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Anisotropic Diffusion-Based Unsharp Masking for Sharpness Improvement in Digital Images

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Abstract

Various available imaging systems are capturing images with deficient sharpness due to numerous unavoidable shortcomings. Perceiving and extracting information from such images is uneasy. Hence, it is required to process these images properly to produce sharper and clearer details. Many methods exist that can be used to increase the sharpness of digital images. Among such, the unsharp mask has gained high popularity due to its rapidness and simplicity. Still, this filter usually degrades the processed images by an overshoot effect, which appears around the edges as white shades. In this study, an anisotropic diffusion-based unsharp mask filter, so-called ADUSM, is proposed, in that the degraded image is filtered using an amended anisotropic diffusion filter rather than processing it only by a low-pass Gaussian filter. This modification permitted the attenuation of the overshoot artefact which yielded to obtain better quality results. The ADUSM is tested with several types of images and assessed with two adequate quality metrics. Many experiments indicated that the proposed filter can outperform different existing methods and produce satisfactory results with reasonable application time.

Keywords: Image sharpening, Anisotropic diffusion, Image enhancement, Unsharp mask.

1. Introduction

The acutance is an important feature in an image since the observer perceives properly if the image owns adequate edges and clear details. These two features are represented in an image by the information that has a high frequency. If such information is reduced or eliminated, the image apparent details will be tremendously degraded (Banham and Katsaggelos, 1997). Quite the opposite, improving such information can lead to noticeable visual improvements (Kim and Kwon, 2010). Image sharpening represents any method that can increase the visibility of edges and vital details of an unsharp image (Wilscy and Nair, 2008). Image sharpening is extensively utilized in recognition, printing, and photography to upsurge the acutance of digital images (Webb, 1989). There exist three key causes to increase the sharpness in an image which are, to highlight certain details, overcome the blurring effect introduced by the camera lens, and to upsurge legibility.

Hence, various methods are made available for image sharpening, wherein their intricacies vary according to the used concept. Such methods can be the use of morphological filtering (Schavemaker et al., 2000), APEX concept (Carasso, 2003), unsharp masking (Kim and Allebach, 2005), downscaling cokriging (Pardo-Igúzquiza et al., 2006), fuzzy bidirectional flow (Fu et al., 2007a), shock-diffusion equation (Fu et al., 2007b), sub-regions histogram equalization (Ibrahim and Kong, 2009), Sobolev gradient flows (Calder et al., 2010), fuzzy logic (Gui and Liu, 2011), Laplacian operators (Ma et al., 2014), Wavelets (Zafeiridis et al., 2016) and many more. As seen, different concepts are used for image sharpening. Among such, tremendous research has been made based on the unsharp mask concept in the past period due to its rapidness and simplicity. Still, it unavoidably degrades the processed image by the overshoot effect (Polesel et al., 2000). Such effect occurs around the edge sides, making these edges perceived with visible white shades (Cao et al., 2011). Thus, it is required to enhance the processing ability of the standard unsharp mask to provide artefact-free outcomes with better sharpness. Despite the major thrive in image sharpening, there still an adequate chance for ameliorating this filter. Therefore, an anisotropic diffusion-based unsharp mask filter, so-called ADUSM, is introduced in this study to provide enhanced sharpness for the processed images without delivering any unwanted effects.

In the proposed ADUSM, the image is processed by an amended anisotropic diffusion filter rather than processing it only by a low-pass Gaussian filter. This tactic provided an adequate chance in reducing the overshoot effect and facilitated the recovery of better-quality images. The developed ADUSM filter is tested with several types of