Survey On Impulse Noise Removal Techniques In Digital Images

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Abstract

The prime factor that reduces the quality of the image is Noise. Noise hides the important details of images. To enhance the image qualities, we have to remove noises from the images without loss of any image information. Noise removal is one of the pre-processing stages of image processing. There are different types of noises which corrupt the images. These noises are appeared on images in different ways, at the time of acquisition, due to noisy sensors, due to faulty scanner or due to faulty digital camera, due to transmission channel errors, due to corrupted storage media. In order to get enhanced images, many researchers present several techniques to remove noises by preserving important image details like structural features, textural information. In this paper, we present a survey on various impulse noise removal techniques and study its drawbacks and limitations.

1. INTRODUCTION

Digital Image Processing is a promising area of research[1] in the fields of electronics and communication engineering, consumer and entertainment electronics, control and instrumentation, biomedical instrumentation, remote sensing, robotics and computer vision and computer aided manufacturing (CAM). For a meaningful and useful processing such as image segmentation and object recognition, and to have very good visual display in applications like television, photo-phone, etc., the acquired image signal must be deblurred and made noise free. When an image gets corrupted with noise during the processes of acquisition, transmission, storage and retrieval, it becomes necessary to suppress the noise quite effectively without distorting the edges and the fine details in the image so that the filtered image becomes more useful for display and/or further processing. The digital images are often corrupted by impulse noise due to transmission errors, malfunctioning pixel elements in the camera sensors, faulty memory locations, and timing errors in analog-to-digital conversion. An important characteristics of this type of noise is that only part of the pixels is corrupted and the rest are noise-free. . Impulse noise can be classified into two types: fixed-valued impulse noise and random-valued impulse noise. The fixed-valued impulse noise is also called salt-and-pepper noise where the gray-scale value of a noisy pixel is either minimum or maximum in gray-scale images. When viewed,the image contains dark and white dots, hence the term salt and pepper noise. The gray-scale values of noisy pixels corrupted by random-valued impulse noise are uniformly distributed in the range of [0, 255] for gray-scale images. In most applications, denoising the image is fundamental to subsequent image processing operations, such as edge detection, image segmentation, object recognition, etc. The goal of noise removal is to suppress the noise while preserving the image details.

2. LITERATURE SURVEY

Much wider range of algorithms is provided to filter the digital images from the impulse noise. Here in this paper we study various algorithms provided by the authors to remove impulse noise.
There are basic two approaches of the image denoising techniques: spatial domain filtering and transform domain filtering.

2.1 Spatial Domain Filtering

Spatial filters are direct and high speed processing tools of images. This is the traditional way to remove the noise from the digital images to employ the spatial filters. Spatial domain filtering is further classified into linear filters and non linear filters.

2.1.1 Linear filter technique:

Mean filter: Mean filtering [16] is a simple, intuitive and easy to implement method of smoothing images, i.e. reducing the amount of intensity variation between one pixel and the next. It is often used to *reduce* noise in images. The idea of mean filtering is simply to replace each pixel value in an image with the mean (`average') value of its neighbours.This has the effect of eliminating pixel values which are unrepresentative of their surroundings.

Draw back and limitation of above algorithms are:

- A single pixel with a very unrepresentative value can significantly affect the mean value of all the pixels in its neighborhood.

When the filter neighborhood straddles an edge, the filter will interpolate new values for pixels on the edge and so will blur that edge. This may be a problem if sharp edges are required in the output.

Wiener filter

The wiener filtering [16] method requires the information about the spectra of the noise and the original signal and it works well only if the underlying signal is smooth. Wiener method implements spatial smoothing and its model complexity control correspond to choosing the window size. Wiener filtering is able to achieve significant noise removal when the variance of noise is low, they cause blurring and smoothening of the sharp edges of the image.

2.2 *Non-linear filter technique:*

Median filter

In non linear techniques the median filter [7] is a non linear digital filter which is often used in digital image processing to reduce noise in an image. In practice, besides reducing noise, it is important to preserve the edges of an image as edges provide critical information on the visual appearance of an image. Median filtering is a smoothing technique which is effective in reducing noise in the smooth regions of an image. But can adversely affect the sharpness in edges. For small to moderate levels of salt and pepper noise the median filter has shown to be useful in reducing noise while preserving edges.

Draw back and limitation of above algorithms are:

- With deteriorating performances at a high level of noise.
- Not suitable for high noise densities and does not preserve the image details like edges for further post processing.

Weighted Median Filter (WMF)

Weighted median filter is one of the branch of median filter (WMF). The operations involved in WMF are similar to SMF except that WMF[12] has weight associated with each of its filter element these weights correspond to the number of sample duplications for the calculation of median value. However the successfulness of weighted median filter in preserving image details is highly dependent on the weighting coefficients and the nature of the input image itself. Unfortunately, in practical situations, it is difficult to find the suitable weighting coefficients for this filter, and this filter requires high computational time when the weights are large.

Centre Weighted Median Filter (CWMF)

It is a special type of median filter. CWM [8] is a filtering technique in which filter gives more weight only to the central value of a window, and thus it is easier to design and implement than general WM filters.

Adaptive Weighted Median Filter (AWMF)

Adaptive weighted median filters (AWMF), which is an extension to WMF[8]. By using a fixed filter size Wm,n,
the weights of the filter will be adapted accordingly based on the local noise content. This adaptation can be done in many ways, mostly based on the local statistics of the damaged image.

Adaptive median filter

The Adaptive Median Filter[2] is designed to eliminate the problems faced with the standard median filter. The basic difference between the two filters is that, in the Adaptive Median Filter, the size of the window surrounding each pixel is variable. This variation depends on the median of the pixels in the present window.
If the median value is an impulse, then the size of the window is expanded.

Draw back and limitation of above algorithms are:

- Above approaches might blur the image since both noisy and noise free pixels are modified.
- Existing systems uses fixed or different window size for detection of impulse noise. No algorithm is exist which can remove the noise from the edges of the gray scale image.

- Existing systems not provides consistent output in both low and high noise conditions.
- Exist systems are not well suited for real time applications because of these algorithms are time consuming nature.

Switching median filter

The switching median filter [3] involves two steps impulse detector and filtering schemes. The various impulse detectors are proposed in the literature are, rank order based median filter, progressive switched median filter, adaptive center weighted median filter, laplician detector based switching median filter, pixel wise median filter, In switching median filter, there are two steps, First, a test decides whether or not a given pixel is contaminated by impulsive noise. A pixel is contaminated, if the absolute difference between the median value in its neighborhood and the value of current pixel itself is greater than a given threshold. If contaminated, a classical median filter is applied. If not, the current pixel is noise free and will not be modified.

Progressive Switching Median Filter

Progressive switching median filter [4] is used for removing salt and pepper impulsive noise from the image. In this case first take one pixel check whether the pixel value is less than the minimum value present in the window value and also check whether the pixel value is greater than the maximum value present in the window then it is a corrupted pixel. Corrupted pixel is replaced by median value. If the calculated median value is corrupted pixel , then increase the window size and recalculate the median value until get correct median value.

Drawback and limitations of above algorithms are:

- perform badly in noise detection, damage image details, retain numerous impulses in the filtered images at high noise ratios.

To avoid the above problem, switching median filter with boundary discriminative noise detection (BDND) algorithm is proposed [5].

- Advantages of BDND algorithms are works well with 90% of noise density, real time applications.
- Limitations are the size of filtering window.

Fuzzy filters:

Fuzzy based filters [13] are those filters which include concept of fuzzy logic in their filtering procedure. Fuzzy based filters can also be further classified into two categories: fuzzy classical and fully fuzzy. Fuzzy classical filters include the filters which extend the traditional filters using fuzzy logic. There are plenty of fuzzy traditional filters on which many researchers have worked. We here mention only some of them. Popular fuzzy classical filters are: Fuzzy Median Filter (FMF), Fuzzy Impulse noise Detection and Reduction Method (FIDRM), Fuzzy Random Impulse Noise Reduction method (FRINR), Fuzzy Weighted Mean (FWM), Adaptive Weighted Fuzzy Mean (AWFM), In fuzzy median filter, and fuzzy weighted mean filter, fuzzy logic is added to enhance the traditional median and mean filters. Fuzzy Impulse noise Detection and Reduction Method [6] and Fuzzy random impulse noise reduction method is two step methods. In first step, noisy pixels are detected from the input image and after detection procedure, noise is removed from the detected pixels this forms the second step. The fuzzy logic is used in detection step by forming the fuzzy rules to decide whether the pixel is corrupted with noise or not. In filtering procedure, traditional filters like mean filter, median filter, weighted mean filter etc. are extended using fuzzy logic.

3. Transform Domain filtering

It is needed when it is necessary to analyze the signal. Here, we transform the given signal to another domain and do the denoising procedure there and afterwards inverse of transformation is done in order to get final output. There are several transforms available like the Fourier transform, Hilbert transform, wavelet transform, etc. The Fourier transform is probably the most popular transform. Among different Fourier transforms fast Fourier Transform (FFT) is considered the best. However the Fourier transform does not give high performance in case of image denoising. Wavelet transform[15] is better for this purpose Wavelet transform further provide different methods for removing noise from image which includes thresholding, non- orthogonal wavelet transform and coefficient model. Wavelet transform [15] is best suited for performance because of its properties like sparsity, multiresolution and multiscale nature, which wavelet is applied depends upon the nature of the application. DWT has a advantage of Shift in variance whereas daubechies wavelet transform is efficient to remove noise and a new technique fast wavelet transform represents with less memory requirement and complexity.

4. Noise detection and Removal Using Cellular Automata:

In this algorithm [14], the first step is the detection of noisy points will be done using Adaptive Boundary Differentiate Noise Detection Method by Cellular Automata. In the second step, the value of detected noisy pixels will be changed according to a Switching Median Filter based on Cellular Automata, which is used to remove impulse noise from noise corrupted images. In this algorithm an efficient Switching Median Filter based on Cellular Automata are proposed to remove low to high value of salt and pepper noise. The proposed filter performs well for gray scale image with different noise model of salt and pepper noise. In this algorithm Adaptive boundary Discriminative Noise Detection can accurately tell where the noise is, only noise affected pixels are replaced by Switching Median Filter based on Cellular Automata and intensity of unaffected pixels within the working window. Cellular Automata is a simple and robust method with parallelization ability used in for image processing applications such as improving image quality and it is best suited for real time applications.

Drawback of above algorithm is:

- However, despite its simplicity, this method like median filter or other noise reduction methods, delivers a good result only when the corrupted noises are low, but in case of a high noise occurrence all effective pixels will change.

5. Performance metrics:

Study the performance of the detection schemes in identifying the noisy pixels in the image at different impulse noise ratios.

5.1.1. Peak Signal to Noise Ratio (PSNR):

PSNR analysis uses a standard mathematical model to measure an objective difference between two images. The PSNR block computes the peak signal-to-noise ratio, in decibels, between two images. This ratio is often used as a quality measurement between the original and a compressed image. The higher the PSNR, the better the quality of the compressed or reconstructed image. The bigger PSNR, the less distortion.

5.1.2. The Mean Square Error (MSE):

The MSE represents the cumulative squared error between the compressed and the original image, whereas PSNR represents a measure of the peak error. The lower the value of MSE, the lower the error, MSE is smaller, the performance is better, which means the filtered image is close to the original.

6. CONCLUSION

This paper surveys the impulse noise removal techniques and comparison of above existing algorithms is studied. Study of all algorithms and compare these to determine better detail preserving algorithm. This survey provides help to researchers for selecting the best algorithm with detail preserving for the removal of impulse noise from the digital images.

REFERENCES

1) R.C. Gonzalez and R.E. Woods, Digital Image Processing. Pearson education.
2) H. Hwang and R.A. Haddad, "Adaptive Median Filters: New Algorithms and Results,"IEEE Trans. Image processing, vol. 4,no. 4, pp. 499-502, Apri1995.
3) S. Zhang and M.A. Karim, "A New Impulse Detector for Switching Median Filter," IEEE Signal Processing Letters, vol. 9,no. 11, pp. 360-363, Nov.2002.
4) R.H. Chan, C.W. Ho, and M. Nikolova, "Salt-and-Pepper Noise Removal by Median-Type Noise Detectors and Detail-Preserving Regularization," IEEE Trans. Image Processing, vol. 14, no. 10, pp. 1479-1485, Oct. 2005.
5) P.E. Ng and K.K. Ma, "A Switching Median Filter with Boundary Discriminative Noise Detection for Extremely Corrupted Images, "IEEE trans.ImageProcessing, vol. 15, no. 6, pp. 1506-1516, June 2006.
6) P.-Y. Chen and C.-Y. Lien, "An Efficient Edge-Preserving Algorithm for removal of Salt-and-Pepper Noise," IEEE Signal Processing Letters, vol. 15, pp. 833-836, Dec. 2008.
7) T. Nodes and N. Gallagher, "Median Filters: Some modifications and Their Properties," IEEE Trans. Acoustics, Speech, Signal Processing, vol. ASSP-30, no. 5, pp. 739-746, Oct. 1982.
8) S.-J. Ko and Y.-H. Lee, "Center Weighted Median Filters and Their applications to Image Enhancement," IEEE Trans. Circuits Systems,vol. 38,no. 9, pp. 984-993, Sept. 1991.
9) W.Luo, "An Efficient Detail-Preserving Approach for Removing Impulse Noise in Images," IEEE Signal Processing Letters, vol. 13, no. 7, pp. 413-416, July 2006.
10) I. Aizenberg and C. Butakoff, "Effective Impulse Detector Based on Rank-Order Criteria," IEEE Signal Processing Letters, vol. 11,no. 3, pp. 363-366, Mar. 2004.
11) Z. Wang and D. Zhang, "Progressive Switching Median Filter for the Removal of Impulse Noise from Highly Corrupted Images,"IEEE Trans. Circuits Systems II, Analog Digital Signal Processing,vol. 46, no. 1, pp. 78-80, Jan. 1999.
12) R.K. Brownrigg, "The weighted median filter," Commun. Assoc. Comput., pp. 807–818, Mar. 1984.
13) K. Arakawa, "Median filters based on fuzzy rules and its application to image restoration," Fuzzy Sets Syst., vol. 77, pp. 3–13, 1996.
14) Songtao Liu, Hongquan Chen, Shaoqing Yang, ―An Effective Filtering Algorithm for Image Salt-pepper Noises Based on Cellular Automata 2008 Congress on Image and Signal Processing. 978-0-7695-3119-9/08 © 2008 IEEE
15) S. G. Chang, B. Yu, and M. Vetterli, "Spatially adaptive wavelet thresholding with context modeling for image denoising," IEEE Trans. Image Processing ,vol. 9, pp. 1522–1531, Sept. 2000.
16) Astola and P. Kuosmanen, Fundamentals of linear and Nonlinear Digital Filtering, Boca Raton, Florida: CRC Press, 1997.