A Comparative Performance Analysis of High Density Impulse Noise Removal Using Different Type Median Filters
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ABSTRACT
This paper focused on the review of some existing nonlinear filtering techniques for reduced impulse noise in different digital images. There are many filters are exists for removal of low density impulse noise, but in case of high density impulse noise filters are not perform very well. In this paper we compare different type of median filters and compare the efficient of the filters to remove impulse noise. Both type of analysis shown in this paper visual as well as quantities result also. For compare the efficiency of filters, we will check the PSNR and MSE values of different existing filters, with the help of chart we easily analysis for exiting filter performance. In this paper shows the different type filters literature, there are Median filter, Weighted Median Filter (WMF), Adaptive Weighted Median Filter (AWMF), Centre Weighted Median Filter (CWMF), Tri-State Median Filter (TSMF), Decision based unsymmetrical trimmed mean filter (DBUTMF), Modified Non-linear filter (MNF).

Keywords:- Impulse Noise, digital image, PSNR and MSE value.

I. INTRODUCTION
Digital image processing is the science of modifying digital images using a digital computer. Digital image technique and applications usually take an image as input and produced output. These outputs are a modified image, and encoded image etc [1]. Images are used in many fields for e.g. entertainment, remote sensing, medical image etc. Image processing refers to a set of procedures which aims at modifying the appearance and nature of an image in order to either enhance its pictorial information content for human interpretation or make it suitable enough for developing applications and autonomous machine perception. Digital image as a finite set of elements, each of which has a particular location and values, called picture elements, image elements, pels and pixels. Each pixel can be a single bit to represent either black or white. In facsimile a black and white image is scanned and converted into a rectangular array of dots called “pixels”. Each pixel is assigned a value 0 (for white) or 1 (for black) according to measured intensity [1]. There are different types of images such as Binary image, gray scale image, RGB image, CMY image and Indexed image. Binary image is formed due to the fact that each pixel is just black or white for which only one bit is required per pixel. Binary image is generally created by a gray scale image. In Gray scale image the range of pixels of this image type is between black to white, a total of 256 states are generally available with an 8-bits representation. Such images are useful for diagnostic photography using X-rays, images of printed works etc and are suitable for recognition of most of natural objects [1].

II. NOISE
Noise is unwanted information or signal presents in original signal or image. This is destroying the quality of image. For data transmission technique visual information is transmitted into channel. This visual information is corrupted in communication channel with noise. Noises are occurred an image different ways such as scanner, noisy sensor, channel error, lighting, camera, storage media etc. Impulse Noises are classifying into two main
categories: Fixed valued impulse noise (salt and pepper noise) and random value impulse noise.

The salt and pepper type of noise are either salt (255) or pepper (0) and it also called the black and white spots on the images. Mathematically $P$ is represent total noise density and salt & pepper noise have a noise density of $p/2$.

\[
Y_{i,j} = \begin{cases} 
0 \text{ or } 255, & \text{with probability } P \\
X_{i,j}, & \text{with probability } 1 - P 
\end{cases} 
\]  

(1)

Where $Y_{i,j}$ represents the noisy image pixel, $p$ is the total noise density of impulse noise and $X_{i,j}$ is the uncorrupted image pixel. At times the salt noise and pepper noise may have different noise densities $p_1$ and $p_2$ and the total noise density will be $P = p_1 + p_2$.

In case of random valued impulse noise, noise will take any gray level value from 0 to 225. During this case conjointly noise is at random distributed over the complete image and probability of prevalence of any gray level value as noise will be same. Mathematically represent random valued impulse noise is following [2].

\[
Y_{i,j} = \begin{cases} 
K_{i,j}, & \text{with probability } P \\
X_{i,j}, & \text{with probability } 1 - P 
\end{cases} 
\]  

(2)

Where $K_{i,j}$ is the gray level value of the noisy pixel.

III. NOISE DETECTION

The feature of impulse noise are that its value jumps to a 0 or 255 gray level value. We know that in each 3x3 window (W) have the nine pixel values. when we detected the noise in image then target window from the pixel value is check and compared with the centre pixel value, if it is equal to 0 or 255 gray level value in window, then it is a noisy pixel and this window is send to the next stage for noise removing, otherwise the centre pixel is noise free and it is left unchanged [3].

A fundamental problem is to effectively remove noise from an image while keeping its fundamental structure constituting of edges, corners, etc., intact or retaining as much as possible the important signal features. This method is called “Image Denoising” [4].

IV. CLASSIFICATION OF FILTERING ALGORITHM

The purpose of denoising is to remove the noise while safe as much as possible original information of the image. The denoising of the image can be done in two ways:

1. Linear Filters

In the case of linear filtering, the noise reduction algorithm is applied for all pixels of the image linearly without knowing about noisy pixel and non-noisy pixel. It is applied for noisy and non-noisy pixel so, linear filter algorithm destroy the non noisy pixel that is main disadvantage of linear filter. Linear filter are used band pass, high pass and low pass filter. Linear filter are tend to blurring sharp edges, black and white dot and in the presence of signal dependent noise perform poorly. Example for linear filters is mean, median and average filter etc. [5].

2. Non-Linear Filters

Nonlinear filters are applied on pixels surrounded by noisy pixels. The noise is removed without any attempts to explicitly identify it. Non linear filter a low pass filtering on groups of pixels with the assumption that the noise occupies the higher region of frequency.
spectrum. Linear filters, such as those used in band pass, high pass, and low pass, nonlinear filters are sometimes used also for removing very short wavelength, but high amplitude features from data. Image enhancement is the operation of taking a corrupted/noisy image and estimating the clean original image. Example for Nonlinear filter are median, min-max filter, centre weighted median filter etc. [5] [6].

V. LITERATURE SURVEY AND RELATED WORK

5.1 Median filter (M.F)

In 1989 A.K. Jain [7] introduced a “Fundamentals of Digital Image Processing”. The proposed method median filter is used to remove salt and pepper noise in this paper. It is very simple to implement and very effective in removing impulse noise at low density levels. The median filter, especially with a larger window size destroys the image details due to its rank ordering process. It acts like a low pass filter which blocks all high frequency components of the image like edges and noise, thus blurs the image. As the noise density increases, the filtering window size is increased to have a sufficient number of encrypted pixels in the neighborhood. Depending upon the sliding window mask, there may be many variations of median filters. In this paper, Median filter with sliding window (3×3), (5×5) and (7×7) are reviewed. Applications of the median filter require caution because median filtering tends to remove image details such as thin lines and corners while reducing noise.

5.2 Weighted Median Filter (WMF)

In 1995,[8][9], R. K. Yang, L. Yin, M. Gabbouj, J. Astola, and Y. Neuvo, proposed a new method “Optimal weighted median filtering under structural constraints,” weighted median filter is one of the branch of median filter . The operations involved in WMF are similar to SMF, except that WMF has weights associated with each of its filter element. these weights correspond to the number of sample duplications for the calculation of median value.[40] the successfullness 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. Some researchers, such as, proposed adaptive weighted median filters (AWMF), which is an extension to WMF. By using a fixed filter size Wh, w, the weights of the filter will be adapted accordingly based on the local noise content.

5.3 Adaptive Weighted Median Filter (AWMF)

In 2008 Deng Xiuqin [12], proposed a new method “A new kind of weighted median filtering algorithm used for image Processing”. This new algorithm first determines noisy pixel in image through noise detection, then adjusts the size of filtering window adaptively according to number of noise points in window, the pixel in the filtering window are grouped adaptively by certain rules and gives corresponding weight to each group of pixel according to similar it, and finally the noise detected are filtering treated by means of weighted median filtering algorithm

5.4 Center Weighted Median Filter (CWMF)

In sept 1991, [10] [11] S.-J. Ko and Y.-H. Lee, proposed a new method “Centre weighted median filters and their applications to image enhancement,” for removal impulse noise. The Centre weighted median (CWM) filter is an extension of the weighted median filter, which gives more weight to centre values within the window. This CWM filter allows a degree of control of the smoothing behaviour through the weights that can be set, and therefore, it is a promising image enhancement technique. These approaches involve a preliminary identification of corrupted pixels in an effort to prevent alteration of true pixel values. In CWM centre pixel of (2k+1) square window considered as test pixel. If centre pixel (k+1,k+1) less than minimum value present in rest of pixel in window and greater than maximum value present in rest of pixel in window then centre pixel is
treated as corrupted pixel. Corrupted pixel is replaced by estimated value of median. Estimated value of median is calculated by sorting all elements of window in ascending order and taking median of elements from L th element to \((N-L)\) th element. N is number of elements in an array.

5.5 Tri-State Median Filter (TSMF)

In Dec 1999, [13] Tao Chen, Kai-Kuang Ma, Li-Hui Chen proposed new method “Tristate Median Filter for Image Denoising” before applying filtering unconditionally, incorporates the Standard Median (SM) filter and Centre Weighted Median (CWM) filter into the noise detection framework to determine whether the pixel is corrupted. Noise detection is realized by an impulse detector, which takes the outputs from the SM and CWM filters and compares them with the origin or centre pixel value in order to make a tri-state decision. The switching logic is controlled by a threshold T and the output of TSM filter.

5.6 Decision based unsymmetrical trimmed mean filter (DBUTMF)

In 2013 [14] K. Aiswarya, V. Jayaraj, and D. Ebenezer proposed a new method for “An improved decision based unsymmetric trimmed median filter for removal of high density salt and pepper noise”. DBUTMF is a non linear filter that is overcome drawback of DBA. In DBUTM, detected noise in 3x3 window then corrupted pixel is replaced by a median value of the pixels. This median value is obtained by trimming impulse values from current window if they are present. It is unsymmetrical filter because only impulse values i.e. corrupted pixels are trimmed to obtain median of the window. The performance comparison shows that PSNR and IEF of DBUTM are greater than that for SMF, AMF and DBA. However, at very high noise density of the order of 80% to 90%, the number of corrupted pixels increases. So it happens that, all neighbouring pixels of central pixel are 0’s or 255’s or both of them, and then trimmed median cannot be obtained. So at high noise density this algorithm does not give better result.

5.7 Modified decision based unsymmetrical trimmed mean filter (MDBUTMF)

In 2011 [15] S. Esakkirajan, T. Veerakumar, Adabala N. Subramanyam, and C. H. Prem Chand proposed a new method for removal of high density salt and pepper noise (SNP) that is – “Removal of High Density Salt and Pepper Noise through Modified Decision Based Unsymmetrical Trimmed Median Filter”. Modified Decision Based Unsymmetrical Trimmed Median Filter (MDBUTMF) is a non linear filter that can perform better in salt and pepper noise removal even under high noise densities. MDBUTMF is used for the noise detection and removal process in this thesis. The filtering process consists of initially detecting noisy pixels. Each and every pixel of the image is checked for the presence of salt and pepper noise. The processing pixel is checked whether it is noisy or noise free. That is, if the processing pixel lies between maximum and minimum gray level values (between 0 and 255) then it is noise free pixel, it is left unchanged. If the processing pixel takes the maximum or minimum gray level (0 or 255) then it is noisy pixel which is processed by MDBUTMF. MDBUTMF are better performances of high noise density as compared to DBUTMF, SMF, WMF, AWMF, CWMF, TSMF etc.

5.8 Modified Non-linear filter (MNF)

In 2013 Dr. G. Ramachandra Reddy, [16] A. Srinivas, M. Eswar Reddy and, T.Sunilkumar was proposed a new method “Removal of high density impulse noise through modified non linear filter”. This method yields better results at very high noise density that is at 80% and 90% and gives better Peak Signal-to-Noise Ratio (PSNR). Modified Non-linear Filter algorithm processes the corrupted images by first detecting the noisy pixels in the image. To check processing pixel is noisy or noise free by verifying whether it lies between maximum and minimum grey level values then it is noise free pixel, else pixel is said to be corrupted. Only
corrupted pixels are processed to replace with noise free pixel value, uncorrupted pixels are left unchanged. The logic behind this paper that is Alpha Trimmed Mean Filtering (ATMF) is symmetrical filter. As symmetric at either end even un-corrupted pixels are trimmed. This leads to loss of image details and blurring of the image. In order to overcome this drawback, an Un-symmetric Trimmed Median and Mean Filter are found. In this method, the selected 3 x 3 window elements which contain 0’s or 255’s or both are removed. Then the median or mean value of remaining pixels is taken. This median or mean value is replaced in corrupted pixel value.

VI. COMPARISON

In this paper eight existing filters are define each filter are many merits and demerits. For comparisons of existing filter we analysis that MF is used to remove image details such as thin lines and corners while reducing noise. It is used to remove noise in image for only low noise density .WMF are similar to SMF except that WMF has weights associated with each of its filter elements. It requires high computational time when the weights are large. CWMF is an extension of WMF which gives more weight to centre value within the window. It is allows a degree of control of the smoothing behaviour thought the weights in this technique. WMF adaptive impulse detection using centre weighted median rank order filtering algorithm. The main disadvantage of the switching median filter and decision based filter is that it is based on the predefined threshold. In order to overcome the disadvantages of these mentioned filtering techniques a two stage algorithm has been proposed. In this algorithm an adaptive median filter is used in first stage to classify the values of the noisy and noise free pixels and detail preserving regularization technique is used in second stage to preserve the details and edges as much as possible [17].AWMF is also an extension of WMF it is used a fixed filter size w the weight of the filter will be adopted accordingly based on the local noise content. TSMF is used to overcome drawback of WMF, CWMF and AWMF. DBUTMF is used to overcome the DBA, but this filter is not better result at high noise 80%-90% .MDBUTMF is removes the drawbacks of DBUTMF algorithm but some disadvantage are also include in this algorithm. MNF is better performance of remove low and high density of noise as compared to other existing filters.

The PSNR and MSE values of the MNF are compared to the existing other filter by wide range of noise density for baboon image are show in table1 and table2. Fig 2 show the different algorithms for baboon image at 60% noise density.

And in fig 3 show a graph for comparisons of different median based filter for reducing noise of corrupted baboon image of PSNR values. This graph help we easily analysis which filter performance is better.

The PSNR and MSE can be expressed as:

$$PSNR = 10 \log_{10} \left( \frac{255^2}{MSE} \right) \quad \ldots \ldots \ (3)$$

$$MSE = \frac{\sum_{i=1}^{m} \sum_{j=1}^{n} (X(i,j) - Y(i,j))^2}{m \times n}$$

Where,

PSNR= Peak Signal to Noise Ratio

MSE= Mean Square Error

X= Original signal

Y= Denoised image

m x n = size of image
Fig 2: Result of different algorithms for baboon image at 60% noise density

Table 1. Comparison of MSE value of existing median filter for baboon image

<table>
<thead>
<tr>
<th>NOISE DENSITY %</th>
<th>MF</th>
<th>WMF</th>
<th>CWMF</th>
<th>TSMF</th>
<th>MDBUTMF</th>
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<td>63.0 983</td>
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<td>892.33</td>
<td>633.648</td>
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Table 2. Comparison of PSNR value of existing median filter for baboon image
VII. CONCLUSION

Conclude the impulse noise reduction is more valuable in traditional digital image processing. This review paper present existing reduction algorithms for impulse noise but they have several merits and demerits for noise reduction of corrupted image. For comparisons of several nonlinear filters MNF filter performance is better. This filter is quite effective in eliminative the impulse noise. Extensive simulation results verify its excellent impulse detection and detail preservation abilities by attaining the highest PSNR and lowest MSE values across a wide range of noise densities.

REFERENCES


[6] IJITEE, ISSN: 2278-3075, volume 2, issue 4, “image denoising techniques a review paper”, kanika gupta , s.k. gupta, march 2013


<table>
<thead>
<tr>
<th>Noise Density %</th>
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<th>WMF</th>
<th>CWMF</th>
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Fig 3: A comparison chart of different median-based filters for the reducing noise of corrupted baboon image of PSNR values.


[40] http://citeseer.ist.psu.edu/article/choi98analysis.html


