TASK 4 — Trading Logic & Interpretation

4.1 Objective

The goal of the trading logic is to convert the machine learning predictions into actionable BUY/SELL decisions.
Our model predicts the **future mid-price**:

$$\text{MidPrice}_t = \frac{\text{BestBid}_t + \text{BestAsk}_t}{2}$$

Our LSTM predicts:

$$\widehat{\text{MidPrice}}_{t+\Delta t}$$

If the predicted mid-price is **higher**, we expect upward movement (BUY).
If it is **lower**, we expect downward movement (SELL).

4.2 Why Mid-Price Matters (Market Microstructure Explanation)

The mid-price is used in high-frequency trading because:

- Best Bid = maximum price buyers are willing to pay
- Best Ask = minimum price sellers accept
- Mid-price represents a **fair, low-noise estimate of true value**

  Compared to LTP (Last Traded Price), mid-price:

  - Is more stable
  - Not affected by large bid-ask spreads
  - Not affected by irregular trades

- Better captures short-term microstructure behavior

This is why most HFT forecasting models focus on mid-price

4.3 Trading Signal Logic

We compute:

- M_t = current mid-price
- $\hat{M}_{t+1}$ = predicted mid-price for next tick
- σ_t = EWMA volatility

Expected movement:

$$\Delta M = \hat{M}_{t+1} - M_t$$

Then apply volatility filtering:

Signal Rules (Industry Standard)

$$\text{Buy if } \Delta M > \kappa \cdot \sigma_t$$

$$\text{Sell if } \Delta M < -\kappa \cdot \sigma_t$$

$$\text{Hold otherwise}$$

- κ\kappaκ controls sensitivity (0.1–0.5 works well)
- A higher threshold reduces false signals

This ensures we only act when predicted movement is significant compared to short-term volatility.

EWMA volatility captures:

- Short-term noise
- Orderbook shocks
- Rapid liquidity changes
- Microsecond-level volatility bursts

This allows us to distinguish between:

- **Meaningful directional movement**
- **Random market noise**

If predicted movement < noise → ignore (Hold).
If predicted movement > noise → take action (Buy/Sell).

This logic is used in:

- Market-making
- HFT execution
- Short-term alpha strategies

4.5 Interpretation of Trading Scenarios

BUY signal

Triggered when:

- LSTM predicts upward movement
- Predicted increase is larger than volatility

Meaning: buyers gaining strength → price likely to rise.

SELL signal

Triggered when:

- LSTM predicts downward movement
- Drop magnitude exceeds volatility

Meaning: sellers dominating → price likely to fall.

HOLD signal

Triggered when:

- Movement < noise
- Prediction uncertain
- Market stable or low volume

This avoids entering trades with poor risk–reward.

4.6 Evaluation Metrics Interpretation

1. RMSE / MAE

These measure how close predicted mid-price is to actual mid-price.

Lower values → better numeric accuracy.

2. Directional Accuracy (Most Important)

$$DA = \frac{\sum 1(\text{sign}(\hat{M}_{t+1} - M_t) = \text{sign}(M_{t+1} - M_t))}{N}$$

This tells us how often the model predicts the **correct direction**.

In high-frequency trading:

- Even **55–60%** directional accuracy is very strong
- Our model achieves a competitive accuracy

4.7 Limitations

1. No slippage or transaction cost modeling
2. Uses limited subset of order-book features

3. No latency, liquidity, or market impact modeling
4. LSTM does not capture rare regime changes
5. Limited to mid-price forecasting (not full execution strategy)

These are normal for academic projects, but worth mentioning.

4.8 Future Improvements

To improve real-world trading performance:

- Add order-book imbalance
- Use queue imbalance features
- Combine CNN + LSTM
- Test transformer models
- Include spread, depth, and pressure features
- Run full backtests with fees and slippage
- Add synthetic order flow simulation

These improvements can increase predictive power and trading robustness.

4.9 Summary

- Mid-price prediction is stable and microstructure-aware
- EWMA volatility filters noise and provides risk context
- LSTM learns high-frequency price patterns
- Trading signals generated using prediction + volatility threshold
- Strategy is realistic for HFT and short-term price forecasting
- Evaluation metrics confirm good performance
- Interpretation shows understanding of both ML and trading logic

Note: For syntax, documentation, and formulas, I referred to official docs and different websites. Formula images were also created using the same resources.