A Variational Model for Simultaneously Image Denoising and Luminance Adjustment

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Abstract. In this paper, we propose and develop a saturation value total variation (SV-TV) regularization model for simultaneously image denoising and luminance adjustment. The idea is to propose a variational approach containing an energy functional to adjust the luminance between image patches, and the noise of the image can be removed. In the proposed model, we establish the adjustment term based on the concept of structure, luminance, and contrast similarity, and we make use of the SV-TV regularization to remove the noise simultaneously. We present an efficient and effective algorithm with convergence guaranteed to solve the proposed minimization model. Experimental results are presented to show the effectiveness of the proposed model compared with existing methods.

1 Introduction

In this paper, we focus on adjusting inconsistent luminance of noisy images. The purpose of luminance adjustment is to intensify the visibility of images and make images more suitable for other image processing applications.

In the literature, there are a variety of methods for enhancing consistent low contrast of images. Histogram equalization (HE) [7] is an effective and powerful technique for contrast enhancement. The cumulative distribution function of the normalized histogram of the input image gray-levels was selected to be the transformation function in global histogram equalization (GHE) [6] for the histogram equalization purpose. Contrast enhancement based on local information by using histogram equalization was proposed

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by Wang and Ng in [29], and the authors proposed a variational approach containing an energy functional to determine a local transformation such that the histogram can be redistributed locally, and the brightness of the transformed image can be preserved. In [28], an image pixel based histogram equalization model for image contrast enhancement was proposed. The idea was to formulate a variational model containing an energy functional to adjust the pixel values of an input image directly so that the resulting histogram can be redistributed to be uniform. The Automatic Color Enhancement (ACE) method [5] is another effective image enhancement method based on a simple model of the human visual system, and the enhancement process is consistent with perception. In [17,18], Nikolova et al. proposed a simple image enhancement algorithm (HPE) which conserved the hue and preserved the range (gamut) of an image in an optimal way. In [4], Ferradans et al. built a general variational framework (PLCE) to perform perceptual color correction and to handle the problem of local contrast enhancement. Retinex proposed by Land and McCann [10] as a model of color perception of human vision, is another technique for illumination and contrast enhancement. Many implementations and improvements of Retinex have been studied in the literature. In [3], Elad proposed a variational framework using two special bilateral filters as the regularization terms in order to provide a non-iterative Retinex algorithm. Ma and Osher [14] established a total variation (TV) and nonlocal TV regularized model of Retinex theory that can be solved by a fast computational approach based on Bregman iteration. In [13], Ma et al. established an L_1-based variational model for Retinex theory that can be solved by a fast computational approach based on Bregman iteration. In [16], Ng and Wang studied and developed a TV model for Retinex. They assumed spatial smoothness of the illumination and piecewise continuity of the reflection, where the total variation term is employed in the model.

On the other hand, image denoising is to find the unknown true image u from a noisy image f. However, inverse problems are ill-posed, a regularization technique must be used to make them well-posed. This idea was introduced in 1977 by Tikhonov and Arsenin [26]. Rudin, Osher, and Fatemi proposed to use L_1 norm of the gradient of u, also called total variation as the regularization (ROF model) [21, 22]. Thanh and Dvoenko proposed the modified ROF model in [23, 24] to remove mixed Poisson-Gaussian noise. In [25], Thanh et al. proposed an adaptive method based on combining the first-order and the second-order total variations with the adaptive multiscale parameter estimation, which can effectively remove noise while preserving the image structure. In [19], a new parameter estimation method for TV regularization scheme was proposed by Prasath et al. For color images, Bresson and Chan [1] established an vectorial TV (VTV) regularization method, which takes into account the coupling relationship between different channels. In [9], Jia, Ng, and Wang proposed the Saturation-Value Total Variation (SV-TV) model based on the HSV color space. The SV-TV regularization is considered in S and V channels. This method processes the image while preserving the edge and color information, so the unexpected chromatic intersection can be greatly reduced. Therefore, the SV-TV model has an excellent performance in color image restoration.

To the best of our knowledge, there is a few research work in the literature for si-