The International Journal Of Engineering And Science (IJES)
||Volume||2 ||Issue|| 7||Pages|| 49-53||2013||
ISSN(e): 2319 – 1813 ISSN(p): 2319 – 1805

Removal of Noises In Medical Images By Improved Median Filter

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-ABSTRACT-
The impulse noise may present in various images such as binary, gray or in medical images which brings blurring in the image, edges being distorted, poor quality. The impulse noise vulnerable to medical images therefore reduction of such noise from medical images is major concern.For removal of impulse noise many linear and non linear filters are used. But linear filters brings blurring. Therefore noise reduction technique by improved iterative relaxed median filter proposed and effect of noise removal by means of median filtering on fuzzy c means clustering is analysed. The performance and results obtained by proposed method are compared with standard median filter, Centre weighted median filter, hybrid median filter & relaxed median filter.

KEYWORDS: *Improved median filter, Standard median filter, center weighted median(CWM) filter, Impulse noise, Relaxed median filter , Clustering, Hybrid median filters.*

Date of Submission: 1July. 2013 Date of Publication: 25.July 2013

I. INTRODUCTION

Medical images are normally characterized by narrow distribution of gray-levels, thus suffered from high spatial redundancy and low contrast and further degraded by noises particularly impulse noise which is introduced during image acquisition, transmission and storage[3]. Removing noises is highly complex because it requires the balance between the gained improvement and the introduced degradation by a particular filter. Filters that are used for the purpose of denoising are broadly divided into two types, linear and nonlinear filter. Linear filters causes blurring & the edges may get distorted.. Median filters belongs to non linear type filters which provides the best results for salt and pepper noise removal. This is based on the fact that in these types of noisy images certain individual pixels have extreme values which can be removed with ease as the filter is primarily concerned about the median value only. Median filter replace every pixel of the image by the median value of its neighbourhood. The median filter performs well for noise densities less than 50% above which the noise present in the neighbourhood is more than the information and hence the filter's performance deteriorates. Adaptive median filter provides better performance at lower noise densities, due to the fact that there are few

corrupted pixels replaced by median values[1]. At higher noise densities, this replacement increases considerably by adaptive window size. However, the corrupted pixel values and replaced median values are less correlated. Relaxed median filter (RMF) provides better noise removal and detail preservation but results in blurring at high noise densities. Hybrid median filter (HMF) uses diagonal neighborhood evaluation for de-noising, but does not perform well at low noise densities.Image segmentation plays an important role in the analysis and applications of medical image processing. The main purpose of medical image segmentation is to extract interesting regions which contain important diagnostic information for clinical diagnosis and pathology research. Many image processing techniques have been proposed for brain Magnetic resonance imaging (MRI) and Computed tomography (CT) images" segmentation, most popularly thresholding, region growing, edge detection and clustering. Among the statistical clustering algorithms, Fuzzy C-Means (FCM) clustering is most popular for medical image segmentation because of its robustness. A conventional FCM does not use spatial information in the image. Its advantages include a straightforward implementation, fairly robust behaviour, applicability to multichannel data, and the ability to model uncertainty within the data. A major disadvantage of its use in imaging applications, however, is that FCM does not incorporate information about spatial context, causing it to be sensitive to noise.

II. FILTERING METHODS

2.1 Standard Median Filter

The main idea of the median filter is to run through the signal entry by entry, replacing each entry with the median of neighbouring entries. This provides very good noise removal but results in loss of fine details. The small filtering window leads to poor elimination of noise and big one leads to loss of fine details[3]. Let Xi and Yi be the input and the output at location i of the filter, then the standard median filter is given by

Yj = med {Wj } = med {Xi+r : r € W}

Where $[W_i]_r$ r=1,...2N+1,the r^{th} order statistic of the samples inside the window Wi is$[w_i]_1 < [w_i]_2 <\dots [w_i]_{2N+1.}$ Median fiters are quite popular because certain types of noise they provides excellent noise reduction capabilities with less blurring than linear filtering. Median filters are widely used as smoothers for image processing, as well as in signal processing and time series processing. A major advantage of the median filter over linear filters is that the median filter can eliminate the effect of input noise values with extremely large magnitudes.

2.2 Center Weighted Median Filter

The center weighted median filter put more weight on the central value of pixels.Since median filters select the output in a different fashion than do linear filters the observation samples must weighted differently[2].In median filtering case weighting is accomplished through repetations . Thus the output of CWM filter is given by

$$Y(n)= MED (x_{1,\dots\dots}x_{c-1,}x_{c<>}w_{c\ ,}x_{c+1,\dots..}x_N)$$

Where $x_{c<>}w_{c\ ,}$denotes the replication operator. $X\ _{c<>}\ w_{c=}.\ x_{c,}\ .\ x_{c\dots\dots}\ \ x_c(w_c$ times).and N=(N+1)/ 2 =N_1+1 is index of center sample. w_c is odd positive integer.A CWM filter with a larger center weight provides better performance in detail preservation at the expense of impulse suppression.CWM filter with larger center weight perfoms well in detail preservation but worse noise suppression than with smaller central weight.As CWM filters preserves the details and edges while reducing noise.The central weight should be carefully selected depending upon both characteristics of input image and its noise.If CWM with 3x3 square window is selected then central weight should be less than or equal to 3.If image has line to be preserved then 3x3 square window performs best but once having noise suppression then larger window size is selected.

2.3 Hybrid Median Filter

In this filter, three median values are calculated in the N xN window: MR is the median of horizontal and vertical R pixels, and MD is the median of diagonal D pixels. The hybrid median value is the median of the two median values and the central pixel DCR [3]. For N=5;

$$\begin{bmatrix} D & * & R & * & D \\ * & D & R & D & * \\ R & R & DCR & R & R \\ * & D & R & D & * \\ D & * & R & * & D \end{bmatrix}$$

MD = median{D pixels & DCR};
MR = median{ R pixels & DCR };
Let Xij and Yij be the input and the output at location (i,j) respectively, then the hybrid median filter is given by
Yij = medianij {MR, MD, DCR} ;

2.4 Relaxed Median Filter

Let $\{x_i\}$ be m dimensional sequence where the index I ε Z_m .A sliding window is defined as subset W ε Zm of odd size 2N+1.W is sliding window $W_i=\{X_{i+r}\}$,rεW to be located at position i. Lower (l) and Upper (u) bounds, define a sublist inside the [Wi](.), which contains the gray levels which are good enough not to be impulse noise. If the input belongs to the sub list, then it remains unfiltered, otherwise the standard median filter is output. Let m = N + 1 and l, u such that 1 ≤ l ≤ m ≤ u ≤2N + 1. The relaxed median filter with bounds l and u is defined as

Yi = Relaxed median {Wi }

$$\begin{cases} X_i & \text{if } X_i\ \varepsilon\ [[W_i]_l,[\ Wi]_u; \\ [W_i]_m & \text{otherwise} \end{cases}$$

where [Wi](m) is the median value of the samples inside the window Wi.

III. PROPOSED METHOD

3.1.Iterative relaxed median filter (IRMF)

Relaxed median filter results in better noise removal with respect to other median filtering methods. Performance of this filter can be improved further by doing iterative filtering of the input image[9].

Iterative relaxed median filter algorithm is given as follows:

1) Peak signal to noise ratio is calculated between filtered image and the original image.
2) Filtered image is subjected to filtering again.
3) PSNR is calculated for the new filtered image.
4) Check the following condition
   [PSNR(i) - PSiVR(i - 1)) < Min(diff)

If the condition is satisfied, stop otherwise repeat steps 3-4. Where PSNR(i) is peak signal to noise ratio between newly filtered image and the original image.

3.2.SIMULATION STEPS

1) For MR brain image conLipted by impulse noise of different probability densities, apply median filtering methods by considering a window of size (mxn).
2) Replace each pixel value by its spatially modified and filtered value and apply FCM algorithm.
3) Calculate PSNR and MAE.

3.3.FCM algorithm steps

4) Initialize U= [uj] matrix, U(O)

5) At k-step, determine the centers vectors C(k)= [c:i] with U(k)

$$Cj = \frac{\sum_{i=1}^{N} uij.Xi}{\sum_{i=1}^{N} uij}$$

6) update U(k),U(k+1)

$$u_{ij} = \sum_{k=1}^{c} \frac{Xi - Cj}{Xi - Ck}$$

7) If [U(K+1)-U(k)]<ε

then stop the iterations otherwise go to step 2.Find out XBm and Vpe.

IV. VALIDITY FUNCTIONS

4.1.Validity functions for noise removal

Peak signal to noise ratio mean absolute error are used for analysis

$$PSNR = \frac{255^2}{\frac{1}{mn}\sum_{i=1}^{m}\sum_{i=1}^{n}\sqrt{(I(i,j) - I0(i,j))}}$$

$$MAE = \frac{1}{mn}\sum_{i=1}^{m}\sum_{j=1}^{n} I(i,j) - I0(i,j)$$

Where I(i,j) and Io(i,j) are the pixel values of restored
and original images respectively at the location (i, j).

4.2.Validity function for clustering
Quality of a partition provided by clustering algorithmsis evaluated by a function called cluster validity index. Often used validity indices for clustering are Xie-Beni Index.

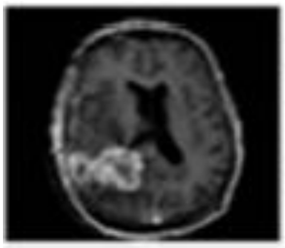
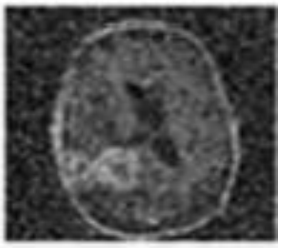
4.3.Xie-Beni Index(XBm)
It is the ratio between the average intra-cluster variation and the minimum distance between cluster centers, and is then related to the ratio between intra-cluster and inter-cluster variance.

V. SIMULATION & RESULTS

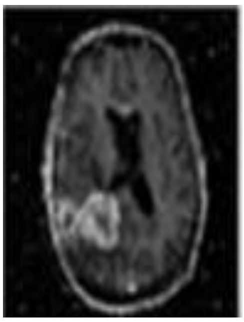
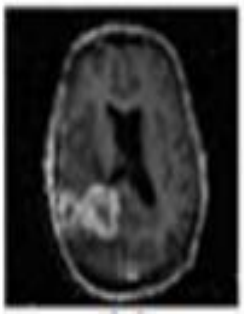
For simulation of noise removal & clustering a 10% to 90% noise is added to MR image.A noisy MR image is filtered by various filters mentioned above & PSNR values are calculated for different noise densities.

Noise Density(%)	**10**	**50**	**90**
SMF	32.05	13.75	5.32
HMF	26.30	14.67	5.58
RMF	27.49	18.26	6.52

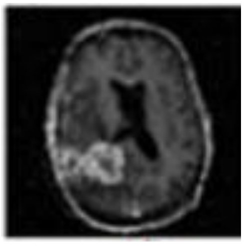
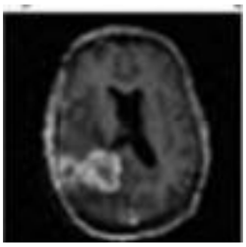
Fig. PSNR for different noise densities

a)MR brain image b) 30% impulse noise added

c) MF filtered image d)HMF filtered image

e)RMF filtered image f)IRMF filtered image

VI. CONCLUSION

From tabular results & images we coclude that IRMF can be used as improved median filter for medical images. It has very good noise removal capability interms of PSNR. Clustering performance is also good for Iterative relaxed median filtered image.

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