UNIVERSITEIT GENT

Studiefiche

Vanaf academiejaar 2024-2025

Selected Topics in Mathematical Optimization (C003701)

Cursusomvang *(nominale waarden; effectieve waarden kunnen verschillen per opleiding)*

Studiepunten 3.0 **Studietijd 75 u**

Aanbodsessies en werkvormen in academiejaar 2024-2025

A (semester 1)	Engels	Gent	hoorcollege
			werkcollege

Lesgevers in academiejaar 2024-2025

Van Liedekerke, Paul	LA26	Verantwoordelijk lesgever

Aangeboden in onderstaande opleidingen in 2024-2025	**stptn**	**aanbodsessie**
Master of Science in Bioinformatics(afstudeerrichting Bioscience Engineering)	3	A
Master of Science in Bioinformatics(afstudeerrichting Systems Biology)	3	A
Master of Science in Bioscience Engineering: Cell and Gene Biotechnology	3	A
Master of Science in de bio-ingenieurswetenschappen: land, water en klimaat	3	A
Master of Science in Pharmaceutical Engineering	3	A
Uitwisselingsprogramma Bioinformatics (niveau master)	3	A

Onderwijstalen

Engels

Trefwoorden

Convex optimization, gradient-based methods, constrained optimization, multi-objective optimization, heuristical methods, shortest path methods, Bayesian optimization

Situering

As a more advanced course within the field of applied mathematics, this course focuses on traditional methodologies and more recent developments in the area of mathematical optimization. This course presents mathematical optimization as a flexible methodology that extends the students' problem-solving abilities. Students are taught how to translate (real-life) problems of substantial complexity into formal mathematical optimization problems. Moreover, students will learn how 'to select, apply and/or create efficient optimization procedures to solve these optimization problems efficiently. The general philosophy behind this course is application-oriented. Driven by a variety of applications in bioengineering (including to, but not limited to bioinformatics), several theoretical concepts on mathematical optimization will be introduced and studied up to a level that allows these concepts to be applicable in practice. Consequently, the main focus will be on the application and efficient implementation (in a scientific programming language) of these concepts.

Inhoud

The main objective of this course is to teach students how to use mathematical optimization techniques to solve a variety of real-life problems. The course consists of three main modules, of which the exact topics can vary from year to year:

1 Continuous convex optimization problems
2 Discrete optimization problems solvable in polynomial time
3 'Hard problems', NP-hard problems and complex problems with no guarantees on optimality and performance
4 Optimization problems with uncertainty

Every part consists of several theory lectures, written and implementation

exercises and a project. Throughout the lectures, several applications of bioinformatics are touched upon, including logistic regression, signal recovery, modelling protein oligomerization, cell tracking, single-cell analysis, microfluidics design etc.
All concepts are illustrated with Python implementations and exercises, available through the course Github repository: STMO.

Begincompetenties

- **Basic knowledge of scientific programming** (knowledge of Python is an advantage, but is not a strict prerequisite if the student is willing to acquire the required skills independently)**.**
- Basic knowledge of mathematics (in particular calculus and linear algebra, some notions of probability theory cfr. Mathematics 1 & 2, bachelor of bioscience engineering).
- A general overview of the kinds of problems in bioinformatics/bioengineering to be able to place the methods and algorithms in their broader context.

Eindcompetenties

1 The student understands and has insight into the main principles of mathematical optimization.
2 The student is able to recognize traditional optimization problems that are often encountered in the field of bioscience engineering.
3 The student is able to translate real-life problems into formal mathematical optimization problems.
4 The student is able to understand and judge the quality of the numerical optimization techniques underlying a variety of (bioinformatics) tools.
5 The student is able to select, apply and/or develop proper numerical optimization schemes to solve mathematical optimization problems.
6 The student is willing to routinely assess the impact of both the translation of a real-life problem into a formal optimization problem, and the optimization technique that is used to solve the resulting problem, on the solution that is found for a given problem in the field of bioengineering in general and bioinformatics in particular.

Creditcontractvoorwaarde

Toelating tot dit opleidingsonderdeel via creditcontract is mogelijk na gunstige beoordeling van de competenties

Examencontractvoorwaarde

Dit opleidingsonderdeel kan niet via examencontract gevolgd worden

Didactische werkvormen

Werkcollege, Hoorcollege

Toelichtingen bij de didactische werkvormen

e-books, python notebooks
Kost van deze cursus: 0€

Studiemateriaal

Type: Laptop

Naam: Python notebooks
Richtprijs: Gratis of betaald door opleiding
Optioneel: nee

Referenties

- H. Bockenhauer and D. Bongartz (2007). Algorithmic Aspects of Bioinformatics. Springer, 397p.
- M. Kochenderfer and T. Wheeler (2019). Algorithms for Optimization. The MIT Press
- S. Boyd and L. Vandenberghe (2004).Convex Optmization. Cambridge University Press, 716p
- J. Nocedal and S.J. Wright (1999). Numerical Optimization. Springer, 634p.
- D.E. Goldberg (1989). Genetic algorithms in Search Optimization and Machine Learning. Addison-Wesley, 412p.
- R. Sedgewick (2002). Algorithms in C: Graph Algorithms. Princeton University

Vakinhoudelijke studiebegeleiding

- Contact hours: 30h (of which 15u theory and 15h exercises)

- Additional information can be provided using Ufora.
- Computer exercises are guided by the teacher

Evaluatiemomenten

periodegebonden en niet-periodegebonden evaluatie

Evaluatievormen bij periodegebonden evaluatie in de eerste examenperiode

Schriftelijke evaluatie, Werkstuk

Evaluatievormen bij periodegebonden evaluatie in de tweede examenperiode

Mondelinge evaluatie, Schriftelijke evaluatie, Werkstuk

Evaluatievormen bij niet-periodegebonden evaluatie

Werkstuk

Tweede examenkans in geval van niet-periodegebonden evaluatie

Examen in de tweede examenperiode is niet mogelijk

Toelichtingen bij de evaluatievormen

- Periodic examination: synthesis project
- Permanent evaluation: evaluation of assignments

Eindscoreberekening

- 50% periodic evaluation
- 50% permanent evaluation