Chapter 8
A Brief Review on Recent Trends in Image Restoration

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ABSTRACT

This chapter gives the opportunity to get an idea of recent trends in image denoising and restoration. It relates to the present research scenario in the field of image restoration. As much as possible the newest break-through regarding the methods of denoising as well as the performance metrics of evaluation has been dealt. The assessments done by the researchers have been included first so as to know how much analysis they propose to be done with respect to the application point of view of the denoising methods. The concept behind the metric selection for the assessment and evaluation has been introduced along with the need for shifting the dependence of the research community towards the newly proposed metrics than the old ones. The new trends in image denoising have been referred duly so that the readers can directly refer to the main algorithms and techniques from the papers proposed by their authors.

INTRODUCTION

The chapter starts with an introduction of the various performance metrics used by researchers and tries to find the suitability of a particular metric for a particular application. The various concepts behind the origin of these metrics have been introduced so that the reader would have an idea empirically choosing a particular metric. The main concern is towards the visual fidelity metrics. Then, the reader is acquainted with the notion and dependence of researchers in using the old metrics of evaluations in their research works. The more dependence on mathematically convenient metrics is pointed out and the reasons to shift towards more visually appreciable quality based metrics have been mentioned. A brief introduction of each such metric has been presented and the applicability of them has been discussed.

After that the recently proposed image denoising algorithms have been dealt, one by one referring to each of the methods in brief. Of course, not all methods can be included so only those methods which are most viable to the research community have been discussed. The readers are encouraged to go through the referred papers of the mentioned researchers for a detailed description of these algorithms.

BACKGROUND

Right from the notion of random nature of noises came in existence, image denoising and restoration have been a very important area of research. Researchers have been trying to analyse the noise type and understand its model so that by knowing how noising in image occurs, they can reverse the process to get the denoised image. Different types of noises identified till now are gaussian noise, heavy trailed noise, salt and pepper (impulse) noise, quantization and uniform noise, photon counting noise, photographic grain noise, speckle noise, rayleigh noise, erlang (gamma) noise, exponential noise, and so forth (Bovik, 2009). Researchers have been trying to introduce or modify the denoising algorithms for respective noise wise denoising till late 90s, but now a search for more specific application wise as well as more robust and versatile denoising algorithms is in trend, also as the development continues, more qualitative and vision dependent assessment techniques for the efficiency and quality analysis are in recent trends. A brief review of these new trends in the denoising as well as metrics of evaluation of last decade follows.

CHOICE OF THE PERFORMANCE METRICS

The choice of the visual fidelity metric for a particular case varies from the test algorithm, the complexity of calculation and subjective judgments made by humans' perceptions. The Performance metrics have a literature of their own, According to (Chandler & Hemami, 2007) fundamentally, the metric of evaluation has been developed either on bottom-up properties of vision or by relying on how our visual system responds to a distorted image. These metric of evaluations can be divided as:

1. **Mathematically Convenient Metrics:** These take in to account the intensity of distortions; for example: Mean-Squared Error (MSE), Signal to Noise Ratio (SNR), Peak Signal-to-Noise Ratio (PSNR), Root Mean-Squared Error (RMSE), and so forth.

2. **Metrics Based on Near-Threshold Psychophysics:** These take in to account a frequency-decomposition algorithm, which uses the contrast detection thresholds along with the elevations in the thresholds due to masking effects imposed by images. For example, weighted MSE or activity based measures (Teo & Heeger, 1994; Lai & Kuo, 1997; Winkler, 1999).

3. **Metrics Based on Overarching Principles:** Overreaching principles could be structural or information extraction. The basic principle is that if structural content (such as object boundaries or regions of high entropy etc.) most closely matches that of the original image, the image could be considered a high quality image. (Wang, Bovik, Sheikh, & Simoncelli, 2004; Sheikh, Bovik, & Veciana, 2005; Zhai, Zhang, Yang, & Xu, 2005; Shnayderman, Gusev, & Eskicioglu, 2006).

Mathematically convenient metrics have been quite in use for a long time and are the choice of many researchers for comparison and evaluation of their algorithms. (Boracchi & Foi, 2011) took in to account the Root Mean Squared Error (RMSE) for a comparison between rescaled and original image which can be computed as:

$$RMSE\left(\hat{y}, y\right) = 255 \sqrt{\frac{1}{\# X} \sum_{x \in X} (\frac{1}{\kappa \lambda} \hat{y}\left(x\right) - y(x))^2}$$

(1)

where, $\hat{y}$ is the rescaled image and y is the original image, κ and λ are the varying parameters.

They also considered the time (Boracchi & Foi, 2011) as a criteria for observing how the restoration performance varies with the exposure

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