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Abstract

Total variation and its variants have been widely used in the video/image restoration area in the past decades. Among them, the nonlocal total variation model introduces penalization on nonlocal gradients and demonstrates remarkable performance gain in many applications. However, this approach tends to suppress intensity-changes of visual contents, and hence cannot restore complicated visual contents well enough. To address this issue, this paper proposes a novel second order nonlocal total variation model for video restoration problems. Firstly, the directed space-time nonlocal gradients are defined in our model to formulate the spatio-temporal intensity-changes of video contents. Secondly, mean-value approximations of these nonlocal gradients are introduced into the model. Based on them, we build up a new model that consists of both first order and second order nonlocal regularization terms. Furthermore, for the purpose of adapting to specific visual contents, it is also augmented with a content-adaptive modification. These features make the proposed second order nonlocal total variation model a high order generalization of the original one. Experimental results on various video restoration problems show that the proposed model significantly improves the restoration qualities, compared with other state-of-the-art approaches.

Keywords: Video Restoration, Nonlocal Total Variation, Regularization Modeling

1. Introduction

Video restoration is one of the most important and fundamental research topics in the video processing area. Its objective is to restore a clean video from a degraded observation. Usually, the video degradation process can be generalized as:

$$\mathbf{b} = \mathbf{A}\mathbf{u} + \mathbf{n} \ . \tag{1}$$

In (1), $\mathbf{u}$ is the original video to restore, $\mathbf{A}$ is a linear mapping that converts $\mathbf{u}$ to the observation space, $\mathbf{n}$ represents additive random noise or statistical error, and $\mathbf{b}$ is the observed data. With different configurations of $\mathbf{A}$ and $\mathbf{n}$, solving problem (1) turns to different restoration tasks. For example, if $\mathbf{A}$ is the identity matrix, (1) corresponds to the denoising problem for which many mature schemes like BM4D [1] have been proposed. But when $\mathbf{A}$ corresponds to certain degradations (like blurring, compressive sampling, etc.), this inverse problem becomes more ill-posed due to the information loss caused by $\mathbf{A}$, and these kinds of problems are the main focus of this paper. Because problem (1) is generally ill-posed, recovering the clean video $\mathbf{u}$ is usually accomplished

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