FIN-472

Computational finance

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Cursus	Sem.	Type
Computational science and Engineering	MA1, MA3	Opt.
Financial engineering minor	H	Opt.
Financial engineering	MA1, MA3	Opt.
Ing.-math	MA1, MA3	Opt.
Mathématicien	MA1, MA3	Opt.

Language of teaching	English
Credits	5
Session	Winter
Semester	Fall
Exam	Written
Workload	150h
Weeks	14
Hours	**4 weekly**
Courses	2 weekly
Exercises	2 weekly
Number of positions	

Remark

MA3 only

Summary

Participants of this course will master computational techniques frequently used in mathematical finance applications. Emphasis will be put on the implementation and practical aspects.

Content

1. Brief introduction to option pricing
Basic stochastic models in finance
Basic tools of stochastic calculus
Monte Carlo simulation based methods

2. Transformation based methods
Affine models
Option pricing via Fourier transforms

3. Density approximation techniques
Polynomial models and calculation of moments
Option pricing via density approximation

4. Option pricing via PDE models
Finite difference approximation of Black-Scholes PDE
American options and free boundary problems
Jump-diffusion processes and integro-differential equations

5. a) Bayesian modelling, Gaussian processes and Regression: Weight space view and Function space view,
b) Choice of Covariance function and Hyper-parameters adaptation,
c) Reproducing Kernel Hilbert Space (RKHS), Duality between RKHS and Gaussian process.

Keywords

financial models, stochastic calculus, option pricing, numerical methods, Matlab, Monte Carlo simulation, PDE, Fourier transform, density approximation techniques, volatility surface

Learning Prerequisites

Recommended courses

Stochastic processes / stochastic calculus

Numerical Analysis
Derivatives

Important concepts to start the course

Basic background in numerical analysis, linear algebra, and differential equations.
Command of Matlab.

Learning Outcomes

By the end of the course, the student must be able to:

- Choose method for solving a specific pricing or calibration problem.
- Implement numerical algorithms.
- Interpret the results of a computation.
- Recall the advantages and limitations of different methods.
- Assess / Evaluate the performance of several financial models.
- Compare the results from different pricing algorithms.
- Recall the basic concepts behind the theory of option pricing in financial models.
- Choose method for solving a specific pricing problem.

Transversal skills

- Use a work methodology appropriate to the task.

Teaching methods

Ex cathedra lecture, exercises in the classroom and with computer.

Expected student activities

Attendance of lectures.
Completing exercises.
Solving problems on the computer.

Assessment methods

60% of the grade is determined by a computer-based final examination. 40% of the grade is determined by take-home exams / graded exercises.

Resources

Virtual desktop infrastructure (VDI)

No

Bibliography

Hirsa, Ali. Computational methods in finance. Chapman & Hall/CRC Financial Mathematics Series. CRC Press, Boca Raton, FL, 2013.

Hilber, Norbert; Reichmann, Oleg; Schwab, Christoph; Winter, Christoph. Computational methods for quantitative finance. Springer, 2013

Seydel, Rüdiger U. Tools for computational finance. Fourth edition. Universitext. Springer-Verlag, Berlin, 2009.

Achdou, Yves; Pironneau, Olivier. Computational methods for option pricing. Frontiers in Applied

Mathematics, 30. SIAM, Philadelphia, PA, 2005.

Glasserman, Paul. Monte Carlo methods in financial engineering. Springer, 2003

Björk, Tomas. Arbitrage theory in continuous time. Third edition, OUP Oxford, 2009.

Shreve, Steven E. Stochastic calculus for finance II: Continuous-Time models, Volume 11. Springer Science & Business Media, 2004.

Lamberton, Damien; Lapeyre, Bernard. Introduction to stochastic calculus applied to finance. Second revised edition. Chapman & Hall/CRC, 2008.

Williams, Christopher KI, and Carl Edward Rasmussen. Gaussian processes for machine learning. Cambridge, MA: MIT press, 2006.

Dixon, Matthew F. Machine Learning in Finance: from Theory to Practice. Springer Nature, 2020.

Additional lecture material will be provided by the instructors.

Ressources en bibliothèque

- Machine learning in finance
- Computational methods for quantitative finance / Hilber
- Arbitrage theory in continuous time / Björk
- Stochastic calculus for finance II: Continuous-Time models / Shreve
- Computational methods in finance / Hirsa
- Introduction to stochastic calculus applied to finance / Lamberton
- Computational methods for option pricing / Achdou
- Tools for computational finance / Seydel
- Monte Carlo methods in financial engineering / Glasserman

Notes/Handbook

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