Generating Realistic Stock Market Order Streams

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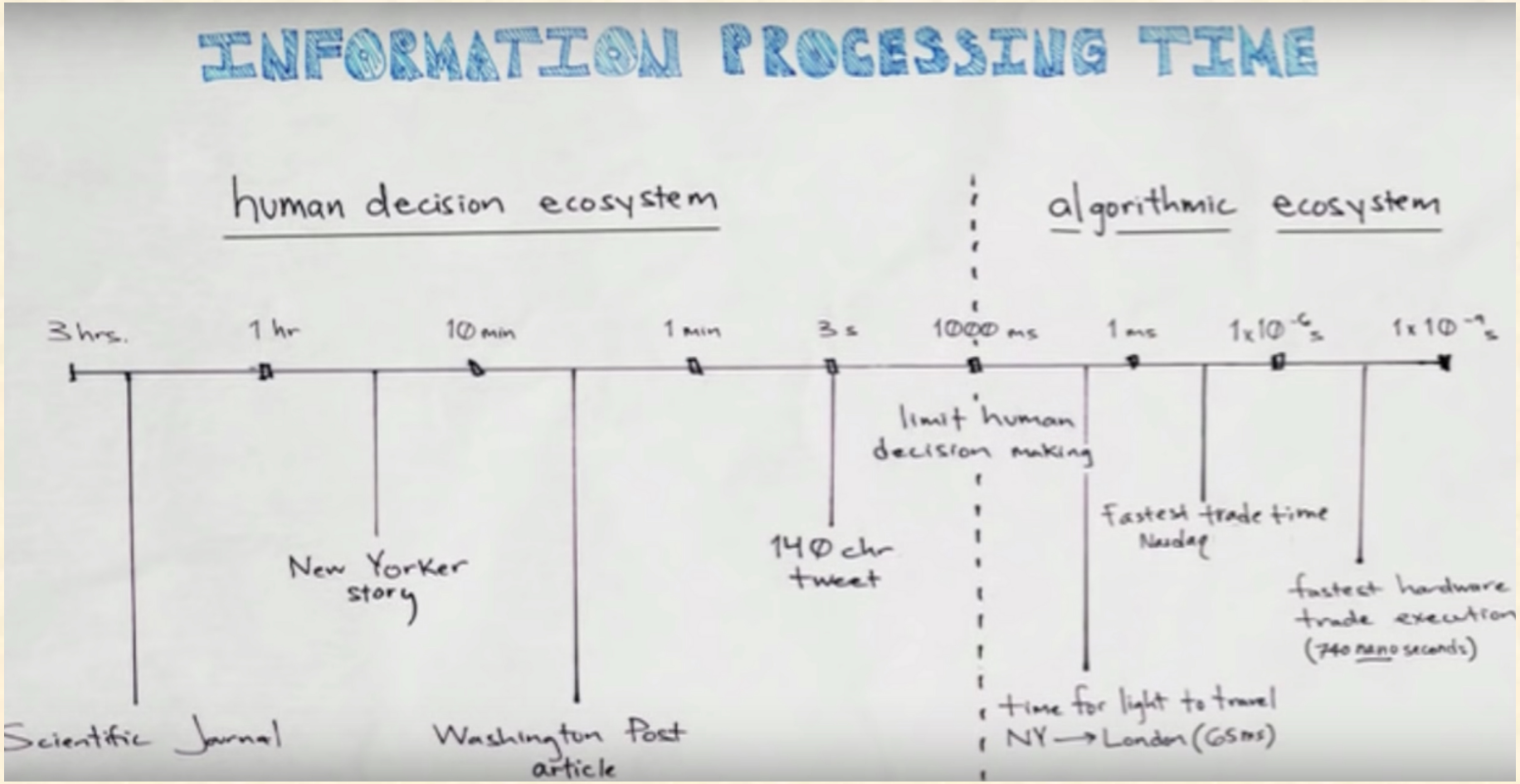
University of Michigan



Source: TEDxNewWallStreet - High frequency trading and the new algorithmic ecosystem by Sean Gourley

Computational Models of Financial Markets

- Analytic Models

  - Extract highly stylized models for tractability to provide key insights;

- Agent-based Models

  - Simulate markets as complex multi-agent systems to reproduce “stylized facts”;

- Generative Models

  - Learn from historical market data to produce realistic and high-fidelity data to facilitate analysis;

Computational Models of Financial Markets

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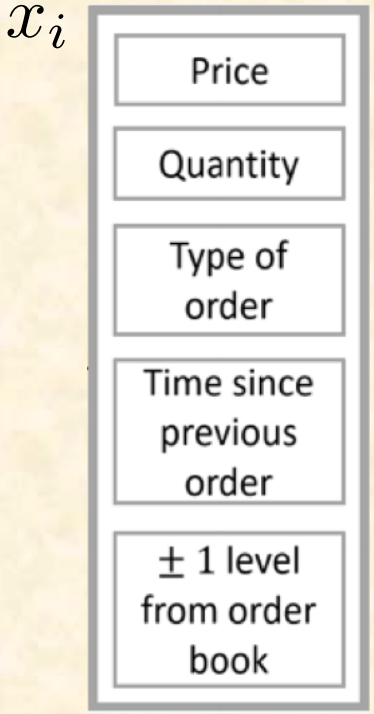
- Generative Models

  - Learn from historical market data to produce realistic and high-fidelity data to facilitate analysis;
  - Generate streams of limit orders that are close in aggregate to the real market of a single stock.

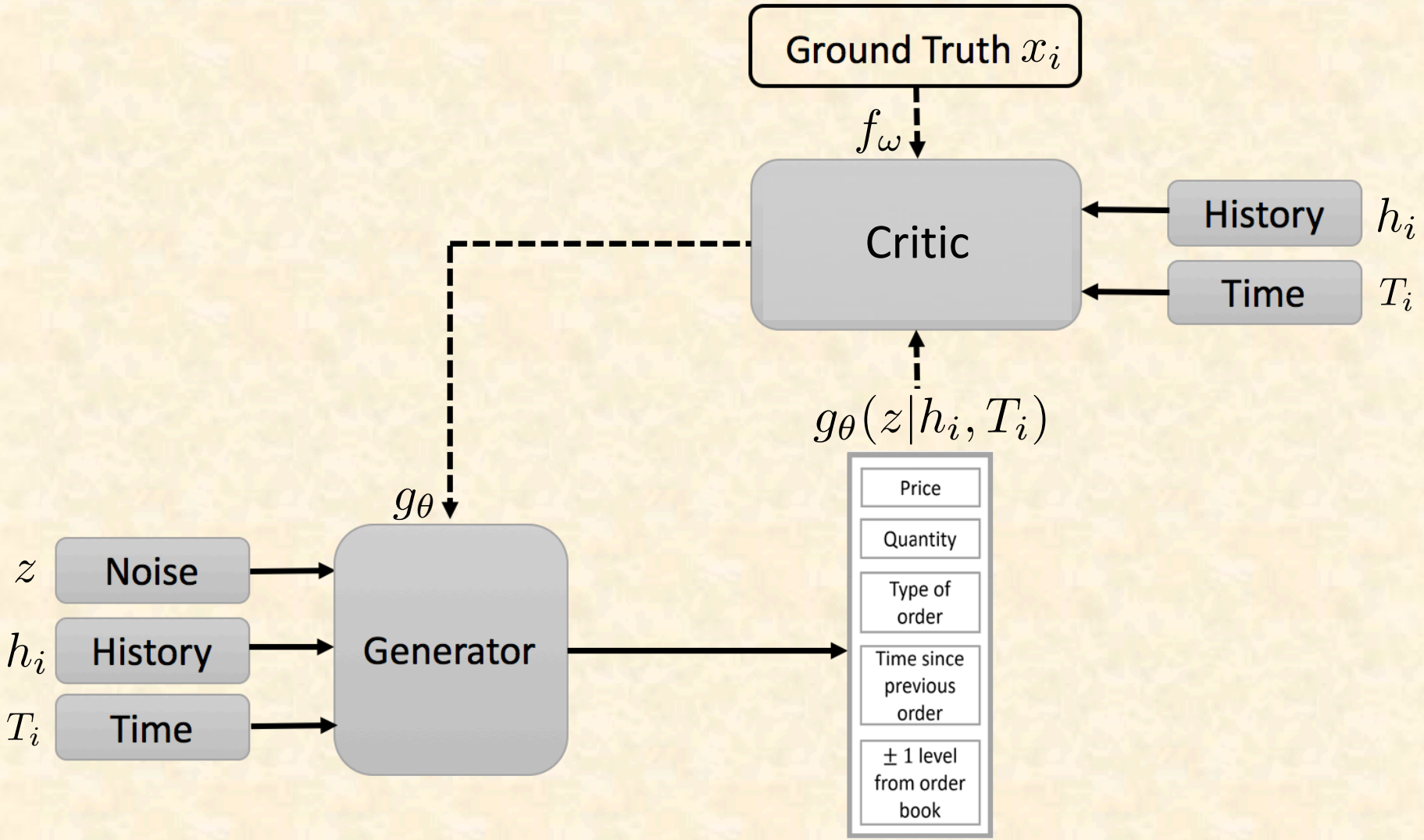
Limit Order Representation

- Limit price
- Quantity
- Type (buy/sell; submit/withdraw)
- Elapsed time
- Best buy price in market
- Best sell price in market

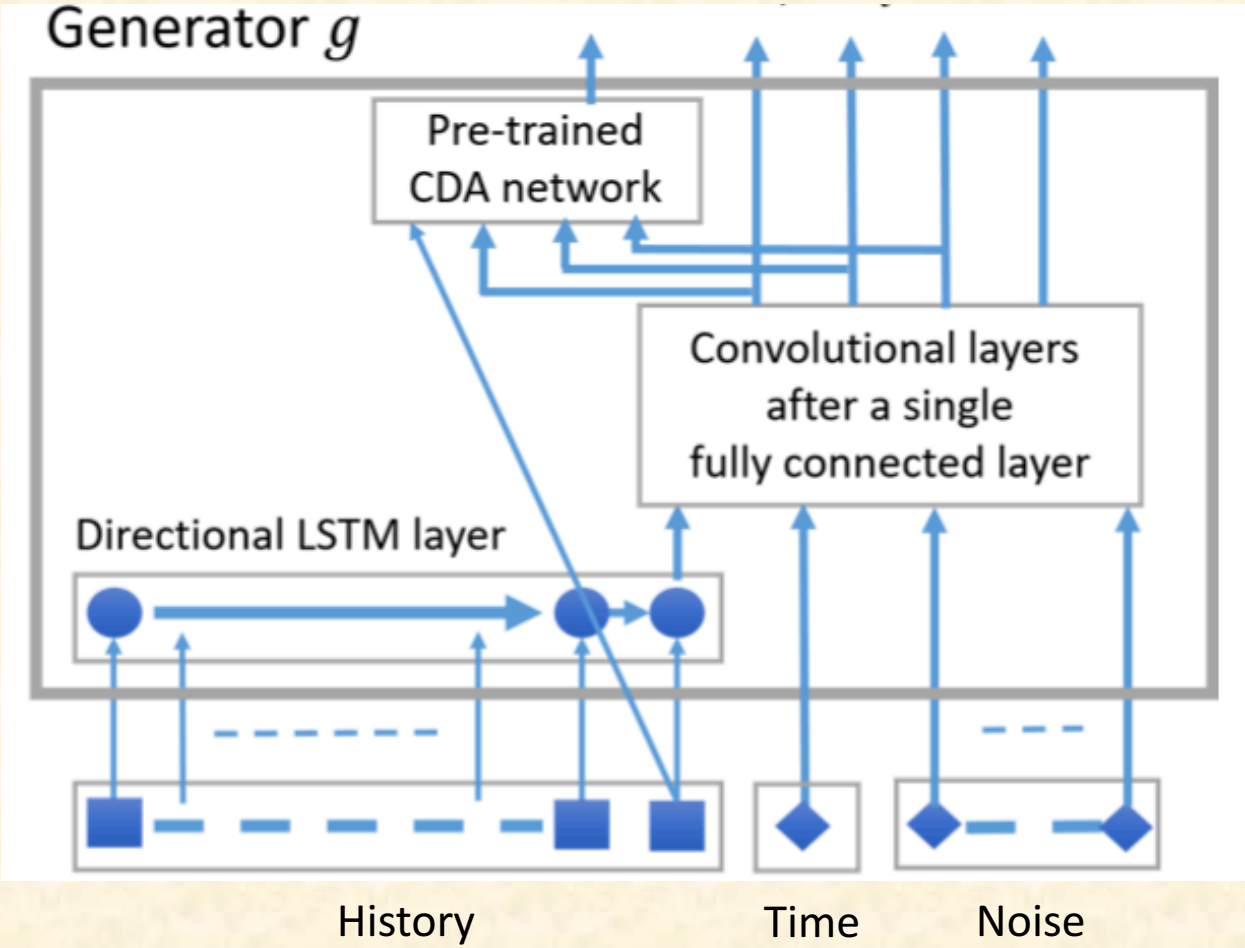


Stock-GAN

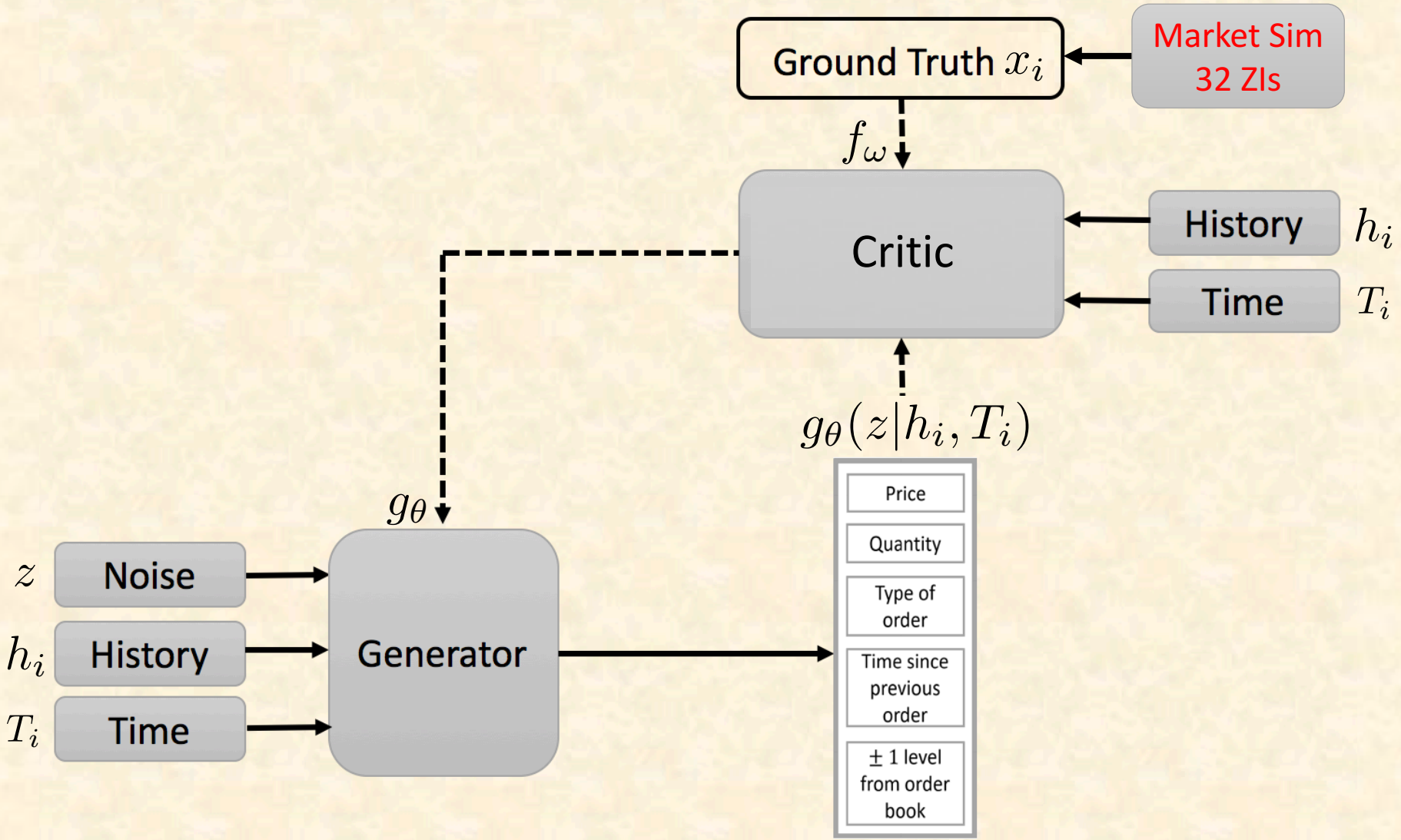
$$L(P_r, P_g) = W(P_r, P_g) = \max_{\omega \in W} \mathbb{E}_{x_i \sim P_r}[f_\omega(x_i|h_i, T_i)] - \mathbb{E}_{z \sim p(z)}[f_\omega(g_\theta(z|h_i, T_i))]$$



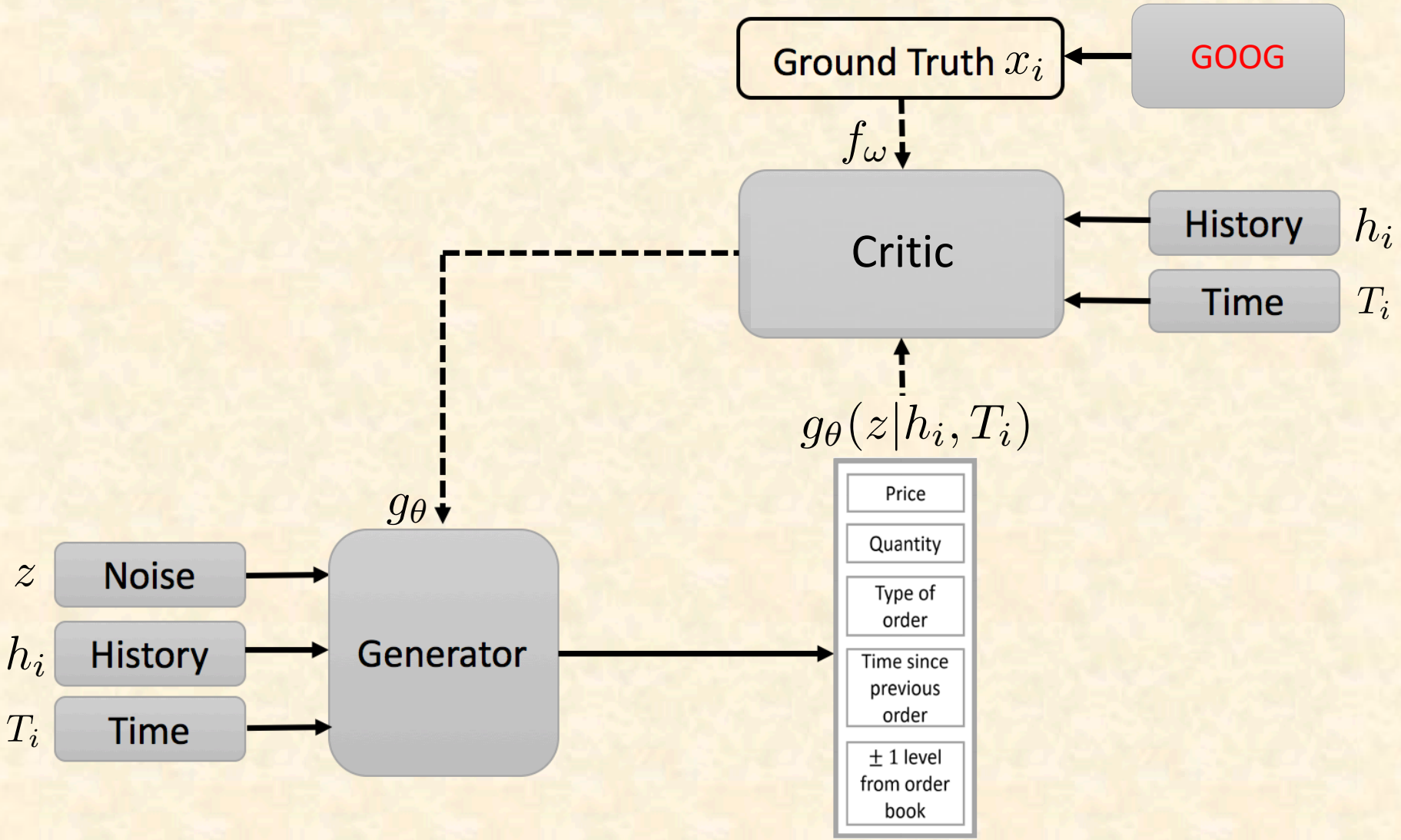
Stock-GAN


Generator g
Pre-trained CDA network
Convolutional layers after a single fully connected layer
Directional LSTM layer
History
Time
Noise

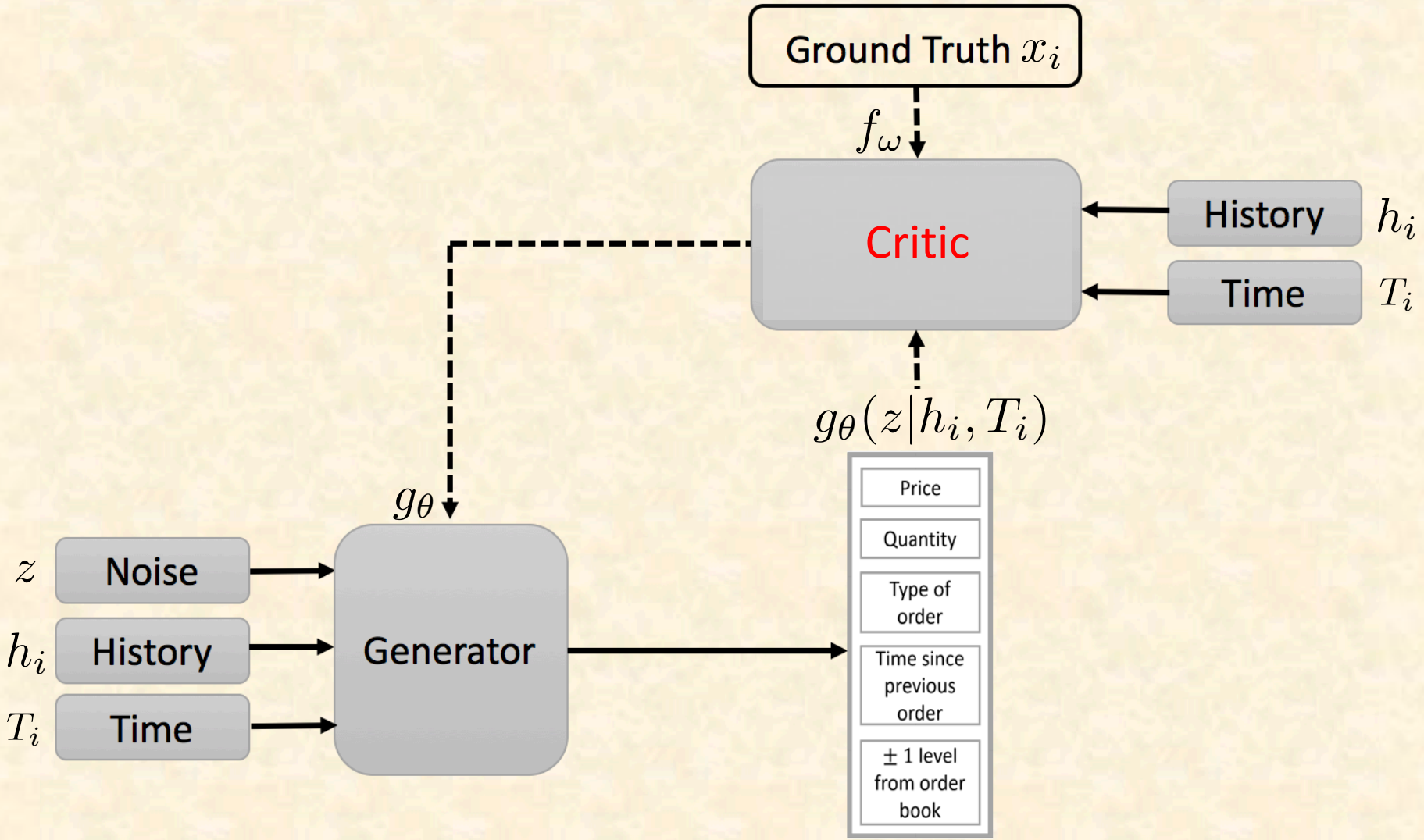
Evaluation – Synthetic Data



Evaluation – Real Market Data



Evaluation – How to Define Realistic?

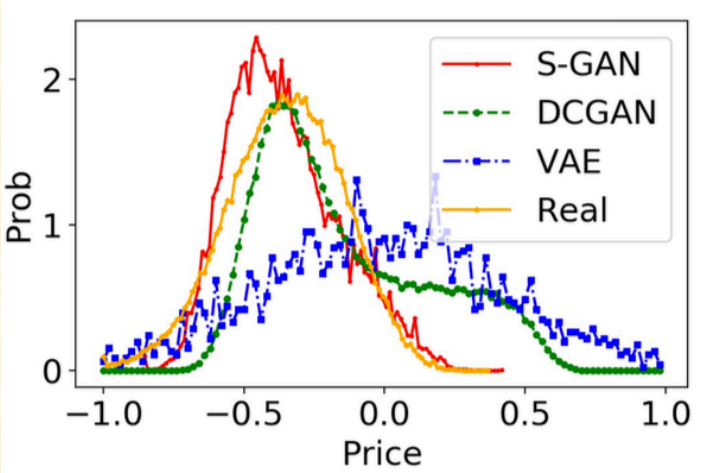


Evaluation – How to Define Realistic?

- Price - distribution over price for limit orders by order type.
- Quantity - distribution over quantity for limit orders by order type.
- Intensity - number of orders for a consecutive period of time.
- Inter-arrival time - distribution over inter-arrival duration for limit orders by order type.
- Best bid/ask evolution - changes in the best bid and ask over time as new orders arrive.

Preliminary Results

Sim



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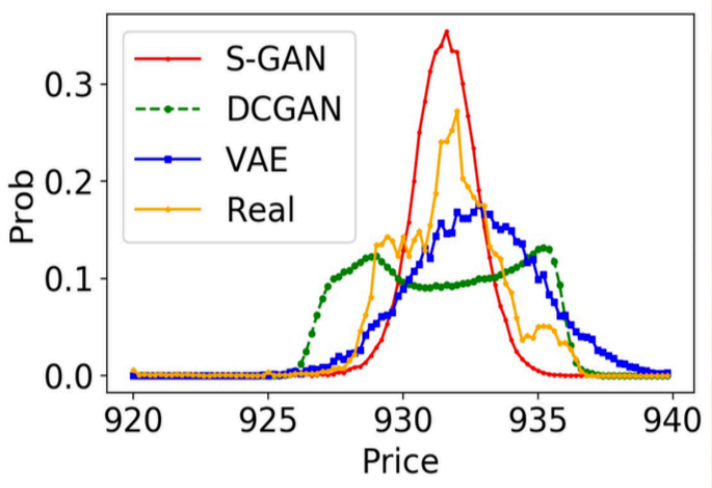
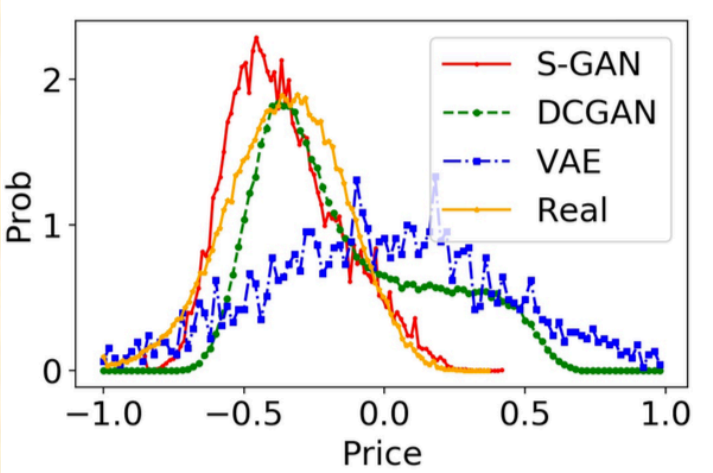
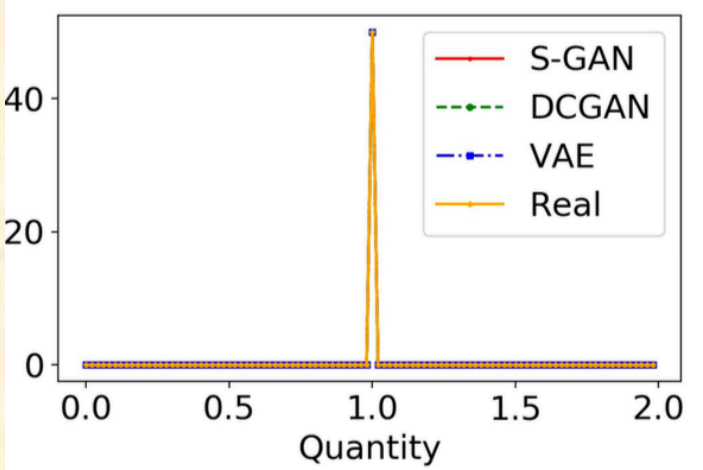


Price Dist.

Preliminary Results

Sim





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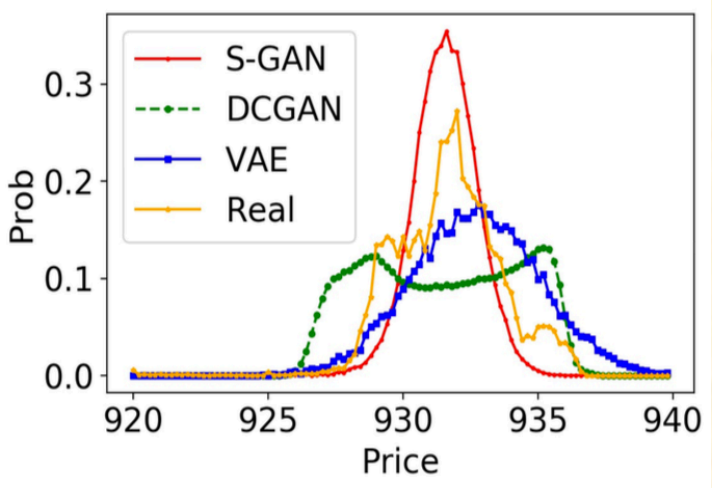
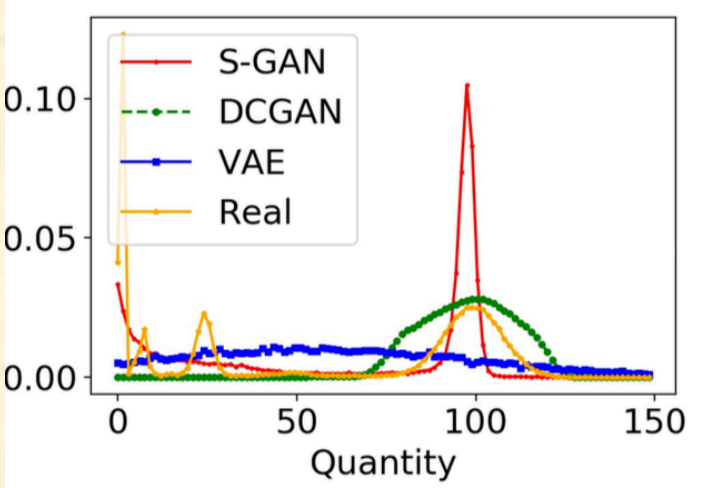


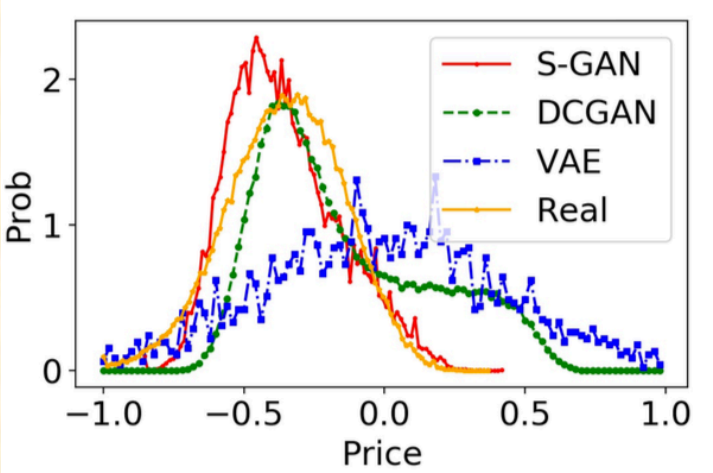


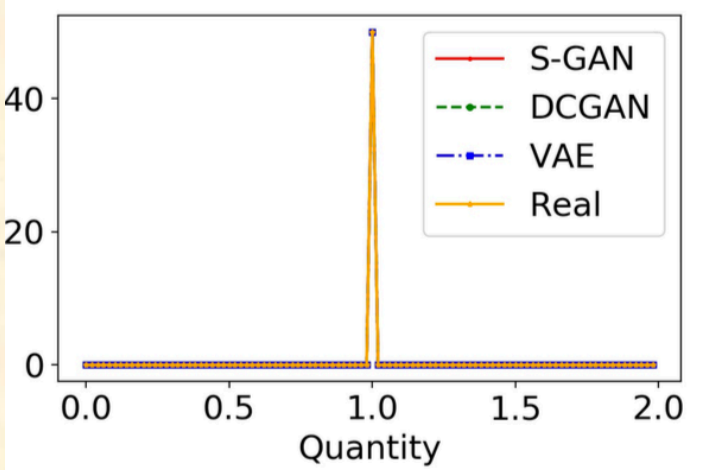
Price Dist.

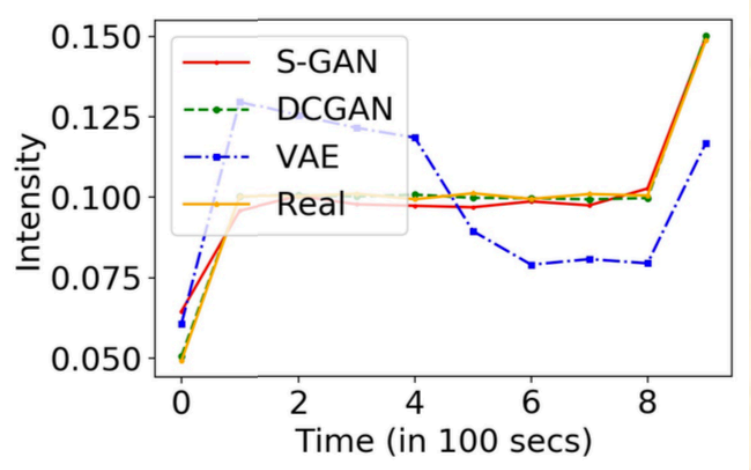
Quantity Dist.

Preliminary Results

Sim







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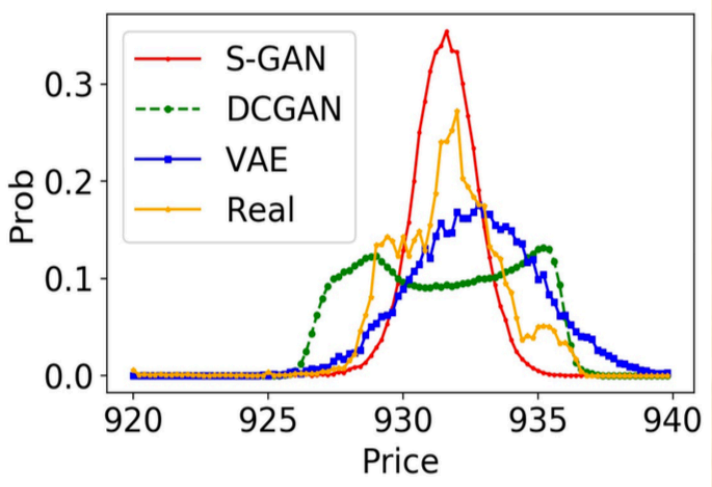
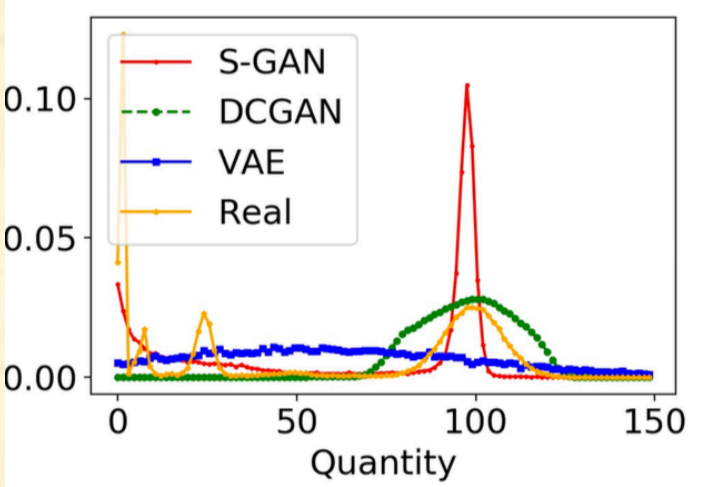
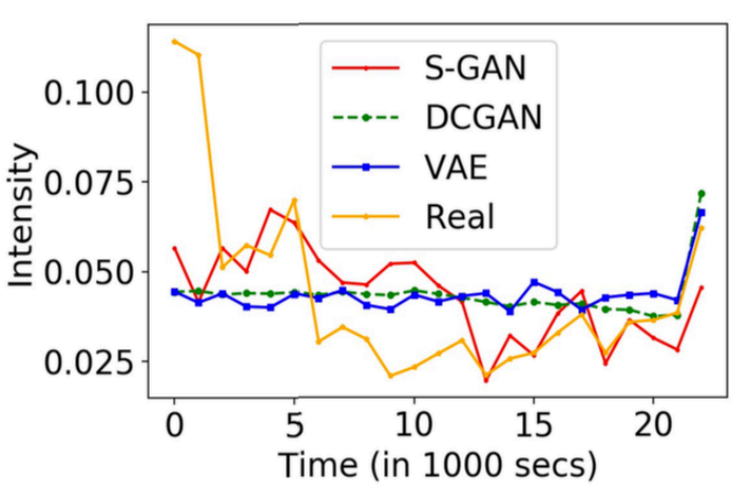


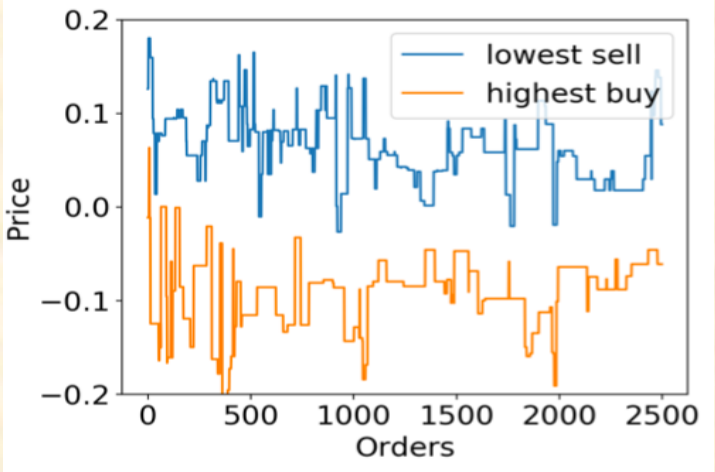


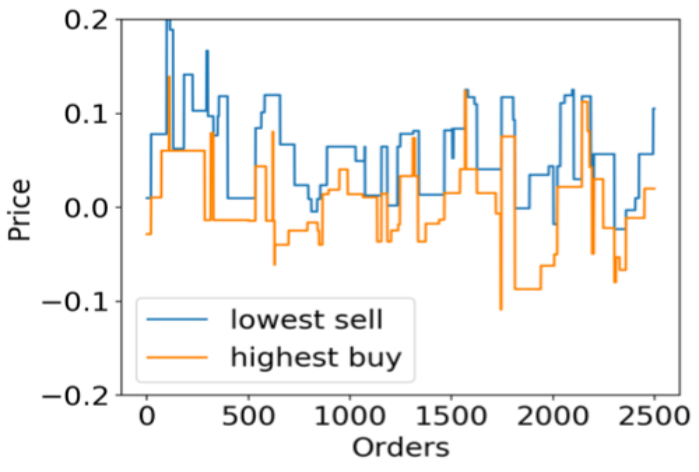


Price Dist. Quantity Dist. Intensity

Preliminary Results

Sim





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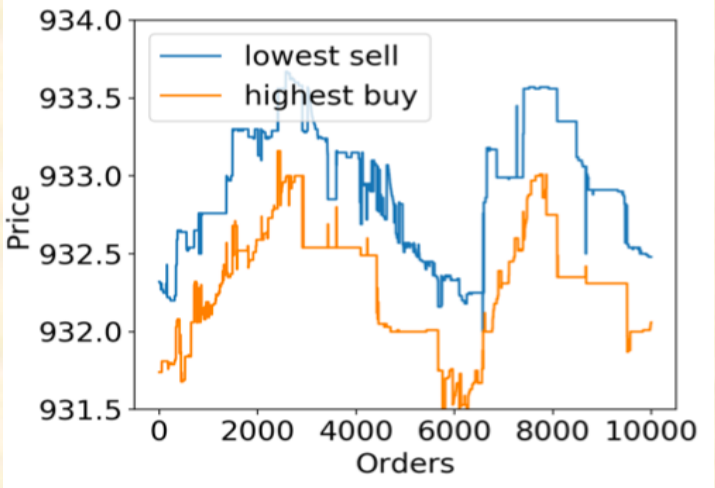
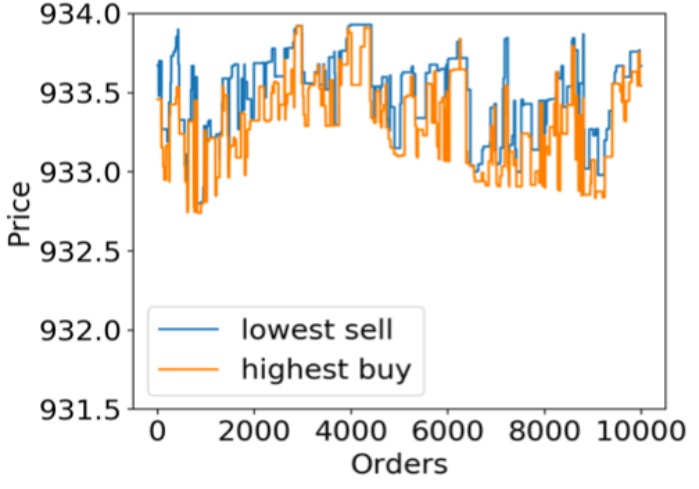
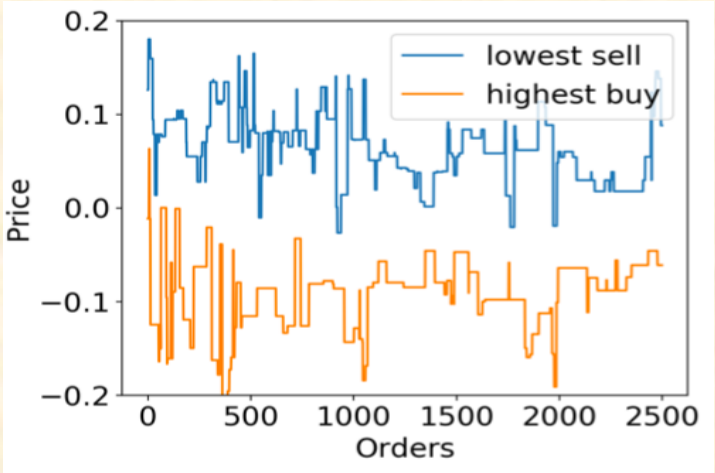


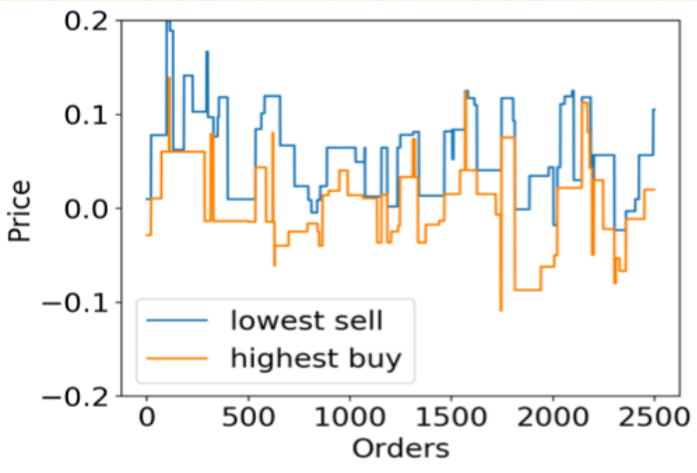


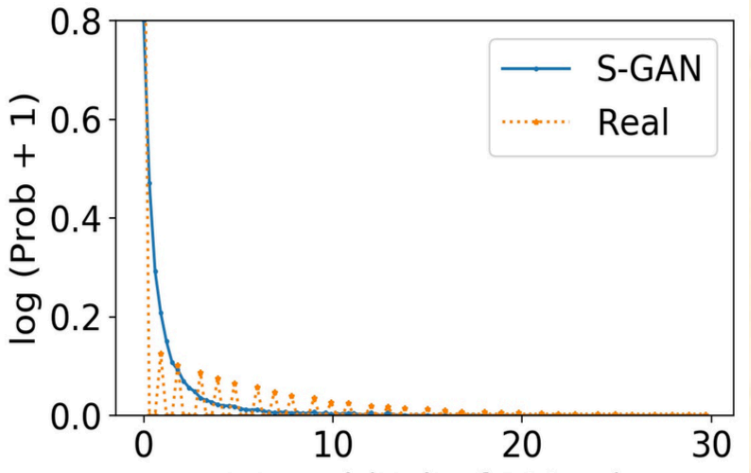
Best Bid and Ask Evolution

Preliminary Results

Sim







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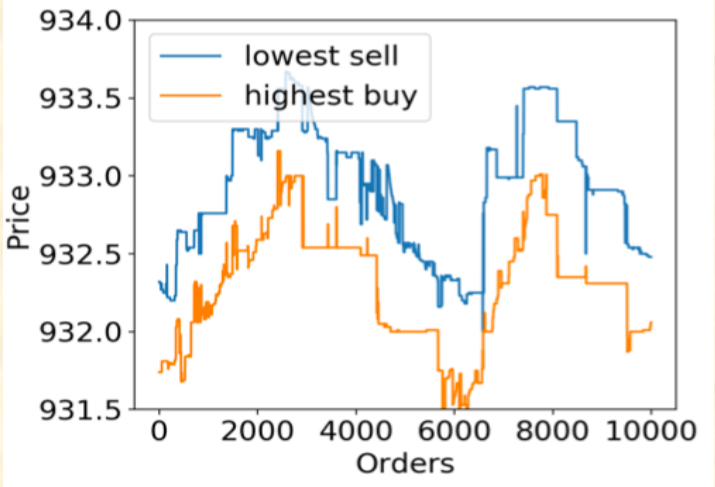

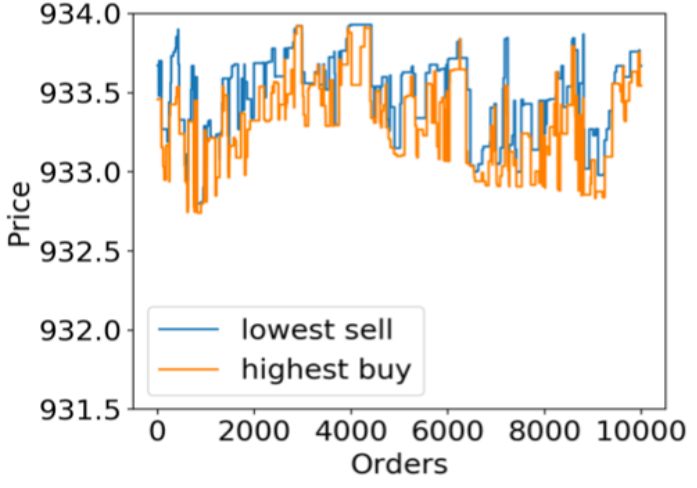

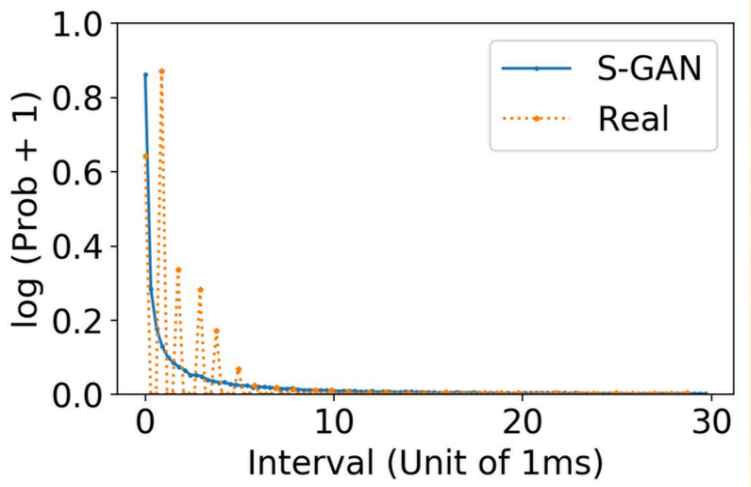

Best Bid and Ask Evolution

Inter-arrival Time

Conclusion and Discussion

- Demonstrate the effectiveness of using Stock-GAN, a conditional Wasserstein GAN, to generate realistic market data in aggregate;
- Propose to measure the quality of generated limit order streams using five statistics;
- Extend Stock-GAN to generate realistic activity traces of a trading agent, while preserve its trading role or intent.

Thank you! Questions?