Survey on Image De-noising Based on Two-Stage Median Filtering Approach

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***Abstract*— This paper addresses briefly the significant benefits of two stage median filtering techniques that detect and remove the noise efficiently. Noise usually occurs due to the transmission error or signal interference. Noises like impulse noise, Gaussian white noise, Poisson noise etc., that affect the image quality and fine details. Two stage filtering concept for de-noising the images usually has detection and filtering stage. Initially, this type of filters detects the noise candidate pixel at the first stage and alters or modifies the detected noisy pixels at the second stage. This process improves the quality of image and maintains the non-noisy pixels as it is. In this comprehensive survey, various kinds of two stage median filter and noise models are discussed in detail.**

***Index Terms*— Noise removal, Noise detection, Median filter, Impulse noise, Signal interference.**

I. INTRODUCTION

Digital image processing is the handling of digital images according to our need for various applications through various kind of processing. The input given to the system is an image which is called picture element and the system process the image with the various efficient algorithms and gives output. It focuses on major tasks like improvement of pictorial information for human interpretation, processing of image for storage, transmission and representation for autonomous machine perception. Medical image processing is application that enables quantitative analysis and visualization of medical images. Medical imaging seeks reveal internal structures hidden by the skin as well as treat diseases of numerous modalities such as PET, MRI, CT, or microscopy.

Noise is an unwanted information or signal that eradicates the original images feature and causes of degradation in image features. Noises may occur at the time of transmission. There are various noise models of impulse noise, namely, random valued impulse noise and fixed valued noise. Random valued impulse noise produces impulse (noisy or corrupted pixel) whose gray level lies within a predetermined range. Noise removal can be achieved by using a number of existing linear filtering techniques which are mathematically simple [1]. The non-linear filtering like median provides the most robust restoration from the noisy image by moving over it uniformly and having every pixels of the image replaced by the median of the pixels chosen from among their neighbourhood, the most suitable noise replacement value considering all visual discontinuities of the image [2]. Different noises like salt and pepper noise, Gaussian white noise, Poisson noise, speckle noise are exists in image processing. Poisson noise is associated in uncertainty of measurement of lights. Speckle noise is caused by interference effects of echoes from irresolvable random scatters due to the coherent nature of ultrasound scanners. This occurs especially in imaging the body organs like as liver and kidney whose underlying structures are too small to be resolved by the transducer. Impulse noise is caused by camera sensors, faulty memory location in hardware or during transmission of signals [3].

Medical image processing is useful to analyze the interior portions of the human body and diagnosis the diseases. Scanner screens the body parts of the affected portions or area and converts the signal which is passing through the organs into images. The converted data may sometimes encountered by the transmission error. It can be cutout by the use of filtering techniques. Image de-noising the efficient tool to detect and shoot out the unwanted noise that affects the image quality. De-noising requires preprocessing of data to identify the pixels that are corrupted by the noise. There are number of filters that drain the noisy pixel efficiently. Traditional median filters took a prominent part to remove the noise while restoring the image but there exist loss of details when the ratio of noise pixel is high.

II. TYPES OF NOISE

An image is affected by various reasons like as environmental condition during sensing or image acquisition. It is random variation of colour information and brightness in images, and is usually an aspect of electronic noise. It is an undesirable by-product of image capture that adds spurious and extraneous information [4]. Commonly occurs noises in images is described in the below section.

A. Salt & Pepper Noise

Salt and pepper noise is also called as an impulsive noise, occurs due to low or high pixel value. In this noise model there are two pixels black and white. Black represent 0

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and white represent 255, where the noise value takes on either the minimum or the maximum intensity range of the gray-scale image. The model for such noise corrupted images can be formulated as:

$$P(x) = \begin{cases} P1 & x = A \\ P2 & x = B \\ 0 & otherwise \end{cases} \quad (1)$$

Where P1 and P2 are the salt and pepper noise.

B. Speckle Noise

Speckle noise is otherwise called as a granular noise that inherently exists and damaged the quality of the medical image especially ultrasound, mammogram image. Speckle noise increases the mean grey of local area, which is more serious issue, causing difficulties for image interpretation. It can be formulated as:

$$g(x,y) = f(x,y) * n(x,y) + n1(x,y) \quad (2)$$

Where *f (x ,y)* is original image, *n(x , y)* and *n1(x, y)* is multiplicative.

C. Gaussian Noise

The Gaussian noise otherwise known to as statistical noise which is having a probability density function is equals to the normal distribution. Where *p* refers the probability of the density. Gaussian noise decreases the scalability of the image.

$$P(x) = \frac{1}{(\sigma\sqrt{2\pi})} * \frac{e^{(x-\mu)^2}}{2\sigma^2} \quad (3)$$

Where *P(x)* is Gaussian distribution, *x* represents original image and σ^2 represent the noise density.

D. Poisson Noise

Poisson noise is also known shot noise. The Poisson distribution is same as the Gaussian distribution. It occurs on the image due to the statistical nature of electromagnetic waves. The Poisson noise appears when the numbers of photons are captured with the sensors with uncertainty. But those sensors are not enough to detect statistical functions. The formula for Poisson distribution is given below.

$$SNR = N/\sqrt{N} = \sqrt{N}. \quad (4)$$

Where *N* is large the signal to noise ratio is very large other noise is greater or slower than $\sqrt{N}$.

III. TWO-STAGE MEDIAN FILTERS

Two stage median filters has two-step process, initial stage is detection stage in this step noise is detected with the help of threshold processing. This step distinguishes the noise pixel from non-noise pixel which is helpful for correcting the noise pixel without making any changes in non-noisy pixel. In second stage, filtering is applied only to the corrupted pixel of image to get restored image.

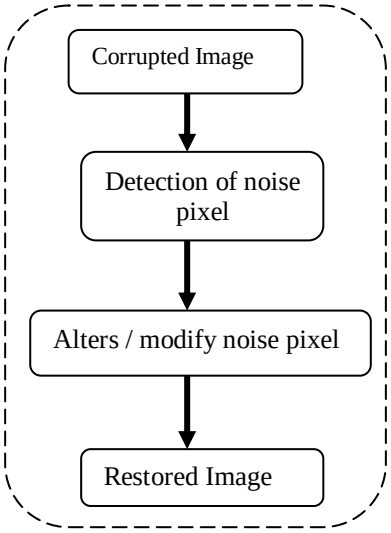

Fig :1 Flow Representation of Two-stage Median filter

The advantage of the two stage filter that applies the filtering to only the corrupted pixels and noise free pixel remains unchanged. Zhu e.t. al proposed a median based algorithm using histogram for removal of noise pixel. Here they have handled the impulse noise filter [5]. In [6] Alavandan e.t.al presented adaptive switching median filter for eliminating impulse noise by detecting the noise regions alone. Murali et.al., proposed a Bayesian based algorithm based on wavelet analysis. Here they have used the techniques like soft and hard thresholding [7]. Vijaya Kumar et.al., explained adaptive window based efficient algorithm for cutout the Gaussian white noise in color images [8]. Nguyan presented spatially adaptive de-noising algorithm for a single window of size 3×3. Local weighted activity local maximum are the techniques used to reducing the noise corrupted images [9].

Direct filter is the single-stage filter which drains noisy pixel and sometimes it may alter the non-noisy pixels. The reason behind is this filter directly works on the whole image without considering the noise pixel. This filter mostly leads to degrading the edges in an image, blurriness and miss out the fine details. Two-stage median is based on the classical median type filter, which has two stages: i) Detection of noise pixel alone, ii) Modification of only the noise pixel. Table 1 given below described the merits and de-merits of two-stage filter based on median concept for the various noises especially impulse noise. The in-depth survey on two-stage filter is tabulated below.

Table: 1 Review report on Two-stage Median filtering techniques

S. no	Author	Two stage median filter	Noise Discussed	Detection of noise pixel	Modifying/ Altering the noise pixel	Issues
1.	Akkoul et.al. [2010].	Adaptive Switching Median Filter (ASMF) [10]	Cosmic noise is detected and processed.	Initially it estimates the weighted mean value standard deviation of the sub-image. Distance between the weighted mean value of pixel and the considered pixel is inverse it is consider as a noise free pixel.	Compute the weighted mean and the standard deviation in the current window surrounding by a consider pixel. ASWM is applied recursively and iteratively. During the iterations in each window, the threshold is decreased.	ASMF can only able detect only the cosmic noise.
2.	Lan et. al. [2014].	Adaptive Non-Local Switching Median Filter (ANSMF) [11]	Random value impulse noise is filtered.	Nonlinear filter removes the noise without blurring the image edges and details. First it tests the window size 3×3 then processing the pixel is checked that is 9 sub windows are checked. Calculate the weighted mean and weighted standard deviation, threshold is calculated. If absolute value is greater than local threshold it is consider as noise.	Find the minimum threshold and the maximum threshold value. If minimum and maximum threshold lies in between the filter is applied otherwise it moved to next window and iteratively process until the noise removed.	If the window size is increased as well as the number of pixel is also increased but the efficiency in computing the noise is reduced due to higher accuracy result from pixels.
3.	Ghanekar et. al.[2010].	Contrast Enhancement Median Filter (CEMF) [12]	It based on random value impulse noise.	It transforms the pixel value evenly and elaborate the space between noisy and noise free pixels. Each central pixel is cutout from all pixels in window from to find normalized absolute variance to estimate the noisy pixel.	Filtering is based on the noise percentage. Number of iterations is take place in order to filter the noise. It computes the absolute difference and sorted in ascending or increasing order. Roughness is computed based on ten smallest to make noise less sensitive. If center pixel is noisy and greater than noise free pixels number of iterations takes place. Iterations are performed after detecting the noise and iterations are based on the noise level.	It can work well only for random valued impulsive noise compared to fixed valued impulse noise.
4.	Pok. et. al. [2003].	Conditional Signal Adaptive Median Filter (CSAMF) [13]	Impulse noise is applied for filtering.	The detection scheme is iteratively applied to the input image and finds the optimum threshold values. The decision measures are made, if the threshold values are not in a center pixel and it is isolated. Other than this is considered as a signal.	The median value is replaced in the separated pixels. It then find the higher and cohesion level for each pixel. Estimate the interaction between the all the pixels and neighborhood to isolate the noise	The false detection is minimized in this conditional signal filter.
5	Dong.et. al. [2007].	Directional Weighted Median Filter (DWMF) [14]	Random value impulse noise is removed.	Variance between the current pixel and its neighbor's pixel in four directions is calculated. It doesn't replace the noisy pixel. It replaces random value impulse noise.	Noise free pixel is locally smooth varying areas separated with four directions. Then calculate the standard deviation of gray level values to find the minimizer of function. Assign weight to each closest direction and restore noisy pixels. It is performed iteratively with decreasing threshold.	It only provides best results for PSNR Ratio.

6.	Luo [2005].	Iterative Median Filter [15].	Impulse noise is detected and removed.	The impulse noise is detected from corrupted image by combining the iterative median filtering. It can detect the impulse noise with high accuracy.	The filter is applied iteratively to improve the quality of restored images it is efficient and low in complexity. It does not require previous training set.	More iteration takes place some while affect such good pixels also.
7.	Crnojevic.et.al [2004].	Pixel wise MAD Median Filter [16].	All types of impulse noise is discussed and processed.	Without optimization it detects the noise effectively. It needs only the simple median. The binary noise map estimates the noisy pixels.	Pixel wise median MAD (Median of Absolute Deviation) apart from the noisy pixels the image details exists. Single median value is subtracted from pixels and the considered median pixel value that modifies the pixel wise MAD. Noise is eliminated by median filter.	Compared to the fuzzy filter it does not get high PSNR value.
8.	Alajlan. et. Al [2004].	Peak and Valley Median Filters (PVMF) [17].	Impulsive noise is detected and filtered.	The noisy pixels are detected based on the minimal mean squared error between the noise and noise free pixels. The detected noisy pixels gray level value is estimated using recursive minimum and maximum method.	The replacement grey value is taken from the neighbors gray value. The filter is applied to all images to avoid modification in all pixels.	The output of the filter is largely influenced by the noisy pixels.
9.	Wang. et. al [1999].	Progressive Switching Median Filter (PSMF) [18].	Impulse noise is removed.	Impulse noise detector is used by the prior detail in natural images. Noise free image are smoothly varied and separated by edges. Continuity of gray scale initial images is noisy image to be detected. Initially, noise detector algorithm generates a gray scale sequence and the binary flag image sequence as same in the detector. It detects the noisy by binary flag image and median value.	The filtering algorithm is applied step by step. Impulse noise is detected progressively. Difference between the impulse detection and a noise filtering is applied in each step of process. In the n^{th} iteration it finds the median value through which the noise is filtered.	The iterative median filter removes the most of the impulse noise, but at high rate impulse noise, it fails to detect it.
10	Chen et al [2001].	Adaptive Weighted Median Filter (AWMF) [19].	Impulse noise is identified and modified.	It adopted the switching scheme for impulse detection mechanism. The aim is to use the center-weighted median filters which are varies in center weights that it operates.	Threshold is applied for corrupted pixels. The algorithms are performed recursively, that obtain current pixel is dependent on the new values instead of the old ones, of previously processed pixels.	In such cases it also causes blurring of image details.
11	Xu. et. al [2004].	Two pass Median Filter [20]	Impulse noise is removed by this filter.	First pass of median filter is to clean the image and obtain an estimated value of spatial distribution and the amplitude of the impulsive noise.	First, the algorithm uses two-pass rank order filtering to remove more noise than is normally when the noise ratio is high. Second, by applying the spatial distribution of the determined impulse noise. The algorithm corrects errors made by the first pass filtering operation.	More number of computations is need for two pass median filters. More time consuming.

IV. CONCLUSION

We comprehensively presented the various types of noises which corrupt the images and the median based two stage filters used to remove the noise in an image. The noises degrade the quality of appearance of images. In digital life images occupies an important role but due to physical interference, it degrades its visual quality. The convenience of two stage filter removes only the noisy pixel but in the other median filter removes the noise as well as noise free pixels also. Each and every existing median based two-stage filter's pros and cons were discussed briefly in our analysis report.

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