Advanced Mathematics for Scientific Challenges

2023-2024

Learning Objectives

- Efficient methods for optimization problems: linear programming and convex optimization
- Homological techniques for shape analysis of data sets
- Ability to select suitable methods depending on each problem and its solution constraints

Assessment

Course marks will be based on assignments and delivery of exercises

Teaching Blocks

1. Optimization (Àngel Jorba, angel@maia.ub.es)

    1.1. Elements of convex analysis

    1.2. Linear optimization. The simplex method

    1.3. One-dimensional optimization

    1.4. Nonlinear unconstrained optimization

    1.5. Nonlinear constrained optimization

2. Topological data analysis (Carles Casacuberta, carles.casacuberta@ub.edu)

    2.1. Simplicial homology

    2.2. Barcodes and persistence diagrams

    2.3. Persistence descriptors

    2.4. Stability theorems

    2.5. Applications to data analysis and machine learning

References

S. Boyd and L. Vandenberghe, *Convex Optimization*, Cambridge University Press, 2004

M. Minoux, *Mathematical Programming; Theory and Algorithms*, John Wiley & Sons, 1986

H. Edelsbrunner and J. Harer, Persistent homology: A survey, in: *Surveys on Discrete and Computational Geometry*, Contemp. Math. 453, Amer. Math. Soc., Providence, 2008, 257–282

R. Ghrist, Barcodes: The persistent topology of data, *Bull. Amer. Math. Soc.* 45 (2008), 61–75

F. Chazal and B. Michel, An introduction to topological data analysis: Fundamental and practical aspects for data scientists, *Frontiers in Artificial Intelligence*, September 2021

N. Otter, M. A. Porter, U. Tillmann et al., A roadmap for the computation of persistent homology, *EPJ Data Science* 6:17 (2017)