PKU Globex Julmester

Data-Driven Optimization and Learning (3 Credits)

数据驱动的优化和学习

(Course Code: 00333734)

Instructor	Bernd HEIDERGOTT, Vrije Universiteit, Amsterdam, The Netherlands (b.f.heidergott@vu.nl)	
Synopsis	This course gives a broad treatment of the important aspects of the use of computer simulation and of streaming data for the analysis and optimization of dynamic stochastic models. The emphasis is on continuous optimization and learning (i.e., we do not cover discrete optimization in this course). The course will introduce students to the use of recursive algorithms in analyzing dynamic stochastic models through simulation-based/data-driven methods for optimization and learning. The leading question of the course is how to use simulation/streaming-data to make better and more responsible decisions for real-life problems. The course will also reflect on the technological and mathematical developments we witness in our societies. While actively working on simulation projects, the course will provide space for reflecting on the mathematical/technological paradigm. That is, next to learning the actual techniques, students will be stimulated to reflect on the history of science and the technological developments around them.	
Audience	Year 3 & 4 Undergraduate and Graduate Students	
Classroom	TBA	
Schedule	Class: 9-12 AM, M-F, July 06-July 24, 2026	Total Contact Hours: 45
Objective	Students learn how to model, analyze and optimize real-life problems by means of recursive learning algorithms. After successful completion of this course, students will be able to use Monte Calo simulation for generating synthetic data and use these for developing/testing optimization and learning algorithms	
Topics	1. Programming language is Python (basic programs will be provided). Other programming languages, such as Matlab, are also fine but are not supported 2. Basics of Monte Carlo Simulation: random number generation, output analysis 3. Standard simulation models: queuing systems 4. Data and simulation: combining simulation with available historical data 5. Estimation of gradients via simulation and their application in learning and optimization: stochastic gradient method, stochastic approximation, supervised learning, non-supervised learning	
Reference	Material of the course is based on *Optimization and Learning via Stochastic Gradient Search*, F. Vázquez- Abad and B. Heidergott, Princeton University Press, 2025. Additional recommended reading: *Handbook of Monte Carlo Methods*, D. Kroese, T. Taimre, Z. Botev, Wiley, 2011 Chapters 1,2,5,6,7,8,9 of *Simulation Modeling and Analysis*, A. Law, Mc Graw Hill, 4-th or 5-th edition. Chapter 11 of *Introduction to Discrete Event Systems*, C. Cassandras and S. Lafortune, Springer, 2nd edition 2008.	
Note	Students need to bring their own laptops for this course.	

Grading	Presentation and written report	30%
	Simulation project written report	30%
	Final exam	30%
	Attendance and discussion	10%
	Total	100%

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Dr. Heidergott is a professor of Stochastic Optimization at the Department of Operations Analytics of the Vrije Universiteit Amsterdam. He has been working at the VU since 2002. Before that, he worked at TU Delft, TU Eindhoven, at EURANDOM, and at Erasmus University Rotterdam. He obtained his PhD in 1996 at the University of Hamburg, Germany. In 2004, he received his Habilitation (non-cumulative) in Mathematics at the University of Hamburg, Germany. Bernd is the author of more than 100 scientific papers and 3 monographs (one of which has been translated into Japanese). From 2013 to 2018, he served as Program Director of Econometrics and Operations Research. Bernd is a recipient of the best lecture award from the School of Business and Economics, Vrije Universiteit, Amsterdam, and the Business Data Science program at the Tinbergen Institute, Amsterdam. He received the INFORMS Outstanding Simulation Publication Award and the Vrije Universiteit Innovation Award. His research interests include simulation-based stochastic optimization, stochastic gradient-based algorithms, model and parameter insecurity, social network analysis, differentiation theory of stochastic models, and Max-plus algebra.