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Deblurring of motion blurred images using Histogram of Oriented Gradients and Geometric Moments

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Abstract

In image processing, various motion deblurring methods have been proposed that are based on camera shake and object motion. This paper proposes an effective method of estimating the point spread function (PSF) parameters based on the concepts of Histogram of oriented gradients (HoG) and statistical properties of an image, given the blurred image itself. In particular, HoG and statistical properties helps in estimating the angle and velocity parameters of the motion based PSF. Once these parameters are estimated, restoration of the blurred image is performed using recently introduced non-blind method in moment domain. The advantage of using moment domain are fast convergence and robust to the variations in the parameters of the PSF. The experiments on both the synthesized and real images show that our method can effectively restore the original images and get comparable results with existing algorithms. This is validated by using PSNR and a well known quality metrics BRISQUE and SSIM for evaluating the image quality.

Keywords: Image deblurring, Histogram of Oriented Gradients, Geometric Moments.

1. Introduction

In most of the image processing applications, the observed image is a degraded version of the original image. Various cause of image degradations are (1) atmospheric distortion (2) out-of-focus blur (3) motion blur resulting from camera shake or the movements of the objects in the scene. In particular, our focus in this paper is on motion blur. Although the degradation process is a nonlinear process, still a large number of problems could be solved using the approach of linear and shift-invariant (LSI) system. Hence, the blurring process is modeled as a LSI system in which the degraded image $g(x, y)$ is expressed mathematically by a convolution between the original image $f(x, y)$, system PSF $h(x, y)$ and the noise $n(x, y)$ as

$$g(x, y) = \sum_m \sum_n h(x - m, y - n) f(m, n) + n(x, y) \tag{1}$$

Here, $h(x, y)$ is the motion blur PSF characterized by two parameters velocity (v) and angle (θ) respectively. One can observe from Eq. (1) that in order to restore the original image $f(x, y)$ back, it is necessary to estimate the system PSF parameters (v, θ) from the degraded image. Hence, there is a need to estimate these parameters accurately.

Image restoration aims to recover the original image from the observed degraded image. The effectiveness of image restoration process depends on the extent and accuracy of the knowledge of the degradation process [1–3]. In particular, motion deblurring is a technique used to improve the quality of images whose quality has been degraded due to the optical device being out of focus thereby causing a loss in quality of an image. However, it can be avoided with higher quality capturing equipment or a better lighting and motion conditions. But these conditions are not always available. Typical application of image restoration is in the areas involving astronomy, remote sensing, microscopy and medical imaging.

The most common image restoration techniques used for restoring the degraded image are Wiener and inverse filtering. In general, the restoration of blurred images can be classified as blind and non-blind problems [4]. In the case of non-blind, the PSF $h(x, y)$ is assumed to be known. However, in case of blind deblurring, both of the original image and the PSF are unknown. There are two main approaches to solve blind image deblurring viz: (i) simultaneously estimate the image and the blur [5–7]; (ii) obtain a blur estimate from the observed image and then use it in a non-blind