Numerical methods in mathematical finance

Lecture, winter semester 2018/19, 4+2 SWS, 8 ECTS
http://www.math.kit.edu/ianm3/lehre/nummethmathfin2018w/en

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An option is a contract which gives its owner the right to buy or sell an underlying asset at a future time at a fixed price. The underlying asset is often a stock of a company, and since its value varies randomly, computing the fair price of the corresponding option is an important and interesting problem which yields a number of mathematical challenges. This lecture provides an introduction to the most important models for option pricing. The main goal, however, is the construction and analysis of numerical methods which approximate the solution of the corresponding differential equations in a stable, accurate and efficient way. The following topics will be treated:

- Mathematical models for pricing stock options
- Itô integral, Itô formula, stochastic differential equations, Black-Scholes equation
- Binomial methods
- Monte-Carlo methods
- Numerical methods for stochastic differential equations
- Random number generators
- Finite difference methods for parabolic partial differential equations
- Numerical methods for free boundary value problems

Participants have to be familiar with

- ordinary differential equations and the corresponding numerical methods (cf. lecture "Numerische Methoden für Differentialgleichungen"),
- probability theory (cf. lecture "Wahrscheinlichkeitstheorie"), and
- programming in MATLAB.

Knowledge about stocks, options, arbitrage and other aspects from mathematical finance is not required, because the lecture will provide a short introduction to these topics.
The course consists of a lecture and a problem class, both given in English. In the problem class the students will solve small exercises which illustrate the contents of the lecture. Moreover, participants are supposed to write short MATLAB programs in order to test and apply the algorithms which will be presented in the lecture.

References

[1] N. H. Bingham and Rüdiger Kiesel. *Risk-neutral valuation. Pricing and hedging of financial derivatives.* Springer Finance. Springer, London, 4nd ed. edition, 2004.

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[3] Martin Hanke-Bourgeois. *Grundlagen der numerischen Mathematik und des wissenschaftlichen Rechnens.* Vieweg+Teubner, Wiesbaden, 3rd revised ed. edition, 2009.

[4] Norbert Hilber, Oleg Reichmann, Christoph Schwab, and Christoph Winter. *Computational methods for quantitative finance. Finite element methods for derivative pricing.* Springer finance. Springer, Berlin, 2013.

[5] Rüdiger U. Seydel. *Tools for computational finance. 4th revised and extended ed.* Universitext. Springer, Berlin, 4th revised and extended ed. edition, 2009.

[6] Steven E. Shreve. *Stochastic calculus for finance. II: Continuous-time models.* Springer Finance. Springer, 2004.

[7] J. Michael Steele. *Stochastic calculus and financial applications.* Number 45 in Applications of Mathematics. Springer, New York, NY, 2001.