Introduction to Financial Engineering
TECHNICAL ANALYSIS

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PROBLEM STATEMENT
The task involves selecting an asset (e.g., stock, bond, ETF) and gathering its closing prices over the past 3 years. Four or more technical indicators, chosen from options like Moving Average, RSI, Bollinger Bands, and MACD, are to be calculated. A correlation analysis of the selected indicators is then performed, followed by creating a combined indicator with weighted averages based on the obtained correlations.
The objective is to devise a methodology for predicting bullish and bearish positions on each timestamp using the combined indicator, with the final step being the reporting of prediction accuracy.

ASSET SELECTION
The asset chosen for the project was **Alphabet Inc Class A (GOOGL) stock** data. The closing price dataset over the last three years for the chosen asset was taken from **Yahoo Finance**.

TECHNICAL INDICATORS
There are 3 general types of indicators:

- **Trend indicators**
  They reflect tendencies in price movements: up moves, down moves and sideways moves. In simple words, they allow to visualize trends in the market.

- **Momentum indicators**
  They record the speed of prices moving over a certain time period. They also track the strength and weakness of a trend. The highest momentum is seen at the start of a trend, and the lowest at its end.

- **Volatility indicators**
  They indicate the size and intensity of price fluctuations. Markets have periods of high and low volatility. Low volatility is followed by increased volatility, and vice versa. They show the intensity of price changes, giving insight into market activity.

In order to cover the maximum possible dimensions of the price trend, it was decided to incorporate the indicators from all the three general types:
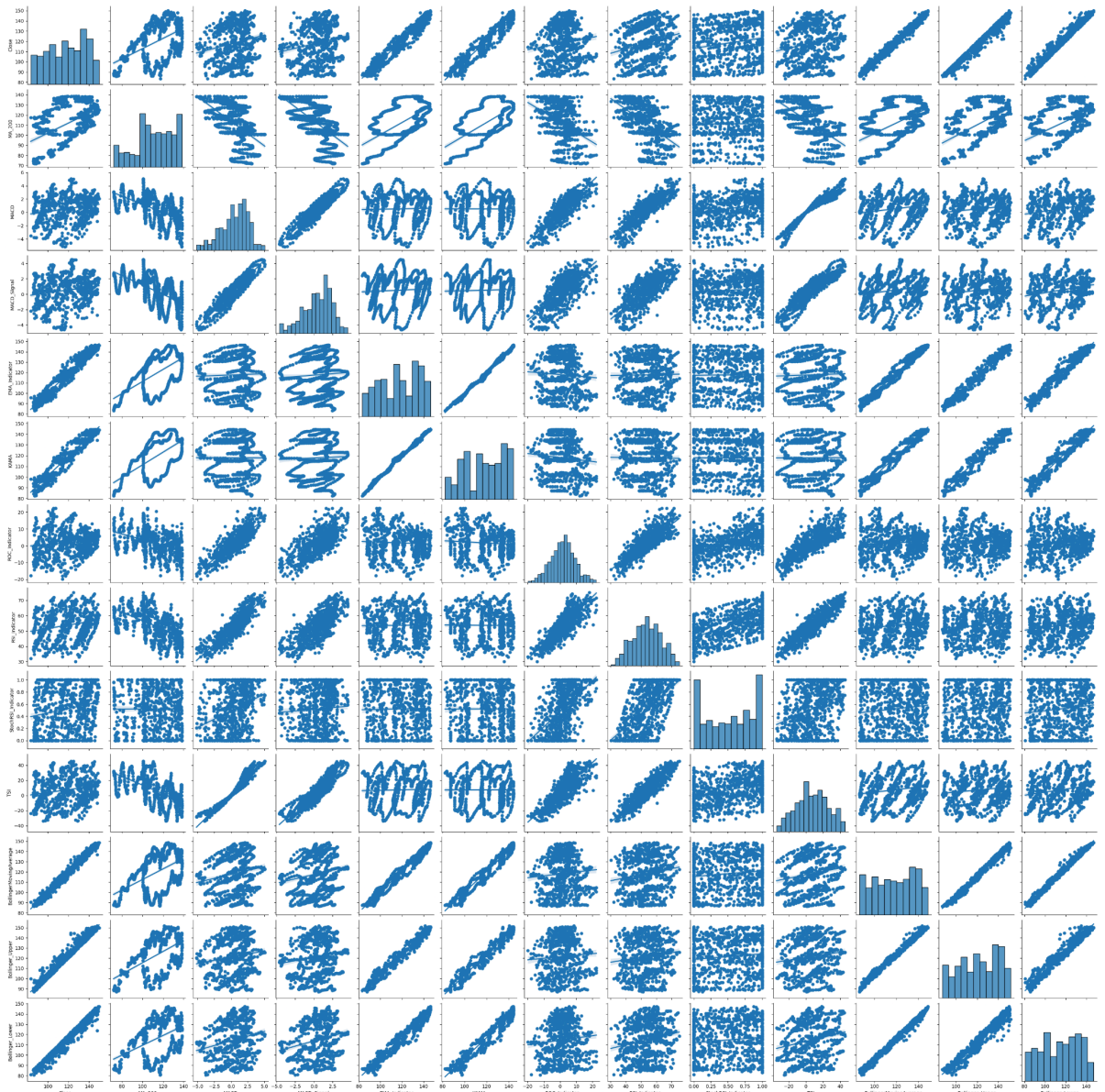
- **Trend indicators:** Moving Average (MA), Exponential Moving Average (EMA), Moving Average Convergence Divergence (MACD)
- **Momentum Indicators:** Relative Strength Index (RSI), Stochastic RSI, Kaufman's Adaptive Moving Average (KAMA), True Strength Index (TSI), Rate of Change (ROC)
- **Volatility Indicators:** Bollinger Bands
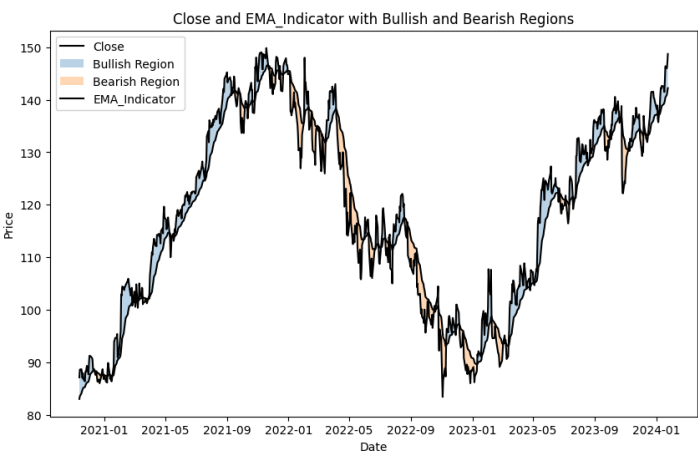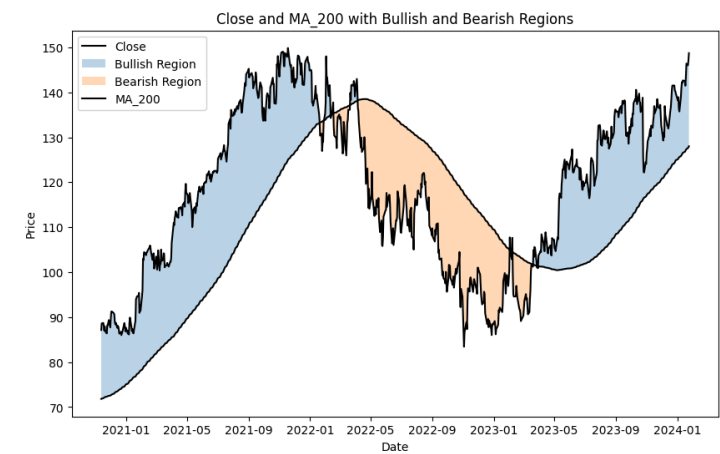
EXPLORATORY DATA ANALYSIS

Alphabet Inc Class A (GOOGL) Equity Closing Prices (Last 3 Years)

The distribution plot of each feature with respect to the others is shown below:
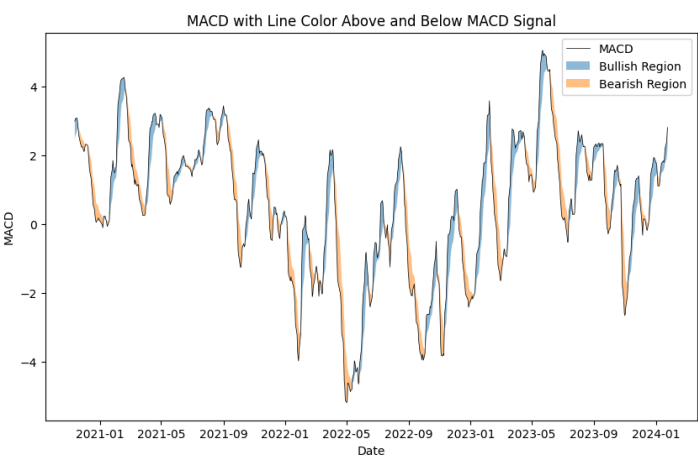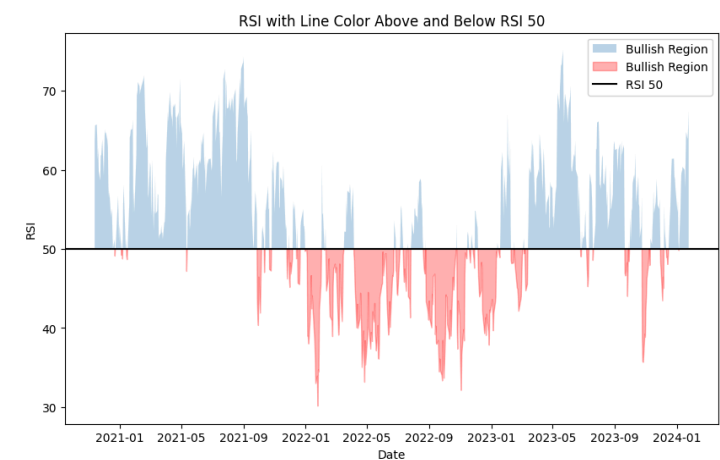
The plots for each indicator highlighting the BULLISH and BEARISH regions are shown below:
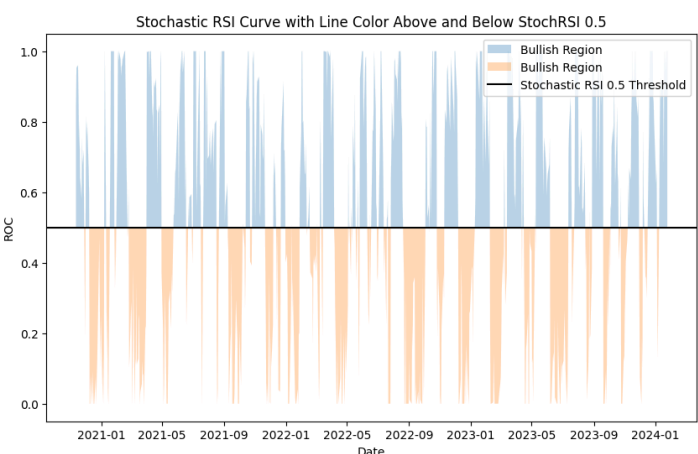

Moving Average (MA) [window size: 200 days]
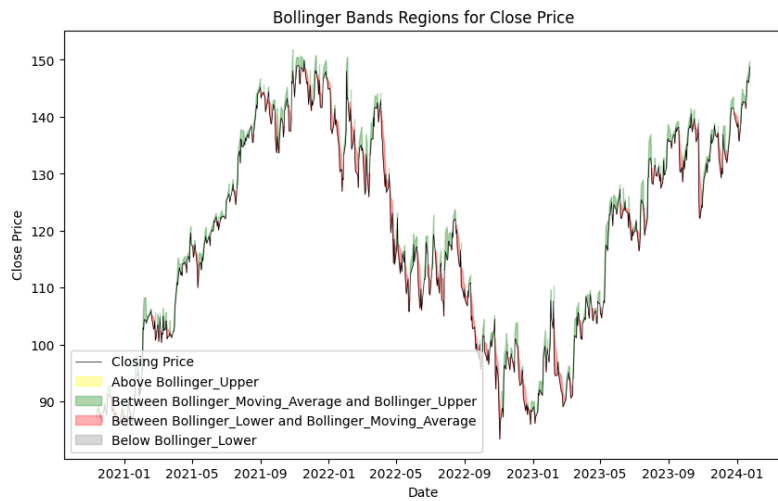
Exponential Moving Average (EMA)

Relative Strength Index (RSI)

Moving Average Convergence Divergence (MACD)
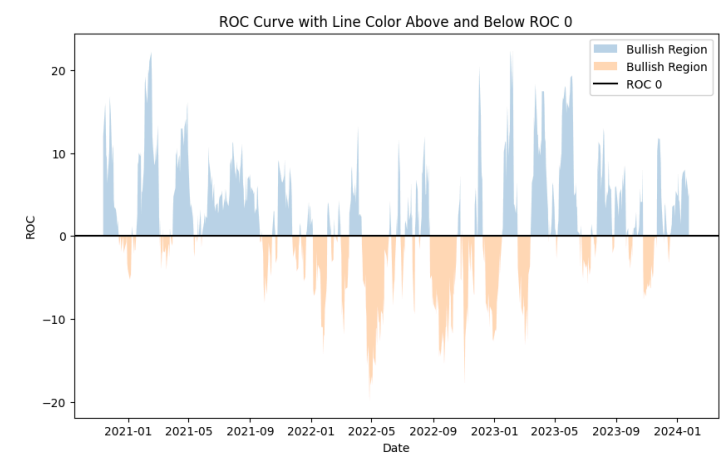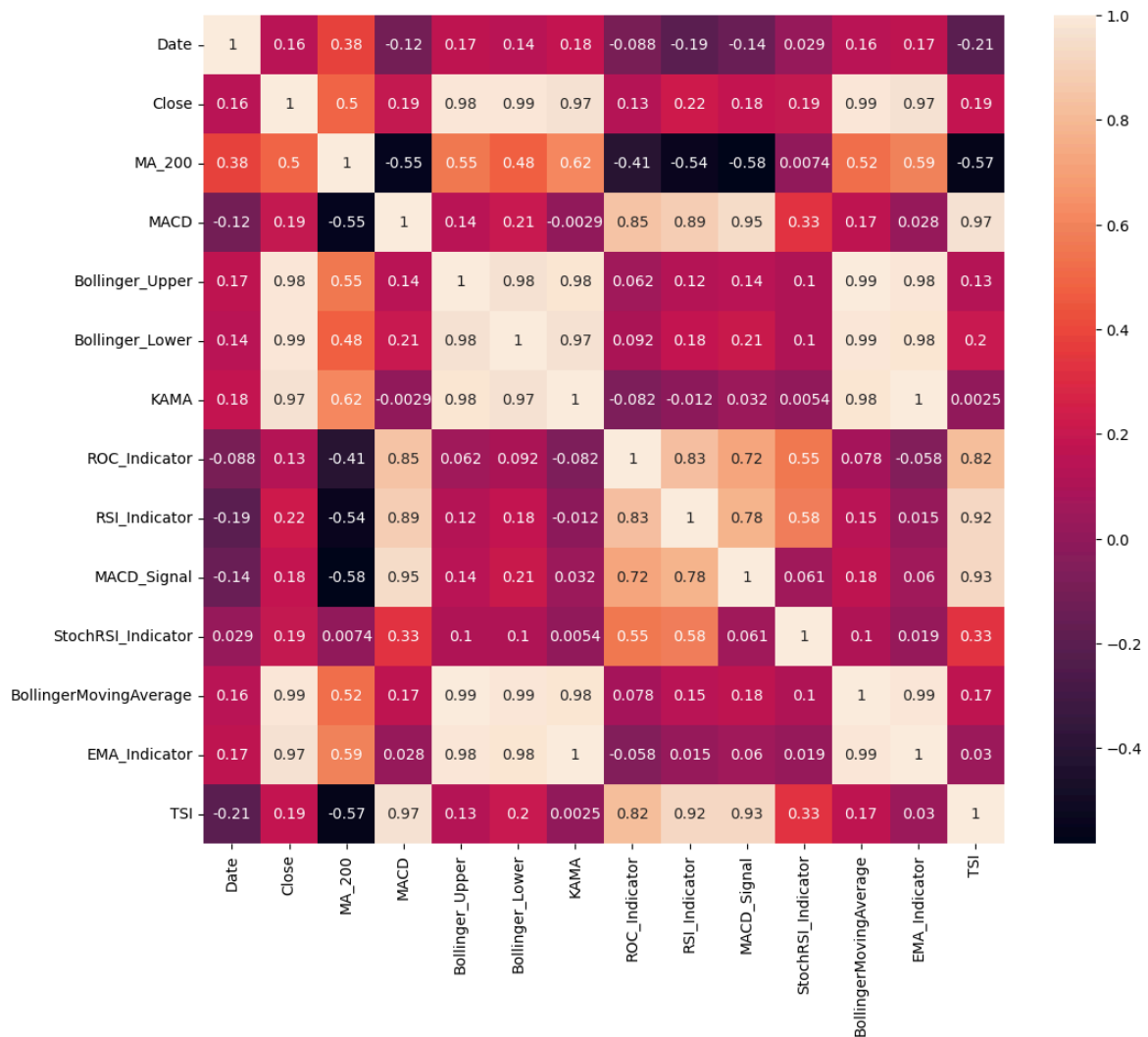
Rate of Change (ROC)

Stochastic Rate of Change (ROC)

Bollinger Bands

CORRELATION ANALYSIS

The correlation matrix (heatmap) plotted between the indicators and the closing price of the asset as well as among the indicators themselves is shown below:

The correlation values of indicators with "closing price" are shown below:

```
Bollinger Bands            0.991184
EMA                        0.974320
KAMA                       0.965830
MA_200                     0.498118
RSI                        0.217430
MACD                       0.194318
Stochastic RSI             0.192073
TSI                        0.189873
ROC                        0.125787
```

Observations based on the correlation heatmap and the correlation values:
- The following indicators showed highly significant (**> 0.95**) correlation with each other:
  - KAMA, EMA and Bollinger Bands
  - MACD and TSI
- These indicators showed very low correlation with the "closing price":
  - TSI
  - Stochastic RSI
  - ROC

Based on the above observations:
- Since, these highly correlated features would not bring additional information and increase the complexity of the overall problem statement, it was decided to eliminate the following indicators, based on the dominant correlation with "closing price":
  - KAMA
  - EMA
  - TSI
- Stochastic RSI and ROC were also eliminated because of very low (**< 0.2**) correlation with the "closing price". MACD was not eliminated despite having a similar low correlation value in order to ensure that the number of remaining indicators remained >= 4.
- After the elimination, it was decided to use the following remaining indicators for constructing the "combined" indicator:
  - **MA**
  - **MACD**
  - **RSI**
  - **Bollinger Bands**

THE "COMBINED" INDICATOR
- **Assigning weights to the indicators**
  - The **correlation values** of the above remaining indicators with the "closing price" were **normalized** to **calculate the respective weights**, as shown below:

```
Bollinger Bands            0.52
MA_200                     0.26
RSI                        0.11
MACD                       0.10
```

  - The above weights were assigned to the respective indicators.

- **Predicting BULLISH or BEARISH positions**
  - Due to the diverse value ranges provided by each technical indicator for the asset it was essential to normalize the technical indicator values to establish a common threshold, enabling the final prediction based on comparison with the resultant value of combined indicators.
  - The following normalization rules for the indicators' resultant values were employed:

    ### Bollinger Bands

    $$\text{BOLU} = \text{MA}(\text{TP}, n) + m * \sigma[\text{TP}, n]$$
    $$\text{BOLD} = \text{MA}(\text{TP}, n) - m * \sigma[\text{TP}, n]$$
    where:
    BOLU = Upper Bollinger Band
    BOLD = Lower Bollinger Band
    MA = Moving average
    TP (typical price) = (High + Low + Close) ÷ 3
    n = Number of days in smoothing period (typically 20)
    m = Number of standard deviations (typically 2)
    $\sigma[\text{TP}, n]$ = Standard Deviation over last n periods of TP

Condition	Predicted Position
Upper BB < Closing Price	Bearish
Middle BB < Closing Price < Upper BB	Bullish
Lower BB < Closing Price < Middle BB	Bearish
Closing Price < Lower BB	Bullish

    ### Relative Strength Index (RSI)

    $$RSI_{\text{step one}} = 100 - \left[\frac{100}{1 + \frac{\text{Average gain}}{\text{Average loss}}} \right]$$

Condition	Predicted Position
RSI < 50	Bearish
RSI > 50	Bullish

    ### Moving Average (Window Length: 200 days)

    $$\text{SMA} = \frac{A_1 + A_2 + ... + A_n}{n}$$
    where:
    A_n = the price of an asset at period n
    n = the number of total periods

Condition	Predicted Position
MA < Closing Price	Bearish
MA > Closing Price	Bullish

Moving Average Convergence Divergence (MACD)

$$MACD = \text{12-Period EMA} - \text{26-Period EMA}$$

Condition	Predicted Position
MACD < MACD Signal	Bearish
MACD > MACD Signal	Bullish

NOTE: For the above predicted positions, the following resultant values was decided:

Predicted Position	Indicator Resultant Value
Bullish	**+1**
Bearish	**-1**

- ○ Based on the above normalization, it was decided to **add weightage to bullish or bearish positions according to the predictions of each indicator** and their corresponding weights.
  The **position with the dominant resultant weightage** was returned as the predicted position for each time-stamp.

LITERATURE REVIEW (supporting the "Combined" Indicator)

- In trading, volatility and momentum are crucial factors. Combining **RSI** with **Bollinger Bands** helps identify market shifts and entry points. When the price hits the upper Bollinger Band and RSI goes above 70, it suggests the asset is overbought. Another signal is when the price crosses the middle Bollinger Band and RSI is rising above its 50 line. Hence, this combination proves to be an effective strategy.

- Market volatility cycles between highs and lows. Combining trends with volatility helps identify potential future trends during heightened market movement.
  Using **Moving Average** and **Bollinger Bands** together is effective. Wider bands indicate high volatility, narrow bands suggest low volatility. Approaching a Bollinger Band signals a likely turnaround, while breaking the middle band indicates continued movement towards the outer band. Considering the dominant trend direction enhances predictions of market movement.

- Momentum indicators, like **RSI**, show the strength of price movements over time, while trend indicators, like the 200 **MA**, reveal directional trends. An efficient strategy involves using the 200 MA for smoothing fluctuations and the RSI for identifying momentum shifts.
  An upward break of the MA line with RSI crossing 50 upwards signals potential upward movement, and vice versa for a downward trend. Additionally, spotting bullish RSI divergence above the 200 MA suggests potential long trades, while bearish divergence below the 200 MA indicates potential short trades.

PREDICTION ACCURACY

The combined indicator gave an accuracy of **75.31%**.

FURTHER IMPROVEMENTS

In this specific project, only the "closing price" data of the asset was utilized, restricting the use of other indicators like volume. The exclusion of additional parameters prevented the exploration of various indicator combinations to improve prediction accuracy.

Inclusion of factors such as "volume", "low" and "high" could have facilitated experimentation with diverse indicator combinations, potentially enhancing predictive accuracy.

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