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Removal of Motion Artifacts in Brain Images using Different Filtering Techniques

M.V.Sruthi [1], Dr.K.Soundararajan [2], Dr.V.Usha Shree[3]

Assistant professor, Dept. of ECE, PVKK Engineering College, Anantapur, Andhrapradesh, India[1]

Retd. Professor, Dept.of ECE, JNTUA Engineering College, Anantapur, Andhrapradesh , India[2]

Director of Acadamics, Dept of ECE,JBIET Engineering college,Hyderabad,Telangana,India[3]

ABSTRACT: This paper proposes different filtering techniques for removal of motion artifacts in the MRI (magnetic resonance image) images of human brain. Motion artifacts are caused by the motion of the object present in the image during the imaging sequence. This motion of the total object while sequencing the image generally results in blurring. often the motion is caused by the heart beating or the patient breathing. Both of them are not eliminated legally. The solution for this is to gate the imaging sequence to the cardiac or respiratory cycle of the patient .cardiac and respiratory motion results in artifacts in Ct scans of the chest. Those artifacts sources include line noise,eyeblinks,eye movements,heartbeat breathing and other muscle activity . In this paper we exploit different filtering techniques like hybrid threshold filter,median filter ,mean filter,spatial temporal filter, resampling filter and other filters contribution in reducing the effect of motion artifacts without causing deterioration of the original image characteristics.

KEYWORDS *:* median filtering,Gaussian blur, min/max filtering,mean filter.

I. INTRODUCTION

Motion of the patient during an MRI scan can cause severe artifacts in the final image. Such motion is commonplace as MRI requires a long data acquisition time to form an image, typically of the order of minutes. Even healthy volunteers can have difficulty remaining motionless for the required time. The situation is exacerbated by the claustrophobic environment within the scanner which makes many people feel anxious, resulting in more motion. Some groups of patients, such as very young children or patients with tremors, are especially problematic. Motion artifacts are baseline changes caused by electrode motion. The usual causes of motion artifacts are vibrations, movement, or respiration of the subject. The peak amplitude and duration of the artifacts are random variables which depend on the variety of unknowns such as the electrode properties, electrolyte properties (if one is used between the electrode and skin), skin impedance, and the movement of the patient. In this CT image signal, the baseline drift occurs at an unusually low frequency (approximately less than 1Hz).This problem, which is commonly, offers the possibility of reduction of noise, removal of blur, reduction of motion aliasing, increase of spatial and temporal resolutions. More complications arise because sampling is not a point operation and there is a blur associated with it, a relative motion may introduce perspective warp of the scene and there may be a noise due to electronic and optical systems in the camera. Many methods have been implemented to remove the noise from noisy ECG signal. The basic method is to pass the signal through high pass, low pass and notch filters. But these filters are examples of static filters. One of the major disadvantages of these static filter is that these also remove some important frequency components in the vicinity of cut off frequency. The static filters have fixed filter coefficients. It is not so easy to reduce the instrumentation noise with fixed filter coefficients, because the time varying behaviour of this noise is not exactly known. To overcome the limitations of static filters, different adaptive filtering methods have been developed. Other examples of dynamic filters are adaptive Kalman filter, wiener filter, modified extended Kalman filter etc. Apart from these methods, from years, continuous processing techniques using adaptive filters, to suppress the effect of motion artifact [1-6-7], has been under investigation, because, these techniques allow fast response times, does not need signal segmentation, and is able to continue processing under moderate artifact conditions. The removal of these components presents a leading problem because the current techniques do not suppress the artifact efficiently: Either the artifact is only partly eliminated,

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allowing some residual contribution in the desired signals, or not only the artifact is suppressed but also part of the valuable information. Different techniques have been used to suppress the power-line artifact.

II . LITERATURE SURVEY

Different methods have been introduced to remove the noise from noisy images. The simple method is to send the signal through high pass, low pass and notch filters. But these filters are examples of static filters. The main disadvantages of this static filter is it remove some important frequency components in the area of cut off frequency. The static filters have fixed filter coefficients. It is very complicated to reduce the physical noise with fixed filter coefficients, because the time varying behavior of this noise is not exactly known. To reduce the limitations of static filters, different adaptive filtering methods have been developed In the paper "Reduction of motion blurring artifacts using respiratory gated CT in sinogram space: A quantitative evaluation showed The motion artifact was quantified by determining the apparent distance between the two functions. The blurring artifact had a linear relationship with both the speed and the tangent of the wedge angles. When gating was employed, the blurring artifact was reduced systematically at the air-phantom interface .In year 2010, Dr. K.L. Yadav and S. Singh showed the adaptive algorithms i.e. LMS and RLS for reduction of noise in the paper "Performance evaluation of different adaptive filters for signal processing" [4]. In other paper titled, "Optimal selection of wavelet basis function applied to ECG signal denoising", B. N. Singh and A. K. Tiwari have applied an optimal wavelet basis function for denoising of an ECG signal [13]. The experimental results have revealed suitability of Daubechies mother wavelet of order 8 to be the most appropriate wavelet basis function for the denoising application .In the paper titled " Performance Analysis of New Hybrid Thresholding Filter on Biological Signals" In thresholding filter the threshold value is fixed using FDR method and Hypothesis method. The inverse wavelet transform is used to reconstruct the modified detailed coefficients into denoised signal.

III. THEORY

A. Hybrid Thesholding filter: In Genernal applications of image processing, the gray levels of pixels belonging to the object are much different from the gray levels of the pixels belonging to the background. Thresholding has become a simple but effective tool to separate objects from the background. Examples of thresholding applications are document image analysis where the goal is to extract printed characters The thresholding technique is used to change or identify pixel values based on specifying one or more values.In this we Separate out regions of an image corresponding to the desired objects to analyze. This separation dependon the variation of intensity between the object pixels and the background pixels.To differentiate the pixels we are interested in from the rest (which will eventually be rejected), we build a comparison of each pixel intensity value with respect to a threshold (determined according to the problem to solve).Once we have separated properly the important pixels, we can set them with a determined value to identify them (i.e. we can assign them a value of 0 (black), 255 (white) or any value that is desired. This filter can be used to transform the intensity levels of an image in three different ways. First, the user can define a single threshold. Any pixels with values below this thresholdwill be replaced by a user defined value, called here the OutsideValue. Pixels withvalues above the threshold remain unchanged.Other way is the user can define a particular threshold such that all the pixels with values above the threshold will be replaced by the OutsideValue. Pixels with values below the threshold remain unchanged.Next, the user can define two threshold values. All the pixels with intensity values inside the range defined by the two thresholds will remain same. Pixels with values outside this range will be assigned to the OutsideValue.

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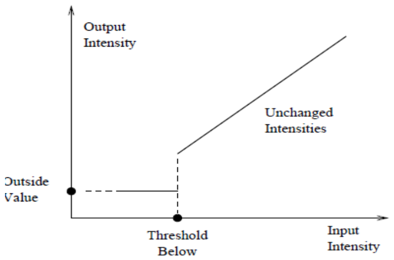

Fig 1:Threshold below mode

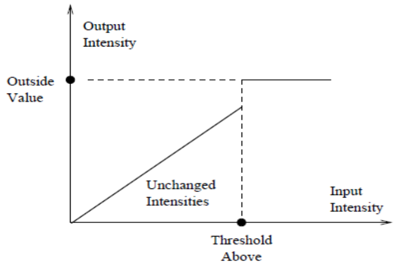

Fig 2:threshold above mode

The above figures shows the threshold modes below mode and above mode of pixel intensities Here we have taken the input MRI image. The image is defined using the pixel type and the dimension. The threshold estimation in this method is independent of thresholding filter used. It calculates level dependant thresholds after performing wavelet transformation on the signal [1],[9]. Let the detailed coefficients e are M in number at a particular level and assume that they are normally distributed.

$$V \delta M = \{\Phi^{-1} [((1-\delta)^{1/M}+1)/2]\}^{2}$$

Φ ( ) is cumulative distribution function. Where δ is error probability parameter. Then calculte the largest of the squared detailed coefficients at that level, represented by e2 (M-1) and compare it to the above value

$$V \delta M. \text{ If } e^2 M/\sigma^2 > V \delta M$$

Where, σ is the standard deviation, e2 M is preserved signal. Next repeat the process with the square of second largest detailed coefficient e2 (M-1). If

$$e^2 (M-1)/\sigma^2 > V \delta M-1$$

The procedure carries on until at some point the bth largest detailed coefficient satisfies $e^2 (b)/\sigma^2 > V \delta b$ The threshold at that level is then set as $\lambda = \alpha e^2 (b)$. The recommended value for δ is 0.05.

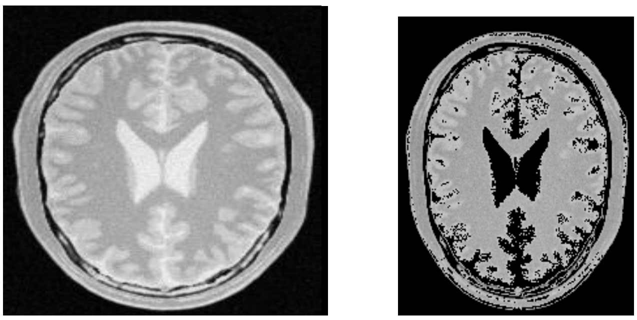

Fig 3: effect of hybrid threshold filter on MRI image

In the figure 3 we have shown the effect of hybrid threshold filter the left image is the input MRI mage an he right side image is the resulting image of hydrif threshold filter.

B.Median Filtering :Median filtering is a nonlinear method used to remove noise from images. It is widely used as it is very effective at removing noise while preserving edges. It is perfectly used in removing 'salt and pepper' type noise. The median filter operates by moving through the image pixel by pixel, replacing each value with the median value of neighbouring pixels. The pattern of neighbors is called the "window", which slides, pixel by pixel over the entire image 2 pixel, over the entire image. The median is calculated by first sorting all the pixel values from the window into

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numerical order, and then replacing the pixel being considered with the middle (median) pixel value. . Median filter aims to change noisy pixels in such a way to be look like its nearby neighbors [1]. Median filtering removes noise without blurring edges when the window size is reasonable (small), but it also makes rooftop edges tabulate [8]. The fundamental consequence of median filtering is that pixels with noisy values are compelled to have nearly similar value like their surrounding neighbors. On the left is an image with signifcant amount of salt and pepper noise. On the right is the same image after processing with a median filter.

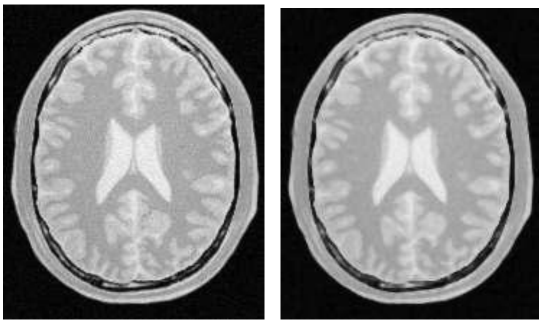


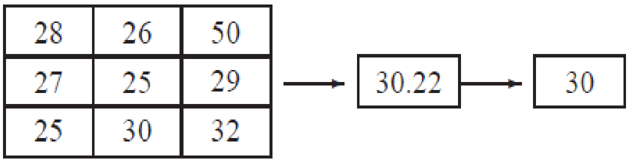
Fig 4:effect of median filter on MRI

In the figure the input image of the median filter and the resulting image is shown.the input is the MRI image with noise and the resulting image shows the reduced noisy image.

C.Mean Filter: Image smoothing is nothing but any image-to-image transformation designed to smoothen or flatten an image by reducing the rapid pixel-to-pixel variation in greylevels [1–5]. Smoothing may be accomplished by introducing an averaging mask that computes a weighted sum of the pixel greylevels in a neighborhood and replaces the centre pixel with that greylevel. The image is blurred and its brightness retained as the mask coefficients are all-positive and sum to one. The mean filter is one of the most basic smoothing filters. Take the average of intensity values in a m x n region of each pixel (usually m = n) – take the average as the new pixel value

$$h(i,j) = \frac{1}{mn} \sum_{k \in m} \sum_{l \in n} f(k,l)$$

– the normalization factor mn preserves the range of values of the original imageThe statistical mean of the neighborhood on the left is passed as the output value



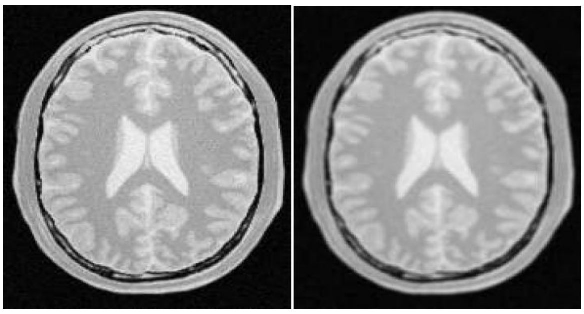


Fig 5: effect of mean filter on MRI image

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In the figure 5 the input and the resulting images are shown the left image the MRI image filtering with the mean filter and the left side image is the filtered image.

D.Linear Smoothing :-The most common, simplest and fastest kind of filtering is achieved by linear filters. The linear filter replaces each pixel with a linear combination of its neighbors and convolution kernel is used in prescription for the linear combination. 4 Linear filtering of a signal can be expressed as the convolution . associated with the pixel at the center of the neighborhood

$$g(m,n)=\sum_{j=0}^{N-1}\sum_{k=0}^{N-1}h(m-j,n-k)\,f(j,k)$$

$$t_g(u,v)=\frac{1}{N}t_f(u,v)t_h(u,v)$$

$$h=\frac{1}{L^2}\begin{bmatrix}1 & 1 & \cdots & 1\\ 1 & 1 & \cdots & 1\\ \vdots & \vdots & \ddots & 1\\ 1 & 1 & \cdots & 1\end{bmatrix}=\frac{1}{L}\begin{bmatrix}1 & 1 & \cdots & 1\end{bmatrix}*\frac{1}{L}\begin{bmatrix}1\\ 1\\ \vdots\\ 1\end{bmatrix}$$

the filter output arising from the input of an ideal Dirac impulse .Now that image filtering is done by applying function and when we apply linear filtering then each pixel is replaced by linear combination of its neighbor. Smoothing with an average actually doesn't compare at all well with a defocused lens . Most obvious difference is that a single point of light viewed in a defocused lens looks like a fuzzy blob; but the averaging process would give a little square Better idea: to eliminate edge effects, weight contribution of neighborhood pixels according to their closeness to the center.

D.Guassian filtering; The Gaussian smoothing operator is a 2-Dconvolution operator cthat is used to `blur' images and remove detail and noise. In this sense it is similar to the mean filter, but it uses a different kernel that represents the shape of a Gaussian (`bell-shaped') hump.

$$G(x)=\frac{1}{\sqrt{2\pi\sigma^2}}e^{-\frac{x^2}{2\sigma^2}}$$

Where σ is the standard deviation of the distribution The distribution is assumed to have a mean of 0. The Gaussian filter works by using the 2D distribution as a point-spread function.This is achieved by convolving the 2D Gaussian distribution function with the image.We need to produce a discrete approximation to the Gaussian function.This theoretically requires an infinitely large convolution kernel, as the Gaussian distribution is non-zero everywhere

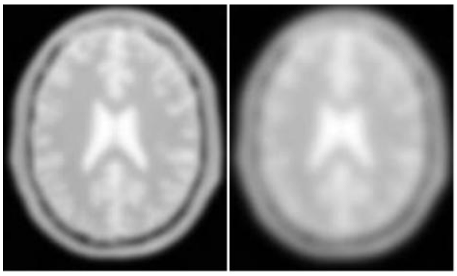

Fig 6:effect of Gaussian filter on a slice of MRI image

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In the figure 6 the left side image is the input MRI image and the right hand side image the resulting image of Gaussian filter.

E.Min and max filters: Max filter is good for pepper noise and min is good for salt noise. max-min filters play a key role in low-level image processing and vision. In practice, they are identical to the basic operations in mathematical morphology: dilation and erosion. Based on a rigorous mathematical foundation morphological image processing has proven to be very effective in image analysis [6]. One can construct morphological operators for smoothing [1], edge detection by gradient magnitude [5], edge detection by a nonlinear second derivative [8], and sharpening

Max Filter:

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

Min Filter:

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

F.Spatial and temporal filtering: Basically denoising methods can be categorized into two major classes based on the information used: spatial filtering and temporal filtering. Spatial filtering treats frames separately and utilizes 2-D imaging denoising techniques to improve image quality frame by frame. Spatial filtering methods contain traditional linear filtering1 , median filtering2 , linear/median hybrid filtering3 , edge-preserving filtering or probability based methods, or other image enhancement methods. In order to improve the performance of noise-suppression, some of the spatial filtering methods take the advantage of wavelet expansion and multi-resolution to efficiently separate signal from noise. Temporal filtering methods have also been investigated actively in last decade. Many methods have been applied,including traditional FIR/IIR filtering, probability based methods12 like Bayesian analyses and maximum likelihood. One advantage of temporal filtering over spatial filtering is that without averaging between neighboring pixels in the stationary areas, temporal filtering can preserve the fine anatomical structure while suppressing noise. Whereas for most spatial filtering methods, there is a trade-off between feature preserving and denoising. However, by averaging across the time dimension, temporal filtering can potentially introduce trailing artifacts in the moving regions, which is made worse by the fact that the catheter and guide-wires, objects which the cardiologists are the most interested in, are the most active moving parts in the field of view. Thus it is relatively natural to try to combine spatial and temporal filtering methods in a synergistic manner. One major difficulty with spatial-temporal filtering is the detection of moving regions in order to adaptively apply the distinct filtering techniques for static and moving regions within each frame The difference with previous methods and our method is the combination of techniques used. Temporal filtering gives very good results in noisy static regions. Due to the fact that temporal filtering may results in trailing artifacts of the moving object.

G.Resampling filters:. Resampling an image is a very important task in image analysis The space coordinates of the image are mapped through the transfrm in order to generate a new image. The extent and spacing of the resulting image are selected by the user. Resampling is performed in space coordinates, not pixel/grid coordinates. It is quite important to ensure that image spacing is properly set on the images involved.

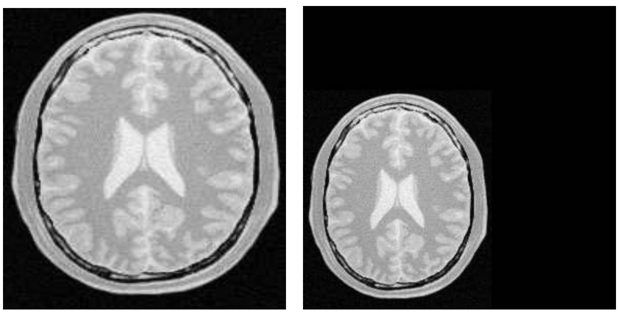

Fig 7:effect of resampling filter on MRI image

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In the figure 7 the left image is input slice of anMRI image and the right side image is the resulting image which is resampled by the resampled filter.

IV.CONCLUSION

Different image filtering techniques are effectively implemented with reduction of motion artifacts. In this paper we have shown different image filtering methods. So, we conclude that hybrid thresholding median filtering approach are the best approach that can be easily implemented with the help of the image histograms. Moreover, this method is too easy to implement concerning its simplicity and high rapidity.

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