*International Journal of Research in Engineering and Science (IJRES)*
*ISSN (Online): 2320-9364, ISSN (Print): 2320-9356*
*www.ijres.org Volume 1 Issue 2 ‖ June. 2013 ‖ PP.27-33*

# Elimination of Gaussian Noise from FPGA Based Co-Processors

Ayush Rai
Department of Electronics & communication Engineering Gyan Vihar School of Engineering & Technology (GVSET) Jaipur (Rajasthan), India

**Abstract** – Noise in Image processing techniques is the most important term to deal with & the removal of noise is an exhausting technique as there are several noises present in imaging environment.Here an attempt has been made to hybridize the general purpose processor (GPP) with a FPGA based Image Processor (FIMP). The idea is to improve the performance of image processer and automate the entire system.However in the implementation of this co – processor as a hardware accelerator some issues came up as well. Noise distortion cropped up as one of the major challenges in this paper. Among the various types of noises Gaussian noise surfaced as the main cause of concern.There are several kinds of image filters, which can be used to enhance the image or remove the noise.

In this paper, the comparison of different filters has been proposed by taking the gaussian noise to be operated on each filter. By using these filters different images are processed which have been combined with 'Gaussian' noise at different standard deviations. The maximum signal error (MSE), maximum pixels size and peak signal to noise ratio (P-SNR) are hereby analyzed for each type of filter. The histograms for each filtered image have been prepared and analyzed.

***Index terms –*** General Purpose Processor (GPP), Field Programmable Gate Array (FPGA),Max'm Signal Error (MSE), Gaussian Noise, Image De-noising.

## I. INTRODUCTION

Digital image processing is a subfield of digital signal processing. Digital image processing has many benefitsover analog image processing; it allows a much wider variety of algorithms to be applied to the input data and can avoid problems such as the build-up of noise and signal distortion throughout processing.

Different hardware systems have been looked for the FIMP processor to reduce complexity and enhance speed.The architecture uses a hybrid computing system – Xtremedata XD1000 development system. It is implemented on FPGA technology. This concept of multi-processing through distribution enables the architecture to perform effectively. It meets all the major objectives, such as – speed enhancement, automation and better image resolution.This has been possible because of the flexibility, easy availability and final design compactness of the FPGA based co-processors.

Every image has noise in it.There are basically two distinct principles to de – noising. Firstly,collectively groupedsimilar image patcheswere subsequently filtered to remove noise for this different filtering technique exists with distinct algorithms.Secondly, construct a clean image out of a series of continuous but noisy measurements. Here all the vestigial sections of the image were aborted. This automatically led to the removal of any sort of noise.

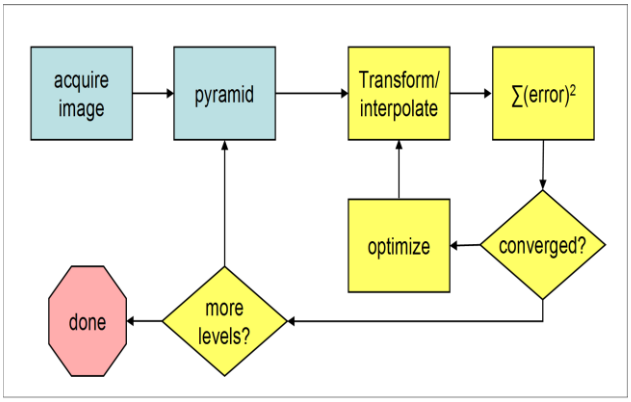



**Figure1: Algorithm Flow Broken Down Into Primary Functions.**

## II. NOISE MODELS

The principal source of noise in digital images arises during image acquisition (digitization) and transmission. The performance of imaging sensors is affected by a variety of factors such as environmental situations during image acquisition and by the quality of the sensing elements themselves. Images are corrupted during transmission predominantly due to interference in the channel used for transmission. There are basically twotypes of noise models which are as follows:

**A.GAUSSIAN NOISE:**

The PDF of a Gaussian random variable, z is given by: $p(z) = 1/(2\pi\sigma)e^{-(z-\mu)^2/2\sigma^2}$….. (i)

Where z represents gray level, $\mu$ is the mean of average value of z, and $\sigma$ is its standard deviation. The standard deviation squared, $\sigma^2$ is called the variance of z.

Because of its mathematical tractability in both the spatial and frequency domains, Gaussian (also called *normal)* noise models are frequently used in practice. In fact, this tractability is so convenient that it often results in Gaussian models being used in situations in which they are marginally applicable at best.

**B**. IMPULSE (SALT-AND-PEPPER) NOISE:

The PDF of impulse noise is given by:

$$P(z) = \begin{cases} P_a & \text{for } z = a; \\ P_b & \text{for } z = b; \\ 0 & \text{otherwise.} \end{cases} \quad \text{…… (ii)}$$

If b > a, gray-level b will appear as a light dot in the image.

Conversely a leva will appear like a dark dot. If either $P_a$ or $P_b$is zero, the impulse noise is called unipolar. If neither probability is zero and especially if they are approximately equal impulse noise values will resemble salt-and-pepper granules randomly distributed over the image. For this reason bipolar impulse noise is also called s*alt-and-pepper noise*. Shot and spike noise terms are also used to refer this type of noise. Noise impulses can be negative or positive. Scaling usually is part of the image digitizing process. Because impulse corruption usually is large compared with the strength of the image signal, impulse noise generally is digitized as extreme (pure white or black) values in an image. Thus the assumption usually is that a and b are "saturated" values in the sense that they are equal to the minimum and maximum allowed values in the digitized image. As a result, negative impulses appear as black (pepper) points in an image. For the same reason, positive impulses appear white (salt) noise. For an 8-bit image this means that a = 0 (black) and b = 255 (white).

## III. FILTERING METHODS

Different remedies of the median filter have been proposed, e.g., the adaptive median filter, the multistate median filter, or the median filter based on homogeneity information. These so called "*decision-based*" or "*switching*" filters first identify possible noisy pixels and then replace them by using the median filter or its variants, while leaving all other pixels unchanged. These filters are good at detectingnoise even at a high noise level. Their main drawback is that the noisy pixels are replaced by some median value in their vicinity without taking into account local features such as the possible presence of edges. Hence, details and edges are not recovered satisfactorily, especially when the noise level is high.

For images corrupted by Gaussian noise, least-squares methods based on edge-preserving regularization functional have been used successfully to preserve the edges and the details in the images. Moreover the restoration will alter basically all pixels in the image, including those that are not corrupted by the impulse noise.

In this paper now we shall study different kind of filters to eliminate the 'Gaussian' noise. These filters are Conventional (Standard) median filter, median filter, degage (relaxed) median filter, adaptive median filter, Gaussian filter.

The first four filters are used to remove the salt & pepper noise from the 2D gray scale images, while the last two filters; Gaussian filter and linear filter are used to remove noise from circular images as well as 2D images. The Gaussian filter is not much relevant in the case of salt & pepper noise, but to study the effect of it over the image, the filter is taken. The detailed description of testing of all these filers with respect to different images at different values of standard deviation is discussed in next sections.

**Adaptive Median filter** –The median filter is a nonlinear digital filtering technique, often used to remove noise. Median filtering is very widely used in digital image processing because, under certain conditions, it preserves edges while removing noise.

The best-known order-statistics filter is the median filter, which as its name implies, replaces the value of a pixel by the median of the gray levels in the neighborhood of that pixel:

$$\bar{f}(x,y) = \underset{(s,t)\varepsilon s_{xy}}{median}\{g(s,t)\} \quad \text{……….. (iii)}$$

The median filter filters each pixel in the image in turn and its nearby neighbours are used to decide whether or not it is representative of its surroundings.

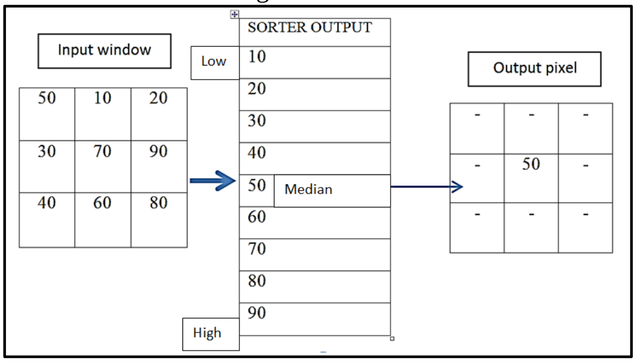



**Figure 2: Process of Median Filtering.**

Normally, instead of replacing the pixel value with the mean of neighboring pixel values, median filter replaces it with the median of those values. That is, the values from the surrounding neighbourhood are first sorted into numerical order, and then the value of the pixel in question is replaced with the middle (median) pixel value. The neighborhood is referred to as the *window*. The window can have various shapes centered on the target pixel.

Adaptive Median Filtering Algorithm:

1. A 2-D window of fixed size say 3x3 is selected. The window is centered round the pixel to be processed. Let the pixel p(x, y) be the pixel under processing.
2. The pixels within the selected window are sorted and arranged in their ascending order. Then the subsequent median value of all these pixels is calculated. It is denoted by $P_{Med}$. The ascending order is decided from maximum and minimum pixel values represented by $P_{Max}$ and $P_{Min}$. The vector of pixels designed out of this is represented as $V_o$. Here the first and the last elements of this vector are written as $P_{Max}$ and $P_{Min}$ respectively. The middle element of this pixel is $P_{Med}$.
3. The value of $P_{Min}$ must be greater than zero and the value of $P_{Max}$ should be less than 255. If the value of the pixel to be processed P(x, y) is between PMin and PMax, then the pixel is considered noise free. Otherwise the pixel is classified as a corrupted one.
4. Two cases arise when P(x, y) is considered a corrupted pixel. These are –
   i) Case 1: If $P_{Min}<P_{Med}<P_{Max}$ and $0 <P_{Med}< 255$, the corrupted pixel is immediately replaced by $P_{Med}$.
   ii) Case 2: $P_{Med}$ is a pixel with noise, in case the condition in the above statement is not reached. Now the difference between each adjacent filter is computed by subtracting the pixel values with the generated vector $V_o$. The vector now prepared is called the difference vector represented as $V_D$. From now on the vector $V_o$ is replaced by its new value after subtraction.
5. The above four steps are repeated time and again. In this way entire image is processed. Thus whole image is taken by clearing parts of image pixel wise. The larger the window size, the better is the resolution and faster is the entire process.

**Adaptive Weiner filter –**The Adaptive Weiner Filter performs spatial processing to determine which pixels in an image have been affected by gaussian noise.They depend on the principle of calculation of error via the filter coefficients. The output of the FIR filter is calculated by the following equation –

$$y(n) = Z^{N-1}_{m=0} \quad w(m)\, x(n-m)$$

The error signal is calculated by the equation mentioned below –

$$e(n) = d(n) - y(n)$$

the mathematical form of the algorithm followed by the Adaptive Weiner filters is stated below.

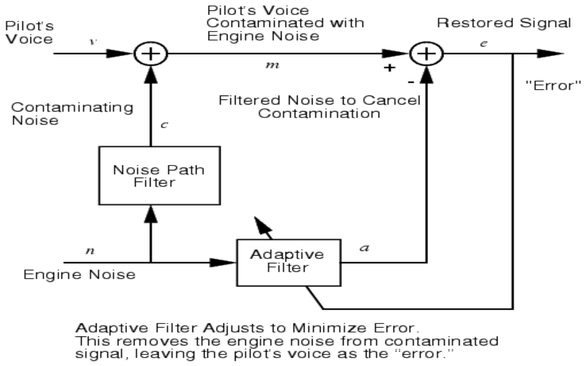



**Figure 3: Block Diagram Representing the Algorithm of the Adaptive Weiner Filter.**

These Filters classify pixels as noise by comparing each pixel in the image to its surrounding neighbor pixels. The size of the neighborhood is adjustable, as well as the threshold for the comparison. A pixel that is different from a majority of its neighbors, as well as being not structurally aligned with those pixels to which it is similar, is labeled as gaussian noise. These noise pixels are then replaced by the median pixel value of the pixels in the neighborhood that have passed the noise labeling test.

Therefore asymmetric decision based adaptiveweiner filter is proposed here to get the better and non-smeared images. It self-adjusts its transfer function according to an optimization algorithm driven by an error signal. Because of the complexity of the optimization algorithms, most adaptiveweiner filters are digital filters. These filter uses feedback in the form of an error signal to refine its transfer function to match the changing parameters.

**Adaptive Window filter** – The window filtering technique has good noise-reducing effects, but its time complexity is not desirable. This paper demonstrates two types of window filtering technique, (i) 3x3 window sizes, (ii) 5x 5 window sizes. The process uses the correlation of the image to process the features of the filtering mask over the image. It can adaptively resize the mask according to noise levels of the mask.

The statistical histogram is also introduced in the searching process of the window size value. Experimental results show that this method reduces the noise and retains the details of the image. The complexity of the process is decreased to O(N), and the performance of noise reduction has effectively improved.The algorithm mentioned below is same for any window size. Only the value of window size is needed to be changed.

1. Let X be the original image with noise.
2. The standard deviation of the noise is taken at two distinct values. It is found out using Immerkaer's fast method.
3. X(i, j) is regarded as the central pixel. A 2 – D filtering window of size 3x3 is taken out of the noisy image. Then each and every element is subtracted with the central pixel. The absolute value of the difference is calculated as AD = [ $S_{i,j}$ – X(i, j) ].
4. The pixel is stored as a one dimensional array named as DA(x). This is done only if the absolute difference AD < (SF * SD). Here SF is the smoothing factor and SD is the standard deviation.
5. In case the number of elements in the DA(x) is at minimum (2*W) – 1, then the mean of DA(x) is calculated and the center value is replaced by it. It was earlier assumed to be X(i, j). W is taken as three for a 3x3 window and five for a 5x5 window.
6. If it is not the case the window size is Incremented and the process is repeated time and again.
7. The $3^{rd}$& $6^{th}$ steps are repeated again and again until and unless the entire image is made crystal clear.

**Relaxed median filter:** The filter is obtained by relaxing the order statistic for pixel substitution. Noise attenuation properties as well as edge and line preservation are analyzed statistically. The trade-off between noise elimination and detail preservation is widely analyzed

As we know that The Median Filter is performed by taking the magnitude of all of the vectors within a mask and sorted according to the magnitudes. The pixel with the median magnitude is then used to replace the pixel studied. If the equation of amedian filter is definedby:

Median filter (x1…xN) = Median (||x1||2……||xN||2)

Here now in this paper the noise at the high densities has been measured. Here we have compared two different images at different noise densities which vary from 0.60 to 0.80.

At the higher noise densities the symmetric decision based adaptive filter has been proved much efficient. Here the Gaussian filter is just taken to analyse the effect of it on the noise.

All the relative images and the simulation results are as follows.

IV SIMULATION& RESULT ANALYSIS

In order to compare all kinds of algorithms,we adopt Tree.jpg & Tree1.tiff shown in figure 4 as the test images, at standard deviation of 0.02&apply different filtering methods to them, proceeding with simulations.

(i)Tree.jpg (ii) Tree1.tiff

**Figure 4: Tree.jpg & Tree1.tiff Test Images**

First of all, through experiment we could get the Histograms of the two images as is shown in figure. 5

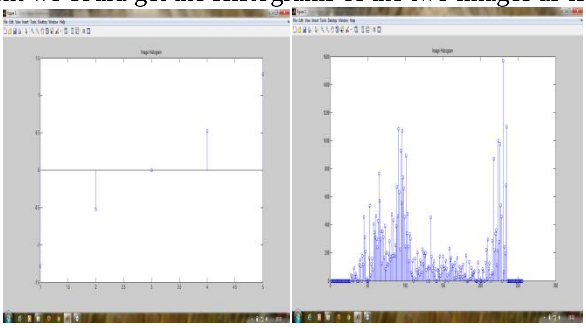
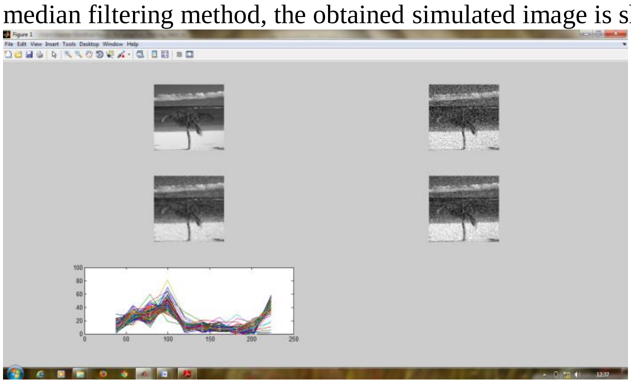


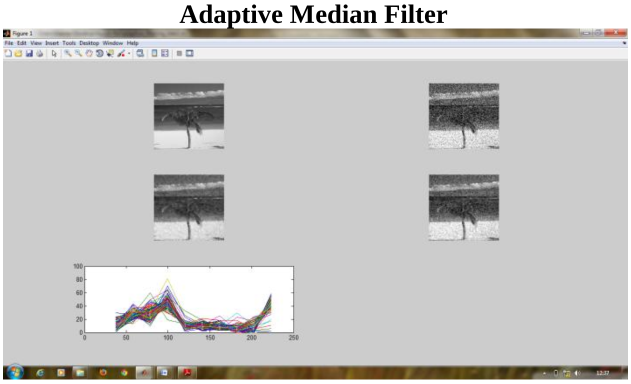
**Figure 5:The Histogram of Tree.jpg & Tree1.tiff**

**A. Simulation Experiment:**

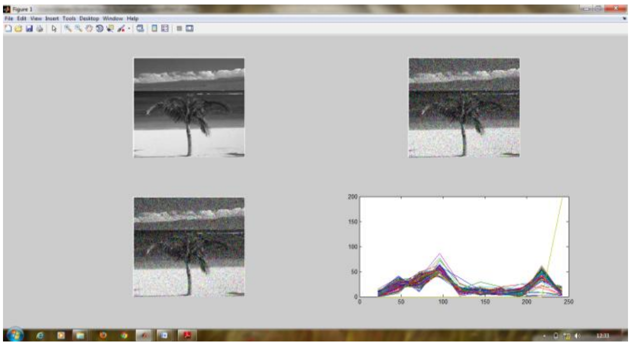
We used adaptive median filtering method, the obtained simulated image is shown in figure 6.



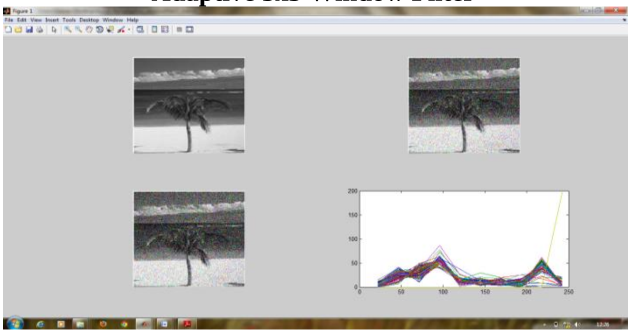
**Adaptive Median Filter**



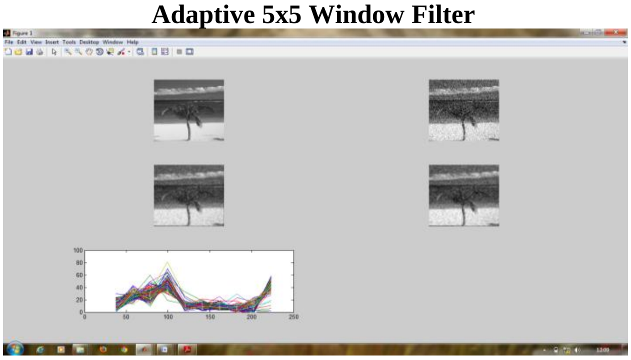
**Adaptive Weiner Filter**



**Adaptive 3x3 Window Filter**



**Adaptive 5x5 Window Filter**



**Relaxed Median Filter**

**Figure 6: Different Image Filtering Algorithm**

**B. Analysis Of Experiment Results:**

For Tree.jpg & Tree.tiff image, apply various filtering methods at different standard deviationsconsideringthe maximum pixel size of 255,& obtain the PSNR, as shown in table.1.

**Table 1:** Obtained PSNR using different filters

| Stan-dard Devia tion | PSNR of The Filters Used | | | |
|---|---|---|---|---|
| | Relaxed MedianF ilter | Adaptiv-eMedian Filter | Adaptiv-e 3x3 Window Filter | Adaptiv-e 5x5Wind owFilter |
| 0.02 | 35.73 | 36.55 | 33.09 | 33.10 |
| 0.04 | 35.63 | 35.53 | 32.71 | 32.72 |
| 0.06 | 35.53 | 34.92 | 32.59 | 32.64 |

For Tree.jpg & Tree.tiff image, apply various filtering methods at different standard deviations considering the maximum pixel size of 255, & obtain the MSE, as shown in table.2.

| SD | MSE of Filter Used | | | |
|---|---|---|---|---|
| | Relaxed Median Filter | Adaptive Median Filter | Adaptive 3x3 Window Filter | Adaptive 5x5 Window Filter |
| 0.02 | 18.97 | 14.95 | 31.98 | 32.02 |
| 0.04 | 19.97 | 19.47 | 34.93 | 34.97 |
| 0.06 | 23.08 | 21.57 | 36.09 | 36.10 |

## IV. CONCLUSION

The performance of the filters has been tested under a range (from 0.02 to 0.06) of Standard Deviation on gray-scale images. Results reveal that the symmetric decision based adaptive 3x3 window filter exhibits better performance in comparison with other existing filtering techniques in terms of PSNR whereas, adaptive median filter exhibits better performance in terms of MSE with respect to other existing filtering techniques . In this paper, we propose a decision-based, detail-preserving restoration method. It is the ultimate filter for removing gaussian noise. Experimental results show that different filtering method performs much better function for different filtering aspects or the edge preserving regularization methods. Even at high Standard Deviations, the Adaptive filters give better results both visually and quantitatively. One can further improve the results by using different noise detectors and regularization functions that are tailored to different types of noises, such as the random-valued impulse noise or impulse – plus – Gaussian noise.This restoration of images is very likely to find potential applications in a number of different areas such as medical diagnostics, archaeology, satellite imaging, etc.

## REFERENCES


[1] Youlian Zhu, Cheng Huang "*An Improved Median Filtering Algorithm for Image Noise Reduction*" Physics – Procedia 25 (2012) 609 – 616.

[2] Abdessamad BenHamza, Pedro L. Luque-Escamilla, Jos´EMart´inezAroza&Ramo´NRoma´NRolda´N"*Removing Noise and Preserving Details with Relaxed Median Filters*" Journal of Mathematical Imaging and Vision 11, 161–177 (1999) Kluwer Academic Publishers.

[3] ZinatAfrose "Relaxed Median Filter: A Better Noise Removal Filter for Compound Images" International Journal on Computer Science and Engineering (IJCSE) ISSN : 0975-3397, Vol. 4/ No. 07 /July 2012

[4] Raymond H. Chan, Chung-Wa Ho, and Mila Nikolova – "Salt-and-Pepper Noise Removal by Median-Type Noise Detectors and Detail-Preserving Regularization" IEEE Transactions On Image Processing, Vol. 14, No. 10, October 2005.

[5] MamtaJuneja,*RajniMohana* "An Improved Adaptive Median Filtering Method for Impulse Noise Detection" International Journal of Recent Trends in Engineering, Vol 1, No. 1, May 2009

[6] HadiSadoghiYazdi, FaranakHomayouni "Impulsive Noise Suppression of Images Using Adaptive Median Filter" International Journal of Signal Processing, Image Processing and Pattern Recognition Vol. 3, No. 3, September, 2010.

[7] Weyori, Benjamin Asubam"An Improved Median Filtering Algorithm for the Reduction of Impulse Noise in Corrupted 2d Grayscale Images" research work.