First Order Optimization Methods

Marc Teboulle
School of Mathematical Sciences
Tel Aviv University

Optimization plays a central role in applied mathematics and widespread in the modeling of real world and complex systems covering a very broad spectrum of disparate areas, such as image science, finance, signal processing, and machine learning to mention just a few. The resulting optimization problems can be convex, often nonsmooth and even nonconvex, and are typically high dimensional. This necessitates the need to develop dedicated algorithms that can beneficially exploit data information and given structures in a given problem to produce simple and scalable algorithms. First Order Methods (FOM), namely iterative schemes based on function and (sub)-gradient values which share computational simplicity and essentially dimensionless iteration complexity are natural and ideal candidates to achieve these goals.

This course will have an algorithmic focus describing recent advances in the theory, design and analysis of first order methods for specific classes of convex and nonconvex optimization problems. The course is intended to equip the students with a solid knowledge on FOM and some of the modern trends, which hopefully will stimulate them to create new algorithms. The course will develop the theory necessary to describe and understand fundamental properties of numerous algorithms for high dimensional problems arising in a broad diversity of applied areas, highlighting the ways in which problem structures and data information can be exploited to devise simple and efficient numerical methods. Key ideas underlying the building of FOM, and the fundamental mathematical tools necessary for their convergence and complexity analysis will be presented in details.