Impulse Noise Suppression Techniques in Digital Images: A Review

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Abstract- Impulse noise is the most common noise present in digital images. Removal of impulse noise from the images is a difficult task in image processing. Impulse noise occurs in images during the process of image transmission and image acquisition. Many noise removal techniques have been proposed, each having its own respective advantages and disadvantages. These noise removal techniques must be designed in order to achieve mainly low computational cost, less hardware complexity and the design must be very suitable for real time applications. This paper presents a brief literature survey of different techniques of suppression of impulse noise.


I. INTRODUCTION

The process of performing different operations and manipulations to a digitized image in order to improve its quality can be termed as image processing. Image processing is widely used in different fields such as Robotics, Medicine and Defence etc for various applications. Noise occurs in the images during different pre-processing steps involved in image processing. They degrade the quality of the image resulting in blurring of the image. There are different types of noises which affects the digital images namely Impulse noise, Gaussian noise, Poisson noise and Speckle noise.

Impulse noise appears as black and white dots in the image. So impulse noise is also called as Salt and Pepper noise. Due to the sharp and sudden changes of the image signal, impulse noise is caused. It is also caused by the dust particles in image acquisition process and by overheated of the faulty components. Impulse noise is also called in different names as Spike noise, Random Noise and Independent Noise. Impulse noises are of two types namely random valued impulse noise and fixed valued impulse noise. Fixed valued impulse noise is a type of impulse noise where the noise occurs in only two values of 0 and 255. Random valued impulse noise is a type of impulse noise where the noise is uniformly distributed over the range 0 to 255.

Gaussian noise model follows Gaussian distribution. Each pixel in the noisy image is the sum of the true pixel value at each point and a random Gaussian distributed noise value. The noise is independent of intensity of pixel value at each point.

Poisson noise is occurred when a number of photons sensed by the sensor are not sufficient to provide detectable statistical information. This noise has the root mean square value proportional to square root intensity of the image. Different pixels are suffered by independent noise values. Practically, the photon noise and the other sensor based noise corrupt the signal at different proportions.

Speckle noise can be modelled by the random variable multiplications with the pixel values of the image and can be expressed as the sum of input image pixels and the uniform pixels of the noise image. This noise deteriorates the quality of active radar and Synthetic Aperture Radar (SAR). This noise is originated because of coherent processing of back scattered signals from multiple distributed points. To remove all these types of noises from the images we use different types of filters.

II. FILTERS

A filter is a small electronic component which is used to remove impurities in an image. Filters are used to remove the noise completely from the image while preserving the details. Filters must locate the corrupted pixel and remove the noise from it. They must not affect the uncorrupted pixels. There are mainly two types of filters namely linear filters and non-linear filters. Linear filters are the filters in which input signals are time varying to produce the output signals subjected to the constraint of linearity. Example of linear filter is adaptive median filter. Non-linear filters are the filters in which the output depends upon the ordering of input values from the smallest to largest or vice versa. At low frequencies all the values are the same or close, so output values will be the original with or without small error. At high frequencies i.e., at the edge, the lower values in lower position and the higher values in higher position are considered. No middle values are considered. Hence non linear filters are also known as edge preserving filter. Example of non-linear filter is median filter. Some of the filters are discussed below.

A. Mean Filter:

The filter determines the average value of the corrupted image in a window. Then the central pixel is replaced by that average value. This process is repeated is for all the pixel values in the given input image. Mean filter is also called as averaging filter.
B. Median Filter:

The filter whose response is based on the ranking of pixel values contained in the filter region. It is also a type of order statistics filter. It is mainly used for reducing certain types of noise. Here the centre value of the pixel is replaced by the median of the pixel values under the filter region. It is used to remove salt and pepper noise. It is also widely used in image processing and signal processing. Major advantage of median filter over linear filter is that the median filter can eliminate the effect of input noise values with extremely large magnitudes.

C. Order Statistics Filter:

It is a type of non-linear filter. Its response depends upon the ordering of pixels covered by the filter area. When the central value of the pixel in the image is replaced by the highest value that is hundredth percentile, then the filter is called maximum filter. When the central value of the pixel in the image is replaced by the lowest value that is zeroth percentile, then the filter is called minimum filter.

D. Adaptive Filter:

The filter which changes their behaviour on the basis of statistical characteristics of the image region covered by filter area is called as adaptive filter. The denoising algorithm used here can be divided into three steps. The first step is the analysis. Here similar image blocks are collected in groups. Blocks in each group are stacked together to form 3-D data always which are de-correlated using an invertible 3-D transform. The second step is the processing. The obtained 3-D group spectra are filtered by hard thresholding. The third step is the synthesis. The filtered spectra are inverted, providing estimates for each block in the group. These block wise estimates are returned to their original positions and the final image reconstruction is calculated as a weighted average of all the obtained block wise estimates.

III. LITERATURE REVIEW

Many researchers have done a lot of work in order to remove the impulse noise from the digital images. The median filters and its various types are extensively used for noise removal. Some of the research works are discussed below.

Pei-Yin Chen and Chih-Yuan Lien [1] proposed an efficient VLSI implementation for impulse noise removal is presented. This design achieves a better visual quality if the noise ratio is as high as 90%. A 7-stage pipelined architecture for simple edge preserving denoising architecture (SEPD) and 5-stage pipelined architecture for reduced SEPD (RSEPD) are developed and implemented. Comparing both architectures, RSEPD architecture outperforms better than other techniques. Less hardware cost, low computational complexity with two line memory buffers. It works for monochromatic images, but can also be extended for RGB images and videos.

Chih-Yuan Lien, Chien-Chuan Huang and Pei-Yin Chen [2] proposed an efficient denoising scheme and its VLSI architecture for the removal of random valued impulse noise is presented. A decision-tree based impulse noise detector is used to detect and remove impulse noise. The noisy corrupt image is converted in a Mat lab environment and impulse noise pixels are detected and the image is restored. The VLSI architecture of our design is implemented in verilog HDL. SYNOPSYS Design Vision is used to synthesize the design with TSMC’s 0.18micrometer cell. This VLSI architecture of our design yields a processing rate of about 200MHz by using TSMC 0.18micrometer technology. It is very suitable for real time applications. The quality of the reconstructed image is notably improved.

V.R Vijaykumar, D.Ebenezer and P.T Vanathi [3] proposed a non-linear filter called detail preserving median filter for removing salt and pepper noise is presented. The proposed filter performance is verified for random valued and fixed valued impulse noise. The proposed algorithm first detects the impulse pixel based on threshold values and the corrupted pixels are replaced by the median value of the uncorrupted pixel in the filtering window. It is implemented in Mat lab 7.1 software which can be equipped in Pentium 4 PC. This method outperforms many of the existing standard median filter, weighted median filter, centre weighted median filter, recursive weighted median filter, progressive switching median filter etc. The visual quality and detail preservation is conserved. The proposed filter works well for the low to medium density impulse noise up to a noise density of 70%.

Pei-Yin Chen [4] proposed an algorithm for removing salt and pepper noise from the corrupted images is presented. An efficient impulse noise detector is used to detect the noisy pixels and an edge preserving filter to reconstruct the intensity values of noisy pixels. The proposed algorithm is composed of two components: efficient impulse detector and edge preserving filter. The detector determines which pixels are corrupted by fixed valued impulse noise. The filter reconstructs the noisy pixels by observing the spatial correlation and preserving the edges efficiently. It detects the impulse noise efficiently while preserving the edges very well. The algorithm is very simple and it is very suitable for real-time applications.

Hang Cheng Yu, Li Zhao and Haixian Wang [5] proposed an efficient algorithm is proposed for removing random valued impulse noise from corrupted image by using reference image. This method uses a statistic of rank ordered relative differences to identify pixels which are corrupted by impulse noise. The noisy pixel is identified and its value is restored by a simple weighted mean filter. Extensive experiments have been conducted on several images to compare our method with many other well known techniques and it performs well. Simulation results also indicate that the algorithm provides a significant improvement over many other existing techniques.

Nemanja I Petrovic and Vladimir Crnojevic [6] proposed a filter in this method is capable of effectively suppressing all kinds of impulse noise, in contrast to many existing filters. In addition, it proposes the usage of a new impulse noise model-the mixed impulse noise model-which is more realistic and harder to treat than existing impulse
noise models. This algorithm uses two detectors where in the first detector identifies the majority of noisy pixels. The second detector searches for the remaining noise missed by the first detector, usually hidden in image details or with amplitudes close to its local neighbourhood. Simulation results show that the proposed two-stage filter produces excellent results and outperforms existing filters. Development of high performance detector structure, excellent performance of removal of salt and pepper noise and uniform impulse noise (together called universal impulse noise).

Yiqiu Dong and Shufang Xu [7] proposed a new impulse detector, which is based on the differences between the current pixel and its neighbours aligned with four main directions. Then we combine it with the weighted median filter to get a new directional weighted median filter (DWM). The DWM filter removes the random-valued impulse noise. It makes full use of the characteristics of impulse and edges to detect and restore noise. Here, the outputs of median filters are improved based on the information of the four directions. Simulation results show that DWM filter performs much better than many existing median based filters as it can preserve edges very well, even thin lines, as removing noise. It can be extended to restore the colour images corrupted by random-valued impulse noise.

Wenbin Luo [8] proposed a new efficient algorithm for the removal of impulse noise from corrupted images while preserving image details is proposed. The proposed method uses the alpha trimmed mean only in impulse noise detection instead of pixel value estimation. The algorithm is based on the alpha trimmed mean, which is a special case of the order statistics filter. Once a noisy pixel is identified, its value is replaced by a linear combination of its original value and the median of its local window. Experimental results indicate that the proposed method performs significantly better than many other existing techniques. Extensive computer simulations indicate that our algorithm provides a significant improvement over many other existing techniques.

Pei-Eng Ng and Kai-Kuang Ma [9] proposed a switching median filter along with impulse noise detection method called boundary discriminative noise detection (BDND) is proposed for effectively denoising extremely corrupted images. It has been further incorporated into a switching median filter as a very powerful denoising scheme. To determine whether the current pixel is corrupted, the BDND algorithm first classifies the pixels of a localized window centring on the current pixel into three groups: lower intensity impulse noise, uncorrupted pixels and higher intensity impulse noise. Four noise models are considered for performance evaluation for impulse noise generation. High accurate noise detection is accomplished by BDND algorithm. It is fairly simple to implement for real time image applications and maintains a fairly low false-alarm rate.

Raymond H Chan, Chung-Watto and Mila Nikolova [10] proposed a decision-based, detail-preserving restoration method is proposed for removing salt and pepper noise. It proposes a two phase scheme for removing salt and pepper impulse noise. In first phase, an adaptive median filter is used to identify pixels which are likely to be contaminated by noise. In second phase, the image is restored using a specialized regularization method that applies only to those selected noise candidates. In terms of edge preservation and noise suppression, restored images show a significant improvement compared to those restored by using just non-linear filters. Improvement can be done to the results by using different noise detectors and regularization methods that are used for different types of noises, such as random valued impulse noise/impulse plus Gaussian noise.

### IV. ANALYSIS

In this section, a number of de-noising approaches are compared for removal of fixed valued impulse noise. In the simulations, the image is corrupted by salt and pepper noise, where 255 represents salt noise and 0 represents the pepper noise. A wide range of noise ratios varied from 20%, 50%, 70% and 80% are tested. Many de-noising methods are compared; Standard Median Filter (MF), New Impulse Detector (NID), Differential Rank Impulse Detector (DRID), Simple Fuzzy Impulse Detector (SFID), Alpha Trimmed Mean Based Method (ATMBM), Decision Based Algorithm (DBA), Switching Median Filter (SMF), Progressive Switching Median Filter (PSMF) and Optimal Detector Noise Filter (ODNF). Peak Signal to Noise Ratio (PSNR) is employed to illustrate the quantitative quality of the reconstructed images for various methods. Table I lists the restoration results in PSNR (dB) of different approaches for image “LENA” corrupted by fixed valued impulse noise with various noise ratios.

| Table I Comparisons of Restoration Results in PSNR (dB) for Image “LENA” |
|-------------------------|---|---|---|---|
|                         | 20% | 50% | 70% | 80% |
| MF                      | 31.00 | 24.41 | 17.03 | 12.95 |
| NID                     | 34.03 | 26.42 | 21.95 | 18.72 |
| DRID                    | 36.22 | 29.94 | 24.07 | 17.84 |
| SFID                    | 37.55 | 26.46 | 18.43 | 14.53 |
| ATMBM                   | 37.42 | 27.03 | 19.09 | 15.21 |
| DBA                     | 37.49 | 32.31 | 28.34 | 26.10 |
| SMF                     | 26.52 | 14.96 | 10.00 | 8.09 |
| PSMF                    | 32.37 | 30.06 | 9.88 | 7.98 |
| ODNF                    | 34.26 | 27.35 | 23.00 | 20.36 |
V. CONCLUSION

In this paper various impulse noise removal techniques are reported in the research. There are different methods for image de-noising which also enhances the quality of the images. In image processing, suppression of impulse noise is important and so as the edge preservation techniques. A brief study of different types of noises and various types of filters are discussed. Many research reports based on the removal of impulse noise from the images are reported here. Thus noise removal technique is always an active field of research with the requirements of more and more efficient techniques which can restore images corrupted by impulse noise to the best possible extent.

REFERENCES


