Super Resolution of Medical images using Example-Based Method for Denoising

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Abstract— In super resolution technique, from many low resolution images an high resolution image is constructed. Super resolution method is used in many applications like in medical, electronics, aeronautic fields etc. In this paper the Iterative Back Projection (IBP) algorithm is used in which the Advanced Non local Mean filter (ANLM) is incorporated. The reconstruction error is minimized by using the IBP method. The ANLM with IBP method , the missing pixels are constructed using the Gaussian Kernels and the main advantage of this method is that it considers both the neighbourhood similarity and the path distance for the reconstruction process. The analysis is carried out using the Magnetic Resonance (MR) images. The experimental results shows that in the proposed method there is 7 percent increase in the PSNR values while considering the existing method.

Index Terms— Super resolution, Iterative Back Projection, Non Local Mean Filter, Gaussian kernels, Patch distance

1 INTRODUCTION

In many fields images play an important role for the formulation of the problems and if we see images should always be of very good quality so that it could be used in these applications. Images with good quality indicates that resolution of the images should be very high. Many technical inventions are being done inorder to increase the resolution of the images. The noise and the other effects are caused during the acquisition process. Medical images play a vital role in diagnosing the disease in the patients. Medical images includes PET(Positron Emission Tomography), MRI(Magnetic Resonance Image) , CT(Computerized Tomography) etc . In the MR images the spatial resolution is increased so as to increase its resolution [2]-[3].

From many low resolution images an high resolution image is constructed, this is the concept of super resolution which was introduced by Huang and Tsai[4]. Super resolution is classified into multi image super resolution[5] and single image super resolution[6]. In single image super resolution technique the nearest search method[7], Sparse coding method [8] are used for mapping of the missing pixels from the databases created. The databases are created for every image. This single image super resolution method is also called as example based method. The multi image super resolution constructs an image using many sub pixel shift values of many low resolution images. Other well known technique is the interpolation technique [9]-[10], where it does not give considerable performance when analysed with image which is corrupted by more amount of noise.

Many existing techniques like POCS(Projection Onto Convex Sets)[12],IBP(Iterative Back Projection)[13], MAP(Maximum A Posteriori)[11], gives better results than the interpolation technique . In multi image super resolution three process are carried out and they are registration, fusion and deblurring, these steps are not needed when we consider the Iterative Back Projection algorithm and this algorithm is said to be very efficient because the error is minimized to a greater extent by the iterative steps. These steps are followed and executed until the error becomes zero. Main disadvantage of this method is that it brings ringing effects and Buades.et.al [14] introduced NLM with IBP method to minimize the effects. The weighted average of the neighbouring pixels is used as an estimate for the missing pixels. Patch distance due to this becomes very large and this causes further blurring. So proper smoothening becomes necessary in these cases. In this paper a new method have been proposed using the NLM filter in which the Gaussian kernels are introduced for the smoothening purpose, the missing pixels are replaced by the Gaussian neighbourhood values. Image source for analysis is from Mithra scans ,Salem, Tamil nadu.

This paper is organized into different directions, where section 2 proposed method is explained, in section 3 the performance analysis for the proposed method is explained and in section 4 gives the conclusion of the paper

2 PROPOSED METHOD

In the proposed method we follow single image super resolution technique which is also called as the example based super resolution method. An advanced version of the non local mean filter is introduced where the Gaussian kernels are used for the estimation of the missing pixels. For increasing the resolution and denoising to be done simultaneously the Iterative Back Projection(IBP) with Advanced Non Local Mean(ANLM) is introduced. The processing of the image is explained below.

2.1 Mean filtering

During the processing of the image the main process is to remove the noise and so a filter is employed for denoising . Many kind of filters are present like mean , median type of filters. In the algorithm which is used the non local mean filter is used. Non local mean filter generally estimates the weighted average of all neighbouring pixels for the missing pixels. In the proposed method along with this an Gaussian kernel is introduced for the smoothening and it is named as advanced non local mean filter(ANLM) . This filter is integrated in the steps of the IBP algorithm.

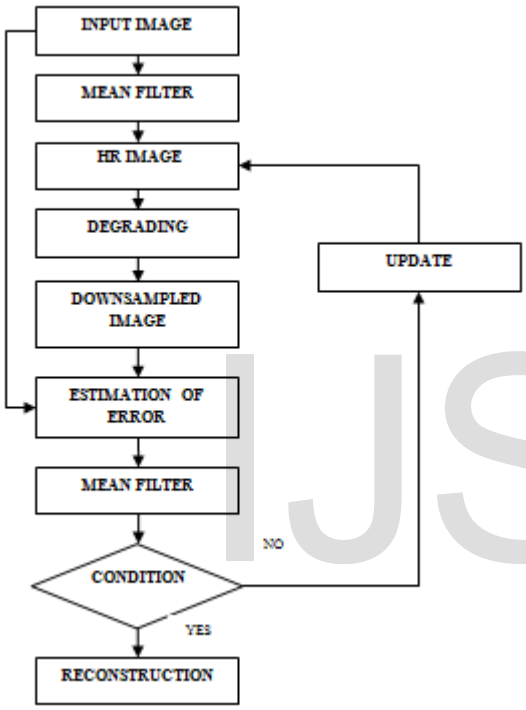

Fig.1 IBP with ANLM steps

The Gaussian kernel function is given to be as

$$z = e^{\left(\frac{-y^2}{2\sigma^2}\right)} \qquad (1)$$

where y is the weighted average value of the neighbouring pixel which is taken for the pixels which are missing. The input image is the low resolution image which is given to the ANLM filter where the estimation of the missing pixel is done to give an output image which is of high resolution. This high resolution are processed further for obtaining more efficient result.

2.2 Degrading

The degrading of the image is the next aspect in the Iterative Back Projection algorithm. The degradation is done so as to find the error estimate between the processed high resolution image and the input low resolution image. During the normal IBP algorithm working, the input image is given directly for degrading without any type of filtering but here in our proposed method filtering is applied so as to reduce the iteration steps and so automatically the complexity of the algorithm is decreased. To reduce the reconstruction error the iterations are further proceeded and for this proceedings this degradation is done. Thus the input image is first filtered to get the high resolution image and after which it is degraded for the error estimation process between the image values.

2.3 Estimating the error

The error estimation is done between the input image and the downsampled degraded image. The difference between the value of the mean square is found in the estimating process. This mean square should be made zero until then the goes for iterations. The degraded images are shown in fig 2(b)(c)(d)(e) and fig (a) is the input image. This step is crucial because this determines the working of the algorithm. Due to the iterations ringing and the jagging effects occurs in the images. These effects cause adverse effect in the algorithm process if it is given directly for the next processing step and so to reduce the errors caused by these effects we use the ANLM filter again. By filtering the interpolation of the image values happen, which helps in satisfaction of estimate condition. The degradation and the restoration are the basic steps involved in the working.

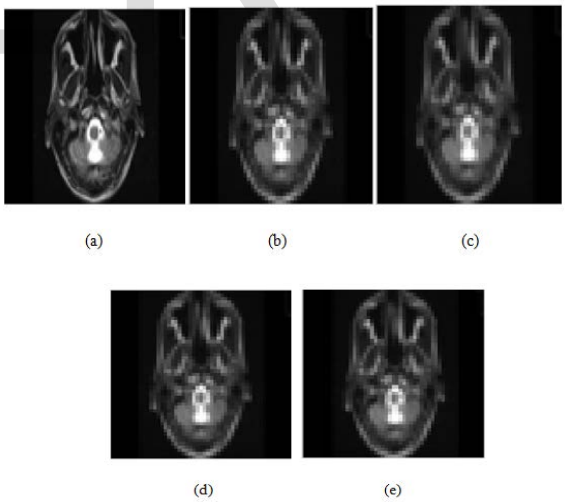

Fig. 2 (a) Input image (b) with 5% of degradation (c) with 10% of degradation (d) with 15% of degradation (e) with 20% of degradation

2.4 Satisfying condition

The IBP method iterates again and again to reduce the errors and for the algorithm to be stopped there should be condition which has to be satisfied . This termination should be fixed . Terminating condition here is the mean square value and this is set to be zero. If this condition is not

satisfied then the iterations have to be proceeded and so updation is done before the degradation process. The updation is done by adding noises for every step of the looping function and then the error estimation is carried out. If the condition is satisfied then the reconstruction of the high resolution image. Thus these are the steps involved in the algorithm. ANLM with IBP gives very good enhancements when considered to the normal IBP method. The Fig 3 shows the MR images using Bicubic interpolation, Sparse coding and the proposed method.

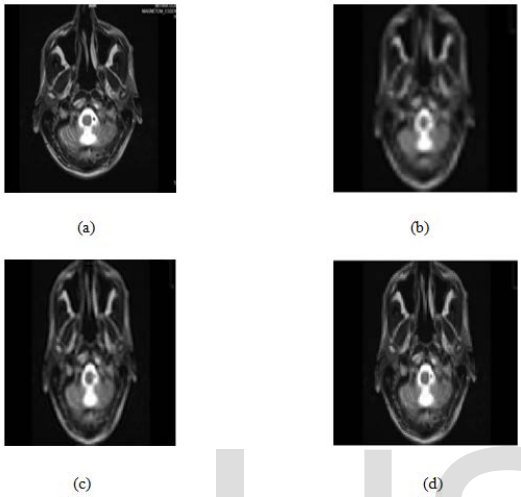

Fig. 3: (a) Input image (b)Bicubic interpolation (c)Spare coding (c)output of IBP with ANLM

3 Performance Analysis

Analyzing the results is an very important aspect as it shows the variations between the existing and the proposed results. The efficiency is checked with various parameters like PSNR(Peak Signal To Noise Ratio),MSE(Mean Square Error), Structural similarity etc . In this paper PSNR and the MSE values between the various methods

The term peak signal to noise ratio(PSNR) is an expression for the ratio between the maximum possible value (power) of a signal and the power of distorting noise that affects the quality of its representation.

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

The MSE represents the average of the squares of the errors between the actual image and the noisy image. The error is the amount by which the values of the original image differ from degraded image.

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2 \quad (3)$$

The graphical representation of the parameters are shown in fig 4. By changes in the sigma values the PSNR and the MSE is found and plotted. By analysing the bicubic interpolation, Sparse coding and the IBP with ANLM, there is an improvement of 7% in the PSNR values. This shows that the proposed method is more efficient than the existing method.

TABLE 1
Performance Analysis

METHODS	MSE	PSNR
Bicubic interpolation	0.0213	58.6354
Sparse Coding	0.0182	62.0356
ANLM with IBP	0.0168	65.5386

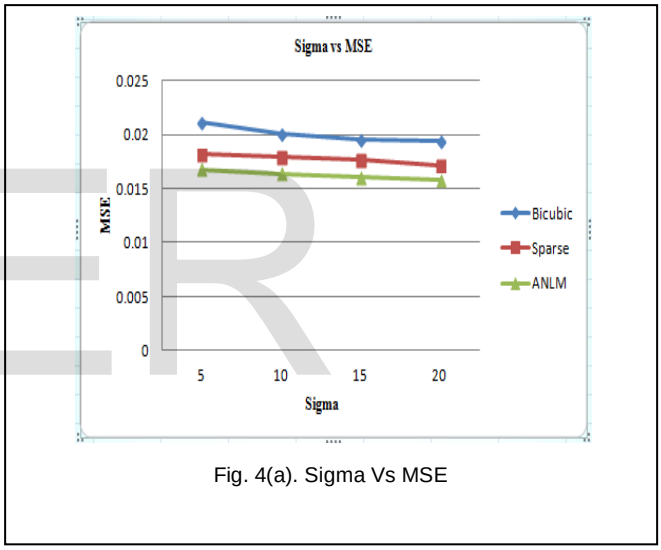

Fig. 4(a). Sigma Vs MSE

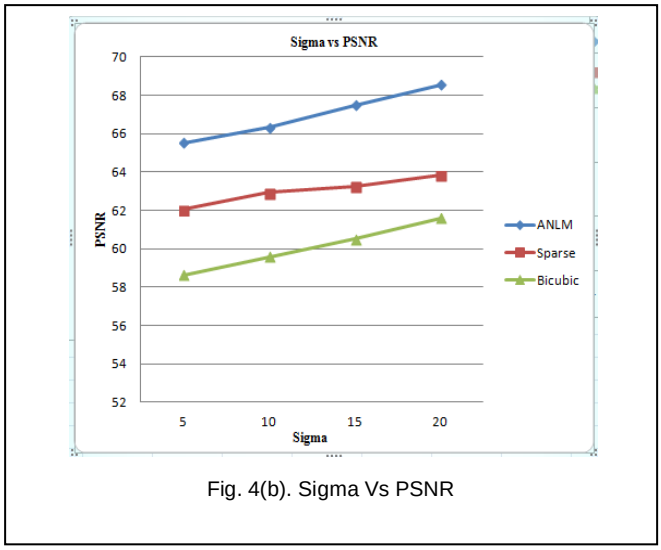

Fig. 4(b). Sigma Vs PSNR

4 CONCLUSION

The proposed method in this paper works well with the images with more amount of noise. This reduces the blurring effects. The Ringing and the jagging effects are reduced further which occurs during the iterations. The IBP with ANLM method is used for MR images and it is showed that there is 7% increase in the PSNR values. Segmentation could be done for future enhancements of this method for more clear diagnosis.

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