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# A COMMON FILTER FOR BOTH IMPULSE AND GAUSSIAN NOISE REMOVAL

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**Abstract** – Image noise is an undesirable by-product of image capture that adds spurious and extraneous information. It can be obtained in film grain, or in the input device (scanner or digital camera) sensor and circuitry, or in the ideal photon detector. It is introduced into images at the time of acquisition and transmission of images. There are many models which explain about various noise, this paper is about defining a Trilateral filter with ROLD statistics and comparing its performance with other filters. It is further used to filter out mixed noise.

*Keywords: Gaussian, impulse, noise,bilateral,trilateral*

## I. INTRODUCTION

Vision is a process in which a number of components of the human eye and brain work together. Vision is one of the most important senses for human survival and evolution. Visual system is used by humans to see or acquire visual information. The field of image processing emphasizes on automating the process of gathering and processing visual information. Like visual sensory system of humans, digital image processing involves the processes of acquiring, manipulating, and analyzing visual information by digital computer

## II. RELATED WORK

Many methods have been proposed for removing noise from images. They could be classified into two categories depending on the type of the noise. For images corrupted with Gaussian noise, linear filtering techniques, are often used due to their simplicity and efficient smoothing

effects. Linear filters, however, tend to destroy the high frequency structure of the images[1] There are many works in the literature aiming to solve this problem; for instance, anisotropic diffusion technique[2][3], the bilateral filter[4][5], wavelet techniques[6][7], robust estimation-based methods[1][8], and least-squares methods based on edge preserving regularization[9][10].W. K. Pratt presented "Median filtering", in [11] presented the algorithm for the Median filter. The technique assumes that noise is normally distributed. R Pushpavalli, G. Sivaradje presented "Switching Median filter for Image Enhancement" in [12] where filter is defined for Salt-and-Pepper noise. Each pixel is compared with the Minimum and Maximum value in the filtering window. Zhou Wang and David Zhang in [13]presented "Progressive switching median filter for the Removal of impulse noise from highly corrupted images," The Progressive Switching Median Filter (PSMF) is designed primarily for restoring highly

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corrupted images through distinct detection and correction phases. Xiaoyin Xu, Eric L. Miller, Dongbin Chen and Mansoor Sarhadiin [14] presented “Adaptive two-pass rank order filter to remove impulse noise in highly corrupted images” In the Rank-order based Adaptive Median Filter (RAMF) algorithm, a pixel is retained if the median of a window around it is strictly between the minimum and the maximum value of the window and the pixel also is strictly between the minimum and the maximum value of the window. Umesh Ghanekar stated a two stage impulse detector where noisy pixels were replaced by the noise free pixels [15] SD-ROM[17] is one of the best filters known so far for the removal of mixed noise. It gives the best detail preservation and noise reduction when the noise level is low, but will seriously blur the images when the noise level is high.

## III. SYSTEM ARCHITECTURE

### A. *The Trilateral filter*

The Trilateral filter given by Garnett[16] in is derived from the existing bilateral filter[4] which derives itself from Gaussian filter and proves to be better than it. The bilateral filter is only defined to filter Gaussian noise.

### A. *Algorithm*

Input: A noisy image

Output: Filtered image

Step 1: Let x be the location of the pixel under consideration, and let denote

the neighborhood of x in (2N+1) x (2N+1) window.

Step 2: Calculate the $W_S$ and $W_R$ components of weight defined as :

$W_S(x,y) = e^{-\frac{|x-}{2\sigma}}$.

$W_R(x,y) = e^{-\frac{|u_x-u}{2\sigma_R}}$.

Step 3: ROAD calculation

Step 3.1: For each pixel y in neighbourhood of x find absolute difference in intensity $d$ as:

$d_{x,y} = |u_x - u_y|$

Step 3.2: sort $d_{x,y}$ in increasing order and define:

$ROAD_m(x) = \sum_{i=1}^{m} r_i$,

where $2 \leq m \leq 7$ and $r_i(x)$ = ithsmallest $d_{x,y}$

Step 4: Use ROAD value found in 3 to calculate Joint impulsivity defined by:

$J(x,y)=1- e^{-\frac{(ROAD(x)+ROAD(y))}{2\sigma_J^2}}$

Step 5: Compute $W_I$ component of weight W:

$W_I(x) = e^{-\frac{ROAD}{2\sigma_I}}$

Step 6: Multiply all three weight components to get final weight for a pixel at location(x,y) :

$W(x,y)=W_S(x,y)*W_R(x,y)^{1-J(x,y)}*W_I(x,y)^{J(x,y)}$.

Step 7: Replace the pixels with the restored pixels.

In the final step, the weights are multiplied with the pixels in image and then these multiplied values are normalized by dividing them with the product of weights.

*ROLD calculation*

Steps involved in the ROLD calculation are:

1: For each pixel y in neighborhood of x find absolute difference in intensity $d$ as:

$d_{x,y} = |u_x -$

2 Apply logarithmic function to the found $d_{x,y}$ in step 1

$D = \log_a$

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3 Convert D to fall in the [0,1] range:

$$D = 1 + \max\{D, -b\}$$

4 Sort values of D in increasing order and define :

ROLD(x) = $\sum_{i=1}^{m} r_i$,

where $2 \leq m \leq 7$ and $r_i(x)$ = $i^{th}$ smallest $D_{x,y}$

The algorithm proposed by Y. Dong, R. H. Chan, and S. Xu used this ROLD statistic (ROLD value calculation for a pixel is explained in the next section) for identification of noisy pixels in stage one of the two-stage methods. The algorithm is as follows:

B. *Algorithm*

Input : A noisy image

Output: Filtered image

Step 1: Set k=0 and u(0) = y.

Step 2: Noise Detection

Step 2.1: Calculate ROLD values for every pixel in u(0) and store in ROLDs matrix.

Step 2.2: If any value in ROLDs(i,j) then set the flag to 1 otherwise 0

Step 3: Noise Restoration

If the pixel x has flag 1 go to step 3.1 else goto step 4

Step 3.1: Get a WxW window K of u(0) and WxW window flag around the pixel x.

Step 3.2:Store the four closest neighbors of x which have flag value 1 in S1

Step 3.3:Store the four closest neighbors of x which have flag value 1 in S2

Step 3.4: Estimate the value of x:

$$\sum \varphi(x - S_1) + 2\,\varphi(x - S_2)$$

Step 4: if k $<K_{max}$ increment k else stop the iteration.

## IV. EXPERIMENTAL RESULTS

A 512x512 sized standard Lena image chosen for the analysis and comparison of the SD-ROM filter, Trilateral filter with ROAD and Trilateral filter with ROLD statistic.

The Trilateral filter performs better with both ROAD and ROLD when the noise level is increased up to 50%. But the ROAD statistic fails to prove its best when the noise level reached to 50%. Grainy appearance is carried out by it in the filtered image.

### A. *Performance Analysis*

Table 1: The PSNR comparison of filters for "Baboon" image.

| Noise % | 10 | 20 | 30 | 40 | 50 | 60 |
|---|---|---|---|---|---|---|
| SD-ROM | 14.7986 | 11.7967 | 9.8855 | 8.9414 | 8.2040 | 8.0523 |
| Trilateral with ROAD | 14.8005 | 11.7999 | 9.8873 | 8.8912 | 7.8554 | 7.0004 |
| Trilateral With ROLD | 14.9167 | 11.8610 | 9.9667 | 9.0044 | 7.9639 | 7.1077 |

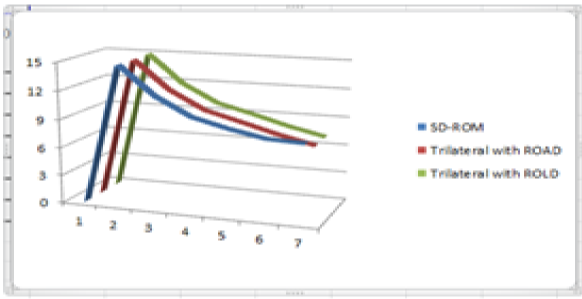


Figure 1: PSNR of different filters for "Baboon" image.

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## V. CONCLUSION

This paper states how the ROLD and ROAD statistics make a big difference in filtering out noise in the image. The ROLD statistic built for filter in [4] is incorporated into the filter explained in [16] to make it more efficient in terms of time and space complexity. The new filter is compared with that of Trilateral filter with ROAD and SD-ROM filter to prove its better performance.

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