Int. J. Electron. Commun. (AEÜ) 68 (2014) 1145–1155

Contents lists available at ScienceDirect

International Journal of Electronics and Communications (AEÜ)

journal homepage: www.elsevier.com/locate/aeue

Fast switching based median–mean filter for high density salt and pepper noise removal

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ARTICLE INFO

Article history:
Received 25 March 2013
Accepted 9 June 2014

Keywords:
Image restoration
Impulse detection
Mean filter
Median filter
Salt and pepper noise

ABSTRACT

This paper proposes a fast switching based median–mean filter for high density salt and pepper noise in images. The extreme minimum value and extreme maximum value of the noisy image are used to identify the noise pixels. In the filtering stage, the corrupted pixel is replaced either by median value or mean value based on the number of noise free pixels in the filtering window. The qualitative and quantitative results show that the proposed filter outperforms the other switching based filters namely ACWMF, PSMF, AMF, DBA and MDBUTMF in terms of noise removal and edge preservation for noise densities varying from 10% to 90%.

1. Introduction

Images are often corrupted by salt and pepper noise during transmission. Generally, linear filtering techniques fail when the noise is non-additive and are not effective in removing impulse noise [1]. This has lead to the use of nonlinear signal processing techniques. Most commonly used nonlinear filter is the median filter. The main drawback of a Standard Median Filter (SMF) is that every pixel in the image is replaced by the median value in its neighborhood as a result of which the desirable details in the image are removed [2]. At high noise densities, SMF often exhibits blurring for large window sizes and insufficient noise suppression for small window sizes. The Weighted Median Filter (WMF) [3] and the Center-Weighted Median Filter (CWMF) [4] were proposed as remedy to improve the median filter by giving more weight to some selected pixels in the filtering window. Although these two filters can preserve more details than the median filter, they are still implemented uniformly across the image without considering whether the current pixel is noise free or not.

Switching median filters [5–14] were proposed with the objective of discriminating between corrupted and uncorrupted pixels prior to non-linear filtering. Possible noisy pixels are identified and replaced by using median value or its variant while leaving uncorrupted pixels unchanged. An Adaptive Median Filter (AMF) proposed in [5] is good at low and medium noise density levels. At higher noise densities, the number of replacements of corrupted pixel increases considerably; increasing window size will provide better noise removal performance; however, the original pixel values and replaced median pixel values are less correlated. As a consequence, the edges are smeared significantly. The Adaptive Center Weighted Median Filter (ACWMF) proposed in [6] is used to remove high density impulse noise. It requires optimized thresholds for both salt and pepper and random valued impulse noise types. Though Progressive Switching Median Filter (PSMF) [7] performs efficiently, it is time consuming and computationally complex as a result of which its hardware implementation becomes difficult.

Recently, some novel decision based median filters such as a Boundary Discriminative Noise Detector (BDND) [8], Decision Based Algorithm (DBA) [9], Simple Adaptive Median Filter (SAMF) [10] and Modified Decision Based Unsymmetrical Trimmed Median Filter (MDBUTMF) [11] have been proposed in the literature to remove high density salt and pepper noise in digital images. The BDND uses a large window of size 21×21 to detect noise pixels. Therefore, it requires high computation time and details get blurred at higher noise densities. A fixed 3×3 window is used for filtering in DBA. In this algorithm, the corrupted pixels are replaced by the median value of the filtering mask. At higher noise densities, the median value may also be a noisy pixel in which case

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http://dx.doi.org/10.1016/j.aeue.2014.06.002
1434-8411/

$X_{i-1,j-1}$	$X_{i-1,j}$	$X_{i-1,j+1}$
$X_{i,j-1}$	$X_{i,j}$	$X_{i,j+1}$
$X_{i+1,j-1}$	$X_{i+1,j}$	$X_{i+1,j+1}$

Fig. 1. A 3×3 filtering window highlighting previously processed pixels.

the most recently processed pixel is used for replacement. Since previously processed pixel is used for replacement, streaking in the image becomes a problem at higher noise densities. The SAMF in [10] is used to remove high density salt and pepper noise. At higher noise ratios SAMF does not preserve edges satisfactorily and moreover an adaptive window of length 15×15 is used for filtering at high noise densities. The Modified Decision Based Unsymmetric Trimmed Median Filter (MDBUTMF) for high density salt and pepper noise removal assumes the minimum value (i.e. 0) and the maximum value (i.e. 255) in the dynamic range as pepper noise and salt noise respectively. The main drawback is that at higher noise densities, if all the pixels in the 3×3 filtering window are corrupted either by pepper noise value (i.e. 0) or by salt noise value (i.e. 255), then it uses mean value of all the elements in the filtering window to replace the noise pixel which is also a noisy value, i.e. 0 or 255.

In this paper, a fast switching based median–mean filter is proposed to remove high density salt and pepper noise with edge preservation and reduced streaking. The noise pixels are detected in the first stage. In the second stage, corrupted pixel is replaced either with median value in the filtering window or mean value

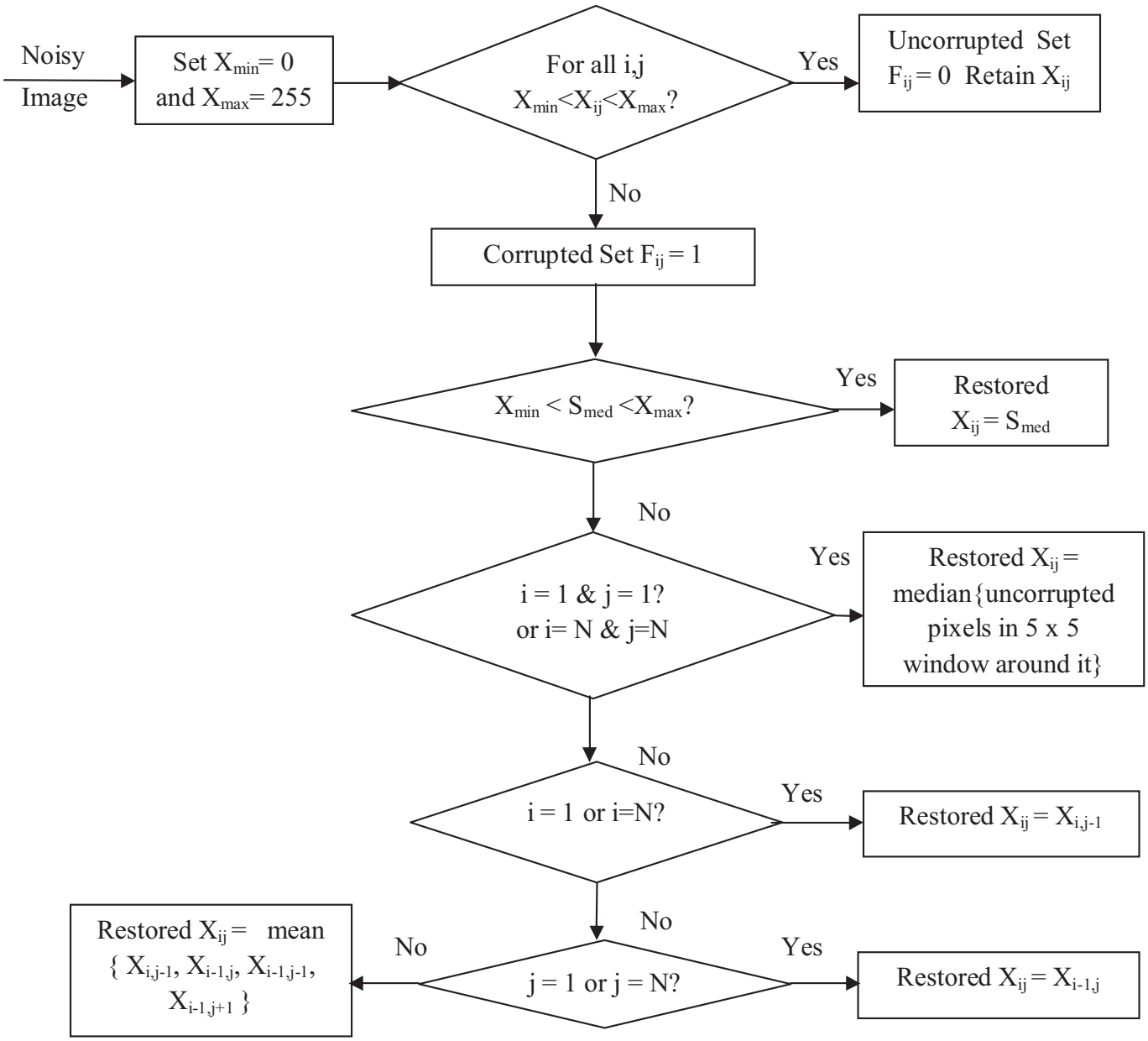

Fig. 2. Flowchart of the proposed algorithm.