Deep Neural Networks Applications in the Capital Markets

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DNNs in the Capital Markets
Riskfuel ... ?

WHAT WE DO
We build “plug and play” approximations to traditional derivatives models. These models are both fast and accurate.

WHY WE DO IT
Slow models are the bottleneck in modern risk architectures. We have fast data, good analytics and visualization. We need fast models.

HOW WE DO IT
Riskfuel uses deep neural networks to learn the traditional model. DNN inferencing is much faster than tradition simulation techniques.

WHO WE ARE
Riskfuel’s team of 12 combines capital markets domain expertise with a broad and deep background in AI/ML
Our Partners

- Microsoft
- DMZ
- University of Toronto
- NVIDIA
- FinTech Sandbox

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Agenda

1 NEED FOR SPEED
Review the current situation: nightly batch, volatile markets, Greeks, FRTB, and more.

2 FAST MODELLING TRENDS
Review how Quant Finance speeds up its models using GPU, AAD, local approximation, and cloud. Understand the pros and cons.

3 DNN ... GET THE PROS, AVOID THE CONS
Learn how deep neural networks weave fast modelling trends together to achieve amazing speeds.

4 A CONCRETE EXAMPLE
Review the results of a recent study using a real-world model.

5 DEMONSTRATION
See how Riskfuel trains a DNN-based pricer, leverages the performance in a real-time risk dashboard, and tests for accuracy.

6 Q&A
Questions will be answered at the end of the presentation.
The Need for Speed ... and Accuracy

- Manage risk in volatile times.
- Reduce the cost associated with meeting regulatory requirements.
- Allow the use of even slower models with increased realism, accuracy, etc.
Fast Modelling Trends

**GRAPHICAL PROCESSING UNITS (GPUs)**
- Match hardware to the task
- Need to port

**APPROXIMATIONS/INTERPOLATION**
- Pre-compute a grid of solutions to support fast look-up
- Curse of dimensionality: per deal, per day computation of interpolation grid

**ADJOINT ALGORITHMIC DIFFERENTIATION (AAD)**
- Leverage common terms used to compute risk sensitivities
- Requires talent, and long lead times

**CLOUD**
- Dynamically provision hardware as necessary
- Metered pricing
DNN ... Get the Pros, Avoid the Cons

- **✓** Does not suffer curse of dimensionality
- **✓** No repeated computation of interpolation grid
- **✓** Computes all first order derivatives at low fixed cost
- **✓** Massive floating point performance
- **✓** Exploits parallelism common in pricing models
- **✓** Plug-and-play integration within existing platform

DNN Implementation

DNNs in the Capital Markets
DNN seems straightforward, but ...

- How do you generate training data in high-dimensional space of sufficiently good quality and quantity?
- How do you generate sufficiently varied training data to reflect market behavior without breaking critical conditions such as no-arbitrage conditions?
- What cost function do you use? Do you punish outliers?
- How do you measure accuracy? Do you train for relative or absolute accuracy?
The 3 Strands of AI in Quant Finance

1. UNSUPERVISED LEARNING: MARKET SIMULATION
   “The Market Generator” – Kondratyev and Schwarz

2. REINFORCEMENT LEARNING: OPTIMAL TRADING STRATEGIES
   “Deep Hedging” – Beuhler et al.

3. SUPERVISED LEARNING: FAST MODELS
   “Deeply Learning Derivatives” – Ferguson and Green
### Study with Microsoft Azure

**REAL PRODUCTION MODEL**
- ✓ FX barrier option priced using finite differences method

**DESIGNED FOR LONGEVITY**
- ✓ Large domain of approximation across each of the state parameters

**HIGH DIMENSIONALITY**
- ✓ 5x12 volatility surface, domestic and foreign interest rate curves with 8 points each, upper and lower barrier levels, relative moneyness, time to maturity.

**UTILIZED MICROSOFT AZURE**
- ✓ To generate 100,000,000 training samples
- ✓ To access the ND40v2 instance with 8 V100 GPUs
“In our study, the combination of a Riskfuel-accelerated version of the foreign exchange barrier option model and with an Azure ND40rs_v2 Virtual Machine showed a 20M+ times performance improvement over the traditional model.”
“It is critical to point out here that the speedup resulting from the Riskfuel model does not sacrifice accuracy. In addition to being extremely fast, the Riskfuel model effectively matches the results generated by the traditional model.”
Demo
Final Takeaways

- Well suited to run on the cloud
- Integrates with existing platform. Plug and play
- No need to commit to huge project. Can accelerate models one by one.
- Can run alongside target model to use for accuracy validations.
Questions?