**Optimization on Manifolds**

**Credits:** 7.5 ECTS

**Course organizer and lecturer**
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**Course period:** Spring semester 2021

**Prerequisites**
Students are expected to have a basic knowledge of Analysis, Linear algebra, Elements of numerical linear algebra and numerical methods, and Programming skills in a language suitable for scientific computation (Matlab, Python, Julia...).

**Objective**
The objective is to develop, analyze and implement numerical algorithms to solve optimization problems of the form: min f(x) where x is a point on a smooth manifold. To this end, we first study differential and Riemannian geometry (with a focus dictated by pragmatic concerns). We also discuss several applications.

There will be one two-hour lecture per week, and one two-hour exercise session including both theoretical work and programming assignments per week.

**Content**
This course covers the following topics:
- Applications of optimization on manifolds
- First-order Riemannian geometry in Euclidean spaces
- First-order optimization algorithms on manifolds
- Second-order Riemannian geometry in Euclidean spaces
- Second-order optimization algorithms on manifolds
- Fundamentals of differential geometry (general framework)
- Riemannian quotient manifolds
- More advanced geometric tools
- Geodesic convexity

**Learning Outcomes:**
By the end of the course, the student must be able to:
- Manipulate concepts of differential and Riemannian geometry.
- Develop geometric tools to work on new manifolds of interest.
- Recognize and formulate a Riemannian optimization problem.
- Analyse implement and compare several Riemannian optimization algorithms.
- Apply the general theory to particular cases.
- Prove some of the most important theorems studied in class.

**Examination**
The examination consists of a written exam and assignments during the course.
Literature


