



UNIVERSITÀ DI PISA

THEORY AND METHODS OF OPTIMIZATION

GIANCARLO BIGI

Anno accademico 2021/22
CdS MATHEMATICS
Codice 577AA
CFU 6

Moduli	Settore/i	Tipo	Ore	Docente/i
TEORIA E METODI DELL'OTTIMIZZAZIONE	MAT/09	LEZIONI	42	GIANCARLO BIGI

Learning outcomes

Knowledge

The course aims at showing the main theoretical concepts and algorithms for nonlinear optimization problems in finite dimension.

Skills

The course aims at enabling students to formulate, analyse and solve nonlinear optimization problems in finite dimension.

Behaviors

The student should open up the mind to the formulation of concrete problems from different fields as nonlinear optimization problems.

Prerequisites

Linear algebra. Basic notions of topology. Convergence in metric spaces. Multivariate calculus.

Syllabus

Classification of optimization problems. Nonlinear optimization: convex functions and convex sets, local and global minima and maxima, convex analysis and subdifferential calculus, optimality conditions, duality theory, algorithms for unconstrained optimization (gradient descent, Newton, subgradient, derivative free) and constrained optimization (conditional gradient, projected gradient and subgradient, penalization, interior point, proximal gradient in composite optimization), nonlinear least squares. Equilibria in noncooperative games. Applications to specific problems (e.g., approximation and data/curve fitting, growth models, spatial configurations of molecules, transportation on urban and telecommunication networks, portfolio management, economic measures and their eventual relationships, economic equilibria), optimization in artificial intelligence and machine learning.

Bibliography

No textbook will be adopted. During the classes the instructor will provide a detailed list of references for each topic. Some handwritten lecture notes by the instructor are available as well.

Lecture notes

<http://pages.di.unipi.it/bigi/dida/tmo/lista.html> (mainly in Italian)

Main references

1. J. Nocedal, S.J. Wright, *Numerical Optimization*, Springer, 1999
2. M.S. Bazaraa, H.D. Sherali, C.M. Shetty, *Nonlinear Programming: Theory and Algorithms*, Wiley, 1993
3. D. Bertsekas, *Nonlinear Programming*, Athena, 2004
4. J.-B. Hiriart-Urruty, C. Lemaréchal, *Convex Analysis and Minimization Algorithms*, Springer, 2006
5. A. Beck, *First-Order Methods in Optimization*, SIAM, 2017

For further references check [this page](#)

Assessment methods

Students who regularly attended classes (32h or more) are free to choose one of the following examination procedures:

1. final interview
2. report and seminar

while those who didn't will be necessarily examined via a final interview on the contents of the course. The seminar will be an approximatively 1h



UNIVERSITÀ DI PISA

talk on an advanced topic related to the contents of the course, while the report provides a detailed analysis of the same topic. The choice of the topic will be jointly made by the student and the instructor. Once the topic is chosen, the student will have 2 months to deliver the report and give the talk.

Class web page

<http://pages.di.unipi.it/bigi/dida/tmo.html>

Updated: 13/08/2021 13:32