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Image restoration a comparative study of some methods applied to color images

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***Abstract*—The present work introduces five different methods to deal with digital image restoration. Particularly deconvolution by Richardson-Lucy method, Wiener filter, deconvolution with Gaussian priors in the frequency domain, spatial domain and the use of sparse priors. The Bayesian methodology is based on the prior knowledge of some information that allows an efficient modeling of the image acquisition process. The edge preservation of objects into the image while smoothing noise is necessary for an adequate model. Thus, we use five deconvolution methods to recover images, all of the presented images are contained on TID 2008, all of them were previously degraded by Gaussian noise and convolved with a disc point spread function (PSF) making reference to a typical fluorescence microscopy degradation. The principal objective when using restoration methods in the context of image processing is to eliminate those effects caused by the excessive smoothness on the reconstruction process of an image which is rich in contours or edges and also is important to consider the process time due to an improvement in this area could lead to a faster application. A comparison between the five methods is presented for a restoration process. This collection of implemented methods has been compared using different metrics such as SNR, PSNR, SSIM and process time. The obtained results showed a satisfactory performance and the effectiveness of the proposed methods on color space.**

Keywords—Digital image processing, image deblurring, deconvolution.

I. Introduction

Image filter and image restoration are two near topics, however its objectives and solving methods differs, while image filter deals only with noise [1],[2],[3]. Image restoration often requires to solve an inverse problem. It amounts to estimate image from a measurement. Given an observed blurry image y and a filter H the deblurring problem can be defined as finding a sharp image x such that:

$$y = H * x \tag{1}$$

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Typically, the inverse of H doesn't exist, H is also called point spread function (PSF) describes the response of the imaging system to a point source or object. It plays a fundamental role in understanding imaging performance. Thus a realistic and accurate knowledge of the PSF is crucial to optimize the performance of a successful image deconvolution, in spite of recent studies to know the PSF is not yet possible to obtain it with all the possible cases [4], in addition, in real problems such as fluorescence microscopy [5], [6] equation (1) is also contaminated whit different kinds of additive noise [6], [7]:

$$y = H * x + n \tag{2}$$

Typical degradation operators include masking, subsampling in a uniform grid and convolution, and the corresponding inverse problems often named interpolation, zooming, and deblurring. To solve them often requires some prior information on the image, or likewise, image models. Finding good image models is therefore at the heart of image estimation.

Nowadays there are several different ways to deal with the reconstruction of an image x given an observed data y, this problem is called image deconvolution and its solution is strongly linked to the knowledge of degradation characteristics.

As we mention a variety of different methods exist for solving for x, such as the Wiener filter, used to produce an estimate of a desired or target random process by linear time-invariant (LTI) filtering of an observed noisy image, assuming known stationary signal and noise spectra, and additive noise. The Wiener filter minimizes the mean square error between the estimated image and the desired image. [8],[9]. And also the well-known and still in use Richardson-Lucy deconvolution algorithm [10], [11],[12],[13].

In order to better understand the implications to solve equation. (1) and (2) It will be useful to express the convolution in the frequency domain, where $H(\nu,\omega)$, the Fourier transform of H is a diagonal matrix: