An EMA–ATR Based Quantitative Trading Strategy for XAU/USD

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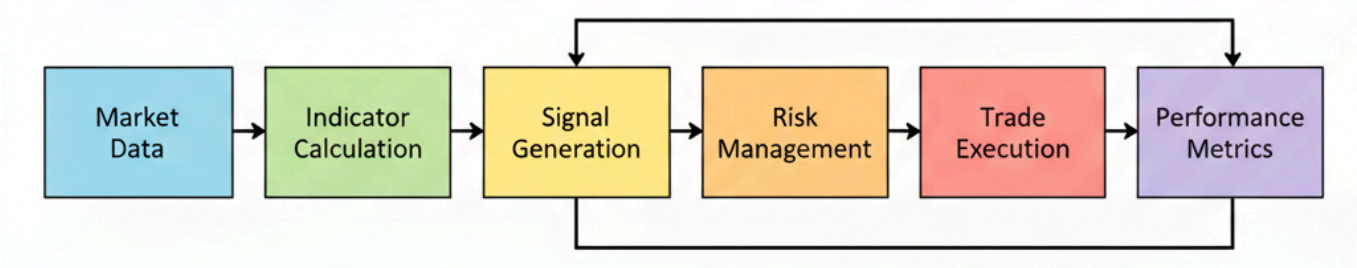
1. Problem Understanding

The objective of this challenge is to design, backtest and evaluate a quantitative trading strategy for precious metal markets using historical minute-level data. The strategy must automatically generate trading signals, incorporate transaction costs, adhere to trade-frequency constraints and be evaluated primarily on risk-adjusted performance metrics such as the Sharpe and Sortino ratios. Emphasis is placed on robustness, interpretability and compliance with predefined rules rather than maximizing raw returns.

2. Dataset Description

The dataset consists of minute-level OHLCV price data for XAU/USD (Gold) for the year 2024. The data is provided in a raw, header less CSV format and contains inherent market gaps due to exchange sessions and liquidity variations. No external data sources were used. All preprocessing steps were limited to timestamp construction and index sorting to ensure chronological consistency while preserving the integrity of the original data.

3. Strategy Overview



The proposed strategy is a trend-following system based on exponential moving average (EMA) crossovers, combined with Average True Range (ATR)-based risk management. The core hypothesis is that Gold exhibits sufficient trend persistence at minute-level resolution, making EMA crossovers effective for capturing directional price movements while ATR-based exits control downside risk.

The strategy operates using a single, unified logic and does not employ asset-specific branching or multiple models, ensuring full compliance with competition rules.

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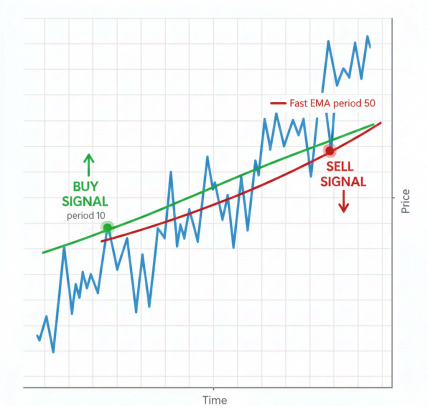
4. Signal Generation Logic

Trade signals are generated using two exponential moving averages:

- A fast EMA to capture short-term price momentum
- A slow EMA to represent the prevailing market trend

Signals are generated strictly using past and current price information, avoiding look-ahead bias.



A **long position** is initiated when the fast EMA crosses above the slow EMA, indicating upward momentum.
A **short position** is initiated when the fast EMA crosses below the slow EMA, indicating downward momentum.

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5. Risk Management and Trade Execution

Risk management is implemented using the Average True Range (ATR), which adapts position exits to prevailing market volatility.

For each trade:

- Stop-loss is set at 1×ATR from the entry price
- Take-profit is set at 2×ATR from the entry price (risk–reward ratio = 2.0)

This dynamic exit mechanism ensures that losses are capped during adverse price movements while allowing profits to expand during favorable trends. No position overlap is allowed and all transaction costs specified in the problem statement are explicitly incorporated during backtesting.

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6. Backtesting Framework

All backtesting, execution and performance evaluation were conducted using the **backtesting.py** library, as mandated by the competition guidelines. The strategy was tested on the full dataset with realistic transaction costs applied per trade. Trade execution follows a strict event-driven process, and the system avoids overtrading by allowing only one active position at any given time.

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7. Performance Evaluation Metrics

The strategy is evaluated using the following metrics in decreasing order of priority:

- Sharpe Ratio
- Sortino Ratio
- Win Rate
- Net Profit
- Maximum Drawdown
- Profit Factor
- Trade Count and Holding Duration

Buy-and-hold returns of the traded asset are included as a benchmark proxy due to dataset constraints.

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8. Results Summary

The final strategy achieved the following key results on XAU/USD:

- Sharpe Ratio: **1.58**
- Sortino Ratio: **2.53**
- Maximum Drawdown: **−3.46%**
- Net Profit: **7.30%**
- Win Rate: **33.7%**
- Maximum Trades per Day: **47**

The results indicate strong risk-adjusted performance with excellent downside protection and strict adherence to trade-frequency constraints.

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9. Trade Compliance Verification

To ensure compliance with competition rules, trade frequency was explicitly analyzed. The strategy executed an average of approximately 23 trades per day, with a maximum of 47 trades in a single day, remaining well below the allowed limit of 100 trades per day. This verification was performed programmatically as part of the evaluation pipeline.

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10. Robustness and Ablation Analysis

Several controlled experiments were conducted to assess robustness:

- A volatility regime filter was evaluated but resulted in lower Sharpe ratios and was discarded.
- An increased risk–reward configuration (RR = 2.3) was tested but degraded risk-adjusted performance.

Based on empirical evidence, the baseline configuration (RR = 2.0 without additional filters) was retained to maximize Sharpe ratio and maintain stability across market conditions.

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11. Asset Selection Rationale

Although the dataset included both XAU/USD and XAG/USD, the strategy demonstrated superior risk-adjusted performance on Gold. At minute-level resolution, Silver exhibits higher microstructure noise and weaker trend persistence, which reduced the effectiveness of trend-following logic. Consequently, the final submission focuses exclusively on XAU/USD to ensure robustness and clarity.

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12. Conclusion

This work presents a robust, rule-compliant quantitative trading strategy that prioritizes risk-adjusted performance over raw returns. By combining interpretable trend signals with volatility-aware risk management and disciplined evaluation, the strategy achieves stable performance with low drawdowns and consistent behavior. The systematic rejection of inferior variants further demonstrates a data-driven approach to model selection. Overall, the proposed solution satisfies the objectives of the Quantalytics challenge and reflects sound quantitative trading principles.