Performance Evaluation of Image Denoising in DIP

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***Abstract* - This paper work presents an unsymmetrical trimmed median filter algorithms for the removal of impulse noise has been proposed with color images rather than gray scale images by separation red- green- blue plane of color image. This proposed algorithm shows better results than the Standard Median Filter (MF), Trimmed Median Filter (TMF). The performance of the system is analyzed in terms of Mean square error (MSE), Peak signal to noise ratio (PSNR) image enhancement factor (IEF) and time required for executing the algorithms for different noise densities**

***Index Terms* - Digital Image Processing (DIP), Image Denoing, Impulse Noise, Filtering, PSNR. MSE**

I. INTRODUCTION

Digital Image Processing

Digital images are often degraded by some accidental errors this deprivation is called noise. Image noise is the random variation of brightness or color information in images created by the sensor and circuitry of a scanner or digital camera. The acquirement or transmission of digital images in real world is often interfered by different kinds of noise. The occurred noise may be Gaussian noise, Impulse noise, Rayleigh noise, Gamma noise, exponential noise, Periodic noise, speckle noise, etc. The spatial property of a noise is that it is independent of spatial co-ordinates and uncorrelated with image itself. The occurrence of noise gives an image a spotty, grainy, textured, or snowy appearance. No imaging method is free of noise, but noise is much more common in certain types of imaging procedures than in others. The presence of noise in an image hide the image features, blurs the image content, degrade the quality of an image and will have impact on object visibility by giving unwanted appearance. It is very important to eliminate noise in the images as a pre-processing step before succeeding processing, such as image segmentation, classification, feature extraction, object detection, and detection of discontinuities such as edges, lines and points in an image. The objective of any denoising or regularization procedure is the procedure has no blurring effect on the image and has no change in the location of edge pixels after regularization. In medical imaging, like X-ray imaging, the images usually have noise, which may prevent identification of significant patterns, such as fractures, the presence of tissue growth and the spread of cataract growth in cornea [1].

Noising

Image noise is an undesirable effect that appears in random variations in intensities of a gray-level image or each channel component of a multi-valued image. Non-ideal sensor elements, any adverse environmental situation such as high temperature, and transmission and compression processes can cause a corruption as a kind of noise in the input image. Noises are usually evaluated in two main categories: additive and multiplicative. The most common additive noise types, which are frequently encountered in digital images, are Gaussian noise (sensor noise) and impulsive noise (transmission noise). A low pass filter (LPF) can be used for eliminating Gaussian noise, and a classical median filter can be used for removal of impulsive noise (salt and pepper noise). However, structure and texture information of the restored image may be inevitably blurred during noise removal processes. For this reason, there have been many approaches for image denoising in order to preserve both structure and texture information of the input image in the literature [2].

One of the extensively used denoising techniques is a linear filtering technique, in which a dishonored image is convoluted with constant matrix or kernel, which fails when the noise is non-additive. Another type of denoising technique uses non-linear filtering techniques which are good and powerful methods applied over corrupted noisy gray scale or color images to offer noise free image. One of the widely used non-linear techniques is Median filters based approaches, in which actions blurs the image if kernel size is increased, while removing the noise [1].

Denoising

Multispectral / hyper spectral images are often noisy in many situations because sensors have narrower spectral sensitivity functions and thus capture less light than normal RGB imaging devices. Whereas various applications, such as classification, target detection, spectral unmixing, and change detection need detailed and accurate spectral information, the noise due to, for example, thermal electronics and dark current, unavoidably contaminates the image acquisition process, which disrupts detailed spectral information and furthermore degrades its performance in the listed applications. Thus, denoising the images is a crucial phase in the preprocessing steps of these applications. It is effective for image denoising methods to exploit inter-channel correlation as well as spatial correlation. Unlike channel-by-channel methods that tend to produce an imbalance of colors, nowadays many smoothing and denoising methods take inter-channel correlation into account to avoid color deterioration [3].

Due to high spatial redundancy of natural images, local averaging of the pixels significantly reduces the noise while preserving the original structure of the image. The existing denoising algorithms range from low fidelity, computationally inexpensive (e.g., location invariant mean filtering) to sophisticated high quality ones such as wavelet-based filtering, nonlocal means filtering, PDE-based methods and vector median filtering. Good denoising performance of these methods, however, comes at a considerable computational cost, prohibiting their application in inexpensive embedded systems, such as consumer digital camera's image processing unit, whose processing power is limited by low cost and battery power consumption [4].

Median Filter

In the past two decades, a variety of median filters have been proposed for restoration of images contaminated by impulse noise. Standard median filter (SMF) was used widely because of its simplicity and capability of preserving image edges. However, it operates equally across images and thus tends to modify both noise and noise-free pixels. To avoid the damage to noise-free pixels, adaptive median filter (AMF) and switching median filter have been existing. These filters first identify likely noise pixels and restore them by median filter while leaving uncorrupted pixels unchanged. Most of subsequent impulse noise removal filters take over this idea. However, these filters and some other recently proposed algorithms restore noise pixels by median filter or its variants and without taking into account local features such as promising presence of edges. Hence, details and edges are not recovered satisfactorily, especially when the noise level is high [5].

Enhance Median Filter

In this paper improved the median filter algorithm, and get comparatively better results than previous methods. For detection of RVIN, EMF use a three row, three column and both diagonal of small 3X3 window for calculating dual threshold. This method much better rather than other previous method [6].

II. RELATED WORK

A diversity of methods for images noise reduction has been developed so far. Most of them successfully remove noise but their edge preserving capabilities are weak. Therefore bilateral image filter was helpful to deal with this problem. Nonetheless, their performances depend on spatial and photometric parameters which are chosen by user. Conventionally, the geometric weight was calculated by means of distance of neighboring pixels and the photometric weight was calculated by way of color components of neighboring pixels. The range of weights was between zero and one. Geometric weights were estimated by fuzzy metrics and photometric weights are expected by using fuzzy rule based system which does not require any predefined constraint. Experimental results of conventional, fuzzy bilateral filter and this approach have been included [7].

Another method uses adaptive median filters with structural information were used to find the impulsive noise pixels. The total variation minimization algorithm was used to remove the Gaussian noise and blurring and restores the image. Their method restores the image very effectively with preserving the structural information and fine details. All three degradation problems are deal with, and by using Conditional Signal Adaptive Median Filter they received more competitive result in comparison with other methods. This is an efficient restoration method for blurred color image degraded with Gaussian and impulsive noise, based on total variance (TV) minimization [8].

Color images that are dishonored with impulse noise are generally filtered by applying a grayscale algorithm on each color component independently or using a vector-based approach where each pixel is considered as a single vector. The first approach causes artifacts especially on edge and texture pixels. Vector-based methods were successfully introduced to overcome this problem [9].

III. PROPOSED METHOD

Removing or reducing impulse noise is a very active research area in image processing. Impulse noise is caused by errors in the data transmission generated in noisy sensors or communication channels, or by errors during the data capture from digital cameras. Noise is usually quantified by the percentage of pixels which are corrupted. Corrupted pixels are either set to the maximum value or have single bits flipped over. In some cases, single pixels are set alternatively to zero or to the maximum value. This is the most common form of impulse noise and is called salt and pepper noise. Nevertheless other types of impulse noise are possible as well.

If $W_G(s,t)$ is the domain filter, $\widetilde{W}_{TMSR}(s,t)$is range filter and $f(x+s,y+t)$ is the neighborhood of $f(x,y)$ in the selected $(N \times N)$ window then UBTMF output $\hat{u}(x,y)$ is given as follows:

$$\hat{u}(x,y) = \frac{\sum_{s=-N}^{N}\sum_{t=-N}^{N} W_G(s,t)\widetilde{W}_{TMSR}(s,t)f(x+s,y+t)}{\sum_{s=-N}^{N}\sum_{t=-N}^{N} W_G(s,t)\widetilde{W}_{TMSR}(s,t)} \quad \text{Eq. (3.1)}$$

Where,

$$W_G(s,t) = \exp\left(-\frac{(x-s)^2+(y-t)^2}{2\sigma_d^2}\right) \quad \text{Eq. (3.2)}$$

And

$$\widetilde{W}_{TMSR}(s,t) = \exp\left(-\frac{\alpha\sigma_d\left(TM-f(x+s,y+t)\right)^2}{n^2}\right) \quad \text{Eq. (3.3)}$$

The domain filter$W_G(s,t)$ weights in this are calculated in same manner as in conventional bilateral filter as given in Eq. (3.2). The range filter of Trimmed Mean Adaptive Bilateral filter $\widetilde{W}_{TMSR}(s,t)$ is calculated as given in Eq. (3.3), Where TM is the trimmed mean value and α is a predefined parameter whose value is empirically set to .003.

UNTMF uses trimmed mean of noisy image for the calculation of range filter weights$\widetilde{W}_{TMSR}(s,t)$ hence only noise free pixels are processed during the range filter calculation. Due to which the computational time of proposed UBTMF algorithm is less as compared to SBF method because SBF requires the processing of all noisy and noise free pixels to calculate range filter$W_{SR}(s,t)$.

IV. UNSYMMETRIC BASED TRIMMED MEDIAN FILTER (UBTMF)

In proposed algorithm, first we separate the three plane of color image. Then we apply UBTMF algorithm on every plane of color image for detection of impulse noise. Checking is performed to determine if the processing pixel of each planes noisy or noise free. It is left unchanged in case of noise free pixel for which the processing pixels of color plane lies between maximum (255) and minimum level (0). Noisy pixel is processed by UBTMF for color image. For noisy pixel, the processing pixels of the plane take maximum (255) or minimum level (0).

Algorithmic Design

1. Read color noise image.
2. Separate the three plane of color of color image i.e. red-green-blue plane.
3. Select either of the planes(R/G/B).
4. Select 2-D window of size 3×3. Assume that the pixel being processed is $P_{ij.}$
5. If the processing pixel has values either greater than 0 and less than 255 i.e. $0<P_{ij}<255$ then P_{ij} is an uncorrupted pixel and its value is left unchanged.
6. If $P_{ij}=0$ or $P_{ij}=255$ then it is a corrupted pixel and further proceeding is based on following conditions
7. Case i): If the selected window contains all the elements as 0's and 255's. Then replace with the mean of the element of window.
8. Case ii): If the selected window contains not all elements as 0's and 255's. Then eliminate 255 and 0's and find the median value of the remaining elements. Replace with the median value.
9. Repeat steps 4 to 6 until all the pixels in the entire plane are processed.
10. Go to step 3 and Select next plane.
11. Restored all three de noise plane.

V. SIMULATION RESULTS

The Original Color Image is Leena, Babon use Salt & Pepper noise and De-noised image using Median filter, Trimmed filter, UBTMF Filter comparisons among them. With image matrices like PSNR, IEF, MSE

Evaluation of Image Quality Metric

PSNR

Objective image quality assessment methods were mainly based on simple mathematical measures such as the Euclidian distance between the pixels of the original image taken as the reference and its distorted version. The Peak Signal to Noise Ratio is one of the most widely used metrics until now due to its analytical and computational simplicity. This makes the PSNR practical for the optimization of image coding, filtering and quality enhancement systems [5]. But simple quantitative measures like PSNR or mean square error do not always reflect the image distortions as perceived by the HVS: for instance, two images with a large MSE distance can be considered nearly identical by the human observer. Peak Signal to Noise Ratio is a classical index defined as the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. It is given by:

$$PSNR = 10\log_{10} 255^2 / MSE \qquad \text{Eq. (5.1)}$$

Where 255 is the maximum gray level of a 8bits/pixel monotonic image. Some correlation based measures that calculate the similarity between the reference and test images are there such as structural content, normalized cross-correlation, quality, etc. The major advantages of these metrics are its simplicity and mathematical tractability, but they are not correlating well with perceived quality measurement because the Human Vision System characteristics are not considered in their models. PSNR is more consistent in the presence of noise compared to the SNR.

MSE

It stands for the mean squared difference between the original image and distorted image. The mathematical definition for MSE is:

$$MSE = \left(1/M \times N\right)\sum_{i=1}^{M}\sum_{j=1}^{N}(a_{ij}-b_{ij})^2 \qquad \text{Eq. (5.2)}$$

In Equation (5.1), aij means the pixel value at position (i, j) in the original image and bij means the pixel value at the same position in the corresponding distorted image. The calculated PSNR usually adopts dB value for quality judgment. The larger PSNR is, the higher the image quality is which means there is only little difference between the original-image and the distorted-image. On the contrary, a small dB value of PSNR means there is great distortion between the original-image and the distorted-image.

Image Enhancement Factor

IEF is mathematically defined as:

$$IEF = \frac{\sum_i \sum_j (\eta(i,j) - Y(i,j))^2}{\sum_i \sum_j (\hat{Y}(i,j) - Y(i,j))^2}$$

Where ή is noisy image, Y is Original image and Ý is denoised image. These metrics were used to check the quality of the image. It checks which technique is giving better output. The output of SMF, TMF and Bilateral Filter is tested using these parameters.

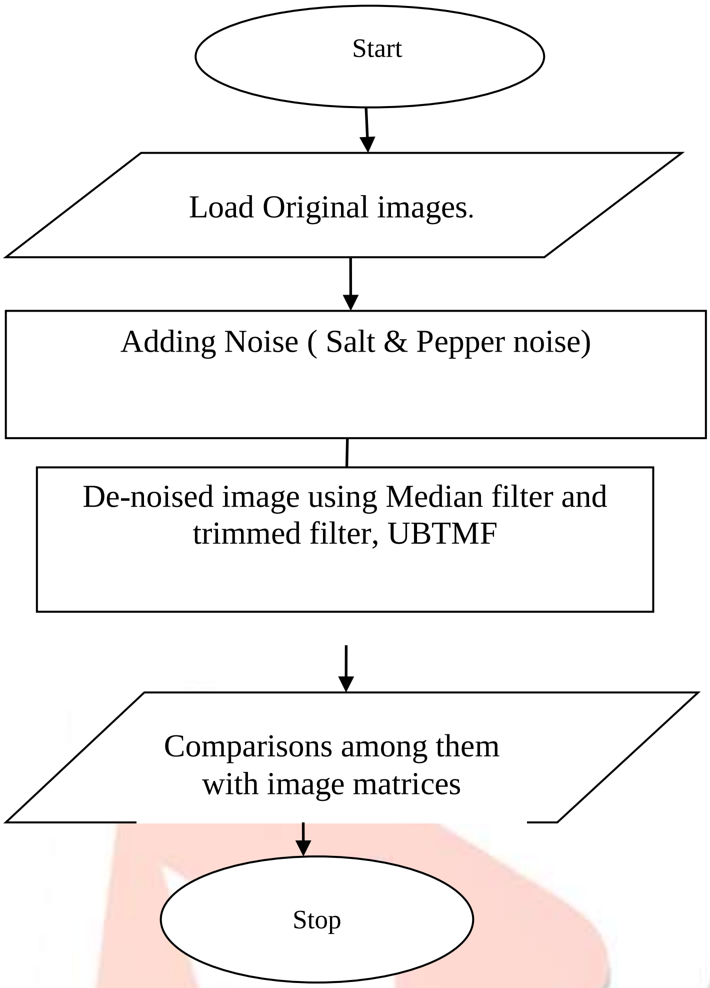


Fig. 5.1 Flowchart of the Methodology Adopted

Load the Original and Distorted Images

Firstly we load the original and distorted images to analyze the quality of distorted images by taking original images as reference. The images used are as follows:

Step1 Load the original color image of Leena

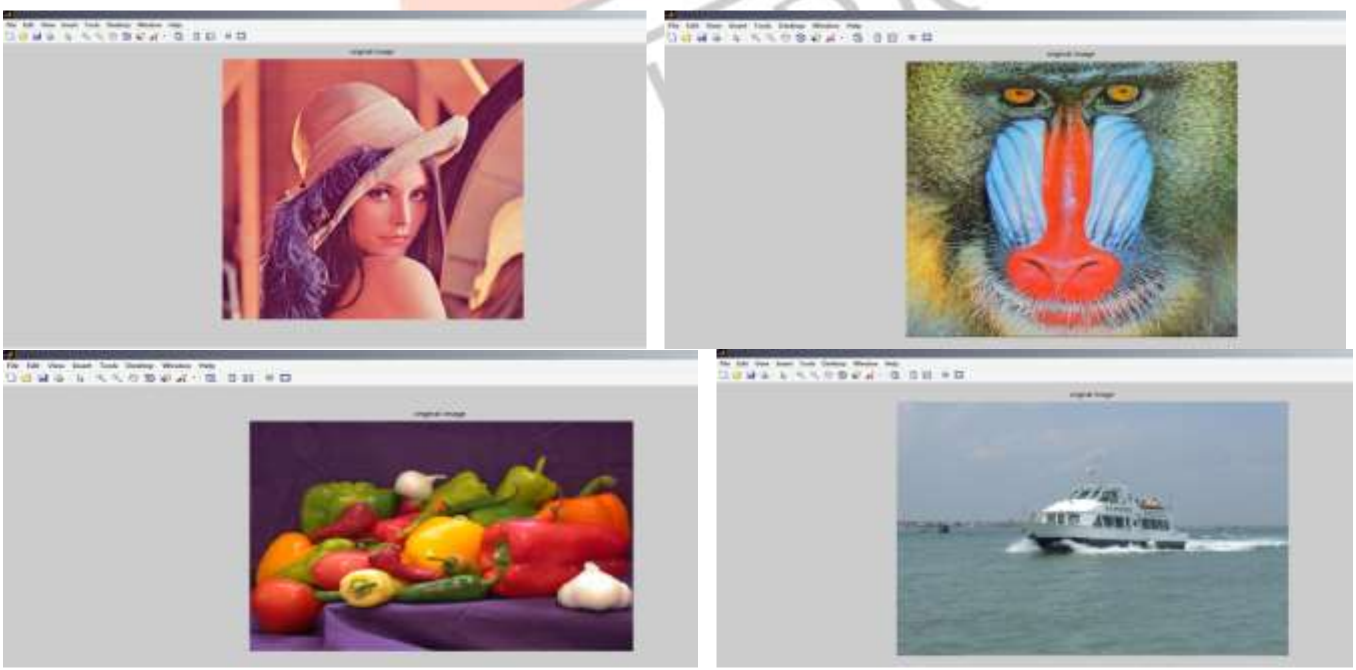


Fig. 5.2 Original Image of Leena,Babons,Peppers

Step2 Separate the three plane of color of color image i.e. red-green-blue plane.

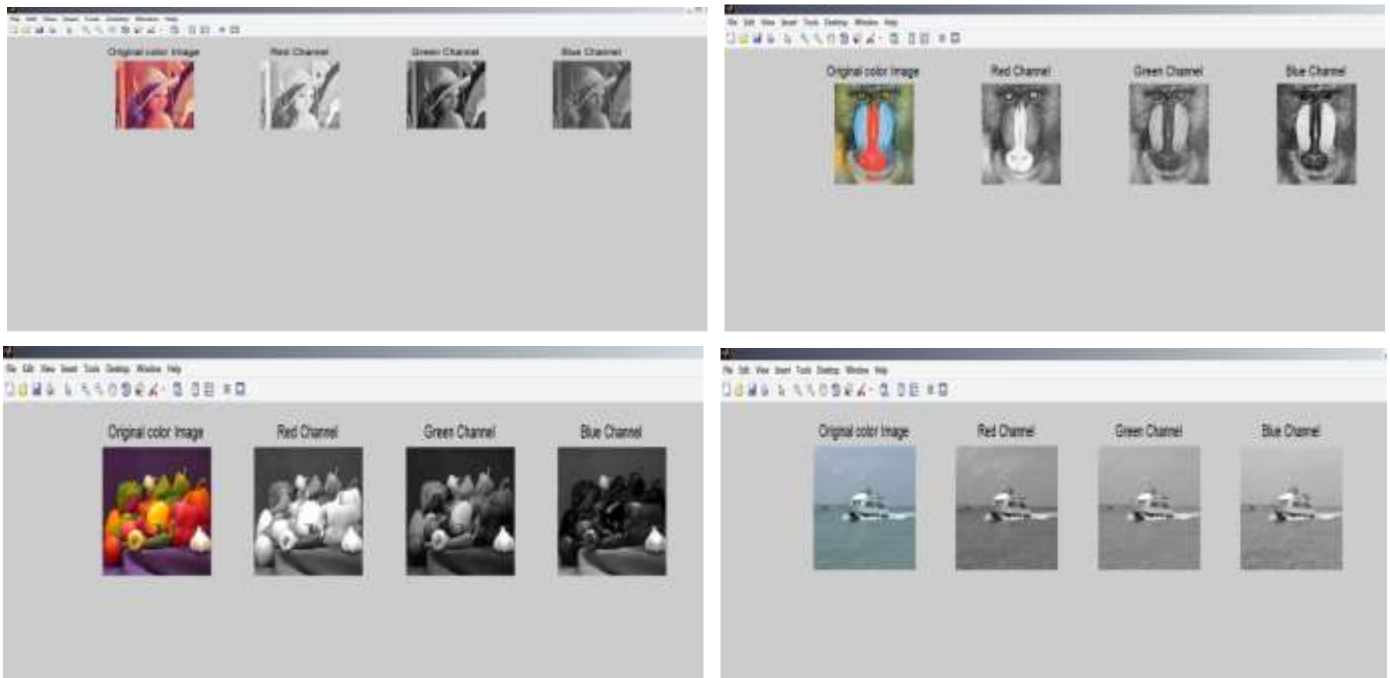
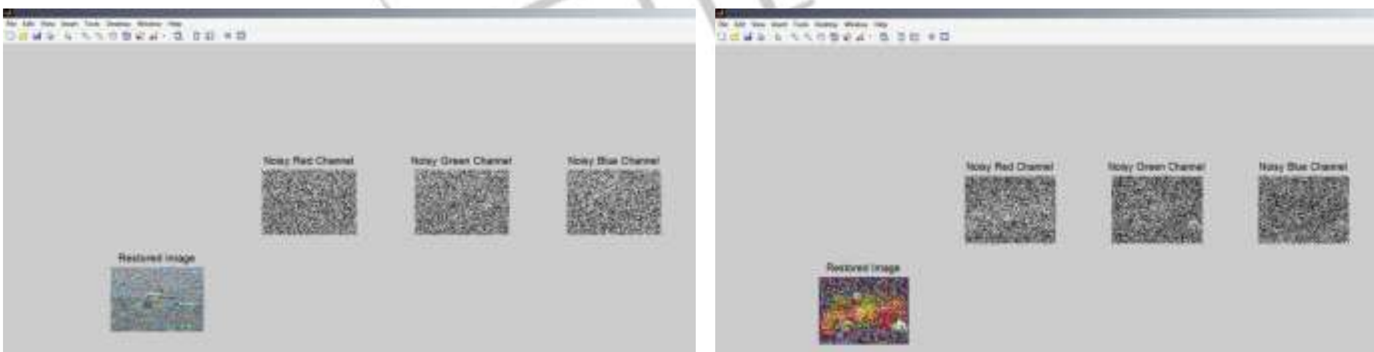


Fig. 5.3 three plane of color   Image of Leena, Babon,Peepers,Boat

Step3 Load the Distorted grayscale image of cameraman at the nose density level 0.9, we may include this density level 0.1 to 0.9. In this work we use the maximum density level of noise, through which we easily check the performance of the our filters and also calculate the image matrices like, PSNR, IEF, MSE

Fig. 5.4 Distorted Image of Lena at density level 0.9



VI. CONCLUSION

In this paper work I have proposed a new algorithm for the removal of impulse noise from the gray scale images. This new algorithm is named as Unsymmetrical Based   Trimmed Mean Bilateral Filter (UBTMF). The purposed filter is capable of removing very high density impulse noise from images and it also preserves the important details of image during denoising. However the time required executing this algorithm is bit more than the existing algorithms .The performance of the algorithm is tested against color images at low, medium and high densities, showing the effectiveness how impulse noise is removed through the color images.

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