# Advanced Mathematics for Scientific Challenges

## 2020-2021

**Learning Objectives**

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

**Assessment**

Course marks will be based on assignments and resolution 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. Persistent homology of a point cloud

    2.2. Barcodes and persistence diagrams

    2.3. Stability results

    2.4. Algorithms and software for persistent homology

    2.5. Applications to data analysis, geometry, 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, arXiv:1710.04019 (2017)

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