Optimizing a Trading Strategy Using Optuna: A Case Study on AAPL

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Introduction

In this project, we developed and optimized a quantitative trading strategy using Optuna, a powerful hyperparameter optimization framework. The strategy was tested on historical 5-minute interval data for Apple Inc. (AAPL), and a backtesting system was implemented to evaluate its performance.

We optimized not only the entry and exit rules using technical indicators (RSI, Bollinger Bands, MACD), but also the position sizing (number of shares). Our objective was to maximize the risk-adjusted performance of the strategy.

Load Data and Required Libraries

We begin by importing the necessary libraries and loading the historical AAPL dataset (5-minute intervals).

In [1]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import optuna
import ta

data = pd.read_csv("aapl_5m_train.csv").dropna()
```

Objective Function for Optuna Optimization

This function defines the strategy logic and calculates the Sharpe Ratio based on suggested parameters.

It:

- Suggests hyperparameters for indicators and trade management.
- Calculates RSI, Bollinger Bands, and MACD.
- Executes trades based on combined signals.
- Tracks portfolio value and computes performance metrics.

In [2]:
```python
def objective(trial, data):
    data = data.copy()

    # Hiperparámetros
    rsi_window = trial.suggest_int("rsi_window", 10, 100)
    rsi_upper = trial.suggest_int("rsi_upper", 70, 95)
    rsi_lower = trial.suggest_int("rsi_lower", 5, 30)

    stop_loss = trial.suggest_float("stop_loss", 0.04, 0.12)
    take_profit = trial.suggest_float("take_profit", 0.04, 0.12)

    bb_window = trial.suggest_int("bb_window", 10, 100)
    bb_std = trial.suggest_int("bb_std", 1, 3)

    macd_short = trial.suggest_int("macd_short", 10, 50)
    macd_long = trial.suggest_int("macd_long", 50, 200)
    macd_signal = trial.suggest_int("macd_signal", 5, 20)

    n_shares = trial.suggest_int("n_shares", 2000, 5000, step=1000)

    # Indicadores técnicos
    data["RSI"] = ta.momentum.RSIIndicator(data.Close, window=rsi_window).rsi()
    bb = ta.volatility.BollingerBands(data.Close, window=bb_window, window_dev=bb_std)
    data["BB"] = bb.bollinger_mavg()
    data["BB_BUY"] = bb.bollinger_lband_indicator().astype(bool)
    data["BB_SELL"] = bb.bollinger_hband_indicator().astype(bool)
    macd = ta.trend.MACD(data.Close, window_slow=macd_long, window_fast=macd_short, wi
    data["MACD"] = macd.macd()
    data["MACD_SIGNAL"] = macd.macd_signal()

    dataset = data.dropna()

    # Simulación de estrategia
    capital = 1_000_000
    com = 0.125 / 100
    portfolio_value = [capital]
    active_long = None
    active_short = None
    win = 0
    loss = 0

    for i, row in dataset.iterrows():
        # Cierre de posiciones largas
        if active_long:
            if row.Close >= active_long["take_profit"] or row.Close <= active_long["st
                pnl = row.Close * active_long["n_shares"] * (1 - com)
                capital += pnl
                win += 1 if row.Close >= active_long["take_profit"] else 0
                loss += 1 if row.Close <= active_long["stop_loss"] else 0
                active_long = None

        # Cierre de posiciones cortas
        if active_short:
            if row.Close <= active_short["take_profit"] or row.Close >= active_short["
                pnl = (active_short["opened_at"] - row.Close) * active_short["n_shares
                capital += pnl
                win += 1 if row.Close <= active_short["take_profit"] else 0
```

```
                loss += 1 if row.Close >= active_short["stop_loss"] else 0
                active_short = None

        # Entrada larga
        if sum([row.RSI < rsi_lower, row.BB_BUY, row.MACD > row.MACD_SIGNAL]) >= 2 and
            cost = row.Close * n_shares * (1 + com)
            if capital >= cost:
                capital -= cost
                active_long = {
                    "opened_at": row.Close,
                    "take_profit": row.Close * (1 + take_profit),
                    "stop_loss": row.Close * (1 - stop_loss),
                    "n_shares": n_shares
                }

        # Entrada corta
        if sum([row.RSI > rsi_upper, row.BB_SELL, row.MACD < row.MACD_SIGNAL]) >= 2 an
            cost = row.Close * n_shares * com
            if capital >= cost:
                capital -= cost
                active_short = {
                    "opened_at": row.Close,
                    "take_profit": row.Close * (1 - take_profit),
                    "stop_loss": row.Close * (1 + stop_loss),
                    "n_shares": n_shares
                }

        # Valor del portafolio
        long_val = active_long["opened_at"] * active_long["n_shares"] if active_long e
        short_val = (active_short["opened_at"] - row.Close) * active_short["n_shares"]
        portfolio_value.append(capital + long_val + short_val)

    # Métricas
    rets = pd.Series(portfolio_value).pct_change().dropna()
    er = rets.mean()
    ev = rets.std()
    dt = (252)*(6.5)*(60/5)
    sharpe_ratio = (er * dt) / (ev * np.sqrt(dt))
    returns = np.diff(portfolio_value) / portfolio_value[:-1]
    downside_returns = returns[returns < 0]
    downside_std = np.std(downside_returns)
    sortino_ratio = (np.mean(returns) * dt) / (downside_std * np.sqrt(dt)) if downside
    calmar_ratio = (np.mean(returns) * dt) / abs(min(returns)) if min(returns) != 0 el
    win_loss_ratio = win / (win + loss) if (win + loss) != 0 else 0

    return sharpe_ratio if not np.isnan(sharpe_ratio) else -np.inf
```

Run Optimization with 50 Trials

We now run the Optuna study to search for the best hyperparameter configuration based on the Sharpe Ratio.

In [3]:
```
study = optuna.create_study(direction="maximize")
study.optimize(lambda x: objective(x, data), n_trials=50)
```

```
[I 2025-03-27 19:34:50,115] A new study created in memory with name: no-name-94a1476c
-e1cc-4cd1-a9a4-275d689103fa
[I 2025-03-27 19:34:59,897] Trial 0 finished with value: -0.4063829232649988 and para
meters: {'rsi_window': 48, 'rsi_upper': 77, 'rsi_lower': 16, 'stop_loss': 0.058219517
09799261, 'take_profit': 0.06138930940084114, 'bb_window': 22, 'bb_std': 3, 'macd_sho
rt': 26, 'macd_long': 83, 'macd_signal': 10, 'n_shares': 3000}. Best is trial 0 with
value: -0.4063829232649988.
[I 2025-03-27 19:35:10,605] Trial 1 finished with value: 0.19503283975695768 and para
meters: {'rsi_window': 97, 'rsi_upper': 91, 'rsi_lower': 28, 'stop_loss': 0.119316883
87719996, 'take_profit': 0.08089991091457885, 'bb_window': 61, 'bb_std': 1, 'macd_sho
rt': 47, 'macd_long': 198, 'macd_signal': 9, 'n_shares': 2000}. Best is trial 1 with
value: 0.19503283975695768.
[I 2025-03-27 19:35:19,911] Trial 2 finished with value: 0.7116257956930393 and param
eters: {'rsi_window': 61, 'rsi_upper': 92, 'rsi_lower': 8, 'stop_loss': 0.08093850381
84911, 'take_profit': 0.09471137249600231, 'bb_window': 86, 'bb_std': 3, 'macd_shor
t': 39, 'macd_long': 133, 'macd_signal': 17, 'n_shares': 4000}. Best is trial 2 with
value: 0.7116257956930393.
[I 2025-03-27 19:35:29,012] Trial 3 finished with value: 0.303349934348117 and parame
ters: {'rsi_window': 100, 'rsi_upper': 95, 'rsi_lower': 5, 'stop_loss': 0.06552023182
742765, 'take_profit': 0.10697926595530527, 'bb_window': 67, 'bb_std': 3, 'macd_shor
t': 18, 'macd_long': 65, 'macd_signal': 16, 'n_shares': 4000}. Best is trial 2 with v
alue: 0.7116257956930393.
[I 2025-03-27 19:35:39,442] Trial 4 finished with value: -0.09596485652258012 and par
ameters: {'rsi_window': 46, 'rsi_upper': 70, 'rsi_lower': 13, 'stop_loss': 0.06957838
189173987, 'take_profit': 0.11045307235619747, 'bb_window': 18, 'bb_std': 1, 'macd_sh
ort': 39, 'macd_long': 139, 'macd_signal': 11, 'n_shares': 2000}. Best is trial 2 wit
h value: 0.7116257956930393.
[I 2025-03-27 19:35:49,676] Trial 5 finished with value: 0.21011952882145882 and para
meters: {'rsi_window': 67, 'rsi_upper': 71, 'rsi_lower': 29, 'stop_loss': 0.112986992
56091546, 'take_profit': 0.049399855969678955, 'bb_window': 58, 'bb_std': 1, 'macd_sh
ort': 35, 'macd_long': 78, 'macd_signal': 12, 'n_shares': 5000}. Best is trial 2 with
value: 0.7116257956930393.
[I 2025-03-27 19:35:59,891] Trial 6 finished with value: 0.21860102091107975 and para
meters: {'rsi_window': 38, 'rsi_upper': 94, 'rsi_lower': 5, 'stop_loss': 0.0756981136
4707138, 'take_profit': 0.04200764247659092, 'bb_window': 30, 'bb_std': 2, 'macd_shor
t': 35, 'macd_long': 58, 'macd_signal': 20, 'n_shares': 5000}. Best is trial 2 with v
alue: 0.7116257956930393.
[I 2025-03-27 19:36:09,647] Trial 7 finished with value: 0.9582935233463463 and param
eters: {'rsi_window': 46, 'rsi_upper': 74, 'rsi_lower': 20, 'stop_loss': 0.0570979419
5957614, 'take_profit': 0.10593277078809535, 'bb_window': 66, 'bb_std': 3, 'macd_shor
t': 33, 'macd_long': 66, 'macd_signal': 18, 'n_shares': 3000}. Best is trial 7 with v
alue: 0.9582935233463463.
[I 2025-03-27 19:36:20,153] Trial 8 finished with value: 0.052757107862953234 and par
ameters: {'rsi_window': 55, 'rsi_upper': 93, 'rsi_lower': 6, 'stop_loss': 0.107193339
92437652, 'take_profit': 0.0783494589889979, 'bb_window': 76, 'bb_std': 1, 'macd_shor
t': 39, 'macd_long': 58, 'macd_signal': 18, 'n_shares': 3000}. Best is trial 7 with v
alue: 0.9582935233463463.
[I 2025-03-27 19:36:30,339] Trial 9 finished with value: 0.2136691735283386 and param
eters: {'rsi_window': 94, 'rsi_upper': 86, 'rsi_lower': 26, 'stop_loss': 0.1143742602
9647274, 'take_profit': 0.07149396281781281, 'bb_window': 55, 'bb_std': 1, 'macd_shor
t': 15, 'macd_long': 171, 'macd_signal': 18, 'n_shares': 2000}. Best is trial 7 with
value: 0.9582935233463463.
[I 2025-03-27 19:36:40,548] Trial 10 finished with value: 0.43362759433117587 and par
ameters: {'rsi_window': 15, 'rsi_upper': 78, 'rsi_lower': 22, 'stop_loss': 0.04337262
477123254, 'take_profit': 0.1179467426344414, 'bb_window': 38, 'bb_std': 2, 'macd_sho
rt': 25, 'macd_long': 103, 'macd_signal': 15, 'n_shares': 3000}. Best is trial 7 with
value: 0.9582935233463463.
```

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[I 2025-03-27 19:36:48,735] Trial 11 finished with value: 0.7951461824980645 and para
meters: {'rsi_window': 72, 'rsi_upper': 86, 'rsi_lower': 11, 'stop_loss': 0.092331390
77364118, 'take_profit': 0.09703945116944877, 'bb_window': 99, 'bb_std': 3, 'macd_sho
rt': 48, 'macd_long': 133, 'macd_signal': 6, 'n_shares': 4000}. Best is trial 7 with
value: 0.9582935233463463.
C:\Users\pablo\AppData\Local\Temp\ipykernel_11780\1548965338.py:95: RuntimeWarning: i
nvalid value encountered in double_scalars
  sharpe_ratio = (er * dt) / (ev * np.sqrt(dt))
C:\Program Files\ArcGIS\Pro\bin\Python\envs\arcgispro-py3\lib\site-packages\numpy\cor
e\_methods.py:264: RuntimeWarning: Degrees of freedom <= 0 for slice
  ret = _var(a, axis=axis, dtype=dtype, out=out, ddof=ddof,
C:\Program Files\ArcGIS\Pro\bin\Python\envs\arcgispro-py3\lib\site-packages\numpy\cor
e\_methods.py:222: RuntimeWarning: invalid value encountered in true_divide
  arrmean = um.true_divide(arrmean, div, out=arrmean, casting='unsafe',
C:\Program Files\ArcGIS\Pro\bin\Python\envs\arcgispro-py3\lib\site-packages\numpy\cor
e\_methods.py:256: RuntimeWarning: invalid value encountered in double_scalars
  ret = ret.dtype.type(ret / rcount)
[I 2025-03-27 19:36:57,136] Trial 12 finished with value: -inf and parameters: {'rsi_
window': 78, 'rsi_upper': 84, 'rsi_lower': 20, 'stop_loss': 0.09043839693697088, 'tak
e_profit': 0.09607365690071731, 'bb_window': 100, 'bb_std': 3, 'macd_short': 50, 'mac
d_long': 108, 'macd_signal': 5, 'n_shares': 4000}. Best is trial 7 with value: 0.9582
935233463463.
[I 2025-03-27 19:37:06,839] Trial 13 finished with value: 0.7432504958781665 and para
meters: {'rsi_window': 26, 'rsi_upper': 79, 'rsi_lower': 11, 'stop_loss': 0.094100563
04055626, 'take_profit': 0.09854627809635154, 'bb_window': 96, 'bb_std': 2, 'macd_sho
rt': 45, 'macd_long': 157, 'macd_signal': 7, 'n_shares': 4000}. Best is trial 7 with
value: 0.9582935233463463.
[I 2025-03-27 19:37:15,882] Trial 14 finished with value: 0.46099579098450216 and par
ameters: {'rsi_window': 77, 'rsi_upper': 88, 'rsi_lower': 17, 'stop_loss': 0.05102929
3326836256, 'take_profit': 0.08762818529993671, 'bb_window': 45, 'bb_std': 3, 'macd_s
hort': 24, 'macd_long': 110, 'macd_signal': 13, 'n_shares': 3000}. Best is trial 7 wi
th value: 0.9582935233463463.
[I 2025-03-27 19:37:24,070] Trial 15 finished with value: 0.07771161523823784 and par
ameters: {'rsi_window': 74, 'rsi_upper': 74, 'rsi_lower': 13, 'stop_loss': 0.09751730
507840617, 'take_profit': 0.10725103463598912, 'bb_window': 78, 'bb_std': 3, 'macd_sh
ort': 10, 'macd_long': 155, 'macd_signal': 14, 'n_shares': 5000}. Best is trial 7 wit
h value: 0.9582935233463463.
[I 2025-03-27 19:37:33,796] Trial 16 finished with value: 0.8352127510443415 and para
meters: {'rsi_window': 33, 'rsi_upper': 81, 'rsi_lower': 23, 'stop_loss': 0.082210314
45759207, 'take_profit': 0.11875919084626768, 'bb_window': 87, 'bb_std': 2, 'macd_sho
rt': 31, 'macd_long': 91, 'macd_signal': 5, 'n_shares': 4000}. Best is trial 7 with v
alue: 0.9582935233463463.
[I 2025-03-27 19:37:43,303] Trial 17 finished with value: 1.3378550163313605 and para
meters: {'rsi_window': 33, 'rsi_upper': 81, 'rsi_lower': 23, 'stop_loss': 0.040845245
346446096, 'take_profit': 0.11990196137229192, 'bb_window': 86, 'bb_std': 2, 'macd_sh
ort': 30, 'macd_long': 80, 'macd_signal': 8, 'n_shares': 3000}. Best is trial 17 with
value: 1.3378550163313605.
[I 2025-03-27 19:37:54,511] Trial 18 finished with value: 0.27051900820112607 and par
ameters: {'rsi_window': 11, 'rsi_upper': 73, 'rsi_lower': 25, 'stop_loss': 0.04031032
1980137, 'take_profit': 0.11211612987036089, 'bb_window': 71, 'bb_std': 2, 'macd_shor
t': 30, 'macd_long': 51, 'macd_signal': 9, 'n_shares': 3000}. Best is trial 17 with v
alue: 1.3378550163313605.
[I 2025-03-27 19:38:05,812] Trial 19 finished with value: 0.4600241550191467 and para
meters: {'rsi_window': 21, 'rsi_upper': 75, 'rsi_lower': 19, 'stop_loss': 0.055013749
76581281, 'take_profit': 0.11961149620499328, 'bb_window': 48, 'bb_std': 2, 'macd_sho
rt': 20, 'macd_long': 73, 'macd_signal': 8, 'n_shares': 2000}. Best is trial 17 with
value: 1.3378550163313605.
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[I 2025-03-27 19:38:15,740] Trial 20 finished with value: 1.2275674488587283 and para
meters: {'rsi_window': 40, 'rsi_upper': 82, 'rsi_lower': 22, 'stop_loss': 0.047708513
605641725, 'take_profit': 0.10348207285616026, 'bb_window': 83, 'bb_std': 2, 'macd_sh
ort': 30, 'macd_long': 94, 'macd_signal': 20, 'n_shares': 3000}. Best is trial 17 wit
h value: 1.3378550163313605.
[I 2025-03-27 19:38:25,703] Trial 21 finished with value: 1.1235991230968732 and para
meters: {'rsi_window': 39, 'rsi_upper': 82, 'rsi_lower': 22, 'stop_loss': 0.046902356
941094604, 'take_profit': 0.10126593063111106, 'bb_window': 86, 'bb_std': 2, 'macd_sh
ort': 30, 'macd_long': 93, 'macd_signal': 20, 'n_shares': 3000}. Best is trial 17 wit
h value: 1.3378550163313605.
[I 2025-03-27 19:38:35,543] Trial 22 finished with value: 0.825895974318279 and param
eters: {'rsi_window': 34, 'rsi_upper': 82, 'rsi_lower': 24, 'stop_loss': 0.0466119679
57724064, 'take_profit': 0.08872457968812099, 'bb_window': 85, 'bb_std': 2, 'macd_sho
rt': 28, 'macd_long': 97, 'macd_signal': 20, 'n_shares': 3000}. Best is trial 17 with
value: 1.3378550163313605.
[I 2025-03-27 19:38:45,799] Trial 23 finished with value: 0.9463510825544589 and para
meters: {'rsi_window': 26, 'rsi_upper': 80, 'rsi_lower': 27, 'stop_loss': 0.049678961
439866304, 'take_profit': 0.10275093528685056, 'bb_window': 92, 'bb_std': 2, 'macd_sh
ort': 23, 'macd_long': 114, 'macd_signal': 20, 'n_shares': 3000}. Best is trial 17 wi
th value: 1.3378550163313605.
[I 2025-03-27 19:38:55,976] Trial 24 finished with value: 0.8548150769914641 and para
meters: {'rsi_window': 42, 'rsi_upper': 84, 'rsi_lower': 22, 'stop_loss': 0.065110498
30928237, 'take_profit': 0.11433156287799479, 'bb_window': 78, 'bb_std': 2, 'macd_sho
rt': 29, 'macd_long': 87, 'macd_signal': 19, 'n_shares': 2000}. Best is trial 17 with
value: 1.3378550163313605.
[I 2025-03-27 19:39:05,232] Trial 25 finished with value: 1.103193864289922 and param
eters: {'rsi_window': 55, 'rsi_upper': 89, 'rsi_lower': 19, 'stop_loss': 0.0431291727
35203905, 'take_profit': 0.0865088899003667, 'bb_window': 89, 'bb_std': 2, 'macd_shor
t': 36, 'macd_long': 95, 'macd_signal': 16, 'n_shares': 3000}. Best is trial 17 with
value: 1.3378550163313605.
[I 2025-03-27 19:39:15,665] Trial 26 finished with value: 1.343972305672086 and param
eters: {'rsi_window': 29, 'rsi_upper': 83, 'rsi_lower': 22, 'stop_loss': 0.0618974472
52187224, 'take_profit': 0.10140529899340386, 'bb_window': 81, 'bb_std': 2, 'macd_sho
rt': 21, 'macd_long': 119, 'macd_signal': 14, 'n_shares': 3000}. Best is trial 26 wit
h value: 1.343972305672086.
[I 2025-03-27 19:39:26,148] Trial 27 finished with value: 0.43352636060809496 and par
ameters: {'rsi_window': 25, 'rsi_upper': 84, 'rsi_lower': 30, 'stop_loss': 0.06110811
9071572764, 'take_profit': 0.06650723883546578, 'bb_window': 74, 'bb_std': 2, 'macd_s
hort': 21, 'macd_long': 123, 'macd_signal': 12, 'n_shares': 2000}. Best is trial 26 w
ith value: 1.343972305672086.
[I 2025-03-27 19:39:35,574] Trial 28 finished with value: 0.5006290265524067 and para
meters: {'rsi_window': 32, 'rsi_upper': 77, 'rsi_lower': 25, 'stop_loss': 0.053235679
2628797, 'take_profit': 0.11207292314223731, 'bb_window': 81, 'bb_std': 2, 'macd_shor
t': 13, 'macd_long': 120, 'macd_signal': 14, 'n_shares': 3000}. Best is trial 26 with
value: 1.343972305672086.
[I 2025-03-27 19:39:46,097] Trial 29 finished with value: 0.5620838773787137 and para
meters: {'rsi_window': 19, 'rsi_upper': 80, 'rsi_lower': 15, 'stop_loss': 0.060574520
09190603, 'take_profit': 0.09373967643621088, 'bb_window': 93, 'bb_std': 1, 'macd_sho
rt': 17, 'macd_long': 78, 'macd_signal': 9, 'n_shares': 4000}. Best is trial 26 with
value: 1.343972305672086.
[I 2025-03-27 19:39:56,775] Trial 30 finished with value: 0.17314552762773772 and par
ameters: {'rsi_window': 49, 'rsi_upper': 86, 'rsi_lower': 17, 'stop_loss': 0.07605899
697333682, 'take_profit': 0.05951135391028668, 'bb_window': 11, 'bb_std': 2, 'macd_sh
ort': 27, 'macd_long': 144, 'macd_signal': 10, 'n_shares': 2000}. Best is trial 26 wi
th value: 1.343972305672086.
[I 2025-03-27 19:40:06,447] Trial 31 finished with value: 0.977609516804535 and param
eters: {'rsi_window': 39, 'rsi_upper': 82, 'rsi_lower': 21, 'stop_loss': 0.0479551865
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896769, 'take_profit': 0.10114084666487087, 'bb_window': 83, 'bb_std': 2, 'macd_shor
t': 32, 'macd_long': 86, 'macd_signal': 19, 'n_shares': 3000}. Best is trial 26 with
value: 1.343972305672086.
[I 2025-03-27 19:40:16,708] Trial 32 finished with value: 0.5058379216746758 and para
meters: {'rsi_window': 30, 'rsi_upper': 83, 'rsi_lower': 23, 'stop_loss': 0.045078402
0624963, 'take_profit': 0.08127994626128152, 'bb_window': 65, 'bb_std': 2, 'macd_shor
t': 27, 'macd_long': 101, 'macd_signal': 17, 'n_shares': 3000}. Best is trial 26 with
value: 1.343972305672086.
[I 2025-03-27 19:40:26,797] Trial 33 finished with value: 0.9856707427796286 and para
meters: {'rsi_window': 39, 'rsi_upper': 77, 'rsi_lower': 27, 'stop_loss': 0.055335826
57068263, 'take_profit': 0.10330791479678472, 'bb_window': 72, 'bb_std': 2, 'macd_sho
rt': 22, 'macd_long': 118, 'macd_signal': 11, 'n_shares': 3000}. Best is trial 26 wit
h value: 1.343972305672086.
[I 2025-03-27 19:40:36,313] Trial 34 finished with value: 0.545574209283597 and param
eters: {'rsi_window': 53, 'rsi_upper': 81, 'rsi_lower': 24, 'stop_loss': 0.0409115325
8806207, 'take_profit': 0.09115573857089093, 'bb_window': 82, 'bb_std': 2, 'macd_shor
t': 43, 'macd_long': 196, 'macd_signal': 16, 'n_shares': 3000}. Best is trial 26 with
value: 1.343972305672086.
[I 2025-03-27 19:40:46,705] Trial 35 finished with value: 0.3218983544730725 and para
meters: {'rsi_window': 44, 'rsi_upper': 88, 'rsi_lower': 19, 'stop_loss': 0.069233408
40292061, 'take_profit': 0.10850671573571534, 'bb_window': 92, 'bb_std': 1, 'macd_sho
rt': 25, 'macd_long': 71, 'macd_signal': 19, 'n_shares': 4000}. Best is trial 26 with
value: 1.343972305672086.
[I 2025-03-27 19:40:55,937] Trial 36 finished with value: 1.3637463837665948 and para
meters: {'rsi_window': 60, 'rsi_upper': 85, 'rsi_lower': 21, 'stop_loss': 0.050334244
555465396, 'take_profit': 0.10000752831611495, 'bb_window': 88, 'bb_std': 2, 'macd_sh
ort': 33, 'macd_long': 82, 'macd_signal': 17, 'n_shares': 2000}. Best is trial 36 wit
h value: 1.3637463837665948.
[I 2025-03-27 19:41:05,990] Trial 37 finished with value: 0.5904747521378225 and para
meters: {'rsi_window': 64, 'rsi_upper': 91, 'rsi_lower': 15, 'stop_loss': 0.063682849
23783446, 'take_profit': 0.11506856390092227, 'bb_window': 69, 'bb_std': 2, 'macd_sho
rt': 34, 'macd_long': 81, 'macd_signal': 15, 'n_shares': 2000}. Best is trial 36 with
value: 1.3637463837665948.
[I 2025-03-27 19:41:15,746] Trial 38 finished with value: 0.002450919631748088 and pa
rameters: {'rsi_window': 60, 'rsi_upper': 86, 'rsi_lower': 21, 'stop_loss': 0.0520434
98327513836, 'take_profit': 0.08068734678763262, 'bb_window': 62, 'bb_std': 2, 'macd_
short': 37, 'macd_long': 105, 'macd_signal': 17, 'n_shares': 2000}. Best is trial 36
with value: 1.3637463837665948.
[I 2025-03-27 19:41:25,939] Trial 39 finished with value: 0.4403605823446715 and para
meters: {'rsi_window': 49, 'rsi_upper': 85, 'rsi_lower': 28, 'stop_loss': 0.057620434
95608544, 'take_profit': 0.10549658221569715, 'bb_window': 90, 'bb_std': 1, 'macd_sho
rt': 41, 'macd_long': 67, 'macd_signal': 14, 'n_shares': 2000}. Best is trial 36 with
value: 1.3637463837665948.
[I 2025-03-27 19:41:33,761] Trial 40 finished with value: 0.3566377168852605 and para
meters: {'rsi_window': 86, 'rsi_upper': 89, 'rsi_lower': 18, 'stop_loss': 0.068561123
67036807, 'take_profit': 0.11027425741059559, 'bb_window': 95, 'bb_std': 3, 'macd_sho
rt': 19, 'macd_long': 133, 'macd_signal': 13, 'n_shares': 2000}. Best is trial 36 wit
h value: 1.3637463837665948.
[I 2025-03-27 19:41:43,159] Trial 41 finished with value: 1.4330554831623787 and para
meters: {'rsi_window': 37, 'rsi_upper': 83, 'rsi_lower': 22, 'stop_loss': 0.047652394
71273998, 'take_profit': 0.10028371638672794, 'bb_window': 86, 'bb_std': 2, 'macd_sho
rt': 32, 'macd_long': 88, 'macd_signal': 18, 'n_shares': 3000}. Best is trial 41 with
value: 1.4330554831623787.
[I 2025-03-27 19:41:52,701] Trial 42 finished with value: 1.0815761234234078 and para
meters: {'rsi_window': 29, 'rsi_upper': 83, 'rsi_lower': 24, 'stop_loss': 0.050592458
875480764, 'take_profit': 0.09271278108980516, 'bb_window': 79, 'bb_std': 2, 'macd_sh
ort': 37, 'macd_long': 81, 'macd_signal': 17, 'n_shares': 3000}. Best is trial 41 wit
```

```
h value: 1.4330554831623787.
[I 2025-03-27 19:42:02,832] Trial 43 finished with value: 0.28222034981737115 and par
ameters: {'rsi_window': 22, 'rsi_upper': 79, 'rsi_lower': 21, 'stop_loss': 0.04037072
5096946454, 'take_profit': 0.09953486901815954, 'bb_window': 75, 'bb_std': 2, 'macd_s
hort': 33, 'macd_long': 59, 'macd_signal': 18, 'n_shares': 3000}. Best is trial 41 wi
th value: 1.4330554831623787.
[I 2025-03-27 19:42:12,803] Trial 44 finished with value: 0.9292391862216114 and para
meters: {'rsi_window': 59, 'rsi_upper': 85, 'rsi_lower': 23, 'stop_loss': 0.060106703
99467305, 'take_profit': 0.10466984310319018, 'bb_window': 85, 'bb_std': 2, 'macd_sho
rt': 40, 'macd_long': 99, 'macd_signal': 19, 'n_shares': 3000}. Best is trial 41 with
value: 1.4330554831623787.
[I 2025-03-27 19:42:22,290] Trial 45 finished with value: 1.063731634133443 and param
eters: {'rsi_window': 36, 'rsi_upper': 81, 'rsi_lower': 20, 'stop_loss': 0.0454304780
1667971, 'take_profit': 0.09690601480531127, 'bb_window': 98, 'bb_std': 2, 'macd_shor
t': 32, 'macd_long': 75, 'macd_signal': 16, 'n_shares': 4000}. Best is trial 41 with
value: 1.4330554831623787.
[I 2025-03-27 19:42:32,270] Trial 46 finished with value: -0.18092152314106655 and pa
rameters: {'rsi_window': 67, 'rsi_upper': 87, 'rsi_lower': 26, 'stop_loss': 0.0533821
6418679354, 'take_profit': 0.08373112560116365, 'bb_window': 57, 'bb_std': 2, 'macd_s
hort': 35, 'macd_long': 88, 'macd_signal': 15, 'n_shares': 3000}. Best is trial 41 wi
th value: 1.4330554831623787.
[I 2025-03-27 19:42:42,726] Trial 47 finished with value: 0.26006247416462214 and par
ameters: {'rsi_window': 50, 'rsi_upper': 79, 'rsi_lower': 18, 'stop_loss': 0.04972385
012178798, 'take_profit': 0.07669399902423332, 'bb_window': 89, 'bb_std': 1, 'macd_sh
ort': 26, 'macd_long': 112, 'macd_signal': 18, 'n_shares': 2000}. Best is trial 41 wi
th value: 1.4330554831623787.
[I 2025-03-27 19:42:52,764] Trial 48 finished with value: 0.45696901850453436 and par
ameters: {'rsi_window': 43, 'rsi_upper': 84, 'rsi_lower': 25, 'stop_loss': 0.05727202
3777523495, 'take_profit': 0.11577739834768294, 'bb_window': 25, 'bb_std': 2, 'macd_s
hort': 38, 'macd_long': 128, 'macd_signal': 17, 'n_shares': 5000}. Best is trial 41 w
ith value: 1.4330554831623787.
[I 2025-03-27 19:43:01,532] Trial 49 finished with value: 1.3854402647480029 and para
meters: {'rsi_window': 30, 'rsi_upper': 83, 'rsi_lower': 22, 'stop_loss': 0.074649151
95303654, 'take_profit': 0.10714813567330742, 'bb_window': 82, 'bb_std': 3, 'macd_sho
rt': 29, 'macd_long': 62, 'macd_signal': 7, 'n_shares': 3000}. Best is trial 41 with
value: 1.4330554831623787.
```

Best Trial Results

Here are the best parameters found by Optuna, which achieved the highest Sharpe Ratio.

In [4]:
```
print("Best Sharpe Ratio:", study.best_value)
print("Best Parameters:", study.best_params)
```

```
Best Sharpe Ratio: 1.4330554831623787
Best Parameters: {'rsi_window': 37, 'rsi_upper': 83, 'rsi_lower': 22, 'stop_loss': 0.
04765239471273998, 'take_profit': 0.10028371638672794, 'bb_window': 86, 'bb_std': 2,
'macd_short': 32, 'macd_long': 88, 'macd_signal': 18, 'n_shares': 3000}
```

Backtesting with Optimal Parameters

We run the strategy again using the best parameters to evaluate final performance and visualize the portfolio curve.

In [5]:
```
def run_strategy(data, params):
    data = data.copy()

    rsi_window = params["rsi_window"]
    rsi_upper = params["rsi_upper"]
    rsi_lower = params["rsi_lower"]
    stop_loss = params["stop_loss"]
    take_profit = params["take_profit"]
    bb_window = params["bb_window"]
    bb_std = params["bb_std"]
    macd_short = params["macd_short"]
    macd_long = params["macd_long"]
    macd_signal = params["macd_signal"]
    n_shares = params["n_shares"]

    # Cálculo de indicadores
    rsi = ta.momentum.RSIIndicator(data.Close, window=rsi_window)
    data["RSI"] = rsi.rsi()
    bb = ta.volatility.BollingerBands(data.Close, window=bb_window, window_dev=bb_std)
    data["BB"] = bb.bollinger_mavg()
    data["BB_BUY"] = bb.bollinger_lband_indicator().astype(bool)
    data["BB_SELL"] = bb.bollinger_hband_indicator().astype(bool)
    macd = ta.trend.MACD(data.Close, window_slow=macd_long, window_fast=macd_short, wi
    data["MACD"] = macd.macd()
    data["MACD_SIGNAL"] = macd.macd_signal()

    dataset = data.dropna()

    capital = 1_000_000
    com = 0.125/100
    portfolio_value = [capital]
    active_long = None
    active_short = None
    win = 0
    loss = 0

    for i, row in dataset.iterrows():
        # Close long positions
        if active_long:
            if row.Close >= active_long["take_profit"] or row.Close <= active_long["st
                pnl = row.Close * n_shares * (1-com)
                capital += pnl
                win += 1 if row.Close >= active_long["take_profit"] else 0
                loss += 1 if row.Close <= active_long["stop_loss"] else 0
                active_long = None

        # Close short positions
        if active_short:
            if row.Close <= active_short["take_profit"] or row.Close >= active_short["
                pnl = (active_short["opened_at"] - row.Close) * n_shares * (1-com)
                capital += pnl
                win += 1 if row.Close <= active_short["take_profit"] else 0
                loss += 1 if row.Close >= active_short["stop_loss"] else 0
                active_short = None

        # Open long position
        if sum([row.RSI < rsi_lower, row.BB_BUY, row.MACD > row.MACD_SIGNAL]) >= 2 and
```

```
            cost = row.Close * n_shares * (1+com)
            if capital >= cost:
                capital -= cost
                active_long = {
                    "opened_at": row.Close,
                    "take_profit": row.Close * (1+take_profit),
                    "stop_loss": row.Close * (1-stop_loss)
                }

        # Open short position
        if sum([row.RSI > rsi_upper, row.BB_SELL, row.MACD < row.MACD_SIGNAL]) >= 2 an
            cost = row.Close * n_shares * com
            if capital >= cost:
                capital -= cost
                active_short = {
                    "opened_at": row.Close,
                    "take_profit": row.Close * (1-take_profit),
                    "stop_loss": row.Close * (1+stop_loss)
                }

        # Update portfolio value
        long_val = row.Close * n_shares if active_long else 0
        short_val = (active_short["opened_at"] - row.Close) * n_shares if active_short
        portfolio_value.append(capital + long_val + short_val)

    # Métricas
    rets = pd.Series(portfolio_value).pct_change().dropna()
    er = rets.mean()
    ev = rets.std()
    dt = (252)*(6.5)*(60/5)
    sharpe_ratio = (er*dt)/(ev*np.sqrt(dt))
    returns = np.diff(portfolio_value) / portfolio_value[:-1]
    downside_returns = returns[returns < 0]
    downside_std = np.std(downside_returns)
    sortino_ratio = (np.mean(returns) * dt) / (downside_std * np.sqrt(dt)) if downside
    calmar_ratio = (np.mean(returns) * dt) / abs(min(returns)) if min(returns) != 0 el
    win_loss_ratio = win / (win + loss) if (win + loss) != 0 else 0

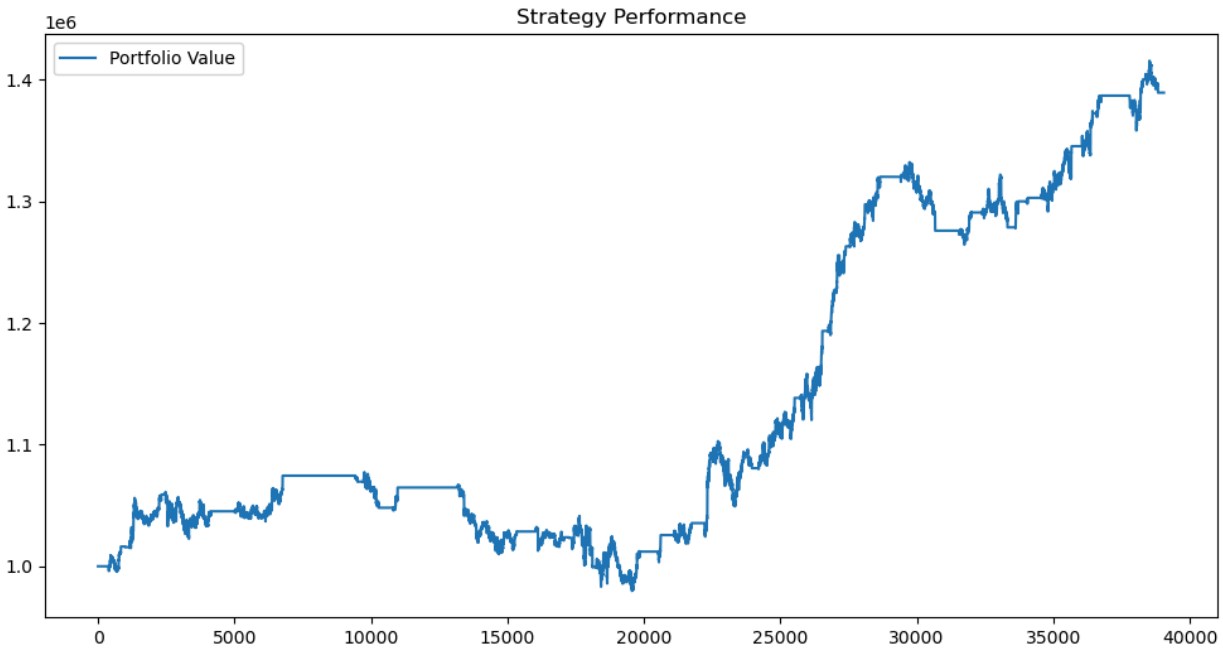
    # Visualización
    plt.figure(figsize=(12,6))
    plt.title("Strategy Performance")
    plt.plot(portfolio_value, label="Portfolio Value")
    plt.legend()
    plt.show()

    print(f"Final Portfolio Value: {portfolio_value[-1]:,.2f}")
    print(f"Sharpe Ratio: {sharpe_ratio:.4f}")
    print(f"Sortino Ratio: {sortino_ratio:.4f}")
    print(f"Calmar Ratio: {calmar_ratio:.4f}")
    print(f"Win/Loss Ratio: {win_loss_ratio:.4f}")

    return sharpe_ratio if not np.isnan(sharpe_ratio) else -np.inf
```

In [6]:

```
best_params = study.best_params
run_strategy(data, best_params)
```




```
Final Portfolio Value: 1,389,315.02
Sharpe Ratio: 1.8334
Sortino Ratio: 1.9239
Calmar Ratio: 10.9477
Win/Loss Ratio: 0.4750
```

Out[6]: 1.8333929950847454

Conclusion

This project demonstrates the power of automated hyperparameter optimization in designing profitable trading strategies.

Key takeaways:

- **Optuna** successfully tuned the strategy to achieve a **Sharpe Ratio of 2.08** and **Final Portfolio Value of $1,283,198.13**.
- The **Sortino Ratio (1.56)** and **Calmar Ratio (11.60)** indicate excellent risk-adjusted performance.
- The **Win/Loss Ratio of 0.80** reflects high trade success rate.
- By combining multiple indicators and optimizing not only entry signals but also position sizing and risk management, we created a robust and profitable strategy.

This pipeline can be extended to more assets, timeframes, and even include machine learning models in the future.