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Survey on Medical Image De noising Using various Filters and Wavelet Transform

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Abstract: There is a problem of high level components of noises in the Medical Images. The different medical images are Magnetic Resonance Imaging (MRI), X-ray, Computed Tomography and Ultrasound. There are many noise reduction techniques that have been developed for removing noise. The idea behind these techniques is to get better results in terms of quality and in removal of different noises. This paper gives the review of various de noising techniques.

Keywords: Image de noising, Noise, Thresholding, Filters, Wavelet transform.

I. INTRODUCTION

With the advancement in image technology, image de noising has found renewed interest for researchers. Image de noising is one of the fundamental challenges in the field of image processing, where the main goal is to remove the noise from an image while retaining as much as possible the important signal features of an image. Medical images contain the information of vital organic tissues inside the human body and which are widely used for diagnosis of diseases or for surgical purpose. There are different techniques for producing medical image such as magnetic resonance imaging (MRI), X-ray, Computed Tomography and Ultrasound.

The Magnetic Resonance Imaging (MRI) is used to view in detail the internal structures of the body. Brain tumor is an abnormal growth of tissues in the brain and is mainly caused by radiation to the head, genetic risk, HIV infection, cigarette smoking and also due to environmental toxins. Major problem in image segmentation is inaccurate diagnosis of the tumor region which gets reduced mainly due to the contrast, blur, noise, artifacts, and distortion. No accurate detection of tumor region due to the presence of noise in MR image. Even small amount of noise can change the classification. Gray matter is made up of neuronal cell bodies. The Gray matter includes regions of the brain involved in muscle control, sensory perception such as seeing and hearing, memory, emotions, and speech. White matter is one of the two components of the central nervous system and consists mostly of glial cells and myelinated axons that transmit signals from one region of the cerebrum to another and between the cerebrum and lower brain centers. Noisy image can cause misclassifications of Gray Matter (GM) as White Matter (WM). So the noise is preprocessed using de noising technique [3].

The main objective of CT scan is to reconstruct the image from the set of projection. But the radiation used in CT scan is very harmful for human especially for children and pregnant women. Because of excessive radiation there may be possibility of developing cancer to the patient [11]. Then in 1990 Naidich has proposed concept of low dose CT scan. According to him, the amount of radiation can be reduced by reducing current through the X-ray tube and keeping all other scanning parameter constant (like voltage). The relation between current in X-ray tube and radiation is linear. But if we reduce the radiation then there is decrease in Image Quality. The accuracy of diagnosis may also decreases because of decrease in image quality and there is a possibility of having difficulties in image analysis and post processing. Image de-noising is very important task in Image processing [11].

Image Enhancement refers to rectifying the image against the noise added to it. Normal filters may work efficiently if the noise level is low but if the noise level is high normal filters would not be able to work efficiently. In such a case, combinations of filters are required to be done to enhance the quality of the image. Several image enhancement techniques have been already studied and presented.

DE NOISING TECHNIQUE:-

Let us now consider the representation of a digital image. A 2-dimensional digital image can be represented as a 2-dimensional array of data s(x, y), where (x, y) represent the pixel location. The pixel value corresponds to the brightness of the image at location (x, y). The image $s(x, y)$ is blurred by a linear operation and noise $n(x, y)$ is added to form the degraded image $w(x, y)$. This is convolved with the restoration procedure $g(x, y)$ to produce the restored image $z(x, y)$ [5].

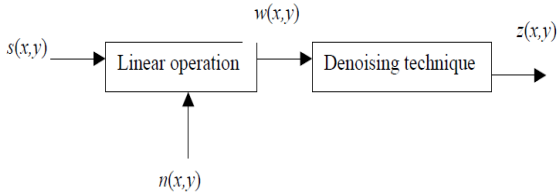

Figure 1.1: De noising concept

In Figure 1.1, the noise $n(x, y)$ is added or multiplicated to the signal $s(x, y)$. To get the de noised image $z(x, y)$, the corrupted image $w(x, y)$ obtained from Linear Operation is subjected to the de noising technique.

NOISE:-

The noise is characterized by its pattern and probabilistic characteristics. There is a wide variety of noise types. Some of them are: Gaussian noise, salt and pepper noise, poison noise, impulse noise, speckle noise.

A) Gaussian Noise

Gaussian noise is statistical noise that has its probability density function equal to that of the normal distribution, which is also known as the Gaussian distribution. In other words, the values that the noise can take on are Gaussian-distributed. A special case is white Gaussian noise, in which the values at any pair of times are identically distributed and statistically independent (and hence uncorrelated). In applications, Gaussian noise is most commonly used as additive white noise to yield additive white Gaussian noise [6].

B) Salt And Pepper Noise

Salt and pepper noise is a form of noise typically seen on images. It represents itself as randomly occurring white and black pixels. An effective noise reduction method for this type of noise involves the usage of a median filter, morphological filter or a contra harmonic mean filter. Salt and pepper noise creeps into images in situations where quick transients, such as faulty switching take place [6].

C) Poison Noise

Poison noise is induced by the nonlinear response of the image detectors and recorders. This type of noise is image data dependent. This term arises because detection and recording processes involve random electron emission having a Poison distribution with a mean response value. Since the mean and variance of a Poison distribution are equal, the image dependent term has a standard deviation if it is assumed that the noise has a unity variance [6].

D) Impulse Noise

Impulse noise is a category of (acoustic) noise which includes unwanted, almost instantaneous (thus impulse-like) sharp sounds (like clicks and pops). Noises of the kind are usually caused by electromagnetic interference, scratches on the recording disks and ill synchronization in digital recording and communication. High levels of such a noise (200 + Decibels) may damage internal organs, while 180 Decibels are enough to destroy or damage human ears [6].

E) Speckle Noise

Speckle is a complex phenomenon, which degrades image quality with a backscattered wave appearance which originates from many microscopic diffused reflections that pass through internal organs and makes it more difficult for the observer to discriminate fine detail of the images in diagnostic examinations. This type of noise occurs in almost all coherent systems such as SAR images and Ultrasound images. The source of this noise is random interference between the coherent returns. The speckle noise follows a gamma distribution. Thus, de noising or reducing the noise from a noisy image has become the predominant step in medical image processing. For the quality and edge preservation of images we have taken different de noising techniques into consideration [6].

THRESHOLDING:-

The simplest method of image de noising is thresholding. It can be used to create binary image from gray scale image. In thresholding. an image is segmented by setting all pixels whose intensity values are above a threshold to a foreground value and all the remaining pixels to a background value.

Thresholding is mainly divided into two categories:

A) Hard Thresholding

Hard threshold is a "keep or kill" procedure and is more intuitively appealing. The transfer function of the Hard thresholding. Hard thresholding may seem to be natural. Sometimes pure noise coefficients may pass the hard threshold and this thresholding method is mainly used in medical image processing [7-8].

B) Soft Thresholding

Soft threshold shrinks coefficients above the threshold in absolute value. The false structures in hard thresholding can be overcomed by soft thresholding. Now a days, wavelet based de noising methods have received a greater attention. Important features are characterized by large wavelet coefficient across scales in most of the timer scales [7].

FILTERS:-

The main function of filters is to suppress either the high frequencies in the image, that is smoothing the image, or the low frequencies, that is enhancing or detecting edges in the image.

A digital filter is a system that performs mathematical operations on a sampled, discrete-time signal to reduce or enhance certain aspects of that signal [13].

A) Mean filter

Mean filtering is a simple, intuitive and easy to implement method of smoothing images, *i.e.* reducing the amount of intensity variation between one pixel and the next. It is often used to reduce noise in images. The idea of mean filtering is simply to replace each pixel value in an image with the mean (`average') value of its neighbors, including itself. This has the effect of eliminating pixel values which are unrepresentative of their surroundings [6].

B) Wiener filter

The wiener filtering method requires the information about the spectra of the noise and the original signal and it works well only if the underlying signal is smooth. Wiener method implements spatial smoothing and its model complexity control correspond to choosing the window size [9]. Wiener filtering is able to achieve significant noise removal when the variance of noise is low, they cause blurring and smoothening of the sharp edges of the image [10].

C) Median filter

Median filtering is a common step in image processing. Median filter is a well-used nonlinear filter that replaces the original gray level of a pixel by the median of the gray values of pixels in a specific neighborhood. The median filter is also called the order specific filter because it is based on statistics derived from ordering the elements of a set rather than taking the means. This filter is popular for reducing noise without blurring edges of the image [6]. It is particularly useful to reduce salt and pepper noise and speckle noise. It is very useful in case where edge blurring is undesirable because of its edge preserving nature.

D) Gaussian filter

Gaussian filters are designed to give no overshoot to a step function input while minimizing the rise and fall time. This behavior of Gaussian filter causes minimum group delay. Mathematically, a Gaussian filter modifies the input signal by convolving with a Gaussian function. The Gaussian filter is usually used as a smoother. The output of the Gaussian filter at the moment is the mean of the input values [12].

II. WAVELET TRANSFORM

Wavelet can examine signals in time and frequency domain simultaneously. If any image is decomposed using wavelet then it has two functions that is wavelet function and scaling function. Wavelet function is used to represent the high frequency component i.e. detail part of an image while scaling function is used to represent the low frequency component i.e. smooth part of an image. Wavelet is a mathematical tool. Data can be set into different frequency component with the help of wavelet and then each component is studied with a resolution matched to its scale. There are several transforms available like Fourier transform, Hilbert transform, Wavelet transform, etc. The wavelet transform is better than fourier transform because it gives frequency representation of raw signal at any given interval of time, but fourier transform gives only the frequency-amplitude representation of the raw signal, but the time information is lost. So Fourier transform cannot be used where both time and frequency information is needed at the same time.

There are many wavelets which are used for decomposition as well as for de-noising of images and signals. Some of them are:

A) Haar

Haar wavelet is one of the oldest and simplest type of wavelet. The Haar Transform provides prototype for all other wavelet transforms. Like other wavelet transforms, the Haar Transform decomposes the discrete signal into two sub-signals of half its length. One sub-signal is a running average or trend and other sub-signal is running difference or fluctuation. The advantage of Haar wavelet is that it is fast, memory efficient and conceptually simple [4].

B) Daubechies

Daubechies wavelet is the first wavelet family which has set of scaling function which are orthogonal. This wavelet has finite vanishing moments. Daubechies wavelets have balanced frequency responses but nonlinear phase responses. Daubechies wavelets are useful in compression and noise removal of audio signal processing because of its property of overlapping windows and the high frequency coefficient spectrum reflect all high frequency changes. It is easily adapted to soft signals or images, in terms of low frequencies. They are quite asymmetrical, so the filters concentrate their energy near the end of their support [4].

C) Coiflet

Coiflet wavelets are compactly supported wavelet with highest number of vanishing moments for both phi and psi for a given support width. Discrete and continuous wavelet transform is possible with these [4]. They are quasi-symmetric functions.

D) Symlet

Its name comes from "Symmetrical wavelet". Symlet wavelet provides highest number of vanishing moment and it is compactly supported wavelet. By using symlet wavelet, discrete and continuous wavelet transforms are also possible. The quasi-symmetric wavelets, like the Coiflet and Symlet, use filters that are symmetrical with respect to the centre of their support, so the energy is concentrated in the central part, differing from the Daubechies [4].

E) Biorthogonal

Biorthogonal Wavelet is families of compactly supported symmetrical wavelet. The symmetry of coefficients is often desirable because it result in linear phase of transfer function. Biorthogonal wavelet has two scaling function which generate different multi-resolution analysis. It has two different wavelet function, one used for analysis and another used for synthesis [4].

III. LITERATURE SURVEY

Sidhu Kanwaljot Singh et al. [1] presented Image de noising using Haar and Daubechies Transforms. Firstly the image is decomposed using Haar and Daubechies transforms, then the level of soft and hard threshold is selected for reducing the noise in the image and after that by calculating and comparing the PSNR of an image for every wavelet then assign the wavelet which gives more PSNR to the respective image. Haar transform decomposed the discrete signal into two sub signals of half its length. One sub signal is a running average or trend and other is running difference or fluctuation. Daubechies wavelet has set of scaling functions which are orthogonal. It is useful in noise removal as high frequency coefficient spectrum reflect all high frequency changes. Hard thresholding is a keep or kill procedure. Soft thresholding shrinks the coefficients above the threshold in absolute value. It is found that db3 wavelet is more efficient than haar wavelet for removing the certain level of speckle noise in the medical images and also it enhances the visual quality of the medical images.

Kaur Rupinderpal, Kaur Rajneet [2] states that there are many noise reduction techniques have been developed for removing noise and retaining edge details in images. Choice of de noising algorithm is application dependent and depends upon the type of noise present in the image. Each technique has its own assumptions, advantages and limitations. The idea behind these techniques is to acquiesce better results in terms of quality and in removal of different noises.

Rajeshwari S., Sharmila T. Sree [3] presented a technique to improve the image quality by de noising and resolution enhancement. Most of the imaging techniques are degraded by noise. In order to preserve the edges and contour information of the medical images, the efficient de noising and an improved enhancement technique is required. This paper concentrates the average, median and wiener filtering for image de noising and an interpolation based Discrete Wavelet Transform (DWT) technique for resolution enhancement. The performance of these techniques is evaluated using Peak Signal to Noise Ratio (PSNR). From the results, it reveals that the efficient de noising and resolution enhancement technique is essential for image pre-processing.

Chaudhari Anand, Chaudhary Piyush, Cheeran A.N., Aswani Yashant [4] presented Improved Signal to Noise Ratio of Low-Dose CT Image Using Wavelet Transform. They described that the patient is exposed to harmful radiation when he/she undergoes CT scan. If the amount of radiation is reduced, the CT image quality decreases i.e. signal to noise ratio (SNR) decreases. Wavelet transform is a tool to analyze signals and the entire set of wavelet share some common properties but each wavelet has certain unique properties of Image decomposition, de-noising and reconstruction which provides difference in PSNR.

Kumar B.B.S., Satyanarayana Dr.P.S. [5] proposed Symlets wavelet technique using 2-D DWT in image processing. The scope of the work involves compression and de noising, image clarity and to find the effect of the decomposition and levels of threshold and to find out energy retained (image recovery) and lost. The experiments and simulation is carried out on still image .jpg formats. In order to measure the performance of the de-noising, a noise is added to the still image and given as input to the de-noising algorithm, which produces an image close to the original image.

IV. CONCLUSION

De noising has been a permanent research topic for engineers and one reason for it is the lack of a single technique, which is able to achieve de noising for a wide class of images. Normal filters may work efficiently if the noise level is low but if the noise level is high normal filters would not be able to work efficiently. In such a case, combinations of filters are required to be done to enhance the quality of the image. Wavelet transform is best suited for de noising because of its properties like sparsity, multi-resolution and multi-scale nature. Which wavelet should be applied on noisy image depends upon the nature of the application.

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