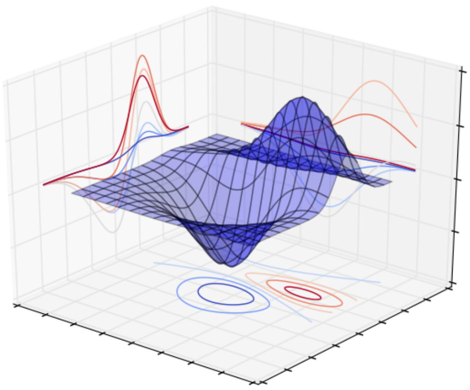
Numerical Methods

Convex optimization applied to statistical signal processing



The course is devoted to the task of estimating parameters from data contaminated by noises. The objective is to help the students to develop the skills needed to derive a possibly optimal algorithm to solve a given practical estimation problem.
It will particularly focus on the implementation. For that a large part of the course will be devoted to mathematical optimization which consists of deriving an algorithm to numerically minimize a cost function over a defined domain.

Theory

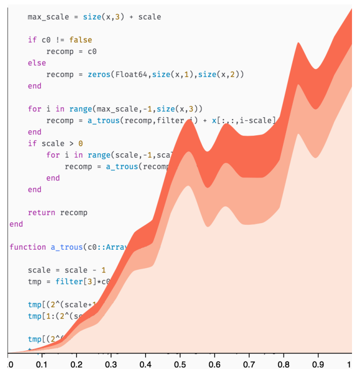
by A. FERRARI

In experimental and observational sciences one is always faced with the problem of drawing conclusions from data contaminated by noises. The theory of deterministic signal processing is insufficient for tackling these problems and we are forced to model and study such data in probabilistic and statistical fashion.

The most common task in this context is the estimation which consists of determining a signal waveform or some signal aspects from noisy measurements. The objectives of estimation theory are: 1. to show how to derive the best possible algorithm for extracting the information we seek, 2. to provide the performances of the algorithm.

In astrophysics these problems arise in all the systems designed to extract information from measurements, e.g. gravitational waves, exo-planets, cosmic microwave background, helioseismology... The same problems arise in a broad range of areas including geophysics, communication, finance, radar, biomedecine...

This problem can be addressed in a range from theoretical exposition by statisticians to the more practical treatment contributed by experimentalists in different areas. The course strikes a balance between these two extremes focusing on the application of state of the art results to practical problems.



In this context, mathematical optimization is a central tool for many practical estimation problems. A large part of the course will be devoted to help the students to develop the skills needed to numerically solve a convex optimization problem. Particular attention will be paid to optimization with constraints and optimization of non-differentiable functions which are both widely used today.

Mathematical optimization arises in many scientific areas and is an important enough topic that everyone in physics should know at least a little about it.

Applications

by A. FERRARI

A large part of the course is devoted to practical projects, where the students will code various algorithms and compare theoretical results with simulation results. Students will have to complete three projects during the course and are welcomed to work in pairs and to submit a single document. The computations will be preferentially carried out in `julia` or `python`.

See also

Course prerequisites: None

Boyd, S., & Vandenberghe, L. (2004). Convex Optimization. Cambridge University Press.

Kay, S. M. (1993). Fundamentals of Statistical Signal Processing, Vol. I: Estimation Theory. Prentice Hall.

Contact

✉ ferrari@unice.fr
☎ +33492076349
http://www-n.oca.eu/aferrari