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Bilevel optimization strategies and applications in imaging problems

Abstract

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In a general image restoration problem, the goal is to obtain a good quality image from some measured data, possibly of a different nature, by removing noise and distortions due to the acquisition process. The classical variational approach consists in two subsequent phases:
a) the design of a suitable regularized model resulting in a functional whose minimum point consists in the desired high quality image, and
b) a numerical optimization algorithm able to achieve that minimum point according to the specific mathematical properties of the functional to be minimized.
In the recent literature, new approaches have been proposed, where the modeling phase or even the entire restoration procedure is replaced with a deep convolutional neural network, whose weights have to be learned with training techniques. The numerical experience with the novel approach shows impressive improvements with respect to the classical one, from the point of view of the quality of the restoration. However, the training procedure requires a very large amount of data and the roles played by the learned parameters and the structure of the network itself in the final output are hard to explain.
In this talk, an idea that is halfway between the two previous approaches will be presented, based on bilevel and unrolling techniques. The first ingredient is based on the variational viewpoint and is the design of a quite general parametric objective function, based on the a priori knowledge of the underlying problem. Then, within a supervised training setting, these parameters are optimized in such a way that the restoration obtained by applying a finite number of iterations of a given optimization method to the objective function is at minimum distance to the desired ground truth image. Applications of the resulting strategy in several image restorations problems will be presented.

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