ADAPTIVE DENOISING TECHNIQUE FOR COLOUR IMAGES

S.R.Preethi[1], P.Latha[2]

[1]*Assistant Professor, Department of ECE, Valliammai Engineering College*
[2]*Associate Professor, Department of ECE, ST.Joseph's College Of Engineering*

Abstract

In digital image processing noise removal or noise filtering plays an important role, because for meaningful and useful processing images should not be corrupted by noises. In recent years, high quality televisions have become very popular but noise often affects TV broadcasts. Impulse noise corrupts the video during transmission and acquisition of signals. A number of denoising techniques have been introduced to remove impulse noise from images . Linear noise filtering technique does not work well when the noise is non-adaptive in nature and hence a number of non-linear filtering technique where introduced. In non-linear filtering technique, median filters and its modifications where used to remove noise but it resulted in blurring of images. Therefore here we propose an adaptive digital signal processing approach that can efficiently remove impulse noise from colour image. This algorithm is based on threshold which is adaptive in nature. This algorithm replaces the pixel only if it is found to be noisy pixel otherwise the original pixel is retained thus it results a better filtering technique when compared to median filters and its modified filters.

Keywords: *impulse noise, Adaptive threshold, Noise detection, colour video*

---***---

1. INTRODUCTION

Digital image processing is used widely in many important fields such as medical imaging for diagnosis of diseases, face recognition for security purposes and so on. Hence it is necessary that image and video should be noise free for various processing. Often the image and video are corrupted by impulse noise. Impulse noise is also known as spike noise or salt and pepper noise. Impulse noise results in dark pixels in bright regions and bright pixels in dark regions. Impulse noise is mainly caused during analog to digital conversion, pre-processing, compressing of images and videos, transmission of signals and acquisition of signals (i.e.) while broadcasting of signals, storing and retrieval of images and videos. Impulse noise is generally of two types fixed value impulse noise and random value impulse noise. In fixed value impulse noise the noisy pixel will have minimum or maximum gray level value, thus it introduce grey level value 0 (salt) and gray level value 255 (pepper) to the original image and hence impulse noise is known as salt and pepper noise. In random value impulse noise the noisy pixel will have random value of gray level value. Impulse noise is generally characterized by replacing some portion of pixels in image by noisy pixels and leaving the remaining part of pixels in the image unchanged.

In section II the related works of various impulse noise removing techniques are discussed. In section III, disadvantages of existing techniques are given. In section IV, the adaptive threshold algorithm is explained in detail. The implementation results are given in section V. In section VI, the results and comparisons are given. The conclusion is presented in section VII and future works is discussed in section VIII.

2. RELATED WORKS

2.1 Impulse Noise Removal using Mean Filters:

Mean filter is a linear filter. In mean filter the pixel is replaced by mean of neighbourhood pixel. Mean filter is a linear filter and it is suitable for removing Gaussian noise from images

2.2 Impulse Noise Removal using Median Filters and Weighted Median Filter[1]:

In median filter the pixel in original image is replaced by median of neighbourhood pixels. Median filter is a smoothening filter and thus it preserves the edges. Median filter preserves the position of boundaries in an image and thus makes the image useful for visual enhancement and various measurements. As a extension of median filters there came Weighted Median (WM) filter. WM filter gives more weightage to some selected pixels. In this filter each window position is assigned a weight and then the sample inside filter window is duplicated to number of corresponding weight. Median values of neighbourhood pixel from the increased list of samples gives the WM output.

2.3 Analysis of Centre Weighted Filter [1]:

Centre Weighted Median (CWM) filter is a sub-class of Weighted Median filter.CWM is one of important WM filter because it is easy to implement and is best understood theoretically compared to many WM filter.CWM filter has useful properties such as noise preserving and suppressing of noises especially heavy-tailed noise. In CWM filtering technique more weight is given only to the centre value of window and thus making CWM filer easier to design and implement than other WM filters.

2.4 Impulse Noise removal by using Simple Adaptive Median Filter [2]:

Simple Adaptive Median (SAM) filter is used to remove impulse noise.SAM is a hybrid of adaptive median filter and switching median filter. In SAM filtering technique noisy pixels and noise free pixels are identified and noise free pixels are sent to the output without any modifications where as noisy pixel values are replaced by values from already precomputed look-up table and hence reducing the execution time.SAM filter uses square filters, this filter is further extended to Circular Simple Adaptive Filter (CSAM)where CSAM uses circular filter. Thus CSAM becomes more efficient than SAM as errors associated with square kernels are minimized. This SAM and CSAM can further be extended to Weighted Simple Adaptive Median (WSAM) filter and Weighted Circular Simple Adaptive Median (WCSAM) filter by adding weights to those filters.

2.5 Impulse Noise Removal using Fuzzy Logic [3]:

In this filtering technique 0's and 255's are removed from the image and the median of the neighbourhood pixel is found and it is used instead of noisy pixel. This technique is based on fuzzy logic.

2.6 Impulse Noise removal using Image Denoising Technique [4]:

In this paper Simple Edge Preserved Denoising (SEPD) and (Reduced Simple Edge Preserved Denoising(RSEPD) techniques have been employed to locate the edge of noisy pixel. Here in this technique a pixel is checked whether it is noisy pixel or noise free pixel, if it is a noisy pixel then SEPD locates if directional edge is existing in the current noisy pixel and it replaces noisy pixel with determined reconstructed value. In SEPD twelve edge differences are considered to detect the proper edge. When more edges are considered the computational complexity is increased by using this technique. Hence to further reduce the computational complexity RSEPD technique is used. This RSEPD technique uses only three edge differences to detect proper edge. But the image produced is of lower quality compared to SEPD but it has much reduced complexity when compared to SEPD.

3. DISADVANTAGES OF PRESENT SYSTEMS

Mean filters is not suitable for removing impulse noise from images . Hence median filters are found to be capable of removing impulse noise. Median filters often remove desirable details and blurs the image. Further, median filters can remove noise only if noisy pixels occupy less than one half of neighbourhood area. It has high computational cost. Though WM and CWM can overcome the disadvantages of median filter they are applied uniformly without considering whether the pixel is noisy or noise free. The disadvantages of WM and CWM filter are overcome by SAM filter but here in SAM filter the noisy pixel value is replaced by value from look-up table without checking if it is correct value by considering the neighbourhood pixels. In noise removal technique using fuzzy logic 0's and 255's are removed without considering them if it is noisy or noise free. Further this fuzzy technique can be used to remove impulse noise from gray scale image only. In denoising techniques such as SEPD and RSEPD there is need to compute three to twelve edge differences thus increasing the time complexity.

4. PROPOSED WORK

In this chapter we propose an efficient noise removal algorithm using adaptive digital signal approach to remove impulse noise which have fixed and random value from gray scale images and from colour images . Here we use threshold whose value is adaptive in nature. The proposed algorithm technique is splitted into two parts which can be used to remove impulse noise. The first part involves detecting if pixel is noisy or noise-free.the second part involves replacing the detected noise free pixel by pixel value found out using adaptive threshold.

4.1 Adaptive Threshold Algorithm

The proposed adaptive threshold algorithm has two parts
1. Noise Detection
2. Adaptive Filter

4.2 Noise Detection

Consider a 3x3 image in which there are 9 pixels as shown below

$f_{i-1,j-1}$	$f_{i-1,j}$	$f_{i-1,j+1}$
$f_{i,j-1}$	$f_{i,j}$	$f_{i,j+1}$
$f_{i+1,j-1}$	$f_{i+1,j}$	$f_{i+1,j+1}$

Fig 1 3x3 window

In the Fig 1 $f_{i,j}$ is currently processed pixel then pixels $f_{i-1,j-1}$,$f_{i-1,j}$,$f_{i-1,j+1}$ and $f_{i,j+1}$ are already processed pixel and thus the mean of done-filtered pixels around the currently processed pixel is computed and stored in variable $DM_{i,j}$ using equation (1)

$$DM_{i,j}=\frac{f_{i,j-1}+f_{i-1,j}+f_{i-1,j+1}+f_{i-1,j-1}}{4} \quad (1)$$

Aside from $DM_{i,j}$ we have another parameter $YM_{i.j}$. The pixels $f_{i,j+1}$,$f_{i+1,j-1}$,$f_{i+1,j}$ and $f_{i+1,j+1}$ are pixels which should be processed. The mean of pixels that have not yet been processed is found out and stored in variable $YM_{i,j}$ which is given in equation(2)

$$YM_{i,}=\frac{f_{i,j+1}+f_{i+1,j-1}+f_{i+1,j}+f_{i+1,j+1}}{4} \quad (2)$$

$DM_{i,j}$ and $YM_{i,j}$ offers local mean for the processed pixel.If currently processed pixel is not corrupted by noise then the pixel value is close to $DM_{i,j}$ or $YM_{i,j}$.

Thus noise detection can be expressed as

$$\begin{cases} \text{if } \left| f_{i,j} - \frac{(DM_{i,j}+YM_{i,j})}{2} \right| > Th & f_{i,j} \text{ is corrupted } f_{i,} \text{ corrupted pixel} \\ \text{otherwise,} & f_{i,j} \text{ is a noise free} \end{cases} \quad (3)$$

where Th is noise threshold.

From equation (3) one can decide if the currently processed pixel is corrupted by noise or it is a noise free pixel. Based on this result non-linear filtering can be done.

4.3 Non-Filtering Technique

Based on the result of noise detection nonlinear filtering procedure is used to remove noise which is given by

$$\begin{cases} f_{i,j}^{\wedge} = DM_{i,j}, & f_{i,j} \text{ is corrupted pixel} \\ f_{i,j}^{\wedge} = f_{i,j}, & f_{i,j} \text{ is noise-free pixel} \end{cases} \quad (4)$$

Thus the corrupted pixels are replaced by average of previously filtered pixels and the noise free pixels are kept as it is. This filtering technique blurs the edges and hence edge detection (ED) is adopted to improve the filtering quality. Thus for filter to work efficiently one has to see if processed pixel belongs to edge or noisy pixel in nonsmooth regions. If the decision is incorrect, either image edges become blurred or noise cannot be removed and also filtered error will be propagated to next processing pixel due to recursive nature of algorithm. Hence accurate computation of edge parameter is needed. Edge computation for noisy pixel is tedious as some of the edges are already destroyed and this gives erratic result due to noisy pixels. Therefore to avoid noisy pixel inclusion horizontal edge factor is adaptively computed using previously processed pixels. The horizontal ED parameter is given in equation (5)

$$ED = \sum_{m=4}^{1} \left| f_{i-1,j-m} - f_{i,j-m} \right| \quad (5)$$

Where pixels $f_{i-1,j-m}$ and $f_{i,j-m}$ have already been filtered. Thus by considering only horizontal ED the computational complexity is reduced.

.

4.4 Threshold Computation

Depending on ED value dynamically adjust noise threshold Th to reduce edge distortions. Noise Ratio (NR) is computed using Noise Counter (NC). The NC increases by one if noisy pixel is found. Depending on ED and NC parameters, the adaptive function F for noise threshold can be given by equation (6)

$$Th = F(ED,NC)=k_1 + k_2 xED - k_3 xNC \quad (6)$$

Here $k_1 \sim k_3$ are constants. NC_{t-1} is the noise count found from the previous processed frame.

4.5 Architecture Of Noise Reducton Processor

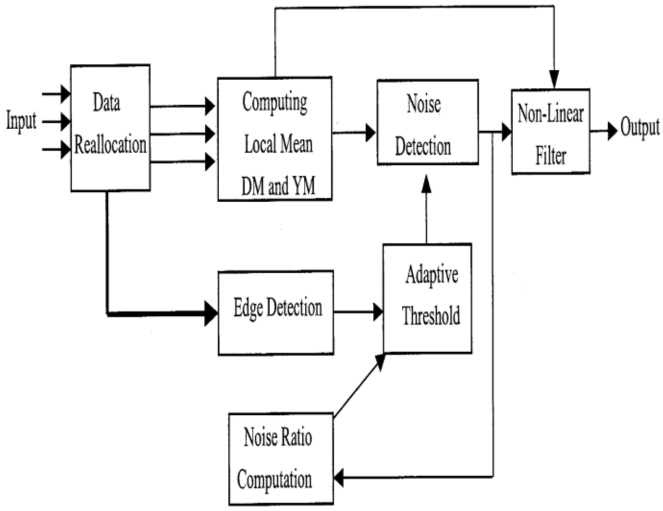

Fig 2 System architecture of noise reduction processor

Fig 2 shows the system architecture of noise reduction processor. Here there are three scanning lines are given as input which are used for data reallocation .Then parameters such as DM, YM and local mean are computed. Edge detection parameter ED is calculated and NR is calculated from previously processed image. These two parameters are used for computation of noise threshold Th. Using these parameters noise detection is performed to check if pixel is noisy or noise free and based on this result non-linear filtering is done.

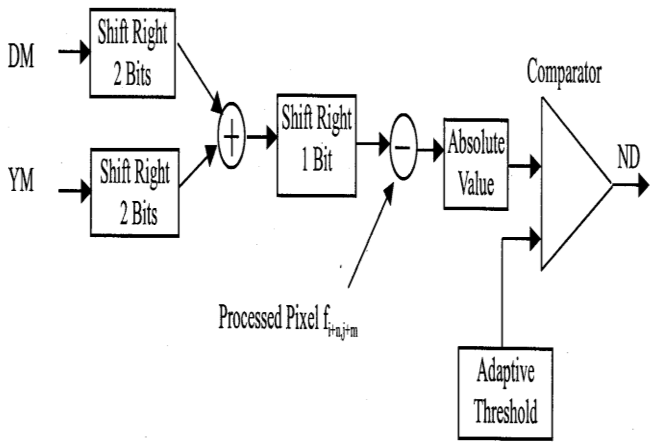

Fig.3 Functional diagram of Noise Detection

In Fig 3 the DM and YM values are averaged by right shift operations and then it is subtracted from processed pixel to get the absolute value. This absolute value and adaptive threshold value are compared to check if current pixel is noisy or noise free.

5. SIMULATION USING MATLAB:

Fig 4 Input image

Fig 5 Output image using adaptive denoising technique for 10% noise density

Fig 6 Output image using adaptive denoising technique for 25% noise density

Fig 7 Output image using adaptive denoising technique for 50% noise density

Fig 8 Output image using adaptive denoising technique for 80% noise density

The fig 4 is given as the input image.Then impulse noise is added with various noise density to input image. The Fig 5 shows the output image for noise density of 10%. The Fig 6 shows the output image for noise density of 25%. The Fig 7 shows the output image for noise density of 50%. The Fig 8 shows the output image for noise density of 80%.

6. RESULTS AND DISCUSSIONS

The quality of sequence of output frames can be measured using PSNR and MSE values. PSNR ratio is often used as a quality measurement between the original and noise removed image. The higher the PSNR, the better the quality of the compressed, or reconstructed image. The MSE represents the cumulative squared error between the compressed and the original image, whereas PSNR represents a measure of the peak error. The lower the value of MSE, the lower the error.

Peak Signal to Noise Ratio (PSNR):

It is measured in decibel (dB) and it is defined as:

$$\text{MSE} = \frac{\sum i \sum j (Xij - Rij)^2}{(MxN)}$$

$$\text{PSNR} = 10\log10 \times \frac{(255X255)}{MSE}$$

Where
X - Original Image.
R - Restored Image
M x N - Size of Image.
MAE - Mean Absolute Error.
MSE - Mean Square Error.
PSNR - Peak Signal to Noise Ratio.
The higher the PNSR in the restored image the better is its quality. Based on the values of PSNR a graph is plotted between noise density in X axis and PSNR values in Y axis and is shown in Fig 9.

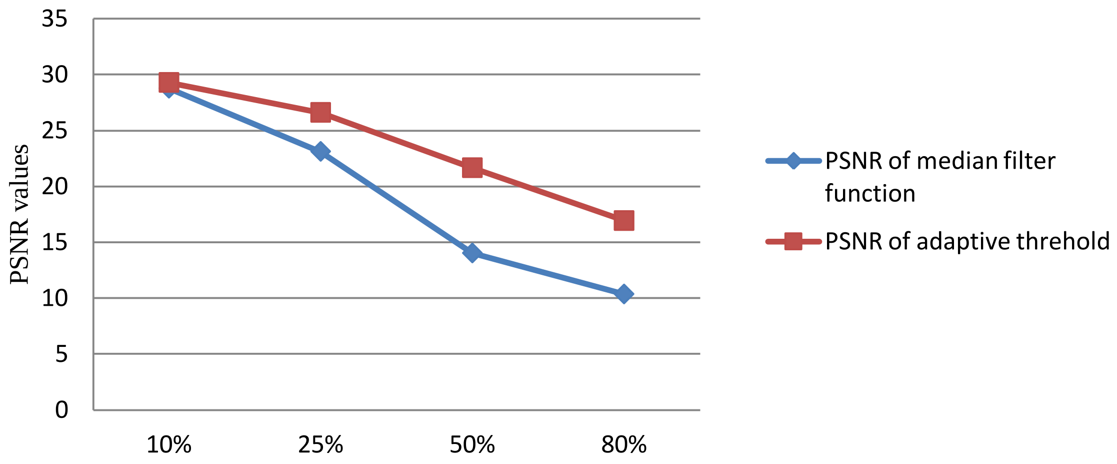

Fig 9 Noise density Vs PSNR graph

From Fig 9 it can be seen that PSNR values of adaptive threshold algorithm are high in 50% and 80% noise density when compared to PSNR values of median filters and adaptive threshold algorithm results in efficient removal of impulse noise.

For colour image processing three noise filter processing have to be done to filter red-green-blue (RGB) components for each pixel directly. However, in order to reduce computational time we can convert RGB image into YUV domain. Since Y is luminance signal, the noise will clearly appear in colour image if Y is corrupted signal. For image noise filtering, Y signal processing is much more important than U and V signals. Hence only Y signal is filtered with one noise filtering process.

7. CONCLUSION

In this paper a high-performance algorithm for removing impulse noise from colour image has been presented. This adaptive denoising technique is suitable for efficient removal of impulse noise in high noise environment. This algorithm provides better and fast filtering of noise than conventional and improved versions of median filters.This can be futher developed and implemented in resonfigurable system on chip to remove impulse noise.

REFERENCES

[1]. Tong Sun, Moncef Galbouj and Yrjo Neuvo,"Analysis of two dimensional centre weighted median filter," Multidimensional systems and signal processing, page no.159-172, January 1994.
[2]. Vipul D.Punjabi,Shiv Kumar and Neetesh Gupta,"A survey on removal of impulse noise from images by reducing execution time,"World Journal of Science and Technology 134-136,April 2012.
[3]. Jasdeep Kaur, Pawandeep Kaur and Preetinder Kaur,"Review of impulse noise reduction techniques using fuzzy logic for image processing," International Journal of Engineering and Research Technology, vol no.01, July 2012.
[4]. P.Kalaiselva ,S.Vasantha,"VLSI implementation of impulse noise removal using image denoising technique,"IJCE,vol.02,no.02,March2012.
[5]. S.-C. Hsia, "Parallel VLSI design for a real-time video-impulse noise-reduction processor," IEEE Trans.Very Large Scale Integr.(VLSI) Syst., vol. 11, no.4,pp. 651–658, Aug. 2003
[6]. G.Sreedevi,Dr.M.ZKuria,"FPGA based denoising technique for efficient removal of impulse noise in images,"IEEE Trans.
[7]. Eduardo Abreu, Michael Lightstone, Sanjit.K.Mitra and Kaoru Arakawa , "A New efficient approach for removal of

impulse noise from highly corrupted images,"IEEE Transactions on Image Processing,vol no.05, June 1996.
[8]. ManoharAnnappa Koli,"Review of impulse noise reduction techniques,"International Journal of Computer Science and Engineering, vol no. 04,February 2012.
[9]. I. Aizenberg and C. Butakoff, "Effective impulse detector based on rank-order criteria," IEEE Signal Process. Lett., vol. 11, no. 3, pp. 363–366, Mar. 2004.
[10]. W. Luo, "Efficient removal of impulse noise from digital images," IEEE Trans. Consum. Electron., vol. 52, pp. 523–527, May 2006.
[11]. P. Latha, Dr. M. A. Bhagyaveni, and S. R. Preethi, ,"Efficient Removal Of Impulse Noise From Video Using Adaptive Threshold Algorithm", Journal of Theoretical and Applied Information Technology, 10th June 2014.