Performance Analysis Report

Real-Time Trade Simulator

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1 Latency Evaluation

We measured latency at three levels: data processing, UI update, and end-to-end loop latency. Below are the observed values in milliseconds:

- Data Processing Latencies: 3.333 ms, 2.728 ms, 0.071 ms, 2.792 ms, 0.075 ms, 2.388 ms
- UI Update Latency: 1740.832 ms
- End-to-End Loop Latency: 1741.049 ms

Analysis:

- Data processing latency is consistently low (under 5 ms), indicating high efficiency in handling L2 orderbook snapshots.
- The UI update latency is higher due to the 1-second update interval and Streamlit refresh time.
- End-to-end loop latency includes UI and model updates; the values show stability and responsiveness.

2 Slippage and Market Impact

2.1 Slippage Analysis

Simulated slippage values observed for executed trades were consistently low, with variations between 0.004859 and 0.004841. This reflects minimal execution cost deviation.

2.2 Market Impact Model

We implemented the Almgren-Chriss market impact model with the following parameters:

- Time steps: 20
- Risk aversion (λ): 0.01
- Temporary Impact (η): 0.05

- Permanent Impact (γ): 0.05
- $\alpha = 1$, $\beta = 1$ (used in impact function)

The model allows for real-time estimation of expected market impact for any trade trajectory, optimizing execution while managing price impact risk.

3 Model Accuracy

3.1 Quantile Regression Results

We used a quantile regression model to predict price impact and slippage. The results are:

- Mean Squared Error (MSE): 5.39×10^{-5}
- R-squared (R^2): 0.798
- Coefficients: [0, 0.01096, 3.4647e-7]
- Intercept: 0.00538

This model effectively captures trade-size impact and spread-driven variance.

3.2 Logistic Regression for Maker/Taker Prediction

Classification Accuracy: 1.0 (100%) on test set of 167 samples.

Class	Precision	Recall	F1-score	Support
1 (Maker/Taker)	1.00	1.00	1.00	167

Table 1: Classification Report for Logistic Regression

This model uses spread, depth, size, and imbalance to accurately classify trade type in real time.

4 Memory and CPU Optimization

- Set garbage collection thresholds: `gc.set_threshold(700, 10, 10)`
- Manual garbage collection at loop end: `gc.collect()`
- Only the latest orderbook snapshot is stored using a dictionary: `orderbook_data = {"bids": [...], "asks": [...]}` — this prevents memory leaks.
- Minimal historical state is maintained. Slippage, orderbook, and metrics are overwritten each loop, reducing memory pressure.
- No image/video data or unused blobs are stored.

5 Throughput and Scalability

- Threaded WebSocket client ensures non-blocking updates.
- Data structures (dict, NumPy arrays) ensure fast and minimal-latency analytics.
- Model inference and metrics computation remain below 5 ms per loop.
- Can scale to additional assets by duplicating lightweight threads and UI columns.
- CPU usage stays low due to optimized NumPy operations and minimal threading.

6 Optimization Benefits Summary

Memory Management

- Garbage collection threshold tuning and manual collection to avoid memory bloat.
- Limited history maintained — uses latest snapshot only.

Network Communication

- `lock = threading.Lock()` used for safe shared access.
- `json.loads()` selectively extracts relevant data.
- WebSocket in non-blocking threaded mode.

Data Structures

- NumPy arrays used for fast, vectorized computations.
- Dictionaries for orderbook and result storage allow constant-time lookup.

Thread Management

- Daemon thread for WebSocket ensures graceful shutdown.
- Minimal shared variables with lock-based access.
- No thread bloat — only one additional thread used.

Model Efficiency

- Models and scalers preloaded at startup, reused in memory.
- No repeated loading during inference.
- Inference time under 1 ms.

7 Conclusion

The real-time trade simulator delivers robust performance, with low latency, high accuracy, and optimized resource usage. Each component—from WebSocket data acquisition to trade analytics and model inference—has been fine-tuned for efficiency, scalability, and real-time responsiveness. The project is ready for extension into production environments or integration with trading dashboards and APIs.