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An Enhancement in Adaptive Median filter for Edge Preservation

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Abstract

Median filtering is a corner stone of medical image processing and it is extensively used in smoothing and denoising of medical images. Edges are one of the important feature in biomedical imaging for the problem such as hair crack detection, tissue damage detection. Median filter removes the noise but during the noise removal phase it also remove the edges that are important feature/information for images in classification/recognition task. In this paper an enhancement in existing median filtering has been proposed that preserve more edges without much lose in Peak signal to noise ratio(PSNR) and signal to noise ratio SNR). In this paper we also proposed a new parameter for performance evaluation Edge Retrieval Index (ERI) that evaluates the edge preservation index in images.The algorithm cleans up the imagenoise in the homogeneous areas, but preserves the edges in other region.

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Keywords: Edge preservation; Adaptive Median filter; Median filters;

1. Introduction

Median filter is extensively used in literature for smoothing and filtering the digital images. Tukeyet. al. [1] has introduced median filter in 1977 as scale invariant nonlinear smoothers for reducing image noise while preserving edges effectively. Tremendous efforts has been carried out into its optimization and refinement

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median filter performs quite well, but it falters when the probability of impulse noise occurrence becomes high. The objective of medical image processing is not only noise suppression but the edge preservation is also an important issue.

Definition 1 [Median Filter] : Given a set of random variables X = (X1;X2; …………XN), the order statistics X(1) , X(2) , X(N) are random variables, defined by sorting the values of Xi in an increasing order. The median value is then given by equation 1 [2].

$$median(X) = \begin{cases} X_K; \text{For n = Odd Number of Terms; K is median} \\ \frac{1}{2}(X_k + X_{K+1}) \; For\ n = Even\ \ Number\ of\ Terms \end{cases}$$

For a grayscale input image with intensity values$X_{i,j}$ two-dimensional median filter can be defined as

$$Y_{i,j} = \underset{(r,s)\in W}{\text{median}}(X_{I+r,J+s})$$

where W is a window , r and s denote rows and column size of window, over which the filter is applied. For the rest of this paper, we assume symmetric square windows of size MXM. In Median filter each pixel is replaced by median value of its neighborhood pixels intensity value.

The mean, median and mode value for Gaussian distribution of intensity is shown in Figure 1. If the data exist in bell shaped curve, the substitution with mean, median and mode may be used for smoothen the data, but if data is very farthest away from the mean it may be noise in data or and its substitution with mean or median will affects the analyzed results.

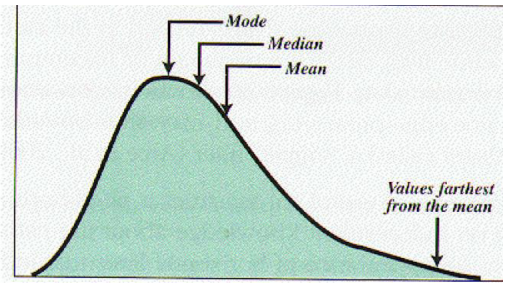

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Fig. 1. Mean, mode and Median of Gaussian distribution of data

The result obtained in experimentation using different versions of median filters are encouraging and pave the way to a further investigation in median filter for edge preservation specially for bio-medical images in which edges are important features for disease detection like hair crack detection in bones, forensic examination of an image.

Edges also occur in biomedical signals when the system moves from one state to another. In order to effectively eliminate impulsive noise [3, 4] has proposed the optimal filter for bi exponential noise in a similar manner as the sliding average is for Gaussian noise.

We summarize our contributions as follows:

1. We proposed an enhanced t median filter that does smoothening, removal in noise in images as well preserve the edges.
2. We propose two new evaluation parameter edge preservation ration and edge retrieval index.

Definition 3 [Continuity Property] - An edge is a trace generated by a pixels in spatial domain, usually represented by a series of ordered points in horizontal, vertical or diagonal direction. If $X_{i,j}$is a part of edge it must be continuous in any of the direction like $X_{i,j+1}$, $X_{i,j-1}$, $X_{i-1,j}$, $X_{i+1,j}$ of its neighboring pixels [5].

Length(Edge) is number of cells covered by edge continuously in any of its eight nearest pixels as shown in Figure 2.

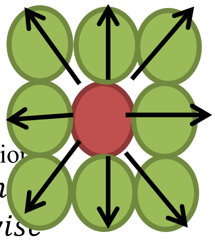


Fig. 2. Eight Nearest neighbor of Pixel.

Noise or edge can be discriminate using equatio

$$I = \begin{cases} length & Noise \\ otherwise & Edge \end{cases}$$

Where ∈ is a threshold value for length of edge that would be consider as an edge, I stored desired output.

Definition 3 [Edge Preservation ratio] – The ratio of edge in original image and edge persist after filtering process is called edge preservation ratio. Ni is number of edge in filtered image No number of edge in image.

$$\textbf{Edge Preservation ratio} = \frac{N_o}{N_i}$$

2. Related Work

In literature median filter is extensively used for all types of images. Median filtering outperforms linear filteringfor suppressing noise in images with edges [6]. Loupaset. al. [7] proposed algorithms adaptive weighted median filter
(AWMF) and it is based on the weighted median for ultrasound images. Ben Weiss et. al [8] introduced concept of Fast Median and Bilateral Filtering that reduces the computational complexity of median filter from O(r) to O($\log^2$(r)), that decreased the computational cost of algorithm.

There are many enhancement over median filter were proposed .An Impulse noise detection & removal with adaptive filtering approach was proposed by mamtajuneja [9] to restore images corrupted by salt & pepper noise. Improved median filter were proposed for salt and pepper noise removal i[10,11]. Loupaet. al [12] These have variable window size for removal of impulses while preserving sharpness of edges.

Edge-preserving smoothing filters are much more suitable for feature extraction. Some examples of this filter class are:

1. Symmetrical Nearest Neighbour Filter (SNN) [13] The SNN smoothing filter is designed to preserve edges by comparing opposite pairs of pixels in the support, and selects those that are closest in value to the central input pixel.
2. Maximum Homogeneity Neighbour Filter (MHN) [14] It is US patent thatidentifies a plurality of homogeneity regions in relative pixel space, that are located relative to a relatively central pixel within a boundary of window.

3. Proposed Approach

Median filters can tend to erase lines narrower than ½the width of the neighborhood. They can also round off corners. Figure 3 show intensity distribution of pixel in image with 0,1 bit for binary image. Pixels value green for 0 intensity and red for 1 intensity. Column 1 of Figure 3 shows the original images and column 2 shows filtered image. It is clear from Figure that median filters and its enhancement version filters filter the edge if it is not covered by ½ of its neighboring pixels. First four row of image in figure 4 were filtered.

In Image 3(a) if central pixel is with high intensity value and its surrounding pixels consist of low intensity, image after filtering replace the central pixel by its surrounding value, this process will continue till the median of pixel image is not affected by high intensity image, which is shown in last column of Figure 2. Small section of image has been taken and result is shown in Figure 3. In practical, some medical imaging problem like hair crack in bones is a thin line that can not be detected by median filtered, due to smoothing value by its surrounding pixels. In median filter edge preservation rate is very less, especially if edges are with low magnitude. Proposed algorithm is specially designed for binary images.

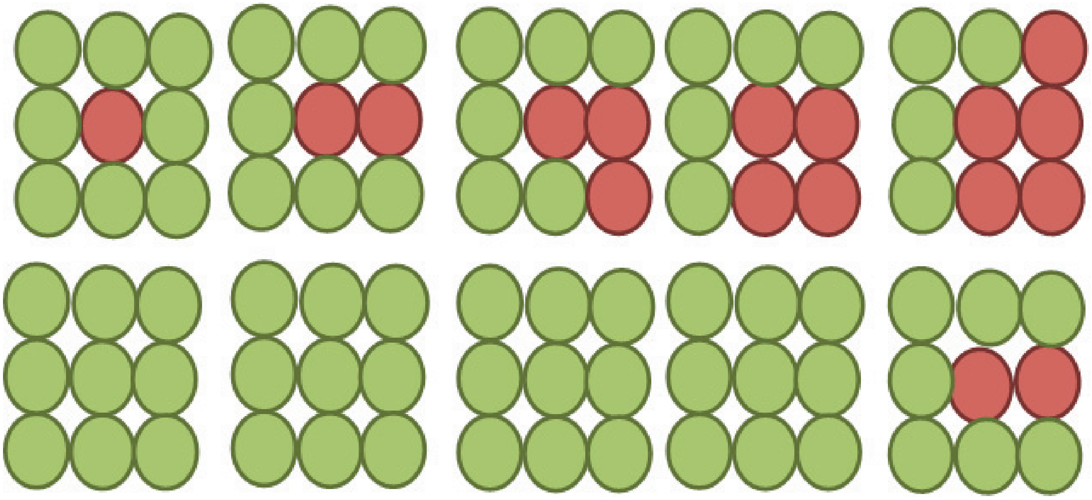


Fig 3. Pixel intensity with 0,1.(a) Column 1 Original image. (b) Filtered Image

For gray scale images a small subsection has been taken that is shown in Figure 4. Its intensity value is shown Figure 5. Result after median filter parsing is shown in second column of Figure 4 and 5 respectively.

Fig. 4. Subsection of an Image (a) Original (b) Median Filtered

10	10	255	255	10	10
255	10	10	10	255	255
10	255	10	10	30	255
10	10	255	10	10	10
10	10	255	10	255	10

→

0	10	10	10	10	0
10	10	10	10	30	10
10	10	10	10	10	10
10	10	10	10	10	10
0	10	10	10	10	0

Fig. 5. Median Filter in Gray scale Image.

Proposed approach overcomes this problem by taking care of edges by considering its neighboring pixels.

Arias et. al. [6] proved that Median filtering outperforms linear filtering for suppressing noise in images with edges, median filter not only suppress the noise it also suppress the edges. In the proposed approach we are considering if the edge by counting it neighboring pixels in all possible directions like horizontal, vertical, diagonal and reverse diagonal. The proposed filter is dependent on user defined threshold∈. not with strength but its length is more than a threshold ∈. It compares pairs of pixels in all direction for support, and selects those that are closest in value to the central input pixel rather than directly median value. It then returns the mean of the selected pixels. In this way, it avoids smoothing across edges.

Algorithm.1 : Proposed Algorithm. An algorithm for Preserving the edge in medical image

Input:I :Input Binary Image;W : SizeofMask, threshold ∈
Output: O :FilterdImaged

1. **compute** [R C] ← size(I) // No of Row and Cols in Matrix
2. I(1,:) ← I; I(R+1,:) ←0; I(:,1) ←0;I(:,C+1) ←0 // zeropadding in First,Last row and First and Last Column of I
3. **compute** N ← W/2;
4. **for each** Row ∈ R //Scan the image from top to bottom
5. **for each** Col ∈ C // Scan the image of mask from left to right
    a. **compute** Mask ← I(Row - N : Row + N; Col - N : Col + N) ;
    b. m← median(median(Mask(:)))
    c. *v1 ←sum(sum(Iedge(i-1:i+1,j-1)));*
    d. *v2 ←sum(sum(Iedge(i-1:i+1,j+1)));*
    e. *h1 ←sum(sum(Iedge(i-1,j-1:j+1)));*
    f. *h2 ←sum(sum(Iedge(i-1,j-1:j+1)));*
    g. *d2 ←sum(sum(Iedge(i==j)));*
    h. **Count**← (v1 ~=0 | v2 ~=0 | h1 ~=0 | h2 ~=0 | d1 ~=0)
    i. **If Count** <∈

Imed(I,j) ←mean (neighbouring(Iedge(i,j)))
Else
Imed(I,j) ← m
End

In algorithm 1 step 1 compute row and columns in input image. In column 2 zero padding in first, last row and first and last column of input image. W is mask of window like 3x3,5x5 always odd number of rows and columns. In step (4) and (5) are used to scan from left to right and top to bottom of image. In step 5(a) it compute small block of mask and step(b) it computes the median value of mask. In step (c)-(g) find number of pixels containing high intensity in horizontal (x-1,y),(x+1,y), vertical(x,y+1),(x,y-1) and diagonal directions of central pixels. If all the neighboring pixels are not zero the count how many of them are supporting pixels if this is less than threshold ∈ then mean of contributing pixels will be considered instead of median positions intensity value. Otherwise median value of mask will be considered for smoothing.

Definition 4 [Edge Retrieval Index]The ability of the filter to retain sharp edges and boundaries in filtered image as that in original noise free image. Its value approaches maximum to 1 for best transformation and minimum to 0 for worst transformation. Assuming that the original noise free image is represented by $I_{i,j}$and filtered image is represented by $F_{i,j.}$ ERI can be represented with equation 5.

$$ERI = 1- \frac{n_i - n_s}{n_i}$$

where n_s is number of edges which are present both in $I_{i,j}$and $F_{i,j.}$ at similar pixel locations i.e i=j.

n_i is number of edges in input image.

4. Evaluation Parameters and Experimental Results

The performance of different filter algorithm can be evaluated using known parameters like Peak Signal to Noise Ration (PSNR), Signal to Noise Ration (SNR) and Mean Square Error (MSE) [16].

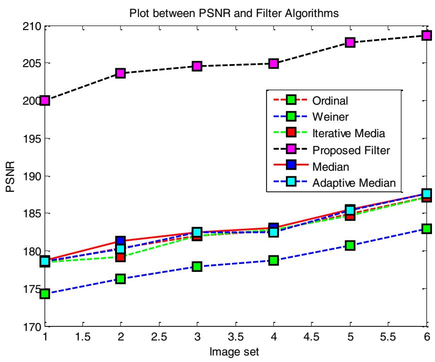
For an experimental evaluation of the proposed detection feature, we make use of a database of altogether 10 never-compressed RGB, gray scale images, stemming from Gonzalea's [15] books digital images and some other sources.. All tests are carried out after converting each image to grayscale prior to any further processing or analysis. The experiments are performed in 5x5 and 7 x7 size of window. The details of images are explained in table 1. In experimentation we have considered median filter, Ordinal filter of mask 4x4, Weiner filter, Iterative median filter, adaptive median filter and proposed filters.

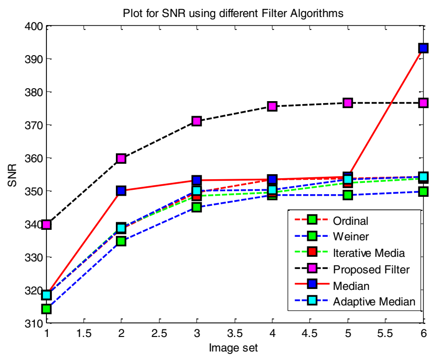
Image	Resolution	DPI	Bit Depth	References
typesoffractures-72	750x486	90 ,90	24	[17]
Bone-images	172x294	96,96	24	[15]
Fig1026(a)(headCT -Vandy)	512x512	300,300	24	[15]
Fig1051(a)(defectiv e_weld)	220x180	100,100	24	[15]
Fig1116(leg_bone)	241x355		24	[15]
Fracture	400x500	96,96	24	[17]

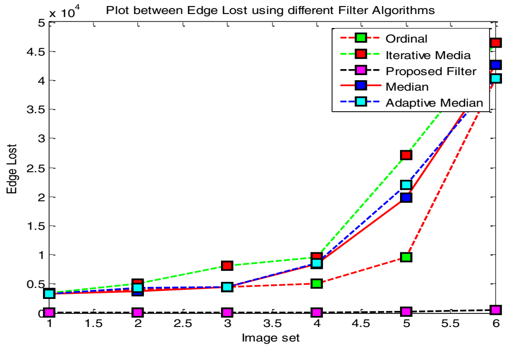
Experimental results are shown in Figure 6,7,8 and 9.

3.1 Discussion

Fig. 6 shows the plot for Peak Signal to Noise ration with different filtering algorithms. To a great extent in the processed image PSNR for Ordinal, Median filter, Iterative filter and adaptive filters are in same range, while proposed algorithm perform better among all and Weiner algorithm performance is lowest for all the images.







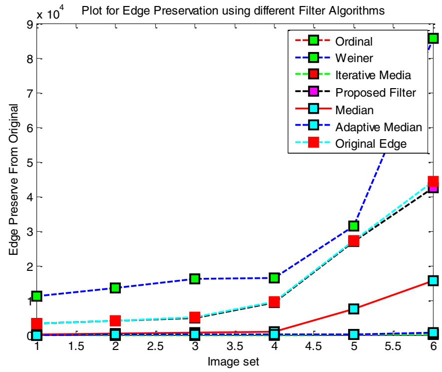


Fig. 6. Peformance plot for PSNR for different median filter`,Fig. 7. Plot for SNR using different filtering technique, Fig. 8. Plot for Edge retrieval index using different filtering technique, Fig. 9. Plot for Edge preservation using different filtering algorithms

Figure 7 shows the plot for SNR, in this criteria again the peformance for Ordinal, Median filter, Iterative filter and adaptive filters are similar upto maximum extent, but in some cases median filter perform better than all other algorithms. Proposed algorithm dominants all other algorithm as shown in figure.

For edge retrieval index as defined in definition 4, ordinal gives good results. The retrieval index is almost same for all remaining filters that we used for experimentation, the performance for proposed algorithm gives dramatically with all test dataset.

Similarly, the edge preservation graph is shown in Figure 9. The blue line with green face shows the edge with original image, the edge preservation is highest for wiener filter. Weiner filter work by converting the image into frequency domain, also increases the thickness of edges.

5. Conclusion

In this paper we proposed an enhancement over median filtering algorithm for edge preservation, by taking care of its neighbouring pixels. Significantly, we have shown that our algorithm can be adapted for noise removal and edge preservation. In experimentation we found that PSNR, SNR are high in compared to other algorithms and edge lost is minimal using our algorithm, while edge preservation is quite effective for most of the images.

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