

Making a new ML forecasting approach practical

Stefan Zohren

Global STAC Live

1-2 November 2021

The Oxford-Man Institute of Quantitative Finance

- A unique collaboration between Oxford University and Man Group plc
 - Opened Summer 2007
 - -Focus: Machine Learning in quantitative finance & alternative investments
 - -Vision to become world leading research centre
- Man Research Laboratory
 - Embedded commercial research laboratory
 - Undertakes research on behalf of Man Group
 - Opportunity for collaboration & academic publication







Markets at the most granular level

Multi-horizon forecasting of short-term price moves

Applications and Conclusion



Bloomberg

Technology Man Group-Oxford Quants Say Their Al Can Predict Stock Moves

By Amy Thomson

June 8, 2021, 10:24 AM GMT+1 Updated on June 8, 2021, 1:49 PM GMT+1

- Machine-learning program hits 80% success rate over 30 seconds
- ► Tape bombs and processing power are challenges to deployment

LIVE ON BLOOMBERG
Watch Live TV >
Listen to Live Radio >





Markets at the most granular level

Limit order book data



MARKET MICROSTRUCTURE



Most of us are familiar with financial **intraday** price **time series.**

However, at any point in time, the so-called **limit order book (LOB)** is in a particular state, representing the buy and sell limit orders that are resting at the exchange.



LIMIT ORDER BOOK



The resting limit orders are **passive** and are said to **provide liquidity**.

Let's assume someone wants to trade now and **take liquidity** by posting a sell order at the best bid.

At time T



Multi-horizon forecasting of price moves from limit order book data

Z Zhang, S Zohren, Risk (2021) https://arxiv.org/abs/2105.10430

Sequences of limit order book (LOB) snapshots The space-time picture







The variation in the order book over time represents an 'image' encoding trading in the asset

Sequences of limit order book (LOB) snapshots The space-time picture







The variation in the order book over time represents an 'image' encoding trading in the asset

Predicting future price moves from LOB data Setup





Output: Predictions of price moves at different future times (e.g. up, down, neutral)

Input: Sequence of LOB snapshots



Predicting future price moves from LOB data Single horizon models





Predicting future price moves from LOB data Single horizon models





Predicting future price moves from LOB data Single horizon models





Predicting future price moves from LOB data Multi-horizon models





Seek inspiration from machine translation









OXFORD-MAN

INSTITUTE

Read in sentence word by word, keeping a memory (hidden state)



Sequence to sequence models for machine translation $\mathcal{I}_{\mathcal{O}}$



OXFORD-

Read in sentence word by word, keeping a memory (hidden state)

Learn abstract meaning (context)





INSTITUT

- Read in sentence word by word, keeping a memory (hidden state)
- Learn abstract meaning (context)
- Reconstruct translation word by word







INSTITUT

- Read in sentence word by word, keeping a memory (hidden state)
- Learn abstract meaning (context)
- Reconstruct translation word by word







INSTITUT

- Read in sentence word by word, keeping a memory (hidden state)
- Learn abstract meaning (context)
- Reconstruct translation word by word

 h_0





INSTITUT

- Read in sentence word by word, keeping a memory (hidden state)
- Learn abstract meaning (context)
- Reconstruct translation word by word

 h_0

 h_1

 χ_1

what





INSTITUT

- Read in sentence word by word, keeping a memory (hidden state)
- Learn abstract meaning (context)
- Reconstruct translation word by word

 h_1

 χ_1

what

 h_2

 χ_2

is

 χ_3

the

 χ_A

price



Sequence to sequence models for multi-horizon foreca



INSTITUTE



- 50

These so-called sequence to sequence models (Seq2Seq) can also be used for time-series data. Other similar models are called Attention.

Attention models for multi-horizon forecasting





Prediction results: FI-2000 benchmark dataset Benchmark dataset



- Predict directions of price moves (up, down, neutral) at horizons 10, 20, 30, 50, 100 ticks into the future (typically few seconds to half a minute).
- Model is first trained on FI-2000 (Nordic equity) benchmark dataset to compare with other studies



FI-2000: Selection of results

In all cases our models multi-horizon models DeepLOB-Seq2Seq and DeepLOB-Attention outperform at large horizons

Z Zhang, S Zohren, Risk (2021) https://arxiv.org/abs/2105.10430

Prediction results: LSE data FTSE100 data and transfer learning



- Model is trained on one year FTSE 100 data (5 stocks) - a realistic dataset with over hundred million observations
- It is further tested on 20 completely unseen stocks (transfer learning)



LSE: Selection of results

In all cases our models multi-horizon models DeepLOB-Seq2Seq and DeepLOB-Attention outperform at large horizons

Z Zhang, S Zohren, Risk (2021) https://arxiv.org/abs/2105.10430

Novel hardware acceleration



- We utilise novel hardware, Intelligent Processing Units (IPUs), to accelerate computation
- In this first financial application of hardware we see speedups of 5-10x when compared to using GPUs.



"If we're seeing that the IPU would enable that type of computation to be done at materially faster timescales then I can guarantee that people will be asking for these to be made available."

Dr Anthony Ledford Chief Scientist, Man AHL







- Reviewed market microstructure and limit order books
- Introduced single and multi-horizon forecasting models
- Seq2Seq and Attention models inspired by machine translation
- Multi-horizon model outperform at larger horizons
- Highlighted hardware acceleration through IPUs

So what are those models useful for?



