HYBRID FILTER FOR THE RESTORATION OF CT/MRI IMAGES FOR TELEMEDICINE APPLICATION

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Abstract -This project is an application of medical image processing. The medical acquisition systems are susceptible to noise, this noise degrades the quality of the image. Hence, noise reduction is very important in digital image processing. The CT images in general are corrupted by Gaussian noise and MR images by rician noise. In the proposed work, noise in medical images is estimated and then smoothing of the images is done. For the filtering of Gaussian noise, bilateral filter with wavelet thresholding was used. For the filtering of rician noise, non-local means filter with wavelet thresholding was used. The wavelet transform is used to decompose an image into frequency sub bands. The noise is estimated from the high frequency components. The algorithms were developed in Matlab2015a and tested on real time and standard database images.

I. INTRODUCTION

An image is a two dimensional array. It is defined by the mathematical function f(x, y), where x, y are the two co-ordinates horizontally and vertically. Pictures are the most common and convenient means of conveying or transmitting information. Human beings are good at deriving information from such images, because of our innate visual and mental abilities. About 75% of the information received by human is in the pictorial form. Image sensor is used in the acquisition of the image. When the sunlight is falls upon the object, the amount of light reflected by the object is sensed by sensors and a continuous voltage signal is generated by the amount of sensed data. In order to create a digital image we need to convert the data into digital form.

Image processing is a method to convert an image into digital form and perform some operations on an image in order to get an enhanced image or the user can extract some useful information from it. Usually image

processing system includes treating images as a two dimensional signals while applying already set signal processing methods to them. Image processing is a technique to enhance raw images received from cameras/sensors placed on satellite, space probes, and aircrafts or pictures taken in normal day -to-day life for various applications. Image Processing systems are becoming popular due to easy availability of powerful personnel computers, large size memory devices, graphics software. Image processing basically includes the following three steps:

1. Importing the image with the scanner or by digital photographer.
2. Analyzing and manipulating the image which includes data compression and image enhancement and spotting patterns that are not to human eyes like satellite photographs.
3. Output is the last stage in which result can be altered image or report that is based on image analysis.

Image acquisition is the first step or process of the fundamental steps of digital image processing. Image acquisition could be as simple as being given an image that is already in digital form. Generally, the image acquisition stage involves pre-processing, such as scaling etc.Image enhancement is among the simplest and most appealing areas of digital image processing. Basically, the idea behind enhancement techniques is to bring out detail that is obscured, or simply to highlight certain features of interest in an image.Image restoration is an area that also deals with improving the appearance of an image. However, unlike enhancement, which is subjective, image restoration is objective, in the sense that restoration techniques tend to be based on mathematical or probabilistic models of image degradation.

Colour image processing is an area that has been gaining its importance because of the significant increase in the use of digital images over the Internet. This may include color modelling and processing in a digital domain etc. Wavelets are the

foundation for representing images in various degrees of resolution. Images subdivision successively into smaller regions for data compression and for pyramidal representation. Compression deals with techniques for reducing the storage required to save an image or the bandwidth to transmit it. Particularly in the uses of internet it is very much necessary to compress data. Morphological processing deals with tools for extracting image components that are useful in the representation and description of shape

Segmentation procedures partition an image into its constituent parts or objects. In general, autonomous segmentation is one of the most difficult tasks in digital image processing. A rugged segmentation procedure brings the process a long way toward successful solution of imaging problems that require objects to be identified individual.

II .Project Description

Removal of noise from the image to make it corrupt free is known as de-noising in Digital Image Processing. The main purpose of image de-noising is to remove noise from the image and preserving the fine details of the image. A lot of different Image de-noising techniques are developed so far each having its own advantages and limitation. Outputs from all acquisition system are subjected to some sort of noise. For example, CT images are susceptible to Gaussian noise.MRI images are susceptible to Gaussian noise. Satellite images are susceptible to speckle noise. Hence, pre-processing is an important step. De-noising can be exhausted in various domains like Spatial Domain, Frequency Domain and Wavelet Domain. Noise suppression in corrupted image remains a fundamental problem in the field of medical image processing. There are mainly two basic approaches involved in image denoising namely spatial domain filtering approach and transform domain filtering approach. The selection of filter depends upon the type and amount of noise present in an image because different filters can remove different types of noise efficiently. In the proposed work, the noisy CT/MR images is given as input .The input is transformed into four sub

band using wavelet transform method, and the standard deviation of the noise is estimated. By using bilateral filter, edge smoothing will be performed. The block diagram of the proposed method is as follows

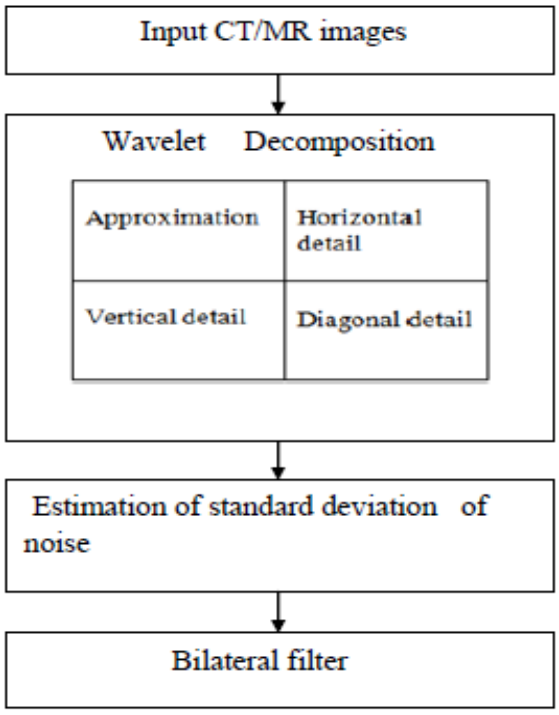


Figure 3.1. Block diagram of the proposed method

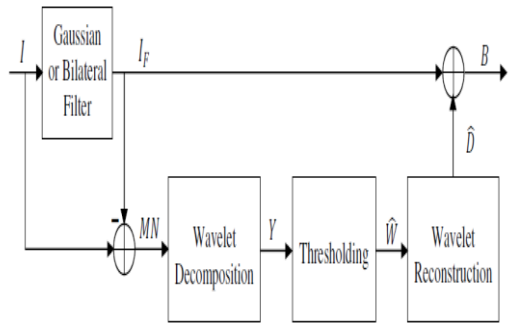


Figure 3.2. Block diagram for denoising of CT Images

III. Noise Estimation

Consider an image $f_{ij}$of size NXN . Assume that the image is corrupted by noise

and the corrupted image y_{ij} can be written as follows

$$y_{ij} = f_{ij} + N_{ij}$$

From the noisy image signal y_{ij} we want to find an approximation fij of the original Image f_{ij}. The MR images in general are corrupted by Rician noise and its distribution function is as follows.

$$p(z) = \frac{z}{\sigma^2} exp\left(-\frac{z^2 + I^2}{2\sigma^2}\right) B\left(\frac{zI}{\sigma^2}\right)$$

Where I is the underlying true intensity, $\sigma^2$is the standard deviation of the noise, and B is the modified zeroth order Bessel function of the first kind. The non-uniform RF coil response in MR imaging produces a bias that varies nonlinearly there by modulating the intensity of tissues in acquired images. The corrupted image in equation can be written as

$$f_{bias(x,y)} = f_{orginal}(x,y)\alpha(x,y)+\eta(x,y) \quad (3.3)$$

From equation .it is clear that the pre-processing algorithm takes into account both Rician noise and bias field effect. The conventional bias field correction techniques are homomorphic filtering, thin-plate or polynomial least squares fitting of selective data points. In the case of CT imaging system, images are corrupted by Gaussian noise.

IV. Improved Bilateral Filter

In spatial domain filtering approach, the filtering is carried out by running the mask (template or kernel) on the image from left to right and top to bottom. The centre coefficient of mask is placed in the pixel to be modified and based on four neighbourhood connectivity or eight neighbourhood connectivity, filtering operation is done.The bilateral filter is a convolution filter and can be used for denoising of CT/MR images in the spatial domain without any loss of edge information .The bilateral filter mask coefficients are identified based on the location of pixels and its gray level values. The bila coefficients are different for each pixel and depend on the geometric closeness and gray level similarity with the pixel in the centre of the bilateral filter window. The bilateral filter kernel is the product of two sub-kernels, gray-level kernel (W_{gk}) and distance kernel (W_{sk}). The gray level kernel is the function of gray level distance and distance kernel is the function of spatial distance. The gray level kernel can be defined as follows.

$$W_{gk} = exp^{\left[-\frac{1}{2}\left(\frac{d_{gk}}{\sigma_{gk}}\right)^2\right]}$$

V .NL-Means Filter

The goal of image denoising is to remove the noise while retaining the important image features like edges, details as much as possible. Linear filter convolves the image with a constant matrix to obtain a linear combination of neighborhood values and has been widely used for noise elimination in the presence of additive noise. This produces a blurred and smoothed image with poor feature

localization and incomplete noise suppression.

VI. NL-Means Filter and Its Method Noise Thresholding

The image denoising framework using the blend of NL-means Filter and its Method noise Thresholding using wavelets (NLFMT) is shown in Fig. 1. A difference between the original image and its denoised image shows the noise removed by the algorithm, which is called as method noise. In principle, the method noise should look like a noise.

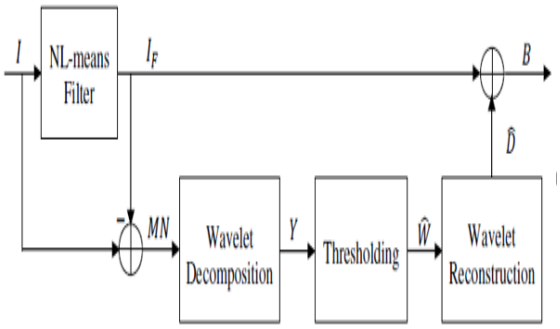


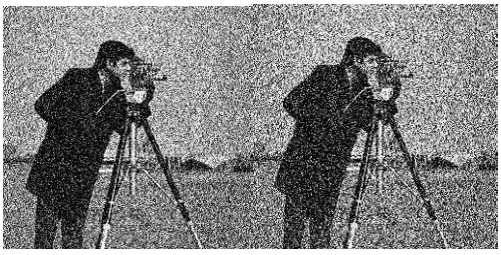
Figure 3.4: Proposed Image Denoising Framework

The application of NL-means filter on the noisy image removes the noise and cleans the edges without losing too many fine structures and details. Eventhough the NL-means filter is very effective in removing the noise at high SNR (with less noise) but as the noise increases, its performance deteriorates. This is because; the similar local patches which are used to find the pixel weights are also noisy..

VII. RESULTS AND DISCUSSION

The algorithms are developed in Matlab 2015a and tested on real time CT/MR images. For the validation of algorithms, standard database images are used. The cameraman image is taken initially for the validation of algorithms.

(a) (b)



(c) (d)

Figure 4.1: Gaussian noise removal by bilateral filter with wavelet thresholding, b (20 % noise), c(60% noise), d(80% noise), (e, f, g) restoration results

The proposed project objective is the denoising of CT/MR images by applying appropriate filter. For the Gaussian noise removal, bilateral filter with wavelet thresholding was used. The Gaussian noise of varying variance is added to the ‘cameraman.tif’ image and the algorithm is validated by the performance metrics like PSNR, VFI and IQI. The PSNR reflects the quality of the filtered image, higher the PSNR value, better the efficiency of the filtering algorithm. The results reveals that bilateral filter with wavelet thresholding generates efficient restoration results. The Visual Fidelity Index and Image Quality Index also reflects the efficiency of the bilateral filter with wavelet thresholding filter.

Table 1: Performance metrics for the rician noise removal in MR images

For the rician noise removal, bilateral filter with wavelet thresholding was used. The rician noise

Rician Noise variance	Noisy Image	Nonlocal Means Filter			Nonlocal Means Wavelet Thresholding		
	PSNR	PSNR	VFI	IQI	PSNR	VFI	IOI
0.10	68.1549	45.12	0.911	.9770	68.12	0.994	.9902
0.20	62.1394	45.55	0.911	.9662	62.43	0.996	.9807
0.30	58.5854	45.45	0.910	.9278	58.03	0.995	.9710
0.40	56.0941	45.45	0.910	.9623	54.92	0.993	.9362
0.50	54.1909	45.21	0.906	.9563	53.13	0.992	.9585
0.60	52.5411	45.02	0.904	.9428	51.85	0.989	.9543
0.70	51.2644	44.86	0.903	.9478	51.42	0.986	.9490
0.80	50.0435	44.65	0.898	.9647	49.78	0.984	.9459
0.90	49.0441	44.46	0.895	.9442	48.92	0.980	.9432

(e) (f)

of varying variance is added to the 'cameraman.tif' image and the algorithm is validated by the performance metrics like PSNR, VFI and IQI. The PSNR reflects the quality of the filtered image, higher the PSNR value, better the efficiency of the filtering algorithm. The results reveals that non local means filter with wavelet thresholding generates efficient restoration results. The Visual Fidelity Index and Image Quality Index also reflects the efficiency of the non-local means filter with wavelet thresholding

VIII .CONCLUSION

The role of pre-processing is vital in image processing and computer vision. The objective of the pre-processing approach is to make the output restored image fit for subsequent processes like segmentation, compression and classification.In the proposed project work, adaptive bilateral filter based on noise estimation from wavelet transform technique. The proposed filtering approach generates efficient restoration results. In phase II, an improved bilateral filter restoration algorithm with reduced computation time will be worked out.

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