



in a user's whole portfolio reaching zero very quickly, to avert this damage good risk management strategies should be in place, such as having a stop loss strategy seen in [35] to ensure that money can be quickly, automatically withdrawn if something goes wrong.

Liquidity can disappear at any moment, as seen in [36] with the "Asian liquidity crisis". This can be due to the nature of the stock market and the latency issues of the bot, the buying/selling price advertised may be different to the price when the transaction has taken place. Unfortunately, there are not many solutions to this problem that the investor can do, as the markets are mostly controlled by the government and large firms [37] apart from stopping investing in the company that is having a liquidity crisis or trying to avert the problem by reading multiple news sources as to why the current company invested in might have one in the future.

### 5.3 Ethical Concerns

As the application in development is planning on using paper money, there are not many ethical concerns to do with the application but some with the context, being artificial intelligence and markets. One of these concerns is the possible loss of jobs [38]. If one AI is able to crush the markets, then this will take over the world of investing and many people will be replaced by this AI or contending AI's. Another ethical concern with robotics being used in investing is the reason for being used, if it is to take advantage of a technical discrepancy then this is deemed as okay, however if it is to manipulate the market [39], e.g. inflating the buy price of a certain stock then this is unethical. Another thing to keep in mind is the unethical procedures behind insider trading, however, this will not be much of an issue as most bots make decisions on public information and technical indicators.

## 6 Further Plans

The first thing planned to do after completion of the main program is decrease latency issues with the trading bot. This can be solved using methods such as using WebSocket instead of RESTAPIs, and placing the server near to the exchange [40]. Using WebSocket will achieve this because it shares the same TCP connection across different requests, whereas a REST API requires establishing a TCP connection for every request. Also, the use of WebSocket will mean that the server can proactively push data to the trading bot. colocation hosting [40] can be achieved by checking the ping to the API and if it returns a high latency solving the issue could be to try a different API server in a different part of the world, or if this is unavailable you can change API server's completely.

Another possible plan is to add a friend's list. This can be achieved by adding another link in the side navigation bar and opening up a friends list with the option to request, add or decline friends. If this was implemented, looking into creating a chat-log for all friends to discuss working strategies and certain stocks to keep an eye on would be a good idea.

A JavaScript framework such as React or Vue could be used instead of vanilla. This

allows for the implementation of animated objects due to the different approaches to state management, making it more time efficient as a programmer and easier to use. However, further investigation will have to go into this topic, as it is also said that vanilla JavaScript [41] is quicker for clients and there is not much benefit to the use of a JavaScript framework.

Incorporating the news into the trading bot is a challenging task as this will encapsulate creating a web scraper that can scour the internet by different means shown in the book [42] containing news and assigning importance to these news headlines. These news headlines will then be incorporated into a neural network along with statistical analysis to try to predict the outcome of the market.

## 7 Evaluation

A multitude of different online brokerage platforms offer users the ability to trade assets, but often lack the feature of algorithmic automation for systematic trading. Furthermore, these platforms do not provide users with visual representations of these algorithms, preventing people from learning about how these algorithms may have performed in the past. Drawing from an extensive amount of conference papers, this literature review explores the feasibility of visualizing stock market data on a web page. It also shows that there is potential to create a profitable strategy that can be integrated into a piece of software to offer a comprehensive tool to enhance user's trading activities. This project therefore seeks to bridge these gaps by offering a sophisticated trading bot that uses multiple algorithms to execute buy/sell orders of various commodities; and serves as an educational resource for users that are interested in how algorithms have affected past market opportunities.

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