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Efficient Quality Analysis of MRI Images Using Pre-Processing Techniques

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Abstract: **MRI images are widely used in the diagnosis of various parts of body like Brain, Spinal cord, Heart, Breasts, Internal organs and Bones, Joints, Blood vessels and also to detect Blood clots. The image classification can be changed with the addition of even small amount of noise. Therefore the reduction of noise is very important. Image pre-processing techniques like de-noising and filtration are employed to remove the noise from an image while retaining as much as possible crucial signal features of the image. In this paper an efficient way to analyze the quality of mri images is carried out using mean, median, wiener filters, whose out comings are subjected to calculation of mean square error (MSE) and peak signal-to- noise ratio (PSNR).**

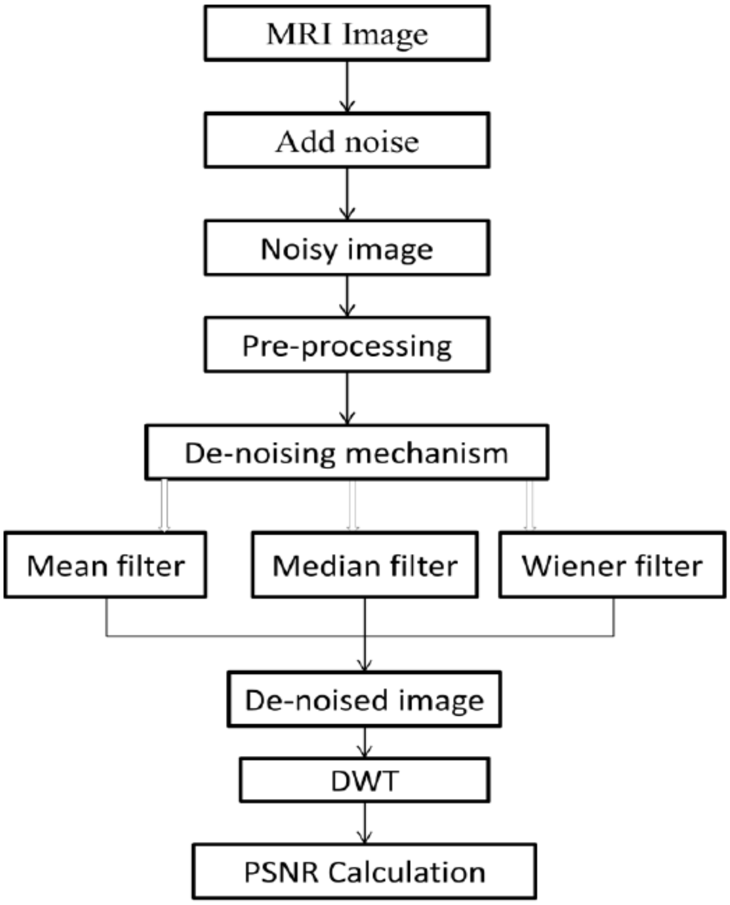
Keywords: **De-noising, Discrete wavelets transform Mean square error, Medical imaging, Peak signal to noise ratio, Salt and pepper noise.**

I. INTRODUCTION

The medical imaging technique, magnetic resonance imaging is been widely exploited to produce a high quality imaging of soft tissues of human body. MRI scans can be used as extremely accurate images for detection of tumour regions, blood clots and other internal organs. A noisy mri image may lead to misclassification of gray matter GM and white matter WM. The gray matter is where cell bodies of neurons reside in the brain and spinal cord. It is mainly composed of neuronal cell bodies and unmyelinated axons. In gray matter axons are unmyelinated, meaning they are not covered by a whitish colored, fatty protein myelin. These are made of glial cells and capillaries. White matter is the myelinated axons that connect the gray matter. It is composed of nerve fibers. It is a component of central nervous system which is used to transmit signals from one region of cerebrum to another. Even a slight amount of noise may lead to misclassification among the gray matter and the white matter. In order to avoid this, the noise must be removed or pre-processed in the denoising stage itself. The resolution enhancement is very important to preserve the edges and contour information since it helps to detect the tumor cells. The denoising mechanism is not better performed along the edge regions. This drawback can be modified using resolution enhancement technique. The mean, median and wiener filters are used here to remove the noise from the image which makes the algorithm to be the most reliable estimate of the original image data given its degraded version. These filters are based on the average gray values, and the neighbourhoods. The wiener filter is based on a statistical approach and assumes the knowledge of degradation function and the power spectra of both the noise and the original image. The wiener filter cannot undo blurring and in addition, the knowledge of power spectra should also be assumed. Obtaining the power spectra of original image is more difficult. This is the reason why wiener felt is less used in many practical applications. However the wiener filters suppress the frequency components that are degraded by noise. The image resolution enhancement technique of discrete wavelet transform DWT is employed here since it yields better results over other techniques and captures both frequency and location information.

II. DENOISING MECHANISM

Exact useful information can be extracted from the mri image only in the absence of noise. Hence to obtain the useful information from the image, denoising technique is required. This paper concentrates the mean filter, median filter, wiener filter for image denoising & Discrete Wavelet transform (DWT) for resolution enhancement. In the initial stage mri image is taken as the input data which is added by salt and pepper noise. The denoising mechanism is performed by using the mean, median and wiener filters and the performance of the denoising technique is evaluated by calculating the peak signal to noise ratio.



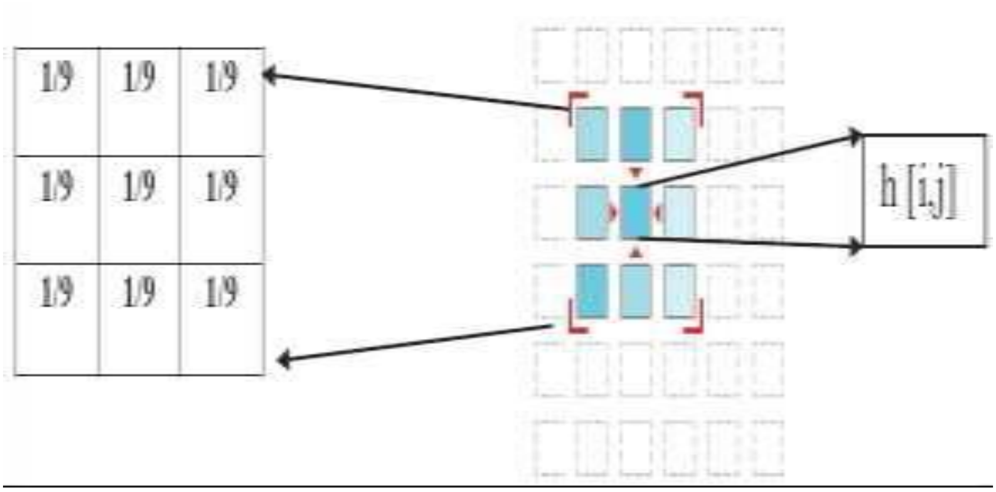
Overview

A. SALT AND PEPPER NOISE:

An image containing the salt-and-pepper noise will have dark pixels in bright regions and bright pixels in dark regions . This type of noise can be caused by dead pixels, analog-to-digital converter errors, bit errors in transmission, etc. This can be eliminated in large part by using dark frame subtraction and by interpolating around dark/bright pixels. This noise is named for the salt and pepper appearance an image takes on after being degraded by this type of noise. Given the probability r (with $0 \leq r \leq 1$) that a pixel is corrupted, we can introduce salt-and-pepper noise in an image by setting a fraction of r/2 randomly selected pixels to black, and another fraction of r/2 randomly selected pixels to white. 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.

B. MEAN FILTER:

The mean or averaging filter is a linear spatial filter which takes the average of intensity values in a mxn region of each pixel usually m=n. It takes the average as a new pixel value. 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. Mean filtering is usually thought of as a convolution filter. Like other convolutions it is based around a kernel, which represents the shape and size of the neighborhood to be sampled when calculating the mean. Often a 3×3 square kernel is used, as shown in Figure 1, although larger kernels (*e.g.* 5×5 squares) can be used for more severe smoothing. (Note that a small kernel can be applied more than once in order to produce a similar but not identical effect as a single pass with a large kernel.)



Functionality of a median filter

$$\mathbf{h[i,j]} = \frac{1}{M}\sum_{(k,1)\in N} \mathbf{f(k.I)}$$

The normalization factor M=mn preserves the range of values of the original image. Median filters are widely used filters for the removal bof salt and pepper noise from the images**.**

C. WIENER FILTER:

The goal of the wiener filter is to filter out the noise that has corrupted a signal. The wiener filter is based on statistical approach. Wiener filters are a class of optimum linear filters which involve linear estimation of a desired signal sequence from another related sequence. It is not an adaptive filter. The wiener filter's main purpose is to reduce the amount of noise present in a image by comparison with an estimation of the desired noiseless image. The Wiener filter may also be used for smoothing. This filter is the mean squares error-optimal stationary linear filter for images degraded by additive noise and blurring. It is usually applied in the frequency domain (by taking the Fourier transform), due to linear motion or unfocussed optics Wiener filter is the most important technique for removal of blur in images. From a signal processing standpoint. Each pixel in a digital representation of the photograph should represent the intensity of a single stationary point in front of the camera. Unfortunately, if the shutter speed is too slow and the camera is in motion, a given pixel will be an amalgram of intensities from points along the line of the camera's motion. The goal of the Wiener filter is to filter out noise that has corrupted a signal. It is based on a statistical approach. Typical filters are designed for a desired frequency response. The Wiener filter approaches filtering from a different angle. One is assumed to have knowledge of the spectral properties of the original signal and the noise, and one seeks the LTI filter whose output would come as close to the original signal as possible . Wiener filters are characterized by the following:

1. Assumption: signal and (additive) noise are stationary linear random processes with known spectral characteristics.

2. Requirement: the filter must be physically realizable, i.e. causal (this requirement can be dropped, resulting in a non-causal solution).

3. Performance criteria: minimum mean-square error.

Wiener Filter in the Fourier Domain as in equation shown below.

$$G(u,v) = \frac{H^*(u,v)P_s(u,v)}{|H\,(u,v)\,|^2\,P_s(u,v) + P_n(u,v)}$$

Where

H(u,v) = Fourier transform of the point spread function

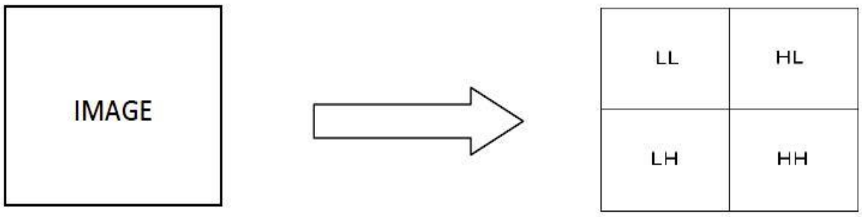
(u,v) = Power spectrum of the signal process, obtained by taking the Fourier transform of the signal autocorrelation

(u,v) = Power spectrum of the noise process, obtained by taking the Fourier transform of the noise autocorrelation

It should be noted that there are some known limitations to Wiener filters. They are able to suppress frequency components that have been degraded by noise but do not reconstruct them. Wiener filters are also unable to undo blurring caused by band limiting of $(u,)$, which is a phenomenon in real-world imaging systems.

D. RESOLUTION ENHANCEMENT:

Resolution enhancement is a critical factor in image processing. A good quality of resolution implies more details in an image. Initially the image is pre-processed using the denoising. Due to this denoising the noise and some features in the image are lost. Resolution enhancement preserves the edges and contour information in the image. Preserving the edges and contour information is important for accurate image.

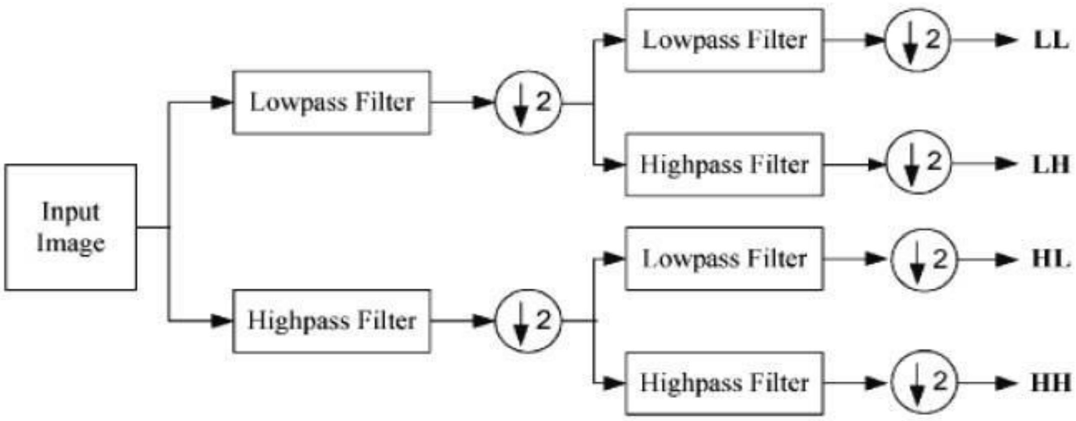


One level decomposition

Resolution is the measurement of quality of a denoised image. In order to enhance the resolution of an image an improved Discrete Wavelet Transform (DWT) is used. DWT preserves the edges and contour information. The performance of the resolution enhancement technique is measured using Peak Signal to Noise Ratio..

E. DICRETE WAVELET TRANSFORM:

Wavelets play a prominent role in many image processing applications. Wavelets are used to examine an image into the different frequency components at different resolution scales. The DWT splits the image into four sub-bands. The discrete wavelet transform is calculated by passing through a series of filters. The samples are passed through low pass filters with the impulse response resulting in the convolution of the two. DWT decomposes the input image into four sub-bands that are low-low (LL), low-high (LH), high-low (HL), and high-high (HH). After decomposition of input image, interpolation is applied on these four sub-bands. The interpolation technique is used to increase the number pixels in an image.



Block diagram of discrete wavelet transform

The high frequency components of the image are contained in the high frequency sub-bands LH,HL and HH. The frequency components of the sub-bands are interpolated to cover the full frequency of the original image. The interpolation stage improves the number of pixels in the image. To obtain a high resolution of the image, high frequency sub-bands are interpolated to low frequency sub-bands.

F. INVERSE DISCRTE WAVELET TRANSFORM:

Inverse Discrete Wavelet Transform (IDWT) is a process by which components can be accumulated back into the original image to get without loss of information is called reconstruction. It reconstructs an image from the approximation and detail coefficients extracted from decomposition. The performance of denoised and enhanced image is evaluated by calculating PSNR value.

III. QUALITY ANALYSIS

The performance of the resolution enhancement can be analysed by the quality analysis between the original image and the noisy image. The quality of the pre-processed images can be evaluated by using the Peak Signal to Noise Ratio. The PSNR block computes the peak signal-to-noise ratio, in decibels, between two images. This ratio is often used as a quality measurement between the original and a compressed image. The higher the PSNR, the better the quality of the compressed or reconstructed image.

The Mean Square Error (MSE) *and the* Peak Signal to Noise Ratio (PSNR) are the two error metrics used to compare image compression quality. 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.

To compute the PSNR, the block first calculates the mean-squared error using the following equation:

$$MSE = \frac{\sum_{M,N} [I_1(m,n) - I_2(m,n)]^2}{M*N}$$

In the above equation, *M* and *N* are the number of rows and columns in the input images, respectively. Then the block computes the PSNR using the following equation:

$$PSNR = 10 \log_{10}\left(\frac{R^2}{MSE}\right)$$

R is the maximum fluctuation in the input image data type. For example, if the input image has a double-precision floating-point data type, then *R* is 1. If it has an 8-bit unsigned integer data type, *R* is 255, etc.

IV. CONCLUSION

Hence the quality analysis of mri images can be done and the result with high PSNR can be considered as the better quality reconstructed image.

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