Markovian Random Fields and Comparison Between Different Convex Criterion Optimization in Image Restoration

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Abstract

The present work illustrates some recent alternative methods to deal with digital image reconstruction. This collection of methods are inspired on the use of a class of Markov chains best known as Markov Random Fields (MRF). All of these new methodologies are also based on the prior knowledge of some information which will permit more efficiently modeling the image acquisition process. The methods based on the MRF's are proposed and analyzed in a Bayesian framework and their principal objective is to eliminate those effects caused by the excessive smoothness on the reconstruction process of images which are rich in contours or edges. In order to respond to the edge preservation, the use of certain convexity criteria are proposed which will lead to obtain adequate weighting of cost functions (half-quadratic) in cases where discontinuities are remarked and, even better, for cases where such discontinuities are very smooth. The final aim is to apply these methods to problems in optical instrumentation.

1. Introduction

The use of powerful methods proposed in the seventies (iterated conditional modes) [2, 3, 9], are nowadays essential at least in the cases of image segmentation and image restoration [1]. The basic idea of these methods is to construct a Maximum a posteriori (MAP) of the modes or so called estimator of true images by using Markov Random Fields (MRF) in a Bayesian framework. The evolution of the basic idea has caused the development of new algorithms which consider new models of contextual information which is lead by the MRF's and the final aim is the restoration of real images (practical data). The idea is based in a robust scheme which could be adapted to reject outliers, tackling situations where noise is present in different forms during the acquisition process.

The image restoration approaches or recuperation of an image to its original condition given a degraded image, passes by reverting the effects caused by a distortion functional which must be estimated. In fact, the degradation characteristics is a crucial information and it must be supposed known or estimated during the inversion procedure. Typically this is a point spread function (PSF) from the distortion which can be linked with the probability distribution of the noise contamination, in the case of MAP filters, usually the additive Gaussian noise is considered. There is another source of information which imposes a key rule in the image processing context, this is the contextual or spatial information, that represents the likelihood or correlation between the intensity values of a neighborhood of pixels well specified. The modelling when using MRF take into account such spatial interaction and it was introduced and formalized in [2] where it is shown the powerfulness of these statistical tools [3, 4, 5, 9, 20]. Combining both kinds of information in an statistical framework, the restoration is lead by an estimation procedure given the maximum a posteriori of the true images when the distortion functionals are known. The implemented algorithms were developed considering a slightly degraded signal, where the resulting non-linear recursive filters show excellent characteristics to preserve all the details contained in the image, and on the other hand, they smooth the noise components.

The section 2 describes the general definition of an MRF and the proposal of the MAP estimator. The potential functions must be obtained or proposed to conduct adequately the inversion process, such functions are described in section 3 where the convexity is the key to formulate an adequate criterion to be minimized. In sections 4 and 5 are discussed briefly the MAP estimators resulting from different MRF structures and some illustrative results. Finally in section 6 are given some partial conclusions and comments.

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