INTRODUCTION TO TRADING

REPORT

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INTRODUCTION

In today's financial world, algorithmic trading has become a dominant force in global markets. Advances in computational power, systematic methods, and automation have made it possible to design and execute trading strategies with greater speed, precision, and discipline. The cryptocurrency market, characterized by its 24/7 operation and high volatility, offers a particularly dynamic environment for such strategies.

This project focuses on the development, optimization, and rigorous evaluation of a systematic trading strategy for the Bitcoin (BTCUSDT) pair using technical analysis. The primary challenge lies in designing a robust model capable of identifying profitable opportunities while effectively managing risk in a highly non-stationary market. By employing a multi-indicator confirmation system and a disciplined walk-forward optimization approach, this project aims to deliver a professional-grade trading framework supported by empirical evidence.

OBJECTIVE

The primary objective of this project is to develop and optimize a systematic trading strategy for the BTCUSDT pair that maximizes the Calmar Ratio, a risk-adjusted performance metric that will be explained in detail later. This focus ensures that the strategy is evaluated not only in terms of profitability but also in its ability to remain resilient during adverse market conditions.

Additionally, the project pursues several sub-objectives:

1. Implement a modular and realistic backtesting environment that accounts for transaction costs and supports both long and short positions without leverage.
2. Design a trading strategy that generates entry and exit signals based on the confirmation of three distinct technical indicators.
3. Optimize the strategy's hyperparameters using walk-forward analysis to reduce the risk of overfitting and enhance generalization.

4. Conduct a comprehensive performance and risk analysis using industry-standard metrics and visualizations on a withheld out-of-sample test set.

THEORETICAL FRAME

To gain a clearer understanding of this project, it is essential to first establish the fundamental concepts and theoretical background. Systematic trading refers to the process of making investment decisions based on predefined rules and quantitative models. Its primary advantage lies in the elimination of emotional and psychological biases, resulting in greater consistency, discipline, and objectivity in decision-making (Prado, 2018).

Technical Analysis

In the same line, technical analysis is a methodology for forecasting price movements by examining historical market data, primarily price and volume. It is based on three key assumptions: market action discounts everything, prices move in trends, and history tends to repeat itself. Although the Efficient Market Hypothesis (Fama, 1970) questions the long-term profitability of technical analysis, its widespread application can sometimes generate self-fulfilling prophecies, particularly in less efficient markets such as cryptocurrencies.

Technical Indicators

To evaluate how these methodologies work and impact on real results, we use Technical Indicators. A technical indicator in finance is a mathematical calculation derived from historical price, volume, or open interest data that helps traders identify market trends, momentum, volatility, and potential reversal points. Indicators serve as tools to support decision-making within systematic and discretionary trading strategies by providing objective, data-driven signals that complement price chart analysis.

Some of the most important technical indicators commonly used in these environments include:

1. **Moving Average Convergence Divergence (MACD):** MACD is a trend-following momentum indicator that illustrates the relationship between two exponential moving averages (EMAs) of a security's price. A bullish signal occurs when the MACD line crosses above the signal line, while a bearish signal occurs when it crosses below (Appel, 2005).
2. **Relative Strength Index (RSI):** RSI is a momentum oscillator that measures the speed and magnitude of recent price changes. It ranges from 0 to 100, where readings above 70 typically indicate overbought conditions and readings below 30 indicate oversold conditions, both of which may suggest potential reversal points (Wilder, 1978).
3. **Bollinger Bands (BB):** Bollinger Bands are a volatility-based indicator composed of a middle Simple Moving Average (SMA) and two outer bands positioned two standard deviations above and below the SMA. When the price touches the lower band, it may signal an oversold condition (potential buy), while touching the upper band may signal an overbought condition (potential sell). The "squeeze" of the bands often indicates periods of low volatility that precede significant price movements (Bollinger, 2002).

Signal confirmation

Signal confirmation is the practice of requiring multiple technical indicators, price patterns, or other analytical tools to agree before executing a trade. This approach aims to reduce false signals and improve the probability of success by ensuring that the trade is supported by converging evidence rather than relying on a single indicator. In systematic trading, signal confirmation increases the robustness of a strategy by filtering out noise and enhancing decision-making reliability.

To enhance the reliability of trading signals and reduce false positives, the strategy will require confirmation from at least two of the three selected indicators before executing a trade.

Performance metrics

Performance metrics are quantitative measures used to evaluate the effectiveness, risk, and profitability of a trading strategy. They provide objective criteria to assess how well a strategy achieves its goals, allowing comparison between different approaches. Common performance metrics include return-based measures (e.g., cumulative return, annualized return), risk-adjusted measures (e.g., Sharpe Ratio, Calmar Ratio), and drawdown statistics, which together help traders understand both the potential rewards and the risks associated with a strategy.

1. **Calmar Ratio:** The primary objective function of the strategy. It is calculated as the annualized return divided by the maximum drawdown over a specified period (Young, 1991).
2. **Sharpe Ratio:** Measures the excess return of a portfolio per unit of total risk, typically expressed as the standard deviation of returns.
3. **Sortino Ratio:** A variation of the Sharpe Ratio that distinguishes harmful downside volatility from overall volatility by using the standard deviation of negative asset returns.
4. **Maximum Drawdown (MDD):** The largest observed loss from a portfolio's peak to its trough before a new peak is reached, reflecting potential risk exposure.
5. **Win Rate:** The percentage of trades that result in a profit, indicating the frequency of successful trades within a strategy.

METHODOLOGY

Data Acquisition and Preprocessing

Using hourly BTCUSDT historical data (OHLCV: Open, High, Low, Close, Volume) the data will be split chronologically into three segments: 60% for initial training, 20% for validation (used during the walk-forward optimization cycle), and a final 20% for out-of-sample testing. The data will be checked for gaps or anomalies and cleaned accordingly (dataset provided from class material).

Strategy Implementation and Backtesting

A custom backtesting environment will be built in Python with a modular design.

Strategy Logic: for each hourly bar, the three indicators (MACD, RSI, Bollinger Bands) will be calculated. Each will independently generate a signal (+1 for Long, -1 for Short, 0 for Neutral) based on predefined rules. A final trade signal is only generated if at least two of the three indicators agree.

Portfolio Simulation: The backtester will simulate trades based on the confirmed signals, accounting for a transaction fee of 0.125% per trade. It will allow for taking both long and short positions in the spot market without the use of leverage. The portfolio value will be tracked over time.

Optimization Framework

To avoid overfitting and ensure robustness, a Walk-Forward Analysis (WFA) will be employed. The training data will be divided into an "in-sample" (IS) period for initial optimization and an "out-of-sample" (OOS) period for validation, rolling this window forward through the dataset. For each IS period, an optimization is done to find the hyper-parameters (e.g., RSI lookback period, MACD fast/slow parameters, Bollinger Band width, stop-loss, take-profit levels) that maximize the Calmar Ratio.

The optimized parameters will then be applied to the subsequent OOS validation period to assess their performance. The set of parameters that demonstrate the most consistent OOS performance will be selected for the final model.

Performance Evaluation

The final, optimized strategy will be executed once, on the completely untouched 20% test set. Its performance will be evaluated using the metrics listed in the Theoretical Frame. A table of key performance metrics (Sharpe, Sortino, Calmar, Max DD, Win Rate) is going to be key to analyze results.

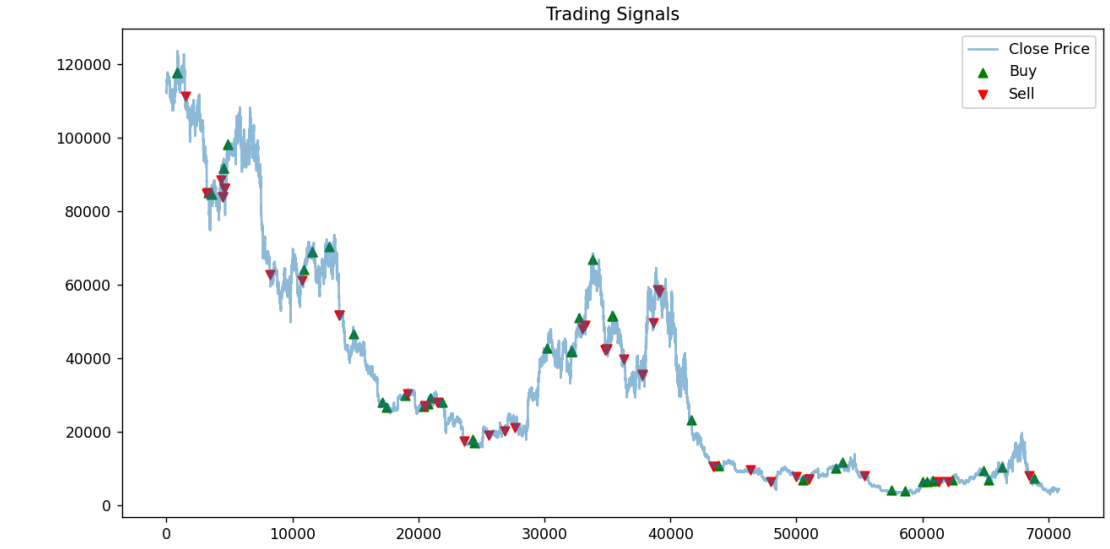
TRADING STRATEGY

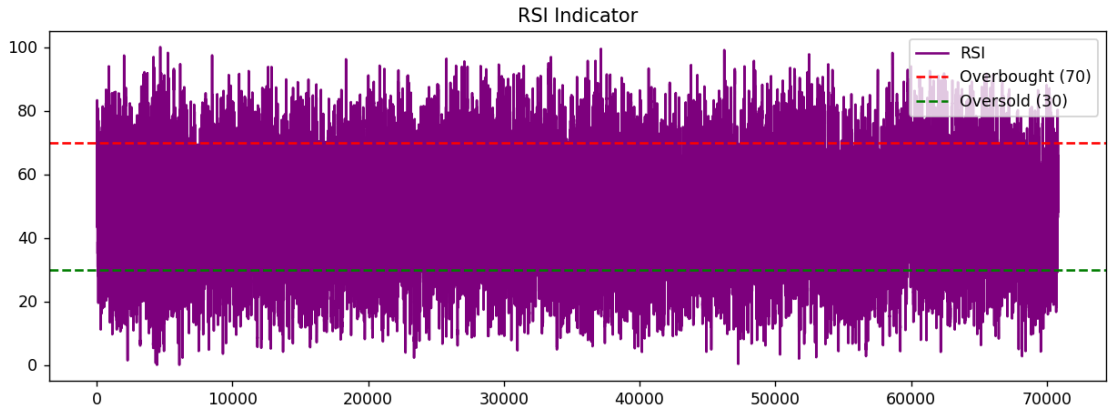
The trading strategy chosen is a multi-indicator, systematic technical strategy designed for trading BTCUSDT or similar assets without leverage. It combines momentum and trend-following indicators to generate buy and sell signals while incorporating realistic trading conditions such as transaction costs and both long and short positions. The strategy relies primarily on two technical indicators: the Relative Strength Index (RSI) and the Exponential Moving Average (EMA). RSI measures momentum and identifies overbought or oversold conditions, triggering buy signals when RSI is below 30 and sell signals when RSI is above 70, calculated over a default period of 14 bars. EMA captures the underlying trend by smoothing price data, with buy signals when the closing price is above the EMA and sell signals when below, using a default span of 20 periods. The system is designed to be easily extended to include a third indicator, allowing for a 2-out-of-3 signal confirmation rule that reduces false signals and overtrading.

Signals are generated based on crossovers and threshold conditions: a buy occurs when RSI is below 30 and the Close price is above the EMA, while a sell occurs when RSI is above 70 and the Close price is below the EMA. This combination captures both trend reversals and continuation moves, increasing robustness. The strategy is backtested in a realistic environment, starting with an initial capital of $10,000 and applying a transaction fee of 0.125% per trade. It supports both long and short positions without leverage. The backtesting module calculates final portfolio value and can produce time-series data for further analysis.

Performance analysis includes standard metrics such as the Sharpe Ratio, Sortino Ratio, Calmar Ratio, maximum drawdown, and win rate. Visualizations are also generated to aid analysis, including plots of Close price with buy/sell signals, EMA versus Close trends, RSI levels with overbought and oversold thresholds, portfolio value over time, and the distribution of daily returns using Seaborn.

The strategy is highly flexible, with hyperparameters such as RSI period, EMA span, stop loss, take profit, and position size subject to optimization via systematic methods such as Grid Search, Random Search, or Bayesian Optimization. Its modular structure allows easy integration of additional indicators, risk management rules, and walk-forward analysis to avoid overfitting. In summary, this approach is a systematic, rule-based trading method that combines momentum and trend-following indicators, realistic execution costs, and long/short capability, providing a robust, extensible, and backtestable framework suitable for further optimization and performance evaluation.





OPTIMIZATION RESULTS

After running the systematic optimization on the trading strategy using the selected hyperparameter ranges, the resulting performance metrics were as follows:

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Performance Metrics:
Calmar: -0.0118
Sharpe: -0.0708
Sortino: -0.0671
Max_Drawdown: -0.9751
Win_Rate: 0.4868
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The performance metrics indicate that the optimized strategy under the tested conditions did not achieve positive returns. Specifically, the negative Calmar Ratio shows that the strategy's annualized return is extremely low relative to its drawdowns, highlighting poor risk-adjusted performance. The negative Sharpe Ratio indicates that the strategy underperformed a risk-free asset when accounting for total volatility, and the negative Sortino Ratio confirms that downside risk outweighed gains, meaning losses are more significant than profits in terms of volatility-adjusted returns.

The Maximum Drawdown of -0.9751 reflects a very large portfolio loss at some point, demonstrating high risk exposure and unsustainable trading behavior. The Win Rate, while near 50%, is insufficient to compensate for the magnitude of losses per trade, suggesting that profitable trades were too small compared to losing trades.

These results suggest that the strategy, even after optimization, fails to provide a profitable or robust trading approach under the current market data and parameter ranges. Improvements could include adjusting hyperparameter ranges to explore more conservative thresholds, incorporating additional indicators or signal confirmation rules, and applying risk management mechanisms such as dynamic position sizing, stricter stop-loss levels, or reducing exposure during high-volatility periods. Overall, the optimization highlights the importance of combining robust parameter tuning with risk management to achieve viable and sustainable trading performance.

TECHNICAL DEBT

1. After the development of this project, several simplifications and conscious trade-offs are noted and can be stated as a technical debt:
2. The model assumes immediate execution at the closing price of the hourly bar, which may not be realistic during periods of high volatility, leading to an overestimation of performance.
3. A flat fee structure is used, whereas real-world exchanges often have a tiered fee system based on volume.
4. he model assumes clean, gap-free data. In reality, cryptocurrency and all types of data can have outliers and micro-orphaned chains.
5. The impact of bid-ask spreads and market liquidity is not modeled.

To address this debt, future iterations could incorporate more sophisticated execution models, regime detection to switch strategy parameters based on market conditions, and integration of fundamental or on-chain data.

CONCLUSIONS

This project presents a comprehensive framework for developing a systematic trading strategy for BTCUSDT. By combining a multi-indicator confirmation system with a rigorous walk-forward optimization process centered on the Calmar Ratio, it aims to produce a robust, risk-aware trading model. The focus on a modular backtesting environment, realistic transaction costs, and a strict train/validation/test split ensures that the results are reliable and not merely the product of overfitting. The final outcome will be a fully implemented strategy, supported by a professional report that explains its rationale, methodology, and provides a critical evaluation of its performance and limitations on out-of-sample data.

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