

Review on Image Enhancement of the Neutron Dosimeter Bubble Detector Image

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Abstract

Filtering is a technique for enhancing an image. With the help of filtering Smoothing, sharpening and edge enhancement Image processing operations can be implemented. Under intense gamma field bubble detector is used to detect the amount of neutron dose. The number of nucleated bubbles yields the neutron dose. The methodologies proposed here is to apply various algorithms to those images of bubble detector and analyzing it, there by contributing an enhanced image to accurately calculate the number of bubbles in the detector.

Keywords: Median Filter, Pixel, PSNR, Spatial Domain, Square Window Size

1. Introduction

Removal of noises from an image is the bvery first problem in the field of image processing. Most of the digital images are assumed to have noises due to the several reasons. Noise removal from an image is the pre processing technique. Before getting data from an image removal of noises is the first step. This study describes the application of various filter technique to remove noises and uses PSNR (Gonzalez and Woods, 2001) value to compare results obtained¹. Set of pixels located relatively to a pixel defines the neighborhood of that pixel. Filtering applies certain algorithms which are used to determine the output image by considering the neighborhood pixel.

Filtering of images happen in two ways:

- Spatial Domain.
- Transform Domain.

Spatial Filtering is the conventional method to remove noise from an image. Spatial domain filters can be divided into linear spatial filter and non-linear spatial filter. And transform domain is divided into frequency domain filtering and wavelet domain filtering [Figure 1 (a)].

In this paper spatial domain filters are applied and its results, PSNR values are obtained and compared.

The spatial domain is to convolution of the given input image $f(i,j)$ with the given filter function $h(i,j)$. This can be defined as

$$g(i,j) = h(i,j) \odot f(i,j)$$

In the frequency space the mathematical operation is identical to the multiplication, but the outcome of the digital implementations vary, here the function of the filter with a finite and discrete kernel has to be rounded off.

'Shift and multiply' operation is used in discrete convolution, where alter the kernel over the image and multiply its value with the corresponding pixel values of the image.

The M X M size kernel this can manipulate the image output using this formula:

$$g(i,j) = \sum_{m=-\frac{M}{2}}^{\frac{M}{2}} \sum_{n=-\frac{M}{2}}^{\frac{M}{2}} h(m,n) f(i-m, j-n)$$

Figure 1 (b) is the original image of the bubble detector, in this image various filters applied with different square window size.

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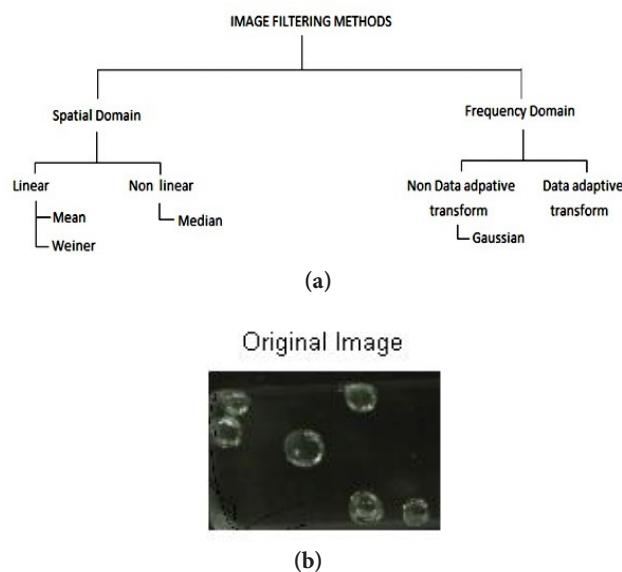


Figure 1. (a) Flowchart of Image Filtering Methods.
(b) The Original image of the bubble detector.

2. Mean Filter

For removing noises and smoothing images applying Mean filtering is a simple, innate and easy to implement over the images². Here Intensity variation can be reduced between one pixel and the next. This approach often used to reduce noise in images. In general the mean filter behave as a low-pass frequency filter. The concept behind the mean filtering is simply to replace each pixel value in an image with the mean ('average') value of its neighbours, including that pixelitself. Thisone the image has the effect of deleting pixel values which are unrepresentative of their near by and surroundings³.

Often a size 3×3 kernel is used, like in Figure 2 (a), although larger kernels (e.g. 5×5 squares) can also be used for more perfect smoothing.

Convoluting the images with various square kernel and obtaining the results.

The problems with mean filtering are follows:

- Any single unrepresentative value of the pixel value would affect the value of every other pixel of the image on applying the filter.
- They may not be able to give sharp edges in the output, when the filter neighborhood straddles an edge.

On applying various square kernel of size of 3×3 mask, 5×5 mask, 7×7 mask, 9×9 maskthe PSNR value decreases as the window size increases. The minimum possible value of PSNR obtained over here is 41.2686.

1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9

(a)

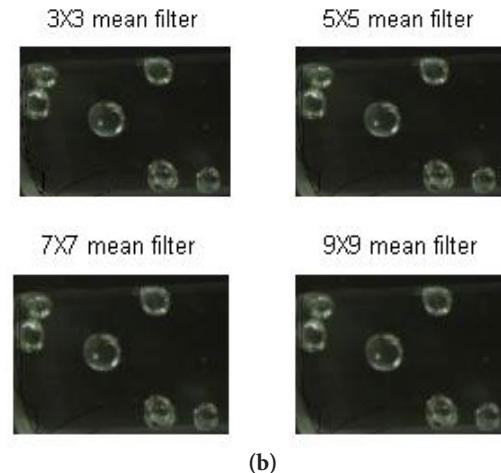


Figure 2. (a) Mean filtering 3×3 averaging kernel. (b) After applying Mean filter of various window size.

Table 1. PSNR values images after applying Mean Filters

Square Window size	PSNR
3	44.8917
5	43.4100
7	42.3321
9	41.2686

3. Median Filter

Likely to mean filter median filter helps in reducing the noise. In addition to that median filter retain and preserves the useful data of the image. Similar to mean filter, the current pixel value depend on its neighborhood pixels. This filter is replaces the pixel by the neighborhood pixels's median value.

The median value '124' is assigned in the place of the central pixel value '150' as it is not representing the surrounding pixels⁴. A 3×3 square neighborhood is taken and used. Here larger neighborhoods will produce more perfect smoothing. Median filter is used to simultaneously reducing noise and preserving edges (MathsWork.Ing).

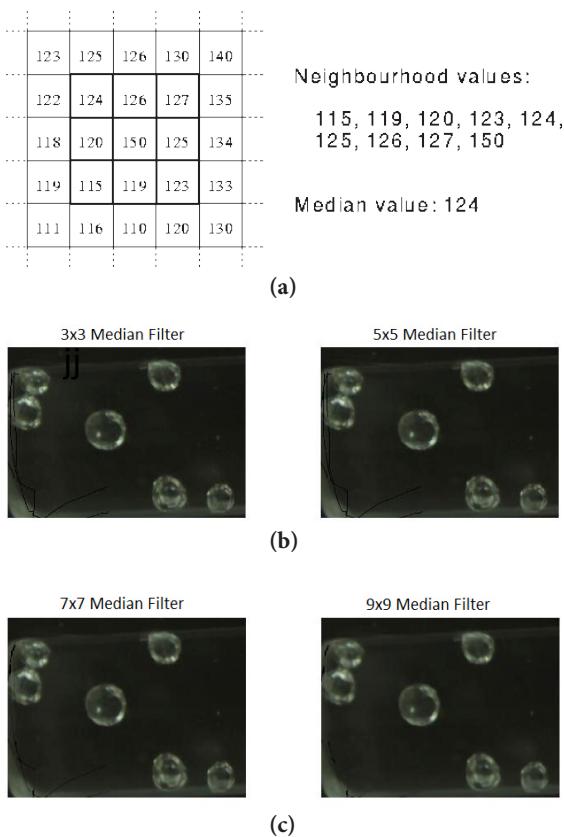


Figure 3. (a) Median value calculation of a pixel neighbourhood. (b) After applying Median filter of window size 3 and 5. (c) After applying Median filter of window size 7 and 9.

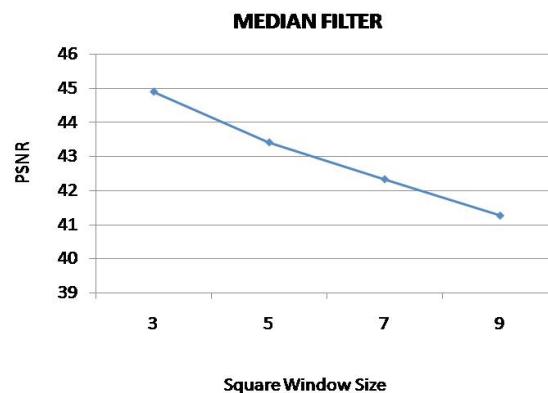
Table 2. PSNR values images after applying Median Filters

Square Window size	PSNR
3	43.4382
5	41.6531
7	40.7134
9	40.0274

At one stage larger square neighborhood will produce blurred image.

The significance of the median filter over mean filter:

- Robust mean is calculated in median where an unrepresentative value does not significantly disturb other pixel values.
- Does not create new unrealistic pixel values when the filter straddles an edge brings an sharper edges at the output⁵.



Graph 1. Plot of PSNR of images of various window size on applying median filter.

- Where median filtering really comes into its own is when the noise produces extreme 'outlier' pixel values.

It proves to be an better filter than mean but it take high computational powers. Clever algorithms can be used to improve its performance.

On comparing mean filter, median filtering of square kernel 3×3 produces non deteriorated image eliminating almost all noise.

On smoothing the noisy image using the larger median filter such as 7×7 , due to the mapping of gray level regions together the image becomes blotchy. Whereas use of 3×3 median filter three times over the image will be more effective without much loss of data.

On observing the values obtained over here on various square kernel of median filter, there is a considerable value of PSNR values on 7×7 and 9×9 .

4. Gaussian Filter

The Gaussian smoothing operator is defined as a 2-Dimensional convolution operator and is similar to mean filter in the fact that it helps in removal of detail and noise and blur the image, but this has a special kernel which is represented the shape of a Gaussian hump which is bell shaped⁴.

The 1-D Gaussian distribution which has the following form⁶:

$$G(x) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{x^2}{2\sigma^2}}$$

where σ is the distribution standard deviation. It is assumed that the distribution has a mean of zero (i.e. it is

centered on the line $x = 0$). The Figure 4 (a) illustrate the distribution.

The following is the 2-Dimensional, an isotropic (i.e. circularly symmetric) Gaussian which has the form⁶:

$$G(x, y) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{x^2+y^2}{2\sigma^2}}$$

This Figure 4 (b) shows the distribution.

The idea considers this 2-D distribution as a ‘point-spread’ function which is obtained by convolution operation. The storage of image as a collection of discrete pixels enforces the need of an operation before performing the convolution which is the production of a discrete approximation to the Gaussian function.

The Gaussian filter applied to the dosimeter image results in

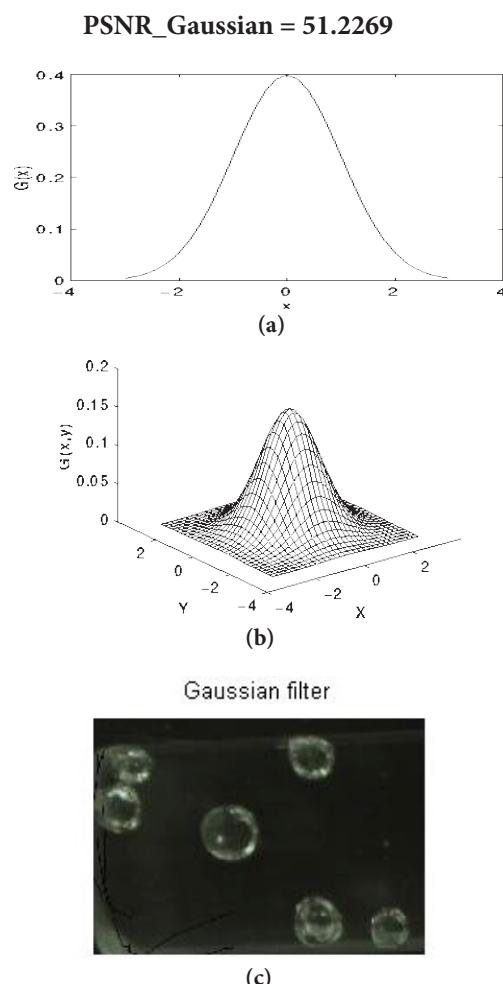


Figure 4. (a) Gaussian distribution when mean 0 and =1. (b) Gaussian distribution with mean (0,0) and =1. (c) After applying Gaussian filter of various window size.

This value is significantly higher than other obtained images. Thus this type of filter is not recommended for dosimeter digital images. On increasing value, the image gets blurred deteriorating.

The standard deviation of the Gaussian determines the degree of smoothing⁷. A Gaussian is better than a similarly sized mean filter. It provides nice smoothing and preserves good edges better as it outputs a ‘weighted average’ of each pixel’s neighborhood, with the average weighted more towards the value of the central pixels.

The frequency response of the Gaussian justifies its use as a smoothing filter. Most convolution-based smoothing has its effect on removing high spatial frequency components from the image by acting as low-pass frequency filter.

4.1 Significance of Gaussian Filter

- Gaussian smoothing results more noise still exists. And although it has decreased in magnitude. This Gaussian filter has been smeared out over a larger spatial region.

4.2 Drawbacks of Gaussian Filter

- Reduction/blur of the intensity of the noise by increasing the standard deviation attenuates high frequency detail such as edges significantly, median filtering, conservative smoothing or Crimmins speckle.

5. Weiner Filter

The most important technique for removal of blur in images due to linear motion or unfocussed optics is the Wiener filter. Blurring is happened due to linear motion in the photograph⁵. Each pixel should represent the intensity of a single stationary point in a digital representation of the photograph. This is a two-dimensional which gives to

$$G(u,v) = F(u,v).H(u,v)$$

where, F is the Fourier transform of an “ideal” version of a given image.

H is the blurring function. In this case H represents a sine function: Ideally one could reverse-engineer a F est, or F estimate, if H and G are known. This is inverse filtering.

Overall Weiner filters are far and away the most common de-blurring technique used because it mathematically returns the best results. Inverse filters are interesting

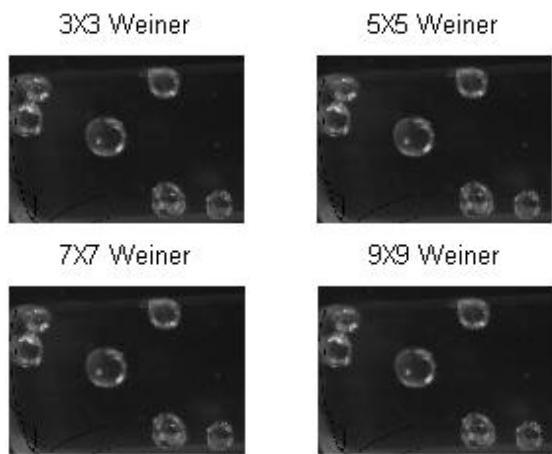
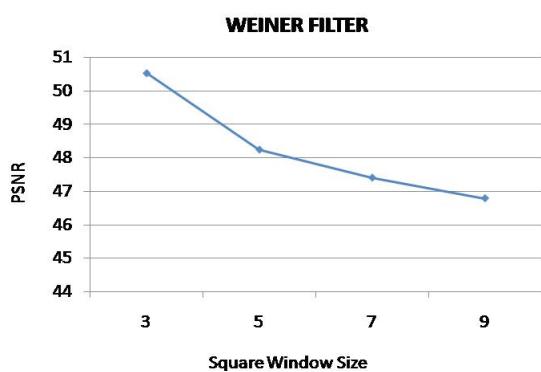


Figure 5. After applying Weiner filter of various window size.

Table 3. PSNR values images after Weiner Median Filters

Square Window size	PSNR
3	50.5296
5	48.2354
7	47.3966
9	46.7782



Graph 2. Plot of PSNR of images of various window size on applying Weiner filter.

because of their simplicity, Wiener filters are much more common filter. It should also be re-emphasized that Wiener filtering is in fact the underlying premise for restoration of other kinds of blur; and being a least-mean-squares technique. This filter which has roots in a spectrum of other engineering applications. Wiener filter is used when the noise in image is a constant power additive noise⁹.

As observed from the graph of the bubble detector neutron dosimeter images on applying Weiner filters, the PSNR values are significantly higher compared to other images. Thus significant enhancement of image is cannot be brought using Weiner filter for this type images.

6. Conclusion

On comparing PSNR values of all filters of various square kernel, mean filter works low, where one insignificant value of the pixel can considerably affect the whole image. Whereas on increased value of standard deviation the edges of the image become highly blurred over a Gaussian filter. In the case of Weiner filter the obtained value of PSNR is significantly higher for the neutron dosimeter images. Over all, median filter is considered to be outstanding the performance to produce an enhancement image than all other filters.

Median filter is much better than mean, Gaussian and Wiener filters. The median filter does not take any extra padded values over the edges⁸. So median filter removes noises with very little affect on the edges. The median filter yields better result for these bubble detector dosimeter images.

7. References

- Gonzalez R, Woods R. Digital Image Processing. Addison-Wesley Publishing Company; 1992.
- Boyle R, Thomas R. Computer Vision: A First Course. Blackwell Scientific Publications; 1988. p. 32–4.
- Image analysis and recognition. 2006 Third International Conference; Povoa de Varzim, Portugal. 2006 Sep.
- Davies E. Machine Vision: Theory, Algorithms and Practicalities. Academic Press; 1990.
- Marques O. Practical Image and Video Processing using MATLAB. IEEE Press, John Wiley and Sons INC. publication.
- Rasmussen CE, Williams CKI. Gaussian Processes for Machine Learning. University Press Group; 2006.
- International Conference on Computational Intelligence and Security (CIS); 2005.
- Jain AK. Fundamentals of Digital Image. Upper Saddle River, NJ, USA: Prentice Hall, Englewood Cliffs, Math works Inc.; 1989.
- Patidar P, Manoj G, Sumit S, Ashok KN. Image Denoising various filters for different noise. Int J Com Appl. 2010; 9(4):0975-8887.