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FUZZY BASED MULTILEVEL MEDIAN FILTER FOR MIXED NOISE

H. S. Shukla, Ravi Verma
Department of Mathematics & Statistics, D. D. U Gorakhpur University, Gorakhpur, India
Department of Computer Science, D. D. U Gorakhpur University, Gorakhpur, India

ABSTRACT

In this paper we have proposed fuzzy based multilevel median filter which is based on the fuzzy classical filter and the multilevel median filter. This filter is capable of reducing the mixed noise, which is the combination of salt & pepper noise, speckle noise and Gaussian noise with different levels of noise variances. The performance result of the proposed filter is found better than the conventional reduction filters such as median filter, Wiener filter and the asymmetrical triangular fuzzy filter with median center (ATMED), the asymmetrical triangular fuzzy filter with moving average center (ATMAV), the symmetrical triangular fuzzy filter with median center (TMED), and symmetrical triangular fuzzy filter with moving average center (TMAV). The comparison of performance is done by using MATLAB with numerical measurement of peak signal to noise ratio (PSNR).

KEYWORD: mixed noise, salt & pepper, speckle noise, fuzzy classical filter, multilevel median filter.

INTRODUCTION

Image quality improvement has been a concern throughout the field of image processing. Images are affected by various types of noises. Thus, one of the most important areas of image restoration is cleaning an image spoiled by noise. The goal of suppressing noise is to discard noisy pixels, while preserving the soundness of the edge and information of the original image. The objective of denoising is to remove the noise effectively while preserving the original image details as much as possible. So far, many approaches have been proposed to get rid of noise [1]. Traditionally, this is achieved by linear processing such as Wiener filtering. A vast literature has emerged recently on signal denoising using nonlinear techniques [2]. Much of the recent research on image denoising has been focused on methods that reduce noise in transform domain. Starting with the milestone work of Donoho, many of the later techniques performed denoising in the wavelet transform domain [3]. Although seemingly very different, they all share the same property: to keep the meaningful edges and remove less meaningful ones. The existing image denoising work can be roughly divided into Statistical Model, Nonlocal Methods, Conditional Random Fields, Anisotropic Diffusion, and Bilateral Filtering [5]. The image denoising is important, because of the evident applications it serves. Being the simplest possible inverse problem, it provides a convenient platform over which image processing ideas and techniques can be assessed [6].

The development of variational partial differential equation based on image restoration techniques offers a new thought to address the problem about image denoising and image edge preserve. It has become the research hotspot in recent years [7]. The noise present in the images may appear as additive or multiplicative components which have been modeled in a number of ways in the literature such as Gaussian noise, Speckle noise, Salt & Pepper noise, Impulse noise etc. [8]. Many conventional image processing algorithms are based on the assumption of local structural regularity, which states that there are meaningful structures in the spatial space of natural images [9].

Any algorithm used for denoising depends on the type of noise in images [10]. For example, in image acquisition step, the photoelectric sensor induces the white Gaussian noise due to the thermal motion of electron is present. On the other hand salt and pepper noise is caused by faulty memory locations, malfunctioning pixel elements in the camera sensors, or there can be timing errors in the process of digitization. To remove the salt and pepper noise, many filters are designed, a simple and effective one is the median filter. Speckle noise is the grainy salt-and-pepper pattern present in radar imagery caused by the interaction of out-of-phase waves with a target. In many applications, these two types of noises present in the image together are named as mixed noise in literature. There are many mixed noise removal methods present in the recent literature, e.g. in [11], "A Hybrid Filter For the Cancellation of Mixed Gaussian Noise and Salt and Pepper Noise"; in [12], "Mixed Noise Correction in Gray Images Using Fuzzy Filters". In [13]," Median-Rational Hybrid Filters "; in [14], "Fuzzy Filters To The Reduction Of Impulse And Gaussian Noise in Gray and Color Images"; in [15] “Mixed-Noise Reduction by Using Hybrid (Fuzzy & Kalman) Filters For Gray and Color Images”. All of above have used Gaussian and salt & pepper noise. We have used all three noises (Gaussian noise, salt & pepper noise and speckle noise) in mixed noise.

NOISE OF IMAGES

The noise embedded in an image manifest in diverse varieties. The noise may be correlated or uncorrelated: it may be signal dependent or independent, and so on. The knowledge about the imaging system and the visual perception of the image helps in generating the noise model and estimating of the statistical characteristics of noise embedded in an image is important because it helps in separating the noise from the useful image signal. For example, in case of Moire noise, which is an extremely narrow-band noise (i.e., energy is concentrated in a very narrow-bands), it is easy to detect the noise from the much wider image spectrum, since its spectrum contains few concentrated peaks in the background. We describe four important classes of noise here.

1. Additive noise: Sometimes the noises generated from sensors are thermal white Gaussian, which is essentially additive and signal independent, i.e., g (z, y) = f (z, y) + n (z, y), where g (z, y) is the result of the original image function f (z, y) corrupted by the additive Gaussian noise n (z, y).

2. Multiplicative noise: The graininess noise from photographic plates is essentially multiplicative in nature. The speckle noise from the imaging systems as in Coherent SAR, ultrasound imaging, etc. are also multiplicative in nature, which may be modeled as

g(z, y) = f (z ,y) * n (z ,y) ,

Where n (z, y) is the multiplicative noise.

3. Impulse noise: Quite often the noisy sensors generates impulse noise. Sometimes the noise generated from digital (or even analog) image transmission system is impulsive in nature, which can be modeled as

g(z,y)=(1-p)f(z,y)+p.i(z,y),

Where i (z, y) is the impulsive noise and p is a binary parameter that assumes the values of either 0 or 1. The impulse noise may be easily detected from the noisy image because of the contrast anomalies. Once the noise impulses are detected, these are replaced by the signal samples.

4. Quantization noise: The quantization noise is essentially a signal dependent noise. This noise is characterized by the size of the signal quantization interval. The quantization noise also removes the image details which are of low contrast.

IMPULSE NOISE EMBEDDED IMAGE RESTORATION

The general strategy to remove noise from an image corrupted with impulse noise is a two-step process:

Step 1: Identify whether the pixel under consideration is noisy. If noisy, then for image restoration of impulse noise embedded images go to step 2, otherwise do not change the pixel value.

Step 2: Replace the noisy pixel by another value to generate a noise-free image. To implement the above steps, we choose a window of size (2M + 1) x (2M +1) around each pixel of the image. To detect if a pixel is noise corrupted, find the difference of the pixel from the median of the pixel values in the chosen window of size (2M + 1) x (2M + 1) around the pixel under test. If the difference is higher than a threshold, the pixel is detected as noisy; else it is a considered a noise-free pixel. The algorithm as presented above, however, cannot remove the impulse noise if the image is too much corrupted with noise. This is because of following two reasons:

1. The choice of a local window alone is unable to reflect the global details of the image
2. The choice of a small local neighborhood does not even consider the local region details. To take into consideration the above two factors, several strategies of noise detection and cleaning may be employed. Wang and Zhang [16] have proposed a scheme, where they have chosen, in addition to a local neighborhood of size (2M+ 1) x (2M+ 1) around each noisy pixel, another window of the same size, located at a different place of the image in the vicinity of the pixel under test at position (i, j). This second window is selected with its center positioned at (k, l), while the first window is selected around the pixel location (I, j).The second window should be chosen at (k, l) in such a way that it is covered by a larger search window of size (2N + 1) x (2N + 1); N > M centered around the noisy pixel at (i, j) location and the pixel at (k, l) is a nonnoisy pixel. Thus, there exist many such candidate second windows and the one that best matches with the first local window as (i, j) should be selected. The best match is identified based on the Mean Square Error. (MSE).

FUZZY FILTERS

In this section, we are concerned with in two fuzzy filters and their filtering performance has been evaluated by M. Wilscy and Madhu S. Nair [26]. This filter applies a weighted membership function to an image within a window to compute the value of the center pixel, it is easy and fast to implement and can suppress low, medium, and high levels of noise with a varying degree of success.

Let x (i, j) be input of two dimension fuzzy filters. Then the output of fuzzy filter is defined as

$$y\,(i,\,j) = \frac{\sum_{(a,b)\;A} F[x(i+a,j+b)].\;x(i+a,j+b)}{\sum_{(a,b)\in A} F[x(i+a,j+b)]}$$

F [x (i, j)] is the general windows function and A is the area of the window of dimension N X N. The range of a and b are [-r<a<r and –s<b<s], where N=2r+1=2s+1. We are concerned with two types of filters, which we shall call the

symmetrical triangular fuzzy filter with median center (TMED) and the asymmetrical triangular fuzzy filter with media center (ATMED).

THE SYMMETRICAL TRIANGULAR FUZZY FILTER WITH MEDIAN CENTER (TMED)

The symmetrical triangular fuzzy filter with the median value within a window chosen as the center value is defined as

$$F_{tmed}[x(i+a,j+b)] = \begin{cases} \dfrac{\{1-|x(i+a,j+b)-x(i,j)|\}}{x_{mm}} & for\,|x(i+a,j+b)-x_{med}(i,j)| \le x(i,j) \\ 1 \quad for\ x_{mm}=0 \end{cases}$$

Where

$$x_{mm}(i,j) = \max[x_{max}(i,j) - x_{med}(i,j), x_{med}(i,j) - x_{min}(i,j)]$$

Here $x_{max}(i,j)$, $x_{min}(i,j) and\ x_{med}(i,j)\ are$ respectively the maximum value, the minimum value, and the median value of all the input values x (i+a, j+b) for (a, b) ϵ A within the window A at discrete indexes (i, j).

The Asymmetrical Triangular Fuzzy Filter with Median Center (ATMED)

The asymmetrical triangle fuzzy filter with the median value within a window chosen as the center value defined as:

$$F_{atmed}[x(i+a,j+b)] = \begin{cases} \dfrac{1-x_{med}(i,j)-x(i+a,j+b)}{x_{med}(i,j)-x_{min}(i,j)} & for\ x_{min}(i,j) \le x(i+a,j+b) \le x_{med}(i,j) \\ \dfrac{1-x(i+a,j+b)-x_{med}(i,j)}{x_{max}(i,j)-x_{med}(i,j)} & for\ x_{med}(i,j) \le x(i-a,j-b) \le x_{max}(i,j) \\ 1 & for\ x_{med}(i,j)-x_{min}(i,j)=0 \quad or\ x_{max}(i,j)-x_{med}(i,j)=0 \end{cases}$$

The triangle windows function in the above equation is asymmetrical. The degree of asymmetry depends on the difference between $x_{med}(i,j) - x_{mim}(i,j)$ and $x_{max}(i,j) - x_{med}(i,j). Here\ x_{max}(i,j)$, $x_{min}(i,j)$ and $x_{med}(i,j)$ are respectively the maximum value, the minimum value, and the median value of all the input values x(i + a, j + b) for (r, s)ϵA within the window A at discrete indexes (i, j).

PROPOSED SYSTEM

In the present work fuzzy based multilevel median filter is proposed to denoise mixed noise in gray images. Each of the two types of fuzzy classical filter- the symmetrical triangular fuzzy filter with median center (TMED), the asymmetrical triangular fuzzy filter with median center (ATMED), operating with multilevel median filter After picture that contaminated with mixed noise(speakle,Gaussian & salt-pepper)noise received, we take window of size 3*3 sliding over all the noisy image and first applying median filter, then we calculate the value of fuzzy filter (ATMED or TMED). The first median filter and the second the fuzzy filter which be consider two input to median filter filter in parallel at the same time to the predicate and observed state respectively and the final output from kalman filter will be back in recursive model for enhance the noisy image window and this explain the adaptive factor for median filter. The operation for the proposed filter can be clarified by the block diagram .

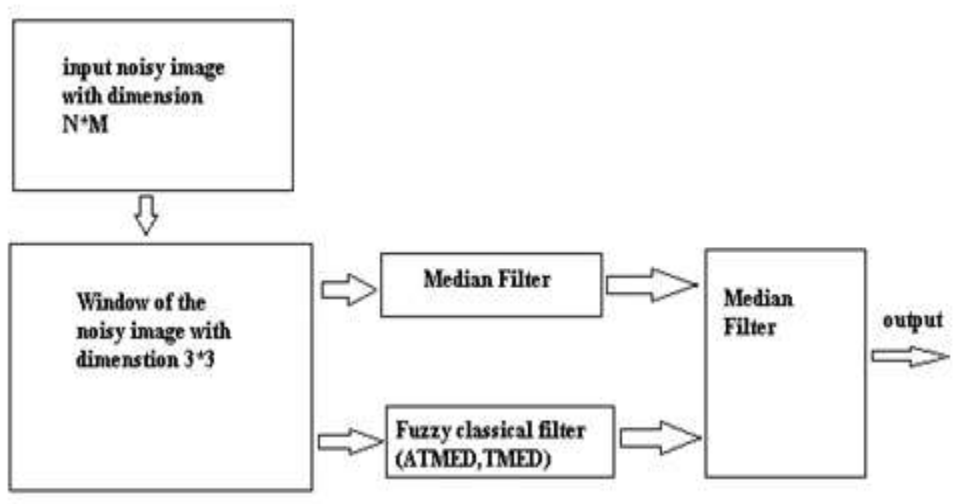

Figure 1: Block diagram of fuzzy base multilevel median filter

RESULT AND DISCUSSION

The performance of proposed filter has been evaluated and compared with conventional filters dealing with additive noise, salt-pepper, using MATLAB. In this section some examples of images contaminated by mixed noise (Gaussian noise, speckle noise and salt & pepper noise) have been taken. As a measure of objective dissimilarity between a filtered image and the original one, we use the mean square error (MSE) and the Peak Signal to Noise Ratio (PSNR) in decibels.

Mean Square Error (MSE), is computed by averaging the squared intensity of the difference in original (input) image and the resulting (output) image pixels where X (i, j) -Y (I, j) is the error difference between the original and the distorted images.

$$MSE = \frac{1}{HW}\sum_{i=1}^{H}\sum_{j=1}^{W}[X(i,j)-Y(i,j)]^2 \quad (3)$$

Peak Signal-to-Noise Ratio (PSNR), Signal–to-noise ratio (SNR) is a mathematical measure of image quality based on the pixel difference between two images. The SNR measure is an estimate of the quality of the reconstructed image compared with an original image. PSNR is defined as

$$PSNR = 10\log_{10}\frac{255^2}{MSE}(dB) \quad (4)$$

Here 255 corresponds to the 8-bit image. The PSNR is basically the SNR when all pixel values are equal to the maximum possible value.

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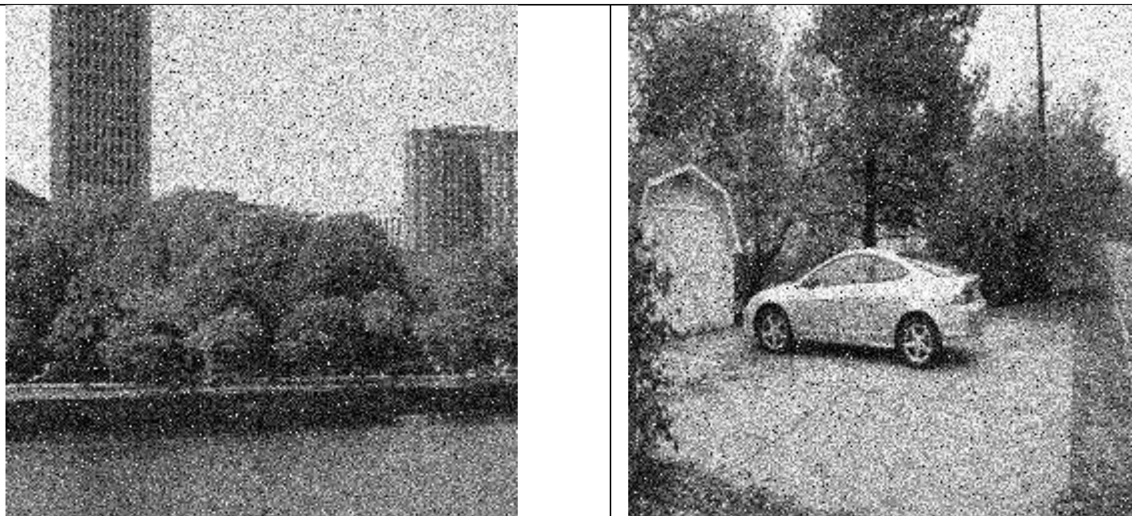
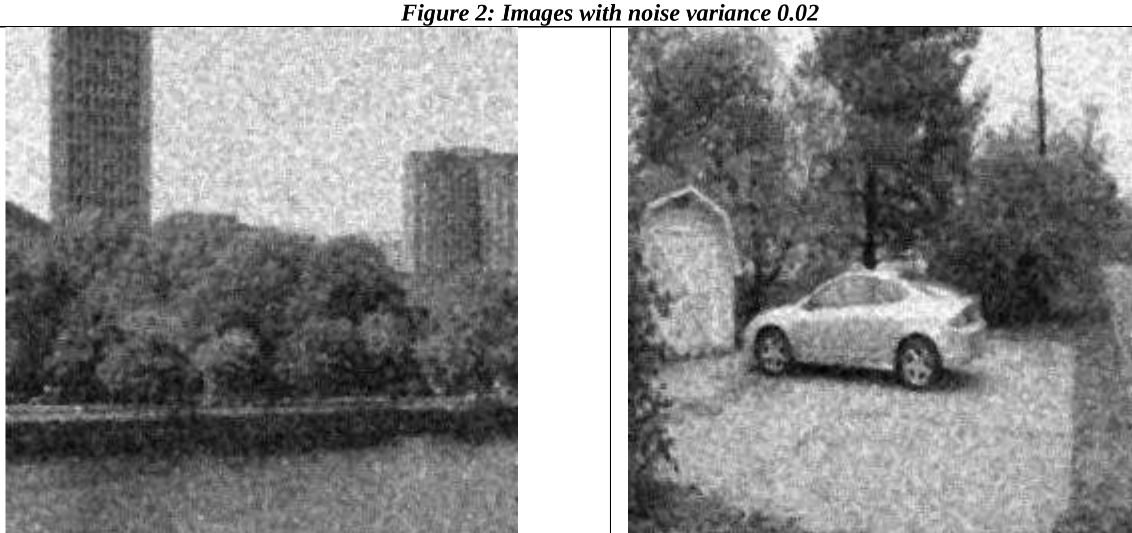


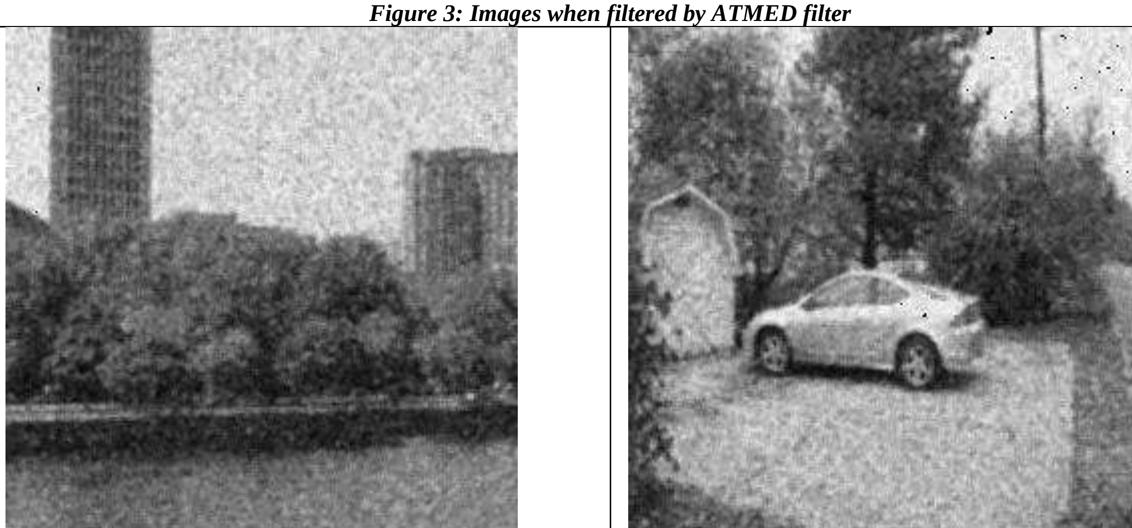
(a) (b)

Figure 2: Images with noise variance 0.02



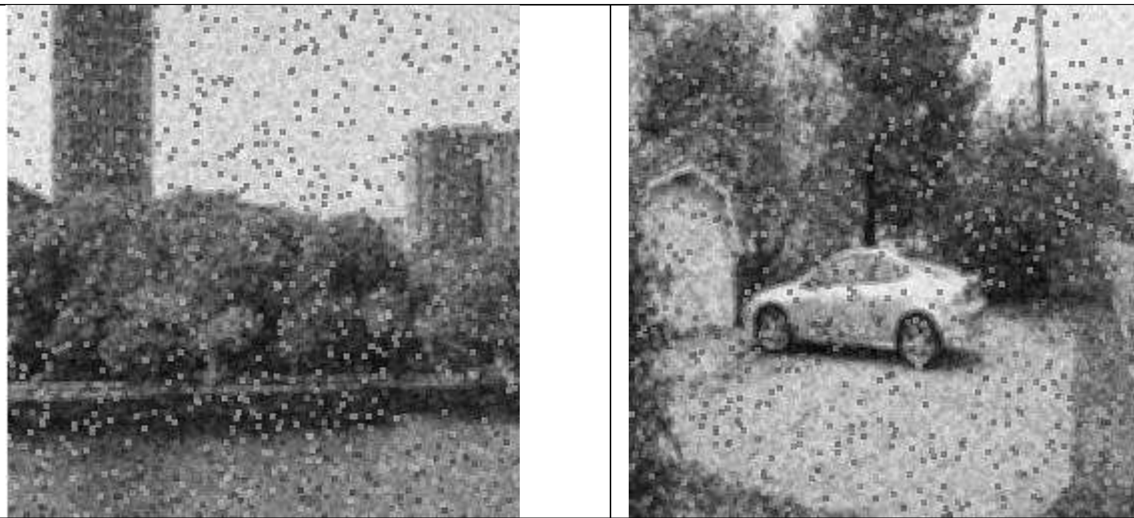
(a) (b)

Figure 3: Images when filtered by ATMED filter



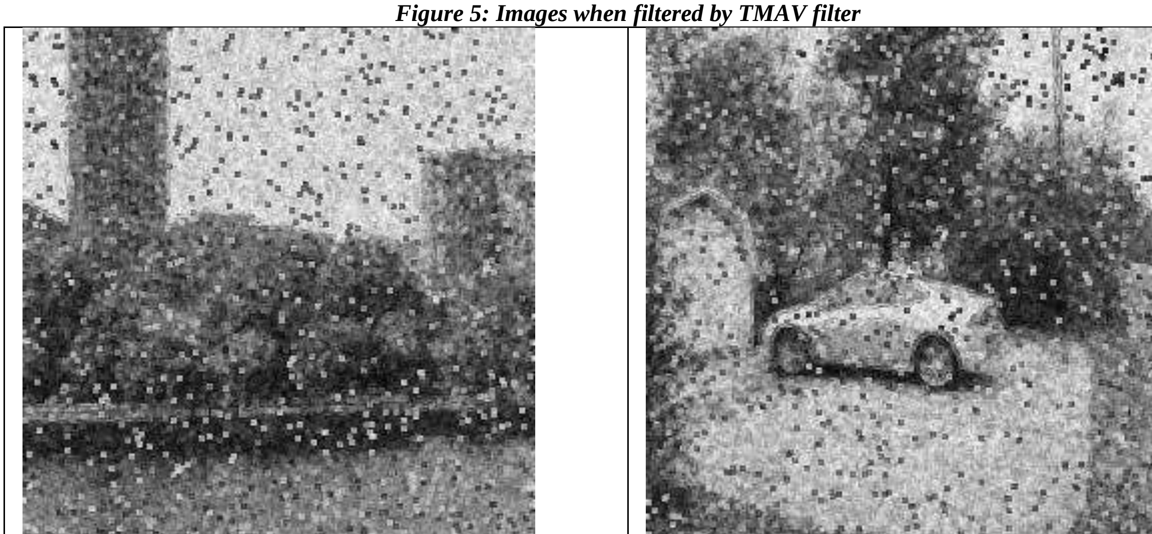
(a) (b)

Figure 4: Images when filtered by ATMAV filter



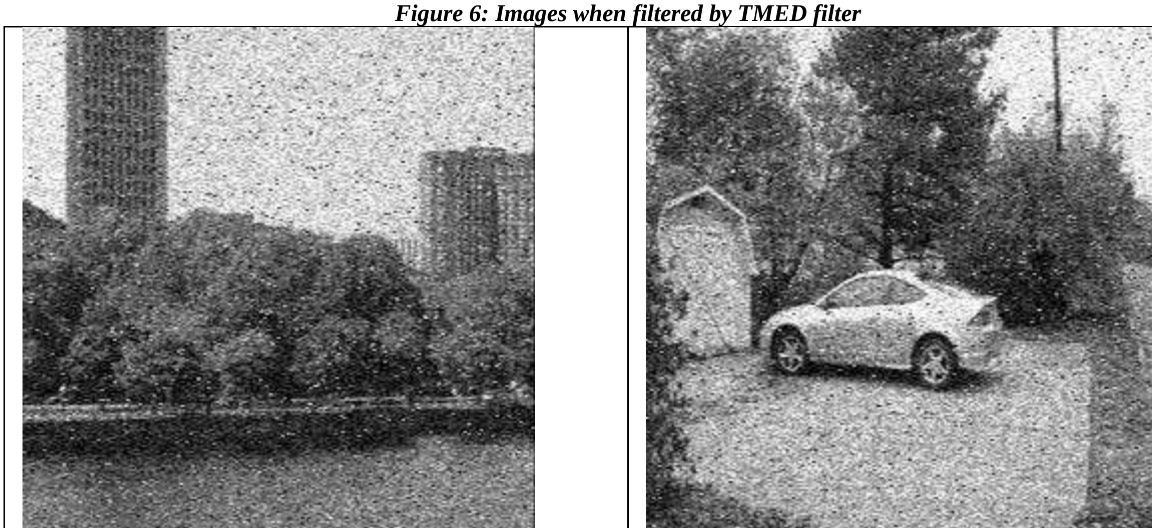
(a) (b)

Figure 5: Images when filtered by TMAV filter



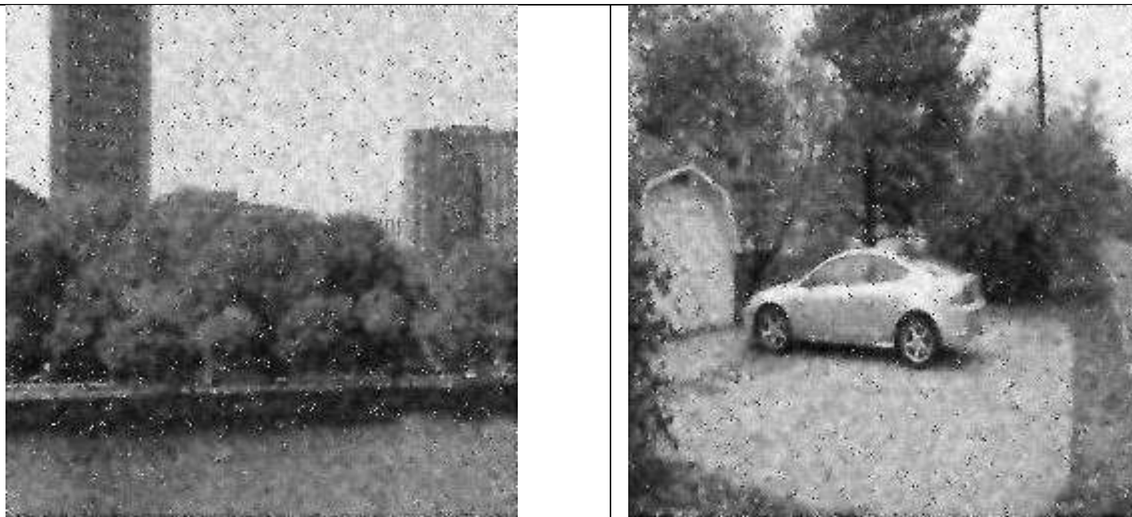
(a) (b)

Figure 6: Images when filtered by TMED filter



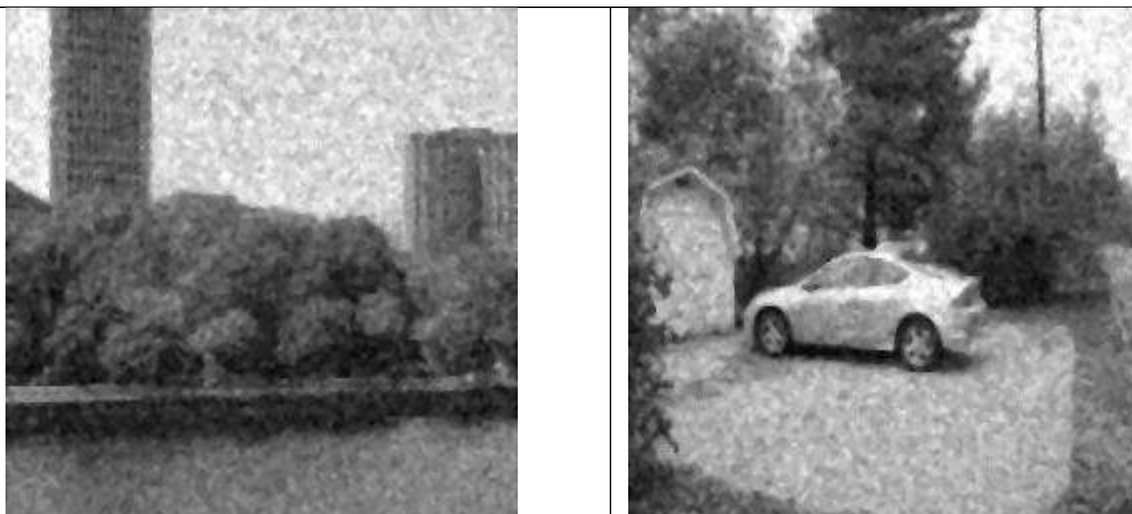
(a) (b)

Figure 7: Images when filtered by median filter



(a) (b)

Figure 8: Images when filtered by Wiener filter



(a) (b)

Figure 9:Images when filtered by proposed filter

Following table shows performance evaluation of proposed filter in terms of PSNR.

Table 1: Performance evaluation of proposed filter with noise variance 0.02

Filter Name	**PSNR (in dB)**	
	Image (a)	**Image (b)**
Median Filter	67.63	67.04
Wiener Filter	69.86	70.75
ATMED Filter	70.53	72.17
ATMAV Filter	69.15	70.17
TMAV Filter	67.06	67.91
TMED Filter	64.67	65.29
Proposed Filter	71.96	73.81

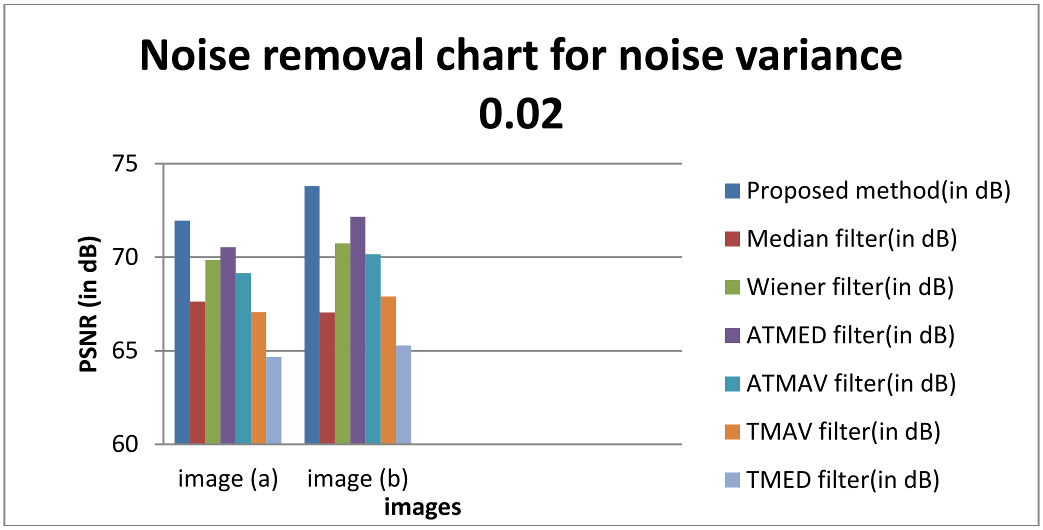


Fig 9: Noise removal performance of our proposed filter (noise variance 0.02) and existing filters

CONCLUSION

A new filter for restoring images corrupted with mixed noise is proposed in this paper. The proposed filter is the fuzzy classical filter with multilevel median filter. Computer simulation with two different images explains that proposed filter is more efficient than conventional filters mentioned in this paper viz. median filter, Wiener filter, ATMED filter, ATMAV filter, TMAV filter and TMED filter. All the filtering techniques have been simulated in MATLAB 7.1 with Core 2 Duo Processor.

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