Reduction of Noise in Images using Modified Sigma Filter to preserve small edge in an image.

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***Abstract*—Noise reduction plays a very important processing step in digital imaging. Different types of filters were used for image de-noising. Among them, sigma filter has shown good results both in terms of filtering accuracy and computational complexity. However, the sigma filter does not preserve well small edges especially for high level of additive noise. Thus we use modified sigma filter which overcomes the disadvantage of the sigma filter. This filter first decomposes the image into four components once in the horizontal and vertical directions and second time in the diagonal directions by performing low and high pass filtering. The Sigma filter is applied on each of these four components and the resulting image is obtained by combining all four processed components.The benefits of the Modified Sigma Filter is that the small edges and thin lines are retained to a great extent. But this method is computationally very complex as the image is to be decomposed into 4 components and the sigma filter is to be applied on each of the component separately. In order to reduce the computational complexity while achieving better results, the Cross Sigma and Recursive Cross Sigma filters are used.**

***Index Terms*—Image de-noising, Gaussian noise, modified sigma filter, signal to noise ratio, Mean squared error.**

I. Introduction

Commotion decrease is an imperative handling venture in all advanced imaging applications. Besides, notwithstanding for the most recent assembling advances of the camera sensors, the clamor level is still high. As an outcome, picture de-noising is and will dependably be a critical research point. The strategies for existing clamor decrease can be generally sorted into the spatial channels and recurrence area channels. The spatial channels are straight channel, for example, normal channel, Gaussian channel and non-direct channels, for example, middle channel, sigma channel. The recurrence space channels are band-pass channel, step channel [1],[2],[3],[4].

In all computerized imaging applications. Also, notwithstanding for the most recent assembling advancements, of the cam-time sensors, the clamor level is still high. As a con-succession, picture de-noising is and will dependably be a critical research subject. Among numerous calculations, that exist in the open writing, the sigma channel [5] is most likely one of the easiest de-noising strategy. Because of its effortlessness, this channel speaks to a decent decision for usage in cell phones. In any case, the edge conservation execution of the sigma channel is bad, particularly for little picture subtle elements with variance near the change of the added substance commotion. With a specific end goal to enhance the detail protection of the sigma channel, other more advanced methodologies were master postured. For example the fluffy channel proposed in [6] utilizes some fluffy appraisals of the nearby subordinate to perform directional separating of the picture.

In spite of the fact that its great sifting exhibitions this approach have the impediment of relative high many-sided quality and an expansive number of parameters that must be setup. Another alternative, called half and half sigma channel, was proposed in [7] for spot clamor lessening and indicated enhanced exhibitions contrasted and the Lee's sigma channel. The half breed sigma channel, nonetheless, does not address the issue of added substance clamor decrease which is the concentration of our work. In this paper we propose another altered sigma channel for added substance clamor diminishment in pictures. In our proposed strategy the info picture is initially decayed in four parts and a sigma channel is connected separately on each of them. The yield picture is then remade from the four separated parts.

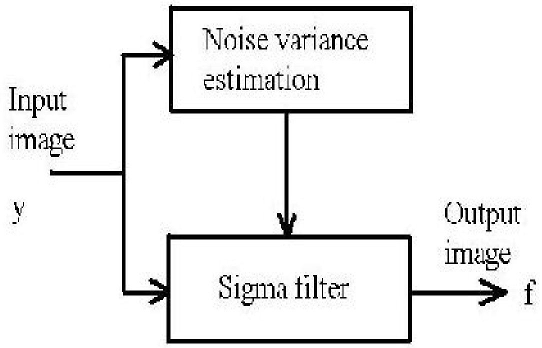

Figure 1: The block diagram of sigma filtering with noise variance estimation.

II. SIGMA FILTER

In this segment, we quickly survey the standard sigma channel for added substance clamor [6] and plot its favorable circumstances and hindrances. We accept the accompanying model for the information picture:

$$y(i, j) = x(i,j) + n(i, j). \quad (1)$$

where y(i, j) is the watched picture, x(i, j) is the first clean picture and n(i, j) is a zero mean Gaussian disseminated added substance commotion. The principle thought of the sigma channel depends on the way that for a Gaussian appropriated variable with mean p and difference (72 a rate of 95.5% of its specimens lies inside the range [p — 2a, p + 2cd. Applying this perception to the model from (1), for each pixel y(i, j) from the watched picture, a nearby affirm age is processed on those neighboring pixels that are inside the interim [y(i, j) — 2(7, j) + 2(7]. Relating pixel of the yield picture f (i, j) is supplanted with this neighborhood normal. This separating plan depends on the suspicion that the pixel esteem y(i, j) is a decent gauge of the nearby mean and there are two issues that must be advertisement dressed. The first is the determination of the neigh-exhausting pixels.

Normally a rectangular M x M window focused at the present pixel is utilized for this (commonly with M from 3 to 9). The second more essential issue is the estimation of the added substance commotion change vim. In down to earth applications the level of the added substance clamor is obscure along these lines, some commotion estimation strategy must be connected to the information picture, earlier separating. For usage in cell phones, such strategies must have low computational many-sided quality and great estimation exhibitions. In this paper we will utilize the approach in [8] that demonstrated great estimation execution at a low computational unpredictability.

As an outcome, a square outline for de-noising in light of sigma channel is portrayed in Fig. 1. The in-put picture is initially gone through the clamor estimation module and the assessed commotion fluctuation is then utilized as a part of the sigma channel for de-noising.

III. ADDITIVE AND MULTIPLICATIVE NOISES

In this chapter we discuss noise commonly present in an image. Note that noise is undesired information that contaminates the image. In the image denoising process, information about the type of noise present in the original image plays a significant role. Typical images are corrupted with noise modeled with either a Gaussian, uniform, or salt and pepper distribution. Another typical noise is a speckle noise, which is multiplicative in nature. The behavior of each of these noises is described in Section 2.1 through Section 2.4.

Noise is present in an image either in an additive or multiplicative form.

An additive noise follows the rule

$$w(x, y) = s(x, y) + n(x, y) ,$$

while the multiplicative noise satisfies

$$w(x, y) = s(x, y)\times n(x, y) ,$$

where s(x,y) is the original signal, n(x,y) denotes the noise introduced into the signal to produce the corrupted image w(x,y), and (x,y) represents the pixel location. The above image algebra is done at pixel level. Image addition also finds applications in image morphing. By image multiplication, we mean the brightness of the image is varied. The digital image acquisition process converts an optical image into a continuous electrical signal that is, then, sampled. At every step in the process there are fluctuations caused by natural phenomena, adding a random value to the exact brightness value for a given pixel.

IV. GAUSSIAN NOISE

It is a statistical noise that has a probability density function (pdf) of the normal distribution (also known as Gaussian distribution). It is a major part of the "read noise" of an image sensor, that is, of the constant noise level in dark areas of the image. Graphically, it is represented as shown in Figure 2.

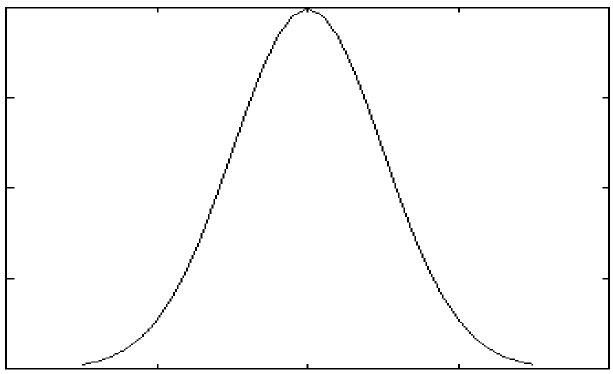

Fig 2

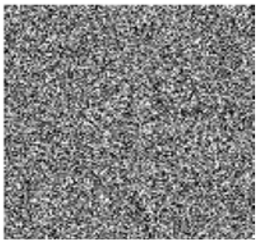

Image 2.1: Gaussian noise (mean=0, variance 0.05)

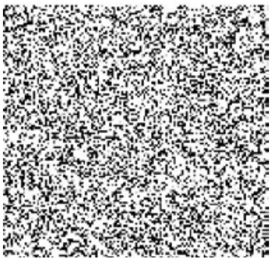

Image 2.2: Gaussian noise (mean=1.5, variance 10)

V. CROSS SIGMA FILTER

The Cross sigma channel is intended to utilize an idea like that of the sigma channel. The picture is crossed, and every pixel in the picture is thusly considered as the turn pixel. The turn pixel is the focal pixel of the area that is being considered. The rotate pixel is contrasted and its contiguous pixels that lie in a similar column. The force contrast between the neighbor and the turn pixel is computed. On the off chance that the distinction is not as much as a specific (sigma) esteem, then the neighboring component power will be incorporated into the averaging. The rotate pixel is at long last supplanted, in the middle of the road picture, with the normal of the chose pixel powers. This procedure will be kept, taking every one of the pixels of the picture thus as the rotate pixel. The yield of the line astute sigma sifted picture is then taken for a similar procedure section shrewd, i.e. the turn pixel is contrasted and the adjoining pixels that lie in a similar segment. On the off chance that the power contrast between the turn pixel and the neighbor is not as much as the sigma esteem, then the neighbor pixel force will be incorporated into the averaging. The turn pixel is supplanted with the normal of the chose pixels in the last goal picture.

Computation of Sigma Value: For best outcomes, the sigma esteem can be figured by assessing the standard deviation of clamor in the picture. This computed esteem can be passed as the sigma esteem for the previously mentioned sifting. Clamor estimation can comprehensively be ordered into two methodologies: Block based and Sifting based systems. In the square based procedure, the picture is isolated into many pieces, and the standard deviation of the power qualities is ascertained for each block.The minimum standard deviation esteem can be thought to be the standard deviation of the gaussian clamor in the picture. In the separating method, low pass channel is connected on the first picture. The distinction picture is figured by subtracting the first and the low pass separated picture. Oslen's calculation is connected on the distinction picture to get the evaluated clamor exhibit in the picture.

Implementation: Let us consider an image of size mxm. Let the input image be Iij and the output image be Oij. Consider the neighborhood to be of size 1xk (for row wise processing) and kx1 (for column wise processing), where k << m. Let the pivot pixel intensity be I. Then, for each pivot pixel, the corresponding output pixel intensity is obtained by the following steps:

1. Differences are calculated between the neighboring pixels and the pivot pixel as below:

$$diff\,(j) = |pij - I| \qquad for\ {-1} < j < +1,\ i = 0$$

2. If the differences are less than sigma value, the pixel intensities pij are summed and averaged, which is the output intensity qij. The value qij is updated in the intermediate image.

$$qij = 1/k\ \Sigma\ pij \qquad for\ diff\,(j) <= sigma$$

$$K = number\ of\ values\ summed$$

else

$$qij = pij$$

3. This intermediate buffer is taken for column wise cross sigma processing, i.e. steps 1 and 2 are repeated in the column direction. The obtained image is the final output image.

$$diff\,(j) = |pij - I| \qquad for\ {-1} < i < +1,\ j = 0$$

$$Oij = 1/K\ \Sigma qij \qquad for\ diff\,(j) <= sigma$$

else

$$Oij = qij$$

. A block diagram depicting the Cross Sigma filtering process has been shown in Fig. 3

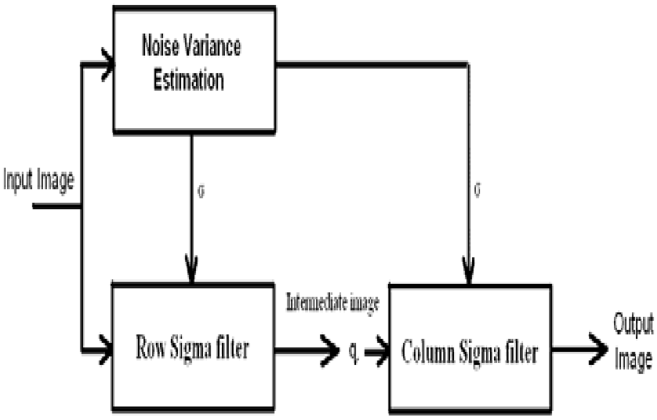

Fig 3

VI. RECURSIVE CROSS SIGMA FILTER

Keeping in mind the end goal to accomplish a higher level of clamor disposal and smoothing, the Recursive Cross Sigma

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Filter has been proposed. The Recursive Cross Sigma channel is intended to widely smooth the picture without loss of critical data. The picture is crossed and every pixel is thus viewed as the turn pixel. The turn component power is contrasted and the two neighboring components that lie in a similar column, and if the distinction between these force qualities is not as much as sigma esteem, then the neighboring component is considered for averaging.

The arrived at the midpoint of significant worth is supplanted in the rotate pixel area instantly and this new esteem is considered as one of the neighbor for the following turn component. This procedure is firstperformed push savvy and afterward the yield of this procedure is taken as the contribution for the recursive colom shrewd sigma handle.

Implementation: Let us consider an image of size mxm. Let the input image be Iij and the output image be Oij. Consider the neighbourhood to be of size 1xk (for row wise processing) and kx1 (for column wise processing), where k << m. Let the pivot pixel intensity be I. Then, for each pivot pixel, the corresponding output pixel intensity is obtained by the following steps:

1. Differences are calculated between the neighboring pixels and the pivot pixel

$$diff(j) = |pij - I| \qquad for\ -1 < j < +1,\ i = 0$$

2. If the differences are less than sigma value, the pixel intensities are summed and averaged, which is replaced in the same image at the same location. The source image is itself updated as the process continues.

$$pij = 1/k\ \Sigma\ pij \qquad for\ diff\ (j) <= sigma$$

K=number of values summed

else

$$pij = pij$$

3. The updated image is taken as input for column wise sigma processing. The above steps, i.e. steps 1 and 2 are repeated column wise and the same image is updated for each iteration. The obtained image is the final output image.

A block diagram describing the recursive cross sigma process has been shown in Fig. 4.

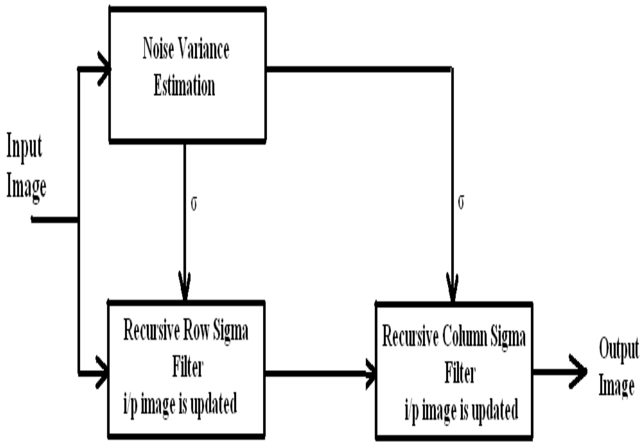

Fig 4

VII. RESULT

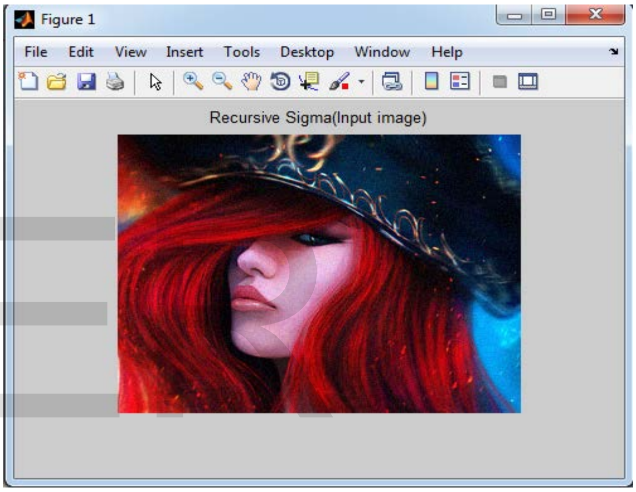

Fig 5(A) Input image of recursive sigma filter

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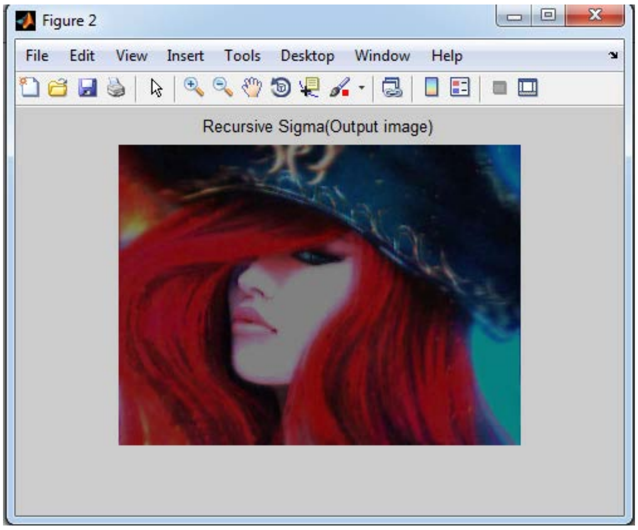

Fig 5(B) output image of recursive sigma filter

In recursive sigma filter, there is no loss of information. Noise is removed with a great extent preserving small edges in an image as shown in fig 5(B)

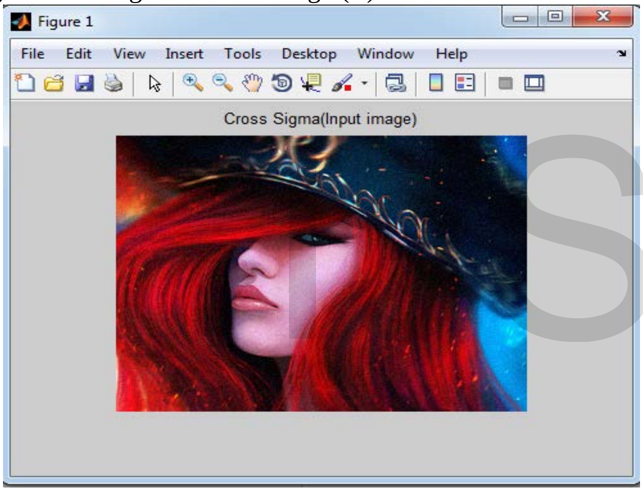

Fig 6(A) Input image of cross sigma filter

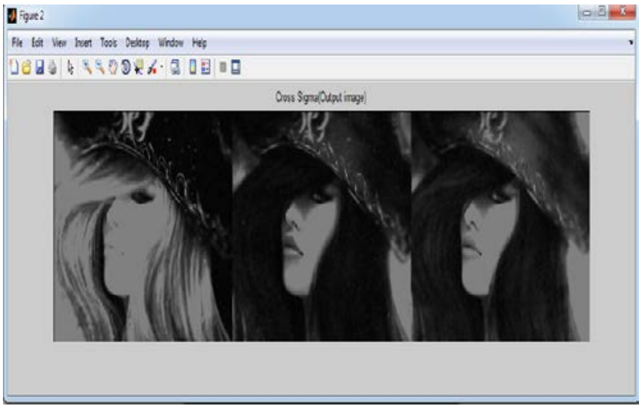

Fig 6(B) Output image of cross sigma filter

The final output is smoothed to a great extent, while the edges are preserved. This method has computationally higher efficiency and is faster. The process is completed in two scans of the image. The main advantage is that the Cross sigma filter eliminates even high amount of additive noise and preserves thin lines

Our work also calculate the peak signal to noise ratio to determine how much noise is reduced with respect to the given signal. And mean square error and mean absolute error is also calculated as shown in fig 7

The resut shows that the proposed method outperforms the previous technology.

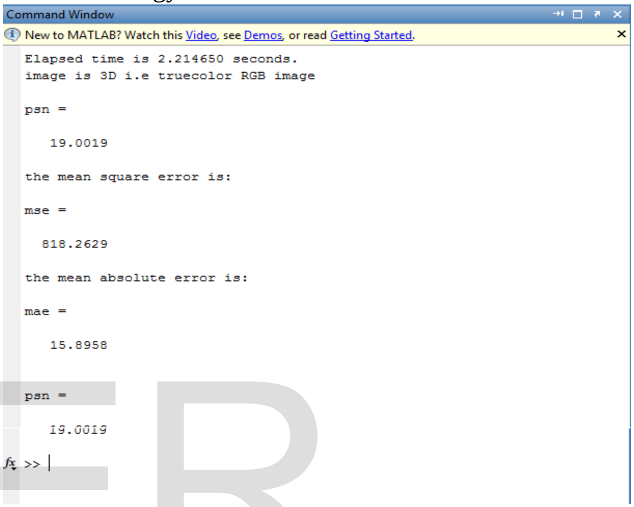

Fig 7 calculation of psnr,mse and mae

A picture has been taken and the Cross Sigma and Recursive Cross Sigma channels have been connected on the picture, with a sigma estimation of 50. The sigma esteem is picked observationally. The resultant yields are exhibited.

The determination of the denoising strategy is application subordinate. Along these lines, it is important to learn and contrast denoising methods with select the system that is well-suited for the application in which we are intrigued. By a long shot there is no rule of picture quality assessment that can be acknowledged for the most part by all. A method to ascertain the flag to clamor proportion in pictures has been proposed which can be utilized with some estimate. This technique accept that the discontinuities in a picture are just because of clamor. A test picture of 512*512 pixel is taken and Gaussian Noise is added to it with the imnoise() work.

Time Complexity:

For Cross Sigma Filter:

Time taken in microseconds = 743930

For Recursive Cross Sigma Filter:

Time taken in microseconds = 685054

For Modified Sigma Filter:

Time taken in microseconds = 1035646

The time required for the Cross and Recursive cross sigma channels to be actualized on the pictures is essentially not as much as the time taken for the changed sigma channel.

VII. Conclusion and Future Scope

This paper represents a new method using a modified sigma filter for image denoising. The new algorithm has improved performances in terms of MSE and also preserves fine details of processed image as opposed with the sigma filter.

In future, we can extend this work with comparison of different types of filters with their ouput of signal to noise ratio and determining the best filter which removes noise without the loss of information and preserving edges with high extent.

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