

## Extended Median Filter For Salt and Pepper Noise In Image

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### Abstract

Image have a significant importance in many fields in human life such as, in medicine, photography, biology, astronomy, industry and defence. Thus, it attracts the attention of large number of researchers, among them those interested in preserving the image features from any factors that may reduce the image quality. One of these factors is the noise which affects the visual aspect of the image and makes others image processing more difficult. Thus far, solving this noise problem remains a challenge point for the researchers in this field, a huge number of image denoising techniques have been introduced in order to remove the noise with taking care of the image featur, in other words, get the best similarity to the original image from the noisy one. However, beside the enormous amount of researches and studies which adopt several mathematical concepts (statistics, probabilities, modeling, PDEs, wavelet, fuzzy logic, etc.), the findings proved to be inconclusive yet. From this point, the current study aims to introduce a new denoising method for removing salt & pepper noise from the digital image through developed Median filter, so as to overcome this problem of noise and achieve a good image restoration.

**Index Terms**— Digital image; noise; salt & pepper noise; image processing; image denoising; Median filter; image restoration; denoising methods.

### INTRODUCTION

Among the different tools of communication between people, there is the image which carries a large amount of information. However unfortunately sometimes this last will be corrupted by parasitic information, which is called: Noise, an alteration of image, which may be caused by the image acquisition process, transmission (Yan, 2013; Zhu, 2014), or storage (X. Li, 2012). More specifically, the main concern of the researchers in this subject is to succeed in solving this problem by removing noise from the noisy image and achieve the best restoration of the original one. In brief, this section provides the necessary information restricted in the primary phase of image processing (image pre-processing), which called Image denoising.

#### A. Salt & pepper noise

In case of grayscale image, impulse noise may be represented by random values (RV) of pixels (value between 0 to 255) in the corrupted image, or by fixed values (FV) which also called "salt & pepper" noise produced by random partial distribution of white pixels (value 255) and black pixels (value 0) into the image (Baghaie, 2016; Habib, Hussain, & Choi, 2015; Yan, 2013), as shown in Figure 1, unlike gaussian noise with entire distribution (all image pixels) (Liu, Chen, Zhou, & You, 2015). The image  $O(i, j)$  corrupted by RV and FV noise is described by  $N_{RV}(i, j)$  (2) and  $N_{FV}(i, j)$  (1), respectively (Habib et al., 2015).

$$N_{RV}(i, j) = \begin{cases} n(i, j) \in [0, 255], & \text{with probability } p \\ O(i, j), & \text{with probability } 1 - p \end{cases} \quad (1)$$

$$N_{FV}(i, j) = \begin{cases} 0 \text{ or } 255, & \text{with probability } p \\ O(i, j), & \text{with probability } 1 - p \end{cases} \quad (2)$$

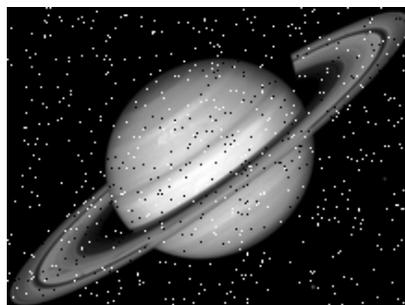


Figure 1: Image with salt & pepper noise

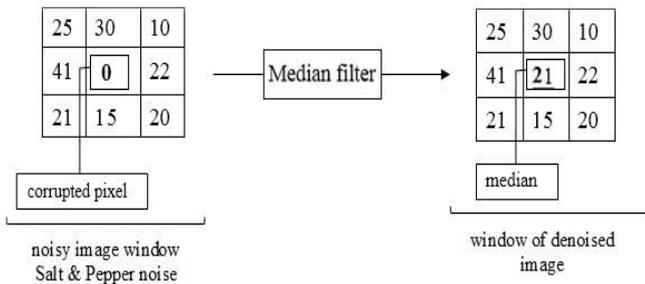
#### B. Spatial domain filtering

Spatial domain filtering is considered as a traditional way to remove corrupted pixels (noise) from the image (Motwani, Gadiya, Motwani, & Harris, 2004), it is a set of mathematical operations that deal directly with the pixel in the image plane, because in this domain, the signal is represented by pixels, or in other words, image elements are pixels. Several denoising methods belong to this category for example, The Gaussian

filter (Lindenbaum, Fischer, & Bruckstein, 1994), The total variation (TV) (Rudin, Osher, & Fatemi, 1992), Yaroslavsky's filter (YNF) in (Yaroslavsky, 1986), bilateral filter (BF) (Tomasi & Manduchi, 1998), and Non local means (NLM) (Antoni Buades, Bartomeu Coll, & J-M Morel, 2005; Antoni Buades, Bartomeu Coll, & Jean-Michel Morel, 2005).

**C. Median-Related Filters**

Median filter (Astola & Kuosmanen, 1997; Gonzalez & Woods, 2008; X. Li, 2012) belongs to the family of non-linear filters, it is a simple filter (Liu et al., 2015), which is based on the rank ordering of pixel values from the processed area. The corrupted pixel is replaced by one (median) taken from all pixels in the analysed window centered on that pixel, instead of the mean value which is derived from a calculated value, and this is an advantage for the median filter (Kumar, Kumar, Gupta, & Nagawat, 2010). Figure 3. presents the concept of median filtering.



**Figure 2:** Concept of Median Filtering Neighborhood values: 0,10,15,20,22,25,30,41 ; Median value: 21.

The median filter is robust to different types of noise, it yields great results with impulse noise (Rani, Singh, & Malik, 2012), and outperforms the linear filter in preserving image edges (Loupas, McDicken, & Allan, 1989; Weiss, 2006). Nevertheless, it shows limitation in case of high density of noise by removing some important informations from the image (Liu et al., 2015).

In order to exceed this limitation, several extension techniques (derived from MF) have been proposed such as: Weighted median filter (WMF) (Brownrigg, 1984) which attach higher weights (coefficients) to the pixels that are closer to the central pixel, knowing that in the case of MF the weights are equal. Whereas, in the case that this additional weight goes only to the central pixel of treated window, the filter will become called the center weighted median filters (CWMF)(Ko & Lee, 1991), directional weighted median filter (DWMF) (Dong & Xu, 2007; Z. Li, Liu, Xu, & Cheng, 2014; Lu & Chou, 2012), switching Median Filter (Ng & Ma, 2006), recursive weighted median filter (RWMF)(Arce & Paredes, 2000) , and others in (Kartik, Anay, & Amitabha, 2016).

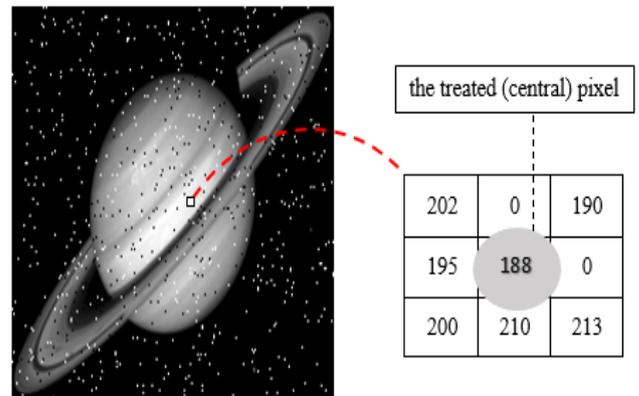
**METHODOLOGY**

Usually in the case of the basic median filter, each pixel's value in the noisy image is replaced by the median of its neighborhood. However, in this paper the proposed denoising method compares first the value of corrupted pixel by the median to diside if it will be replaced or not, which gives more efficiency to the standard median filter and better result to the denoising operation. The principle of this comparison is detailed below.

The proposed denoising technique is occurring in the noisy image through the following steps:

**Step 1:**

In the first step we calculate the median "M" of the treated (central) pixel "TP" with its neighbors in the noisy image. Where this treated pixel may be noise or not. Figure 3 is presented as an example of this operation.



**Figure 3:** The Treated (Central) Pixel with Its Neighborhood.

In this example the treated pixel takes the value 188 (TP = 188) as illustrated in Figure 3. Where the neighbors values are: 202, 0, 190, 195, 0, 200, 210, 213. In this case the median value is 195 (M = 195).

**Step 2:**

In the second step, the calculated median is taking as a reference and will be compared with the treated pixel to decide if this pixel should be changed by this median (which is 195 in this example) or keep the initial value 188. This comparison is made according to the following formula :

$$abs(TP - M) \leq \delta \tag{3}$$

Whre  $\delta$  is a color-related parameter (positive integer). We choose  $\delta$  when the addition of  $\delta$  to the pixel's value, does not change the appearance of the color in this point.

If the formula (3) is realized, that means that the difference between the colors in the two points (treated pixel and median) is indistinguishable. In this case the treated pixel is considered

as uncorrupted pixel and preserving its former value. Otherwise, this pixel is considered as a noise and should be replaced by the median. Where this operation is applied for all pixels in the noisy image. In our example if we replace  $TP$  and  $M$  by their values in (3) and if  $\delta$  take the value 20 then the formula (3) is realized according to (4). Therefore, in this case the treated pixel keep the initial value 188.

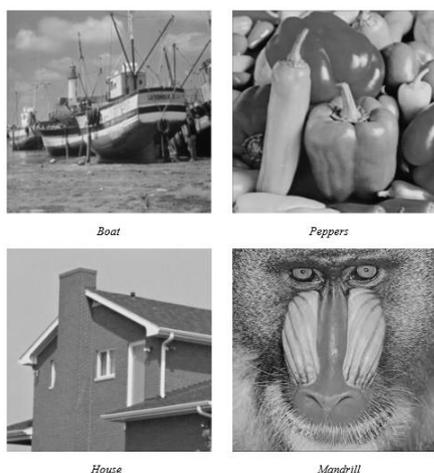
$$abs(TP - M) = abs(188 - 195) = 7 \quad (4)$$

Usually in the case of others image filtering methods which adopt the noise detection phase in its processing, the filter is first look for the corrupted pixel (detection) and then look for witch value (alternate pixel) should replace this pixel, in order to treat only the corrupted pixels and keep others with same values (objective of noise detection phase). However, in our approach we look to achieve that objective with other way, we look first for the alternate pixel (median in this case) then decide to replace the treated pixel or keep it with the original value. This manner of detection is chosen to avoid the complex calculations occur in this phase and ensure that all corrupted pixels (noise) were captured.

Through this very simple proposed denoising technique we ensure that the uncorrupted pixels in the noisy image keep the same value after the denoising operation, and others corrupted pixels are changed by the most appropriate value (most closer to the original value). In order to get the most similar version to the original image.

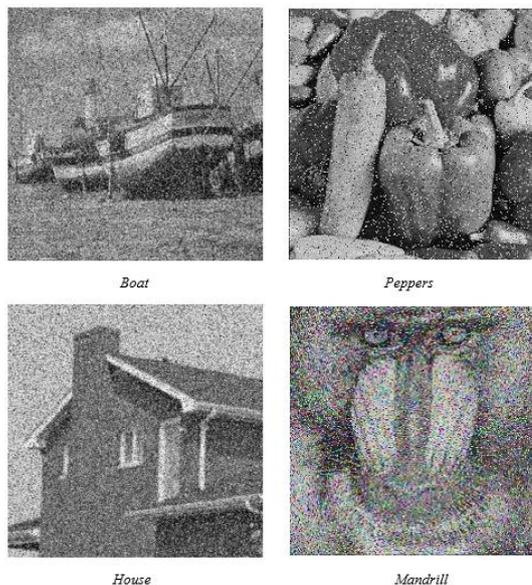
## RESULT & DISCUSSION

In order to test the performance of the proposed denoising technique, eight images sampling have been used which are presented in Figure 4 (Boats, Peppers, House, Mandrill). The result of those filtering methodes is indicated visually (pictures) in Figure 5 and quantitatively PSNR in Table 1, with the proposed technique, in several values of noise amount assigned by percentage.

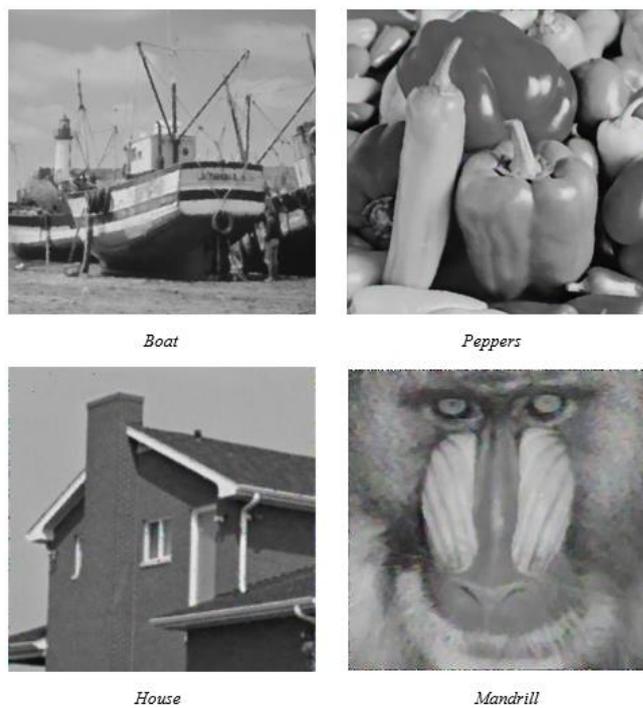


**Figure 4:** The Sampling Images Without Noise (Original Images)

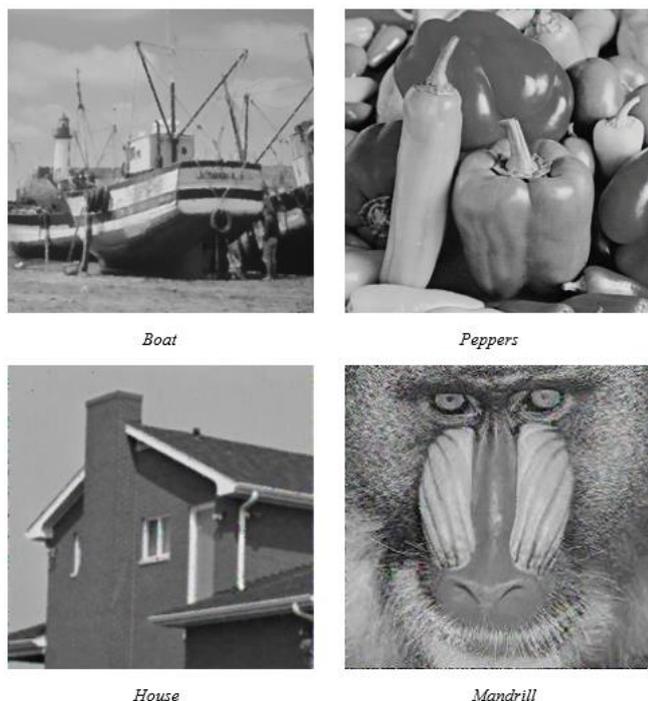
The primary implementation of this filter to remove salt and pepper noise, gives an acceptable results compared with some methods which considered as an efficient methods for removing impulse noise from image : Standard median filter (SMF), weighted median filter (WMF), directional weighted median filter (DWMF).



Images With 20% Salt & Pepper Noise



Images Filtered With SMF



Images Filtered with the Proposed Method

**Figure 5:** Comparison of restoration results of the SMF with the proposed technique for images corrupted by fixed-valued impulse noise.

**Table 1:** Comparison of restoration results in PSNR for images corrupted by fixed-valued impulse noise (salt & pepper)

Images \ Methods	SMF	WMF	DWMF	Proposed	
Boats	20%	33,18	35,55	37,11	38,05
	60%	22,40	24,74	26,34	26,85
Peppers	20%	35,25	37,12	39,11	39,89
	60%	25,45	27,20	30,34	31,00
House	20%	33,72	35,90	37,11	37,89
	60%	22,06	24,45	27,34	28,05
Mandrill	20%	31,21	34,32	36,11	37,22
	60%	22,64	25,76	26,34	26,78

The results presented in Figure 5 and the table 1, illustrate that the proposed denoising technique gives an acceptable performance comparing the existing methods whether visually or quantitatively with PSNR.

## CONCLUSION

This work is carried out to treat the problem of Salt & pepper noise in the image, which threatens its visual quality and make others image processing more difficult such as segmentation and compression. The chosen way for that is the spatial filtering by developing the standard median filter in which the process is simple and deals direct with the pixels as done in the median and mean filter. In order to derive a new values for the corrupted pixels that be subject to the same features and give a

perfect restoration of the image with preserving the fine details (originality of image). Finally, this denoising method is proved as an efficient way to restore the image comparing with current familer filters in aspect of evaluation criteria.

Besides of what this denoising method provides as an extending of the range of solutions against this problem of noise in the image, it's also holds limitations which should be exposed. One limitation is that the study is constrained by the number of sampling images which is four images (Boat, Peppers, House, Mandrill). Whenever the number of samplings images higher whenever the method proves its efficiency in restoring all image models. Another limitation is about the performance of the filter which decreases with the rise of the noise's amount in the noisy image, while this drop should be very slow to preserve the stability in the filtering performance. Furthermore, the study propose a denoising technique confined in removing one type of noise which is Salt & pepper noise. Where, a great number of image used in many fields in our life is corrupted by the two others types of noise (additive and multiplicative), for example the medical image is usually corrupted by the speckle noise.

The ideal value of the paramter  $\delta$  is considred as a point of reaserch with the aim of developing this proposed method by increasing the performance of this denoising method, then maintain the stability of this performance even with high amount of noise in the treated image.

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