Splitting Algorithms and Generalized Normalizing Flows

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PGMO and M2 Optimisation

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Lecture 1 - Tuesday, February 7, 10h00-12h45, Amphi Gay-Lussac
Lecture 2 - Tuesday, February 7, 14h15-17h00, Amphi Gay-Lussac
Lecture 3 - Thursday, February 9, 10h00-12h45, Amphi Carnot
Lecture 4 - Thursday, February 9, 14h15-17h00, Amphi Carnot

Variational methods are a quite universal and flexible approach for solving inverse problems, in particular in imaging sciences. Taking into account their specific structure as sum of several different terms, splitting algorithms provide a canonical tool for their efficient solution. Their strength consists in the splitting of the original problem into a sequence of smaller proximal problems which are easy and fast to compute.

Operator splitting methods were first applied to linear, single-valued operators for solving partial differential equations in the 60th of the last century. More than 20 years later these methods were generalized in the convex analysis community to the solution of inclusion problems and again more than 20 years they became popular in image processing and machine learning. Nowadays they are accomplished by so-called Plug-and-Play techniques, where a proximal denoising step is substituted by another denoiser. Popular denoisers were BM3D or MMSE methods which are based on (nonlocal) image patches.

Meanwhile certain learned neural network do a better job. However, convergence of the PnP splitting algorithms is still an issue. Normalizing flows are special generative neural networks which are invertible.

We demonstrate how they can be used as regularizers in inverse problems for learning from few images by using e.g. image patches. Unfortunately, normalizing flows suffer from a limited expressivity. This can be improved by applying generalized normalizing flows consisting of a forward and a backward Markov chain. Such Markov chains may in particular contain Langevin layers.

We will also consider Wasserstein-2 spaces and Wasserstein gradient flows, where the above Langevin flow appears as a special instance. We will discuss recent developments for estimating Wasserstein gradient flows by neural networks.

This lecture series is jointly organized by Ecole Polytechnique, INRIA, Master d'Optimisation of Paris Saclay and IPP, and Fondation Mathématique Jacques Hadamard, in the framework of the Gaspard Monge Optimization Programme, with the support by EDF.

Registration (free of charge) on https://www.fondation-hadamard.fr/fr/la-fmjh-soutient/recherche/home/pgmocourses/

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