MATH-450 **Numerical integration of stochastic differential equations**

Nobile Fabio

Cursus	Sem.	Type
Computational science and Engineering	MA1, MA3	Opt.
Computational science and 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	Oral
Workload	150h
Weeks	14
Hours	**4 weekly**
Courses	2 weekly
Exercises	2 weekly
Number of positions	

Summary

In this course we will introduce and study numerical integrators for stochastic differential equations. These numerical methods are important for many applications.

Content

Review of stochastic calculus; Brownian motion, Stochastic integral; Ito's formula, stochastic differential equations; generator; Feynman-Kac's formula
Numerical methods for stochastic differential equations; Euler Maruyama scheme; strong and weak convergence; Milstein scheme and other higher order integrators; stability; Multi-level Monte-Carlo methods
Other topics that may be addressed if time permits:
numerical integration of non-Lipschits SDEs; approximation of mean exit time and stopped diffusion; long time integration and approximation of invariant measure; numerical integration of jump diffusion processes; numerical integration of McKean Valsov equations.

Learning Prerequisites

Recommended courses

Numerical Analysis, Advanced probability, Stochastic processes (or equivalent), Stochastic calculus

Learning Outcomes

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

- Analyze the convergence and the stability properties of stochastic numerical methods
- Implement numerical methods for solving stochastic differential equations
- Choose an appropriate numerical method to solve stochastic differential equations
- Manipulate Ito calculus to be able to perfom computations with stochastic differential equations
- Manipulate models based on stochastic differential equations

Teaching methods

Ex cathedra lecture, exercises in classroom and computer lab

Assessment methods

Mini-project + oral exam (presentation of the project + questions on the course)
Dans le cas de l'art. 3 al. 5 du Règlement de section, l'enseignant décide de la forme de l'examen qu'il communique aux étudiants concernés.

Supervision

Office hours	No
Assistant.e.s	Yes
Forum	Yes

Resources

Bibliography

P.E. Kloeden, E. Platen, "Numerical Solution of Stochastic Differential Equations", Springer, 1999.
G.N. Milstein, M.V. Tretyakov, "Stochastic Numerics for Mathematical Physics", Springer, 2004.
D. Higham, P. Kloeden, "An Introduction to the Numerical Simulation of Stochastic Differential Equations", SIAM 2021
L.C. Evans, "An Introduction to Stochastic Differential Equations", AMS, 2013
H-H. Kuo, "Introduction to Stochastic Integration", Springer, 2005.
L. Arnold, "Stochastic Differential Equations, Theory and applications", John Wiley & Sons, 1974

Ressources en bibliothèque

- Stochastic Numerics for Mathematical Physics / Milstein
- An Introduction to Stochastic Differential Equations / Evans
- Numerical Solution of Stochastic Differential Equations / Kloeden
- Introduction to Stochastic Integration / Kuo
- Stochastic Differential Equations, Theory and applications / Arnold

Notes/Handbook

some handwritten notes will be made available

Moodle Link

- https://go.epfl.ch/MATH-450