Introduction
To Trading

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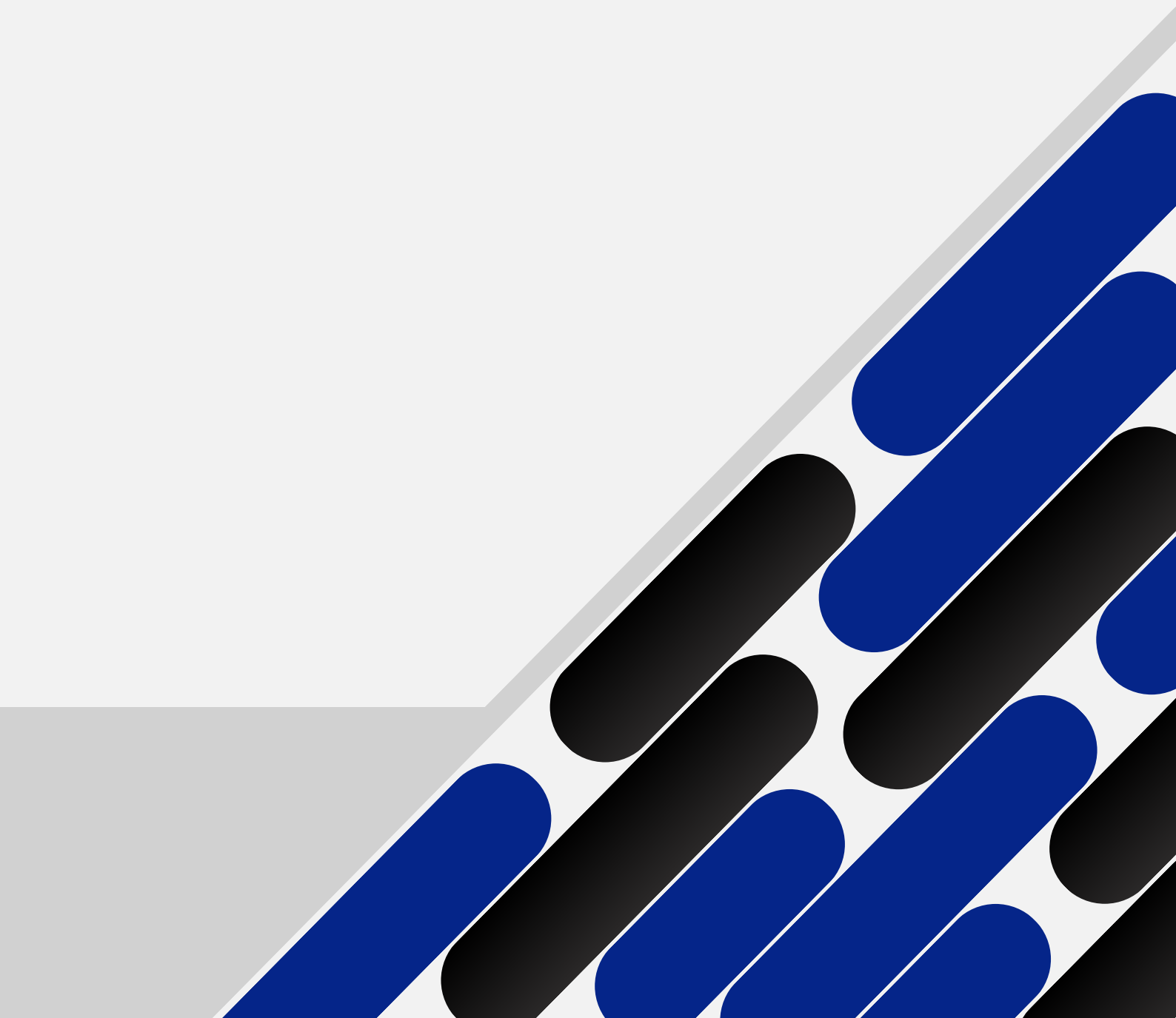
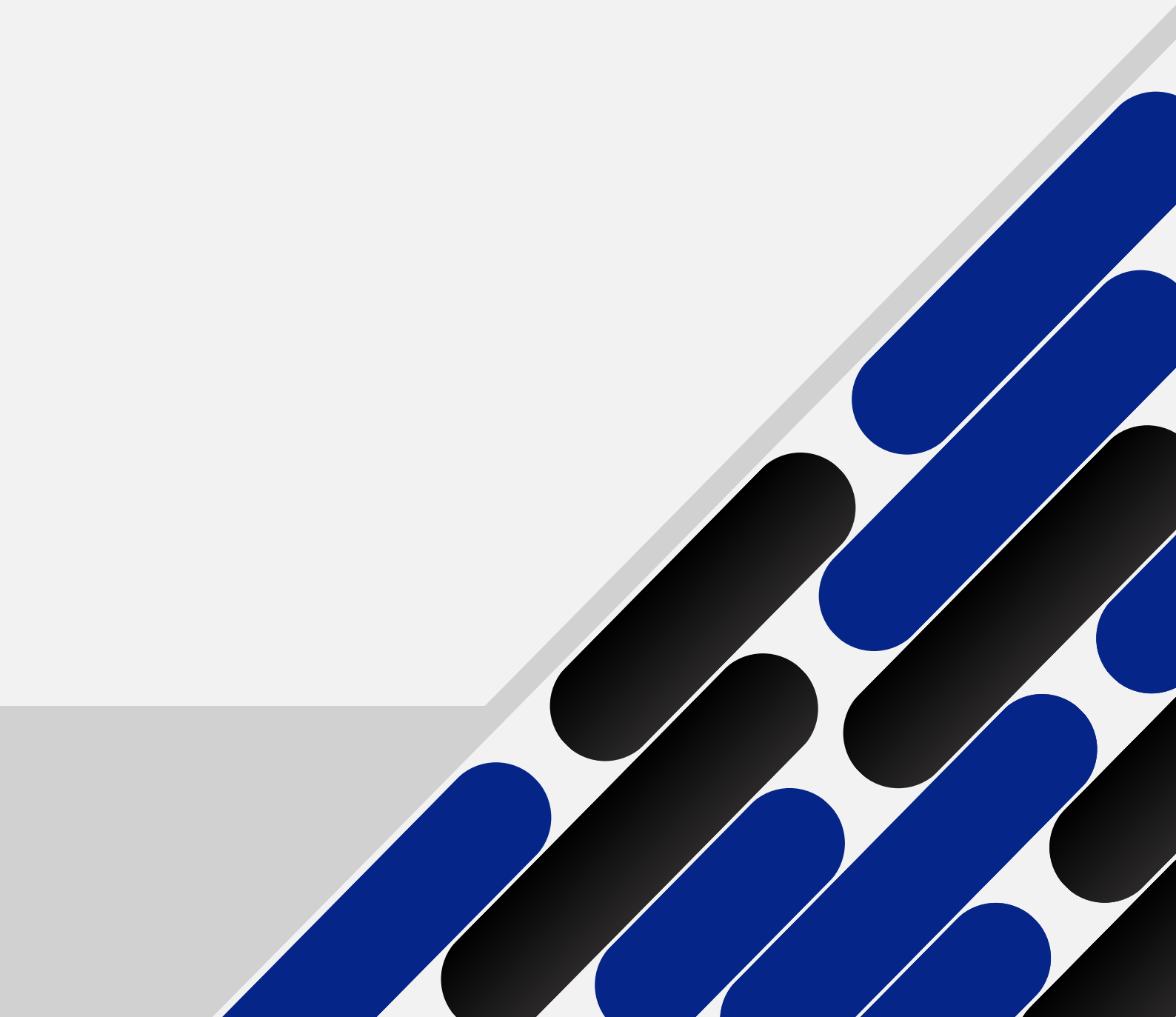


OBJECTIVE

The objective of this project is to implement, and evaluate systematic trading strategies for the BTC/USDT market using multiple technical indicators.

This project seeks to maximize the Calmar Ratio while ensuring strategies remain adaptable through walk-forward analysis. The work aims to balance technical rigor with practical relevance.



STRATEGY

The trading strategy implemented in this project is a **multi-indicator** technical analysis system designed to generate high probability trading signals. Instead of relying on a single indicator, which can often produce false signals.

This strategy combines three complementary indicators, each capture different aspects of the market´s behavior.

- **MACD** is used to detect shifts in momentum and potential trend reversals through the crossover of the MACD line and the signal line.
- **RSI** identifies overbought, providing insight into whether the market is likely to reverse or continue its current direction.
- **Bollinger Bands** capture volatility and price extremes, signaling potential reversal points when the price interacts with the upper or lower bands.

STRATEGY

The core idea is that market movements are more reliable when multiple technical signals align. Therefore, the strategy follows a **2-out-of-3 confirmation rule:**

“A trade is only executed when at least two indicators agree on the direction of the signal. This approach reduces noise and increases the likelihood of entering trades with stronger momentum and trend confirmation.”

If fewer than two indicators agree, the system remains out of the market to avoid unnecessary risk.

By integrating multiple indicators and requiring confirmation before entering trades, this strategy seeks to balance signal accuracy and trade frequency, aiming tomaximize the **Calmar Ratio** over time.

DATA ANALYSIS

The historical data used (Binance_BTCUSDT_1h.csv) consists of hourly OHLCV data from Binance.
Preprocessing Steps:

- Imported using pandas, skipping metadata rows if present.
- Removed missing values (dropna) to ensure indicator stability.
- Calculated derived features:
  - RSI
  - MACD
  - Bollinger Bands

No resampling or smoothing was performed; indicators were applied directly on hourly closes for responsiveness.

METHODOLOGY

Backtesting Engine

A walk-forward backtesting approach was adopted to mitigate overfitting. The data was split into:

- Training Set (70%) – used for parameter optimization.
- Testing Set (30%) – used for performance validation.

During simulation the system:

- Generates long or short signals based on 2/3 indicator confirmation.
- Opens one position per direction (long or short).
- Tracks portfolio value over time, accounting for realized and unrealized profits.

The code models each trade via a Position class storing entry price, shares, stop-loss, take-profit, and position type.

METHODOLOGY

Optimization

Parameter tuning is handled using Optuna, a Bayesian optimization framework.

The objective function maximizes the Calmar Ratio, defined as:

$$\text{Calmar} = \frac{\text{CAGR}}{|\text{Max Drawdown}|}$$

Hyperparameters optimized include:

Category	Parameter	Range
RSI	rsi_window, rsi_buy, rsi_sell	5-30, 5-30, 70-95
MACD	macd_fast, macd_slow, mcd_signal	5-15,20-40,5-15
Bollinger Bands	bb_window, bb_dev	10-30,1.5-3.0
Risk	stop_loss, take_profit	1-10%,1-20%
Position size	n_shares	0.1-4

RESULTS

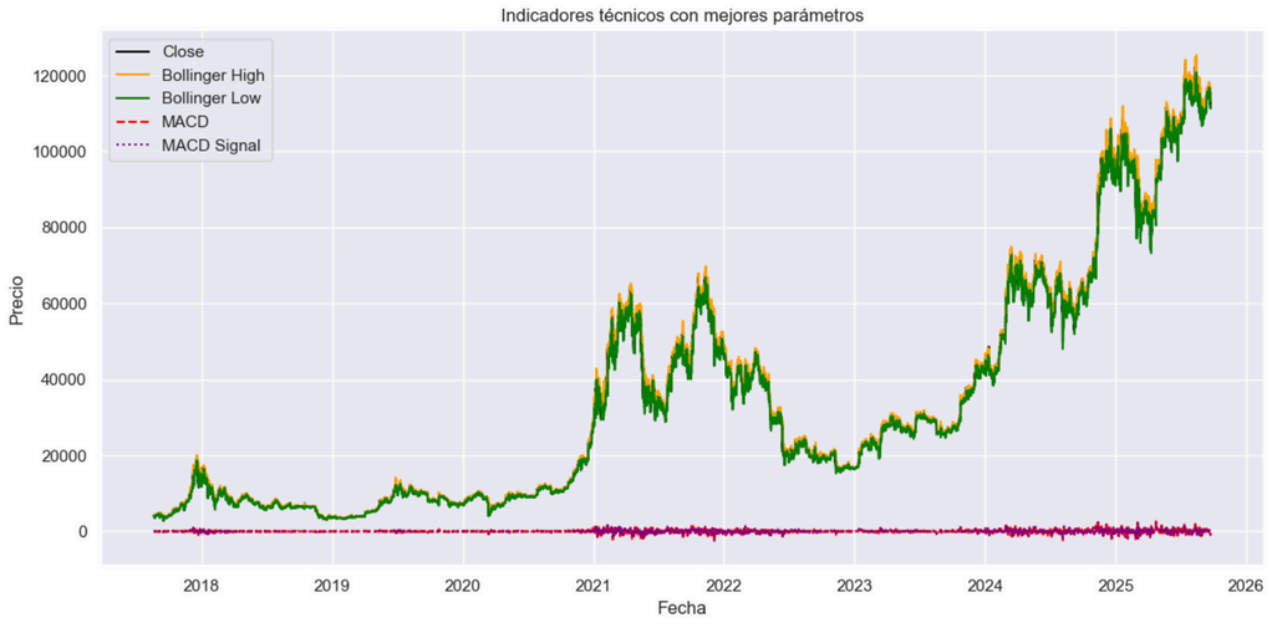
After 50 optimization trials, the study produced the following best configuration and the Best Calmar Ratio 1.33, this indicates strong annualized growth relative to the worst drawdown experienced.

Parameter	Value
RSI Window	7
RSI Buy	24
RSI Sell	88
MACD Fast	14
MACD Slow	32
MACD Signal	5
Bollinger Window	17
BB Deviation	2.2
Stop Loss	0.089
Take Profit	0.068
n Shares	0.568

METRICS GRAPHS & TABLES

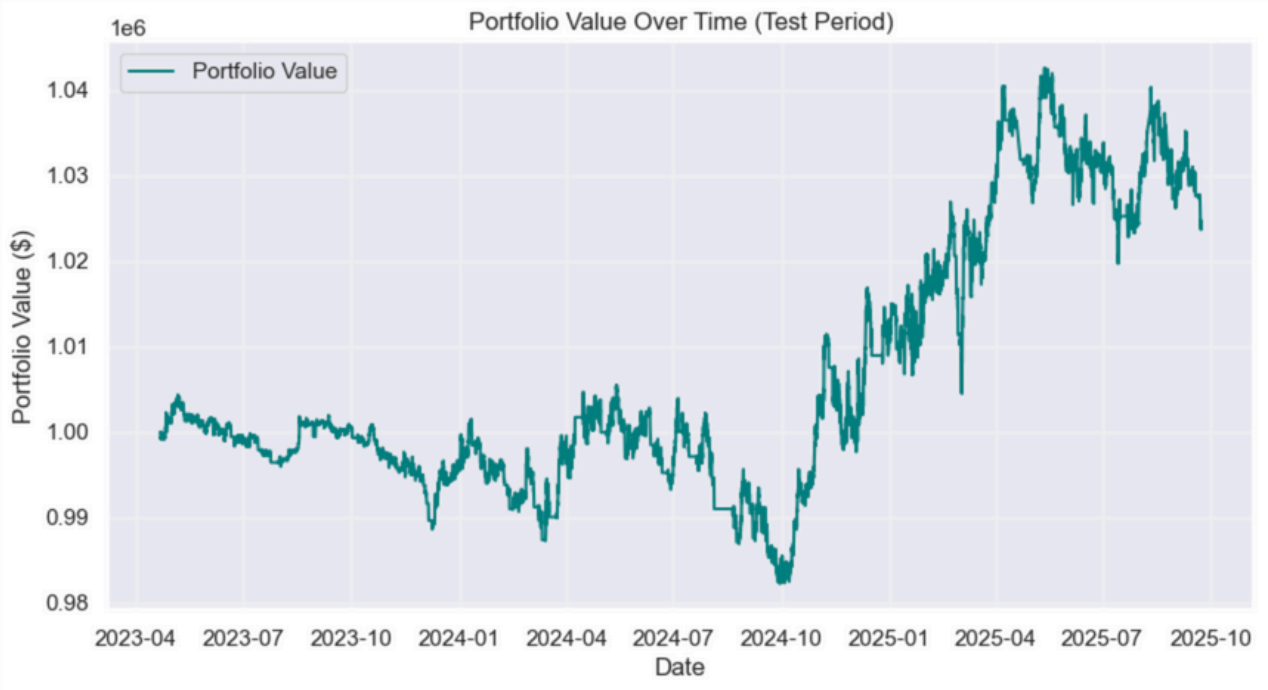
The optimized strategy produces a steadily growing equity curve, with periods of consolidation during high volatility phases.

Chart 1. Technical indicators with the best parameters



METRICS GRAPHS & TABLES

Chart 2. Portfolio value over time with the best parameters.



METRICS GRAPHS & TABLES

Table 1. Calmar Ratio over the years.
This yearly breakdown shows the strategy adapts reasonably well across different market conditions, peaking during strong trending years.

Year	Calmar Ratio
2017	5.781
2018	0.892
2019	1.777
2020	5.010
2021	1.085
2022	0.958
2023	7.166
2024	3.723
2025	0.625

RISK ANALYSIS OR LIMITATIONS

Strengths

Uses diverse indicators momentum, trend, volatility, improved robustness.

Walk forward design prevents overfitting by testing on unseen data.

Optuna optimization automates fine tuning for global parameter search.

Risks and Limitations

Nonstationary markets, parameters tuned on one regime may underperform when volatility or structure changes.

Execution risk, real slippage and latency are not simulated.

No leverag limits capital efficiency, though improves safety.

Simplified position sizing, fixed n_shares rather than dynamic risk based sizing.

Overfitting possibility even with walk-forward, repeated optimization might adapt too closely to past data.

CONCLUSIONS

The developed trading system demonstrates a robust and adaptive approach to technical analysis by effectively combining momentum, trend, and volatility indicators into a cohesive, data driven framework.

Through the integration of RSI, MACD, and Bollinger Bands with a signal confirmation rule, the strategy achieves a balance between responsiveness and noise reduction, leading to more reliable entry and exit points. The use of walk forward backtesting and optimization via Optuna enhances the model's ability to generalize by preventing overfitting and identifying optimal parameter combinations that maximize the Calmar Ratio.

Results indicate that the strategy delivers consistent performance across different market conditions, maintaining strong risk adjusted returns.
However, its effectiveness is still dependent on market regimes, execution conditions, and parameter stability.