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A Novel Video De-Noising Algorithm for Removing High Density Impulse Noise

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ABSTRACT
Impulse noise is one of the prominent noise which affect the video as well as the image very badly rendering it look unclear and hazy. Median filter approach for removing such kind of noise proved very inefficient if the noise density is high. In this paper, a novel algorithm is proposed for removing the high density salt and pepper noise from the video sequence. This scheme incorporates noisy pixel detection algorithm prior to applying the filtering operation. a hybrid of median, min and max filter method is used for removing the noise from the video frames. Experimental results shows that the performance of this method is far better than the simple median filter approach.
Keywords:- Median filter, Max Filter, Min Filter, Non-linear filter

I. INTRODUCTION

VIDEO signals can be thought of as a a series or sequence of two-dimensional imagess, projected from a dynamic three-dimensional scene onto the image plane of a video camera. Luminance and chrominance are 2 basic attributes which describe the color sensation in an exceedingly video sequence of an individual's being. Luminance refers to the perceived brightness, while chrominance corresponds to the color tone of the sunshine[1-2].

The quality of the images or videos are very affected by the different kind of noises which is added in the video sequence during the acquisition time or during the transmission time. Shot noise, AWGN(Additive white Gaussian noise), impulse noise or salt and pepper noise are some of the common noise which affect the video sequence and degrade its quality. Among the different kind of noise salt and pepper noise or impulse noise affect the video sequence most and degrades the quality of the video[1]. It is therefore essential to have some kind of algorithm which can remove such kind of noise from the video. Medial filter, being a non linear filter is considered as the best filtering approach for removing such kind of noise but even this method is fail to perform under high noise density[2-8].

Removing the noise from the video is same as the removing the noise from the image. The only difference is that in video sequence, video is first converted ti frames and then each of these frames are then undergoes the filtering operation individually.

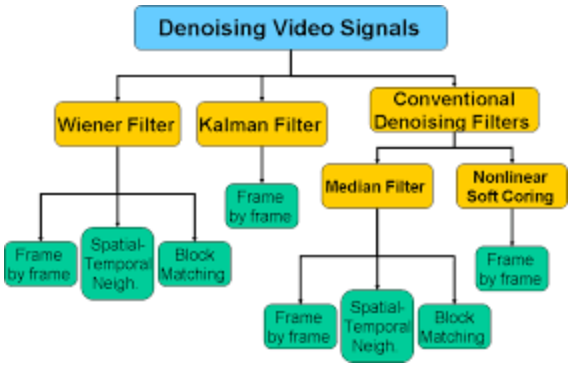

Figure 1 Denoising methods for video Sequence

Once all the frames are filtered then again these frame are converted in to the video[9].

In the past different kind of noise removal algorithm have been proposed for video.

accommodative weighted averaging (AWA) filter based video denoisisng[10], method based on temporal redundancy[11][12], method based on the combination of spatial and wavelet[13], spatio temporal based method on wavelet domain[14], content adaptive based approach[15], wavelet domain based approach[16], spatio temporal based approach in pixel domain[17], wavelet based noise estimation methodology based approach[18] are some of the common approach which have been used for video sequence noise removal.

In this project work a noise filtering algorithm is carried out on the video file to remove the salt and pepper noise from the video. Detail methodology of the proposed video sequence noise removal algorithm is presented in the next section.

Figure 2 Noisy Video(left) and Filtered Video(right)

III. METHODOLOGY

Over all procedure for proposed methodology of this project is shown in the figure 4.1. As per the figure 4.1, first of all, the Noisy video file is given as the input to the system. This video file may be in colour or in gray scale format. This system is applicable for both type of video file.

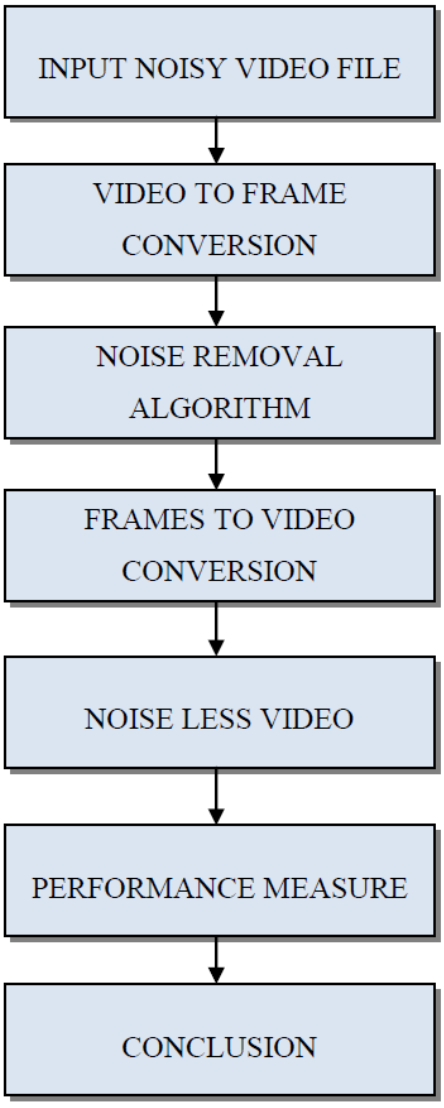

Figure 3 Over all Methodology Block diagram

Once the video file is given to the system then the next step is to divide the video in to its constituent's frames. This is very important step in any type of video processing algorithm. Any type of video is processed by first converting the video in to different constituent's frames and then processing the different frames individually. This is the common procedure for the video processing algorithm and in this project same procedure is adopted. Once the noisy video file is converted in to a frames then in the next step of the methodology, proposed noise removal algorithm is applied to each frames by taking one frame each time.

Once all the frames are processed for removing the noise by the proposed algorithm, we get all the noise-less frames. In the next step of the methodology, these noiseless video is then again converted in to a video. In any video filtering algorithm or image filtering algorithm, performance measure play very important role of judging the performance of the filtering algorithm or how good is the filtering algorithm for removing the impulse noise or salt and pepper noise from the video or image. Peak signal to noise ratio (PSNR), MSE (Mean squared Error), Image quality index(IQI) are some of the common performance measure parameters for image and video. In the next step of this algorithm, the above mentioned parameters are computed between original video filtered video to see how effective the filtering algorithm is.

Finally a conclusion is drawn on the basis of the computed performance measure parameters.

In the proposed methodology, the whole process is divided in to a different part. In the first part, original video file is taken and added the salt and pepper noise or impulse noise to the video to get the noise video. This noisy video is then used as the input file for the proposed noise filtering algorithm. In the second part proposed filtering algorithm is applied to the noisy video to get the noise-less video. In the next section each step of the proposed methodology is explained in detail-

A. Proposed Filter

In order to remove the impulse noise from the video/image, linear filter can be applied but due to the poor performance of this kind of filter in removing the impulse noise, it is obviously not a good alternative. Apart from this linear filter tends

to filter out the high frequency component from the video/ image and produced a blurry edges which is not desirable.

Therefore it is important to design and develop some kind of filtering algorithm which can be able to remove not only the impulse noise but also preserve the high frequency component. Non-linear filter are considered as the best filter to remove such kind of noise but even these filter also fail to perform well if the video/image is corrupted with high density of impulse noise. It is due to the fact that these filter process all the pixel during the filtering operation without considering whether the pixel is noisy or not.
The proposed filtering algorithm, process each pixel by first testing that the present pixel is noisy or not. If it is noisy then it is processed otherwise it will be kept intact.

B. Impulse Noise Detection

In the proposed filtering approach, noise detection stage is applied before applying the filtering algorithm. Noise detection stage, first of all detect whether the present pixel is noisy or not. Any of the pixel whose values gets change drastically to either 255 or 0 or any other values which is much higher than the neighbouring pixel are assumed as the noisy pixel. Once the pixel is detected as the noisy one then filtering stage is applied to this noisy pixel to compute the actual value of the pixel. In the next section, filtering algorithm for the noisy pixel is described.

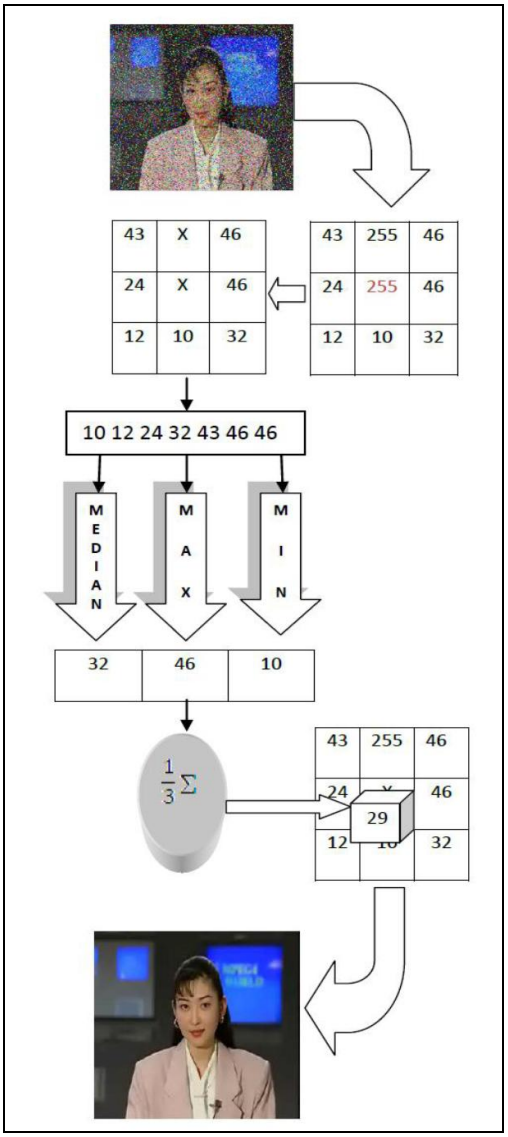

Figure 4 Illustration of the proposed filter for single noisy frame

A. Proposed Algorithm

The pixel value of the frames impregnate with impulse noise differs considerably from that of the neighbouring pixel. This type of noise can be removed in spatial domain only effectively. In spatial domain, median filter, max filter, min filter are those non linear filter which are used for removing the impulse noise. if these non linear filter are used in some modified form then a better noise suppression cab be achieved. Considering all these important points,this hybrid filter is designed. Block diagram of proposed filter is depicted in Fig,4. First a 3X3 window is made to run across the noisy frames from left to right and top to bottom.

The detection of noisy or noise-less pixel is governed by checking whether the value of the central pixel of the selected window lies in

between the maximum and minimum values within the window. If the value of considered pixel lie within this range then this is considered as uncorrupted pixel and left intact. But if the value of considered pixel doesn't lie within this range then it is considered as corrupted pixel and undergoes filtering operation. This corrupted pixel value is replaced with a new pixel value which is obtained by applying three non linear filtering operation, i.e. median operation, max operation, min operation in a modified shaped window.

Since the Median filter removes both salt and pepper noise while max and min filter are used for removing pepper noise and salt noise respectively, therefore by applying all the three operation and then computing the average of all the three output gives a very effective and efficient noise removing algorithm. Modification of window shape as per the noise free pixel present in the selected window is carried out as described in next section . In the above figure 4. X is a Pixel values which are noisy and hence considered in processing.

The Max, Median and Min filters are defined as

$$\hat{f}(x,y) = \max_{(s,t)\in S_{xy}} \{g(s,t)\}$$

$$\hat{f}(x,y) = median_{(s,t)\in S_{xy}} \{g(s,t)\}$$

$$\hat{f}(x,y) = \min_{(s,t)\in S_{xy}} \{g(s,t)\}$$

Where

$\hat{f}(x,y)$ = Restored Image

S_{xy} = Set of coordinate in rectangular window of size m x n, cantered at point(x, y)

B. Window shape Modification

In this proposed filtering method the size and shape of window is very important. The size of window is chosen as of having odd dimension. It is started from 3 x 3 dimension up to 9×9 dimension. Since by carrying out extensive experiment it was observed that 3×3 window gives better result than any other dimension therefore, the size of the window is chosen as 3×3 size. The size of the window is kept fixed throughout the filtering process. But it is a shape of the window that is made to changes as per the number of noise-less pixel within the selected window.

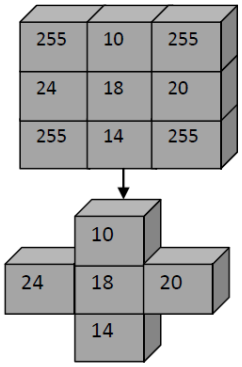

Figure 5 Shape modification of 3x3 Window

As shown in fig.5 only the shape of the window is modified as per the noise-less pixel obtained within 3×3 window and therefore this shape is dependent upon the number of noise free pixels present in the neighbouring of the processing pixel. A 3x3 window can have any shape out of 29 different possible combination shape.

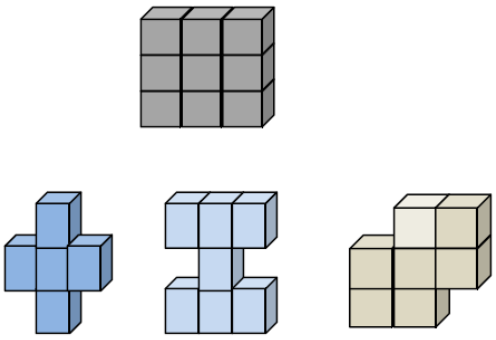

Figure 6 Some possible shape of 3 X 3 Windows

IV. EXPERIMENTAL RESULTS

In order to test the proposed method of noise filtering in the video, a video is taken and converted in to a frames with the help of video to frame conversion module. then each of the frames are corrupted with the salt and pepper noise of different density. This corrupted noisy frames are then again converted in to a video by using frame to video conversion module which is designed for this vary purpose.

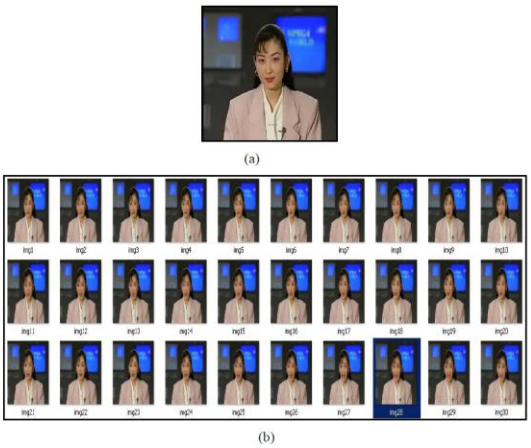

Figure 6 (a) Original Video(akiyo) (b) First 30 Frames of the video

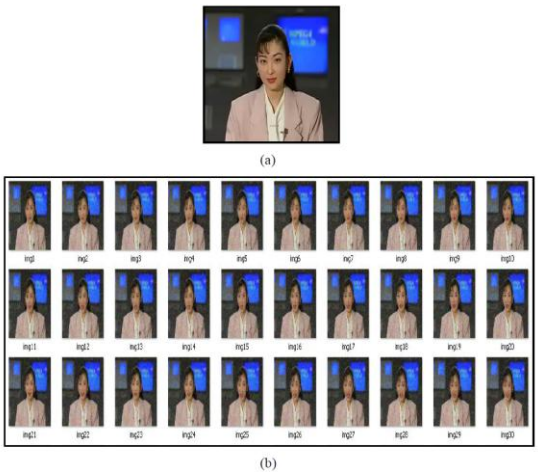

Figure 7 (a) Original Video (b) First 30 frames corrupted with 10% salt and Pepper Noise

The proposed algorithm works on the basis of fixed size(3x3) but variable shape window. The akiyo Video is taken as a test video and it is been corrupted to various percentages of impulse noise. Since the main objective of this algorithm is to suppress the noise and noise suppression can be identified by the parameter MSE. The proposed algorithm is tested for Akiyo, rhino and coastguard video corrupted with various noise percentages.

Table 1: PSNR comparison of Proposed, Standard method

Impulse Noise (in percentage)	PSNR for "Akiyo" video	
	PSNR for Proposed method	PSNR for standard method
10	28.94	25.72
20	27.6	23.61
30	26.5	20.62
40	25.3	17.39
50	23.77	14.28
60	21.27	11.48
70	17.34	9.32
80	13.04	7.55
90	8.99	6.15

Table 2: MSE Vs Impulse noise for Akiyo Video

Impulse Noise (in percentage)	MSE for "Akiyo" Video	
	Noisy Image	Filtered Image
10	**1984**	**81.64**
20	**4118.5**	**111.67**
30	**6167.8**	**143.16**
40	**8140.1**	**188.63**
50	**10055**	**268.65**
60	**12174**	**477.59**
70	**14217**	**1180.3**
80	**16042**	**3176.1**
90	**18184**	**8063.6**

Proposed algorithm is compared with the standard method which is given in IP tool box of Matlab All the algorithm was implemented in MATLAB® Version 2009B with system configuration of 3.0 GHz processor speed and 2 GB RAM.

The results were taken with the parameters like PSNR, MSE, which are shown in Table 1, Table 2 , Table 3. From Fig.8, Fig. 9, and Fig. 10, it is observed that the proposed algorithm outperforms the standard method algorithm.

Table 3: MSE comparison of Proposed, Standard method

Impulse Noise (in percentage)	MSE for "Akiyo" Video	
	MSE for Proposed method	MSE for standard method
10	81.64	171.6

20	111.67	278.6
30	143.16	553.6
40	188.63	1167.3
50	268.65	2386.7
60	477.59	4548.8
70	1180.3	7475.8
80	3176.1	11245
90	8063.6	15527

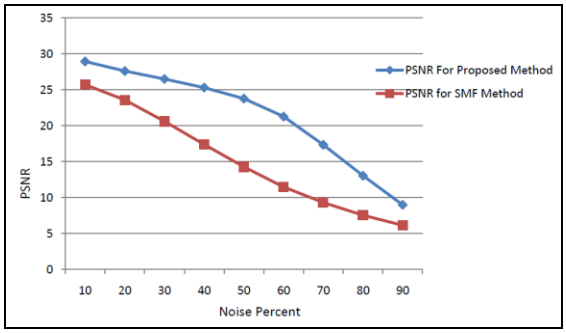

Figure 8 PSNR Comparison for proposed, standard Median Method

Figure 8 represent the comparison graph for PSNR between SMF(Standard median filter method) and proposed method of noise filtering. From this graph it is clear that for each and every noise percentage PSNR value for the proposed method is better than the standard median filter method. In case of standard medina filter method as we increase the noise percentage the PSNR value start decreasing. Same pattern is followed in case of proposed filter method. In case of noise percentage 50, PSNR for the proposed method is around 24 dB while for the standard median filter method it is around 14dB.

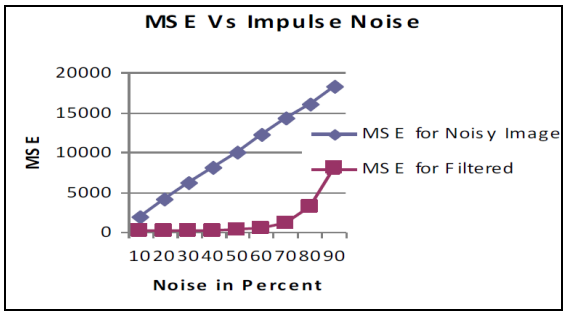

Figure 9 MSE Vs Impulse Noise for noisy and filtered video

Figure 9 represent the MSE versus noise density graph for noisy and filtered video. From this graph it is clear that MSE for the filtered video by proposed method is very less as compared to the MSE of the noisy video. must be as low as possible.

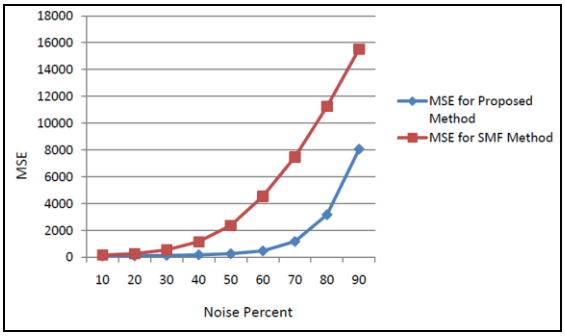

Figure 10 MSE Vs Impulse Noise for "akiyo" video

Up to the noise percentage of 60, MSE for filtered video remains almost constant nearly equal to zero after that it start increasing. For good or noise free video the value of the MSE is very less.

On the basis of this , it is clear that proposed method is much better in overcoming the noise from the video.

Figure 10 represent the MSE Versus Impulse noise curve for both proposed filter method and the standard Median filter method. It is evident from this graph that the MSE value is much less than the SMF method for almost all the noise percentage. This curve shows that the video filtered by the proposed method has less error with respect to the original video.

III. CONCLUSION

One of the primary motive of this work is to design and develop an efficient and effective algorithm of filtering for removing the salt and pepper noise from the video impregnate with high density of such type of noise. In this paper, such type of framework has been proposed and developed. The main focus was not to develop the framework for the noise removing but to study and analyse the de-noising phenomenon in video sequence and to find out the possible reason why the median filter based approach go flat in case of high density noise affected videos. A very efficient noise filtering algorithm has been presented here in this regard which before applying the de-noising algorithm , detect the existence of the noisy pixel. Simulation result shows that the proposed filter outperform the standard median filter based de-noising algorithm by fair margin in removing the high density impulse noise from the video sequence..

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