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Mathematical Analysis of Stochastic Regularization Approach for Super-Resolution Reconstruction

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Abstract

Traditionally, several distorting processes affect the quality of image sequences or video acquired by commercial digital cameras. Some of the more important distorting effects include warping, blurring, down sampling and additive noise. The term SRR (Super-Resolution Reconstruction) ranges from blur removal by deconvolution in single image to the creation of a single high resolution image from multiple low resolution images having relative sub-pixel displacements. In all cases, the goal of SRR is to remove the effect of possible blurring and noise in the LR images and to obtain images with resolutions that go beyond the conventional limits of the uncompensated imaging system. Thus, the major advantage of this approach is that the cost of implementation is reduced and the existing low resolution (LR) imaging systems can still be utilized. Due to the importance of SRR research and the advantages of the SRR algorithm, this article aims to review the mathematical analysis of the SRR algorithm based on stochastic regularization approaches, one of the most popular techniques introduced by the SRR research community during the last two decades. The mathematical models of SRR algorithm based on classical L1 and L2 norms with several classical regularization functions are comprehensively derived. Finally, the mathematical solutions of each case are obtained by the classical systematical approach.

Keywords: *Digital image processing, digital image reconstruction, stochastic regularization, Laplacian regularization.*

Introduction

Due to several advantages of Super-Resolution Reconstruction (SRR), applications for the techniques of SRR from image sequences grow rapidly as the theory gains exposure. Continuing researches and the availability of fast computational machineries have made these methods increasingly attractive in applications requiring the highest restoration performance. SRR techniques have already been applied to problems in a number of applications such as satellite imaging, astronomical imaging, video enhancement and restoration, video standards conversion, confocal microscopy, digital mosaicing, aperture displacement cameras, medical imaging, diffraction tomography and video freeze frame (Kang and Chaudhuri 2003; Ng and Bose 2003; Park *et al*. 2003; Rajan *et al*. 2003; Patanavijit 2009).

Usually, the SRR is a process that attempts to reconstruct or recover an image that has been degraded by using some *a priori* knowledge of the degradation phenomenon. Therefore, SRR algorithms are oriented toward modeling the degradation and applying the inverse process in order to recover the original image (Gonzalez and Woods 1992).

In the next section, a succinct overview of some basic concepts in mathematical inverse problems is provided. The discussion there is nontechnical so that the reader may obtain an intuitive comprehension of the fundamental ideas prior to the presentation of greater detail in subsequent sections.