ISSN 2348 – 9928
IJAICT Volume -1, Issue-7, November 2014 Doi:01.0401/ijaict.2014.01.26 Published Online 05 (05) 2014

IMPROVED NON LOCAL MEANS TO REMOVE GUASSIAN NOISE IN NATURAL IMAGES

Ms. G. Dhivya
Department of Electronics and Communication,
Saveetha Engineering College,
Chennai, Tamilnadu , India.

Abstract— ***Noise removal and image enhancement are the important tasks addressed by many Image Processing algorithms, especially, when the images are corrupted by high noise level e.g. in the case of remote imaging, thermal imaging, night vision etc. Image denoising has been a well studied problem in the field of image processing. Denoising technique is a pre-processing step in compression, segmentation and restoration. Denoising is classified into two types: Local and Non local means. The presence of similar patterns and features in an image are referred to as Non Local means. Non local means algorithm assumes that the image contains excessive redundancy and these redundancies can be used to remove the noise present in the image. It estimates noise-free pixel intensity as a weighted average of all pixel intensities in the image, and the weights are proportional to the similarity between the local neighborhoods. The recently proposed non local means achieves excellent performance in digital image processing. In addition to the conventional non local means, a new technique called improved non local means has been explored. By using pre-classification, similar block searching and weighted averaging, the INLM filtering is more efficient than conventional NLM.***

Keywords— Denoising, Local and Non local means, Gaussian Noise, Pre-classification.

I. INTRODUCTION

Conventional NLM reduces the redundancies and improve the visual quality. Using this NLM technique both high and low frequency noises are removed from images. Non local means method is generally used in natural images to recover the original image. It exploits the concept of self similarity. The conventional NLM method has two major drawbacks large computational time required by the process of distance calculation in the whole image, especially on 3D volume data every block in the image is used in the weighted averaging no matter whether they are similar or dissimilar with the block to be denoised which may lead some errors in a severely noisy image. To overcome the drawbacks, an improved NLM algorithm is used. Here only the similar blocks are used in the weighted averaging step. The similarity is evaluated by a given threshold. Only similar blocks are used in weighted averaging. To reduce the number of blocks taken into account in the searching a pre classification is used. Improved non local means is a regularized iterative reconstruction method.

II. NON LOCAL MEANS ALGORITHM

Local means techniques remove only the high frequency contents present in the image and low frequency noise is not taken into consideration. The major drawback of these filters is that comparing only grey level values in a single pixel neighboring pixel which is not robust when these values are noisy. To overcome this, non local means are introduced. Non local is easy and instinctive, [5]. Non local means recommends replacing the local comparison of pixels, which are corrupted by noise highly. This is done by non-local comparison of pixels using the redundancy information present in the image. For selecting the relevant features in an image, pixels are evaluated, [6]. Non local means is basically a neighborhood filter. Non local means depends on calculating weights that reflect on the neighborhood similarity, which includes comparison of neighborhood between all likely pixels in an image, therefore it is computationally pricey, see [7].

The Non local means method not only compares the grey level in a single point but the geometric configuration in a whole neighborhood, see [2]. Non local methods achieve de-noising by searching similar pixels that are not necessarily within the neighborhood. Non local mean is one of the first non local methods. In this it calculates weights for all patches in a selected window, where the weights exponentially decay in dissimilarities, and then denoises the current patch as a weighted average. Similar blocks are grouped and transformed into a new domain. While assessing the similarity, the pixel under consideration as well is taken into account. The non local means (NLM) filter estimates a noise free intensity as a weighted average of all pixels intensities in the image, and the weights are proportional to the similarity between the local neighborhoods of the surrounding pixels. The main advantage of NLM technique is to preserve image details when denoising. The disadvantage of this technique is that it is more complex and computationally expensive, see [3]. To measure, the method noise, to evaluate and compare the performance of digital image denoising methods. If $v = \{v(i)| i \in I$ is the noisy image, then the estimated value will be NL[v](i), for a pixel i, is computed as a weighted average of all the pixels in the image, see [2].

$$NL[v](i) = \sum_{j \in I} w(i,j) v(j) \qquad (1)$$

Similarity is computed by taking noisy pixel under consideration and its neighborhood is taken into account. Mathematically, it can be expressed as [1],

$$NL[u](x) = \frac{1}{C(x)} \int e^{-\frac{G_a * |u(x+.)-u(y+.)|^2)(0)}{h^2}} u(y)dy \qquad (2)$$

The integration is carried out over all the pixels in the search window. Where

$$C(x) = \int e^{-\frac{G_a * |u(x+.)-u(y+.)|^2)(0)}{h^2}} u(y)dy \qquad (3)$$

C(x) is normalizing constant. G_a is a Gaussian kernel and h is a filtering parameter.

Step 1: Take a window centered in x and size (2m+1 X 2m+1), A(x,m).

Step 2: Take a window centered in x and size (2n+1 X 2n+1), W(x,n), w_{max}=0;

Step 3: For each pixel y in A(x,m) and different from x, compute the difference between W(x,n) and W(y,n) as d(x,y).

Step 4: Compute the weight from the distance d(x,y) as **w(x,y)=exp(-d(x,y)/h);**

Step 5: If w(x,y) is bigger than w_{max} then $w_{max} = w(x,y)$;Compute the average, **average+=w(x,y)*u(y);** Carry the sum of the weights, total weight+=w(x,y);

Step 6: Give to x the maximum of the other weights, average+=w_{max}*u(x); total weight+=w_{max}; Compute the restored value, rest(x)=average/total weight;

Step 7: The distance is calculated as follows:

```
Function distance(x,y,n)
{
    distancetotal=0;
    distance=(u(x)-u(y))^2;
    for k=1 until n
    {
        for each i=(i1,i2)
            pair of integer numbers such that
max( |i1|, |i2| ) = k
        {
            distance+=(u(x+i)–u (y+i))^2;
        }
  aux=distance/(2*k+1)^2;
distancetotal+=aux;
    }
    distance/=n;
}
```

III. IMROVED NON LOCAL MEANS ALGORITHM

The algorithm can be expressed as:

$$INLM(x_i) = \sum_{j \in N, \|x_i - x_j\| < \varepsilon} w_{ij} x_j \qquad (4)$$

If the $\| x_i - x_j \| < \varepsilon$, the two blocks can be considered similar. Otherwise it is considered dissimilar and ignored. Considering the zero mean noise, if two estimated blocks are similar, they should have average gray values and standard deviations. Using this, the map of block means and standard deviations are computed. If they are located in agiven region, the distance will be calculated. Otherwise block are considered dissimilar and the distance is set to ∞, (5)

$$d(\bar{N}_i - \bar{N}_j) = \begin{cases} \frac{\| \bar{x}_i - \bar{x}_j \|_{2,a}}{L^2}, \eta_1 < \frac{E(\bar{x}_i)}{E(\bar{x}_i)} < \eta_2, \sigma_1^2 < \frac{\mathrm{var}(\bar{x}_i)}{\mathrm{var}(\bar{x}_i)} < \sigma_1^2 \end{cases}$$

The maps of local means and local standard deviations are pre-computed in order to avoid repetitive calculations of moments for one same neighborhood. The method can speeded up by the pre-classification method as most of the dissimilar blocks are discarded by this processing.

The steps of the proposed algorithm can be summarized as:

- Initialization: $n = 1, \vec{f}[n,1] = 0;$
- Data projection iteration, for m=2

$$N_{data} : \vec{f}[n,m] = \vec{f}[n,m-1] + \vec{M}_i \frac{gi - \vec{M}_i . \vec{f}[n,m-1]}{\vec{M}_i . \vec{M}_i}$$

- Positivity constraint

$$f_j[n] = \{ f_j[n, N_{data}], f_j[n, N_{data}] \geq 0$$

- Improved non local means filtering

$$f' = INLM(f)$$

- Initialize next loop

$$\vec{f}[n+1,1] = \vec{f}'$$

The iteration is stopped when there is no appreciable change in the intermediate images.

IV. NEIGHBORHOOD CLASSIFCATION

To pre-classify the image blocks and thereby reduce the number of weight computations in the non local means denoising algorithm two types of filters are identified. One filter is based on average neighborhood gray values, and the second one is based on gradient. Finding easily computed measures for neighborhood similarity is fundamental to make the NLM practical. Average the gray values in the neighborhood of each pixel as one measure of similarity. Intuitively, considering zero mean additive noise, similar neighborhoods should have similar gray values.

In the proposed algorithm, for each pixel i ,a maximum of 2n+1 weights are calculated, for the 2n+1 pixels *j* with closest neighborhood average value to that of *i*. Depending on the selected value of n, the average of obtained 2n+1 neighborhoods might be too far from the average for the neighborhood of the pixel being processed [9]. Therefore, in addition to using a fixed pre-defined number of blocks the ratio of average gray value in the neighborhoods of pixels *i* and *j* when computing *w(i , ,j).* The NLM filter can be viewed as a selective smoothing filter which gives increased weight to pixels with similar neighborhood intensities. It can be observed that when the centered pixel signal stands out from its surrounding neighborhoods, the weight distribution is heavily contributed by the pixel itself. For a pixel located on a boundary, the weights are distributed on the same curved line. For a pixel located in the flat region, the weights are evenly distributed within the same region. Therefore, the NLM is able to preserve a prominent signal in a uniform background while smoothing out small variations caused by noise.

The required computation time is shorter for the block-wise than for the pixel wise implementation, the relative contribution of the non multithreaded operations in the overall computation time (opening and closing of file, computation of the local maps, etc.) is much higher in the pixel wise compared to the pixel wise implementation. As a consequence, the speedup factor will be higher in the later. To conclude, the different improvements included in the proposed **Optimized Block-wise NL-means** filter, [8]. Recently, they have also been applied in medical imaging for image registration, segmentation and reconstruction. Iterative methods are preferable when the recovery problem becomes ill-posed, for example, when the data are noisy, few view or limited in angle.

V. EXPERIMENTS AND RESULTS

The clinical datasets are collected using 100keV voltage and 3mA tube current. The standard test image is added with additive white Gaussian noise (AWGN). This image is given as input to non local filters. The MSE and PSNR values of different standard test images are calculated. MSE, PSNR and visual quality provides the objective and subjective measurements respectively [2]. In the Table 1, MSE and PSNR values of proposed non local means technique is estimated.

Table 1: MSE and PSNR values of different standard test images.

Filter	Images	Pout	Trees	Barbara
Improved Non Local Mean	MSE	110.28	48.99	112.49
	PSNR	27.24	31.26	27.24

Corresponding Author: Ms. G. Dhivya, Saveetha Engineering College of Nursing, Chennai, Tamilnadu , India

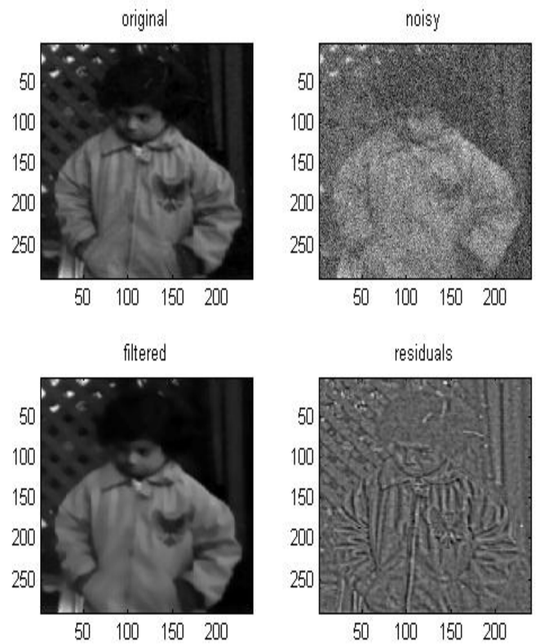

Fig 1(a): Pout image corrupted by Gaussian Noise, 1(b) Image obtained using Non local Means Filter.

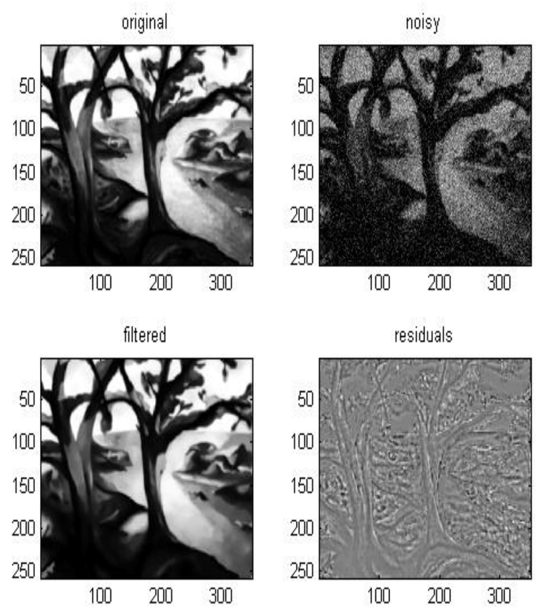

Fig 2(a): Trees image corrupted by Gaussian Noise, 2(b) Image obtained using Non local Means Filter

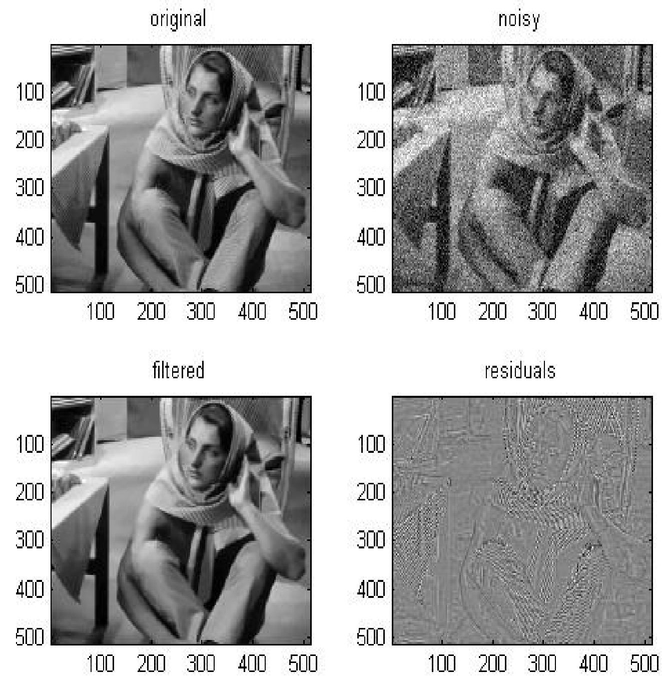

Fig 3(a): Barbara image corrupted by Gaussian Noise, 3(b) Image obtained using Non local Means Filter.

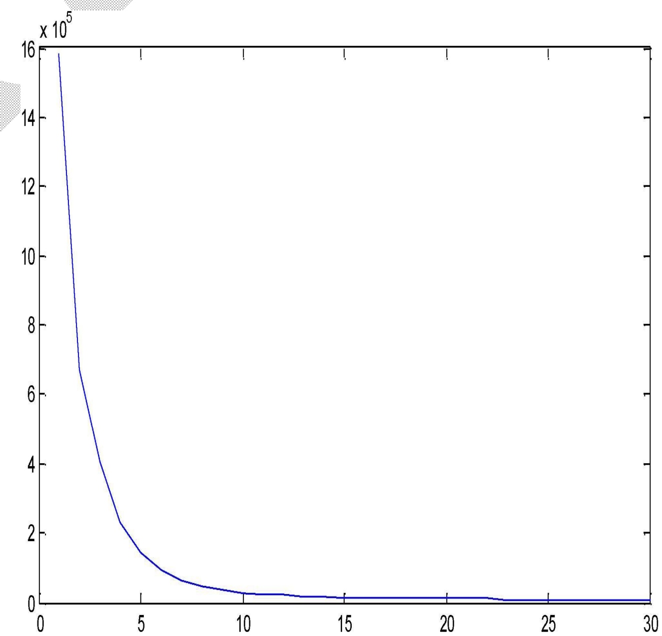

Fig 4: The curve of MSE value versus number of iterations.

VI. CONCLUSION AND FUTURE WORK

In this work the image corrupted by Gaussian noise is filtered by using non local means algorithm. It is based on the principle of self similarity which a normal natural image possesses. The resultant output image is reconstructed with less artifacts and more smoothens. The fine details like edges are preserved and maintained. It estimates pixel intensity based on information from the whole image and thereby exploiting the presence of similar patterns and features. In the future, the proposed algorithm may be improved by using a locally adaptive filter based on KL transform to keep track of noise variance. The implementation of this algorithm in removing the noise present in medical images can also be investigated. An improved non-local mean regularized iterative reconstruction method for low-dose dental CBCT, and compare the performance with FDK result. Clinical experiments demonstrate that this method improve PSNR than FDK reconstruction and achieves better visual quality. In additional, the low-contrast parts and details information are well preserved.

Reference

[1] Dixit A.A, Phakdhe. A.C, "Denoising of Gaussian Noise Affected Images by Non local Means Algorithm," Interantional Conference on Circuits, Power and Computing Technologies, 2013, Pune, India.

[2] Antoni Baudes, Bartomeu Coll, Jean- Michel Morel,"A non local algorithm for image denoising", IEEE Computer Society Conference on Computer Vision and Pattren Recognition, 20-26June 2005, San Diego, CA, USA.

[3] B. Goosens, H.Q. Luong, A. Pizurica, W. Philips, " An Improved Non Local Means Algorithm," International Worshop on Local and Non local Approximation in Image Processing, 25-29 August 2008, Lausanne, Switzerland.

[4] Dixit A. A and Phakdke A.C," Image Denoising by Non Local Means Algorithm", International Conference on Signal Processing, Image Processing and Pattern Recognition, 2013.

[5] Saachin Chachada, Byung Tae Oh, Namgook Cho, San A. Phong, Daniel Manchata, C. C. Jay Kuo, "Extension of Non Local Means (NLM) Algorithm with Gaussian Filtering for Highly Noisy Images", University of Southern California, Los Angeles, USA.

[6] Wanjun Chen, Mingyue Ding, Yalin Miao, Lei Luo,"Ultra-sound image denoising with multi-shape patches aggregation based non local means", International Conference on Intellligent Compuation and Bio-Medical Instrumentation, 2011.

[7] Weifeng Sun, Min Han," Adaptive Search Based Non Local means Image De-noising", Shandong University, China.

[8] An Optimized Blockwise Nonlocal Means Denoising Filter for 3-D Magnetic Resonance Images Pierrick Coupé*, Pierre Yger, Sylvain Prima, Pierre Hellier, Charles Kervrann, and Christian Barillot.