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Enhancing Inverse Halftoning via Coupled Dictionary Training

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Abstract

Inverse halftoning is a challenging problem in image processing. Traditionally, this operation is known to introduce visible distortions into reconstructed images. This paper presents a learning-based method that performs a quality enhancement procedure on images reconstructed using inverse halftoning algorithms. The proposed method is implemented using a coupled dictionary learning algorithm, which is based on a patchwise sparse representation. Specifically, the training is performed using image pairs composed by images restored using an inverse halftoning algorithm and their corresponding originals. The learning model, which is based on a sparse representation of these images, is used to construct two dictionaries. One of these dictionaries represents the original images and the other dictionary represents the distorted images. Using these dictionaries, the method generates images with a smaller number of distortions than what is produced by regular inverse halftone algorithms. Experimental results show that images generated by the proposed method have a high quality, with less chromatic aberrations, blur, and white noise distortions.

Keywords: Coupled Dictionaries, Image Restoration, Inverse Halftoning, Enhancement, Training

1. Introduction

Printing a digital image requires a conversion from a digital representation to an analog representation. This process is often linked with digital halftoning, which is the technique of converting continuous-tone images into images with a limited number of tones (known as halftones) [1, 2]. The technique generates images that, although having a limited number of levels, convey the illusion of having a higher number of levels. Halftoning techniques can be applied both to grayscale and color images. On the other hand, inverse halftoning is the process of generating a reconstruction (or an approximation) of the original continuous-tone image from their halftoning versions. The inverse halftoning process is an important image restoration problem and is frequently associated with several other multimedia problems, such as content protection using watermarking [3], visual cyptography [4], compression of multimedia content [5], error concealment [6], and image quality assessment [7, 8].

Since halftoning techniques discard a considerable amount of information from the original continuous-tone image, distortions are frequently introduced in halftone images. As a consequence, the design of inverse halftoning techniques is challenging and, when compared to the original image, restored images may contain distortions. Most common distortions include color distortions, noise, or blur. Over the years, several inverse halftoning methods have been proposed. Examples include the works of Freitas *et al.* [9] and Saika *et al.* [10], who propose inverse halftoning methods that restore continuous-tone images from ordered dithering (OD) halftones. Xiong *et al.* [11], Kite *et al.* [12], and Neelamani *et al.* [13] propose wavelet-based approaches that restore images from halftones generated using error diffusion algorithms [14].

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