MathFinance Training
Machine Learning & Artificial Intelligence Applications for Financial Markets

27 May – 29 May

Why this course?

Machine Learning (ML) as part of artificial intelligence is one of the key technologies which are currently applied in many disciplines with overwhelming results. This course will develop a solid understanding on the most relevant techniques to offer an overview and the knowledge for developing own applications. Moreover, a particular focus is laid on applications in financial markets. This will give participants the theoretical and practical background necessary to deal successfully with the application of machine learning techniques in finance.

Prior Knowledge

Calculus, probability theory, linear algebra, basics of stochastic processes and financial product knowledge up to Hull is also needed. Programming skills are helpful but not essential.

Who should attend?

This course is meant for all those, who are interested in machine learning ("**ML**") and its application to financial markets. It is intended to deepen the understanding of the most important ML techniques and to open possible future application areas. During the course, we will provide several practical working examples and with ready implementations.

- Quants/Financial Engineers: to learn how AI can be used and what are the risks
- Traders: : to deepen the technical background
- Risk Managers: to understand the benefits and risks of ML
- Structurers: To learn more about pricing and models
- Researchers: To understand the practical matters
- Sales: to get the overview of applications of ML

Learning Objectives:

- Gain an understanding of AI, machine learning, big and small data and the applications in Finance
- Appreciate flexibility of the new machine learning paradigms and learn about associated risks
- Learn about the most key recent applications in Finance
- Understand how Deep Hedging, Deep Pricing, Deep Calibration et c works

Pricing

Regular: EUR 2500 p.p*
Group discount (2 or more): 20% off at EUR 2000 p.p.*
* 19% VAT will be added

http://www.mathfinance.com/trainings

Your instructor

Thorsten Schmidt is Professor for Mathematical Stochastics at University Freiburg (successor of Ernst Eberlein) and Senior Financial Engineer at MathFinance AG. From 2017-2019 he was fellow of the Freiburg institute of Advanced Studies (FRIAS). Prior to this he was professor for Mathematical Finance at Chemnitz University of Technology since 2008, held a replacement Professorship from Technical University Munich in 2008 and was Associate Professor at University of Leipzig from 2004 onwards.

His Ph.D. he obtained from University in Giessen in 2003 on credit. He has published numerous articles in Mathematical Finance and Probability in internationally leading journals and is frequently presenting on conferences around the world on his latest research. In particular, he is a well-known scientist in the area of affine models, interest rates, credit risk, incomplete information, risk management, filtering, and energy markets. He has a strong background in statistics and information technology and teaches probability, mathematical finance and machine learning at the university of Freiburg.

He is currently editor of a volume of Risks on the topic „Machine Learning in Finance, Insurance and Risk Management"

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DAY 1

Introduction to AI, big data, small data in Finance

The course starts with a review of useful techniques which will be essential for the latter applications. Thereafter, some important aspects are deepened, providing a solid basis of the methods in the field.

Review on financial applications: modelling, statistics, applications

- Financial markets
- Basic Models in discrete and continuous time
- Black-Scholes, Heston, and extensions
- Pricing and Hedging

Advanced topics

- Term structure modelling, multiple yield curves and credit
- Affine models
- Fourier pricing methods
- Basics on time series and econometrics
- Maximum Likelihood, Least Squares and beyond
- Bayesian statistics
- Estimation vs. Calibration
- Risk management: risk measures
- Back-testing and assessment of model quality
- Advanced hedging methodologies

Advanced classical techniques

- Monte Carlo pricing, importance
- Filtering: how to deal with incomplete information
- Kalman filter, extended Kalman filter, the EM-algorithm

Overview of Pricing Models used for ML

- Black-Scholes model, Greeks, Pricing and classical calibration
- Local volatility models, pros and cons and where they fail
- Stochastic volatility models, pros and cons and where they fail
- Affine models

After the basics are settled, an overview of basic technologies of AI follow, on a quite general level. This allows to grasp the most important aspects of this large field and shows already potentiality of AI without neglecting accompanying risks.

Basic technologies of Artificial Intelligence ("AI")

- ML Basics: approaches, key applications and key results
- Data examples
- Preprocessing, learning, evaluation and prediction
- The key to optimization: stochastic gradient descent
- Model validation: how to ensure ML works as intended
- Cross validation and back-testing
- Generalized linear models
- Dimension reduction with principle component analysis (PCA)
- Latent linear models and the EM algorithm
- Applications, python notebooks and numerical experiments

Time series analysis and econometrics with ML

- Statistics and why naïve application of ML can be very dangerous
- Time series for financial data: GARCH and beyond
- Estimation
- Machine Learning and the non-parametric prediction
- Python notebooks and numerical experiments

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DAY 2

One important technology, providing both high flexibility and large speed are deep neural networks. On day 2 the course will start with an introduction into this important field. Some case studies show how to get hands-on pricing, calibration and hedging with deep neural networks.

Neural networks

- Architecture
- Backpropagation
- Regularisation & Optimization
- Universal Approximation

Deep neural networks (DNN)

- Motivation & Examples
- Gradient-based learning
- Feed-forward networks
- Regularisation
- Robustness against noise – how to achieve generality
- Bagging, Dropout and further technical details
- Hyperparameteroptimzation

Applications of DNNs in Finance

- From support vector machines to deep learning: the advance of deep neural networks
- Gradient-based learning

Case study: Deep pricing

Equipped with the technology of deep neural networks, pricing algorithms can be implemented with high efficiency.

- Classical pricing techniques: Monte Carlo, PDEs, explicit results
- Neural network approximation of the pricing algorithm
- Optimizing network and training design
- Deep pricing in the Black-Scholes model and beyond
- Applications, python notebooks and numerical experiments

Advanced Deep pricing

- Incomplete markets
- Pricing with risk measures
- Python notebooks and numerical experiments

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DAY 3

Case study: Deep calibration

Like in many applications, the aim of neural networks in this module is to achieve an off-line approximation of complex functions, this time the pricing function which are typically time-consuming to calculate. The application in this module highlights the generality of this idea which can successfully applied in many different contexts.

- A new perspective on model calibration
- Optimizing the network and training designs
- Deep calibration: Black & Scholes
- Deep learning volatility
- Different volatility models, rough volatility
- Python notebooks and numerical experiments

Case study: Deep hedging

- Hedging with risk measures, transaction costs and market impact
- Deep Hedging
- Case studies: Black & Scholes, Heston
- Python notebooks and numerical experiments

High frequency: Universal price formation

Stochastic control and machine learning

Wherever optimality needs to be achieved in a financial context, stochastic control comes into play. Very often this leads to complicated results, and here we show how to compute some of them with machine learning techniques.

- Stochastic control
- Optimal trading
- Optimal Portfolio management
- Deep approximation of stochastic control
- Statistical arbitrage
- Markov decision problems and approximate dynamic programming
- Python notebooks and numerical experiments