Chapter 2

Impulse Noise Filtering:

Review of the State-of-the-Art Algorithms for Impulse Noise Filtering

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ABSTRACT

Digital images are often corrupted by various types of noises amongst which impulse noise is most prevalent. Impulse noise appears during transmission and/or acquisition of images. Intrusion of impulse noise degrades the quality of the image and causes the loss of fine image details. Reducing the effect of impulse noise from corrupted images is therefore considered as an essential task to be performed before letting the image for further processing. However, the process of noise reduction from an image should also take proper care towards the preservation of edges and fine details of an image. A number of efficient noise reduction algorithms have already been proposed in the literature over the last few decades which have nurtured this issue with utmost importance. Design and development of new two dimensional (2D) filters has grown sufficient interest amongst the researchers. This chapter attempts to throw enough light on the advancement in this field by illustratively describing existing state-of-the-art filtering techniques along with their capability of denoising impulse noises.

1. INTRODUCTION

Digital images are often corrupted by various types of noises amongst which impulse noise is most prevalent. Impulse noise appears during transmission and/or acquisition of images. Intrusion of impulse noise degrades the quality of the image and causes the loss of fine image details. Reducing the effect of impulse noise from corrupted images is therefore considered as an essential task to be performed before letting the image for further processing. However, the process of noise reduction from an image should also take proper care towards the preservation of edges and fine details of an image.

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A number of efficient noise reduction algorithms have already been proposed in the literature over the last few decades which have nurtured this issue with utmost importance. In regard to this, algorithms like standard median filter (SMF) (Huang et al., 1979), center weighted median (CWM) filter (Ko & Lee, 1991), adaptive median filter (AMF) (Hwang & Haddad,1995), progressive switching median filter (PSMF) (Wang and Zhang, 1999), multi-state median (MSM) filter (Chen and Wu, 2000), modified decision based un-symmetric trimmed median filter (MDBUTMF) (Esakkirajan et. al., 2011) and decision-based coupled window median filter (DBCWMF) (Bhadouria, Ghoshal, & Siddiqi, 2014) have been proposed in subsequent times. These algorithms have judiciously pointed out the limitations of the preceding algorithms and come up with solutions to mitigate those shortcomings. As a matter of fact, design and development of new two dimensional (2D) filters has grown sufficient interest amongst the researchers.

This chapter aims to throw sufficient light on the advancement in this field by illustratively describing existing state-of-the-art filtering techniques towards the elimination of impulse noises from the two-dimensional image. Each of these algorithms has been described with the help of mathematical backbone and the capability of noise elimination has been explained analytically. Numerical results have been included in order to substantiate the claims of the authors and to make a comparative study amongst various algorithms.

The entire chapter has been organized as follows: section II provides a brief description about various types of impulse noises available in practice and section III projects median filter as an efficient tool to eliminate the effect of impulse noise while section IV highlights some of the recent trends employed for this specific application. Section V makes a comparative analysis amongst various methods with the avenues of future research have been indicated in section VI. Finally, the chapter is concluded in section VII.

2. VARIANTS OF IMPULSE NOISE

Images are often corrupted by impulse noise during the process of acquisition and transmission. Impulse noise may be of type unipolar or bipolar. Bipolar impulse noise is commonly known as salt-and-pepper noise (SPN) (Gonzalez & Woods, 2002; Huang, Yang, & Tang, 1979). The main property of salt-and-pepper noise is that the pixel corrupted by this noise gets the maximum or minimum value present in the dynamic range of available values, such as 0 and 255 in case of 8-bit gray-scale image. The SPN is commonly modeled in accordance with

$$Y_{i,j} = \begin{cases} \{0,\ 255\} & \text{with probability } p \\ X_{i,j} & \text{with probability } 1-p \end{cases} \tag{1}$$

where $X_{i,j}$ and $Y_{i,j}$ denote the intensity value of the original and corrupted images at coordinate (i,j) respectively and p is the noise density.

Various methods have been proposed in the literature for estimating the intensity values of noisy pixels. Some of the best existing methods are opening-closing sequence (OCS) filter (Ze-Feng Zhou-Ping, & You-Lun, 2007), edge-preserving algorithm (EPA) (Chen & Lien, 2008), switching-based adaptive weighted mean (SAWM) filter (Zhang & Xiong, 2009), decision-based average or median filter (DAM)

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