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Medical Image Restoration Using Non-Local Means Algorithm

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ABSTRACT

Generally, the removal of noise from medicalimages is difficult. This noise can be removed easily by Non-Local Means(NLM) method. NLM filter helps to differentiate image data and noise data. First, the image is restored by Laplacian of Gaussian (LoG).To restore corrupted pixels,theLoGfilterisapplied on white Gaussian noiseforSmoothing and removing. After, the Image is interpolated by the NLM algorithm by averaging all pixelsinthe requiredimage.Therefore,ImprovedPSNR,MSE,andgood image quality are determined with this algorithmand the result isobtained.

KEYWORDS

Image Restoration, Laplacian of Gaussian Filter, Non-local Means Filter, Gaussian Noise, PSNR, MSE.

Introduction

The images are mostly affected by Gaussian noise during the process of acquisition and transmission. Thus, an competent noise suppression method is needed before a following image processingoperation.Medianfilter(MF)isoftenutilizedin noise removing methods thanks for its denoising abilityand the computational efficiency. However, it's efficient just for less corrupted images.

A challenge is given by [1] for many median filters likea standardmedianfiltertorestoretheimagecorruptedbyhigh-density noise. This technique removes only the noisy pixels and restores the image up to 90%. Also, the maximum level of edge preservation isobtained.

The image enhancement factor is improved in this method. Suppressing the image uses the Cloud model in [2]. Adaptive Iterative Mean (AIM) filter is used along with an iterative noise detector to eliminate the general noise [3].

Decision-based variation methods, adaptive multi resolution-based algorithm are some examples. Highly competitive and good edge preservation schemes are discussed in this paper. An independent edge-preserving algorithm [4] shows the best results for images corrupted by multiple noises. The algorithm outperforms with reduced computational complexity irrespective of the nature of the noise and distribution of the noise.

The need for image smoothing has become necessary forremovalofnoise.Thebestfilter is used in image processing. De-noising an image is removing the noises that affects the image and conserve edges. Twomodels areusedforde-noisingthey arelinearmodel and nonlinear model. Basically, linear model isuseful for their speed and limitation. But it can't preserve those edges as in better form.

The proposed algorithm is done in two-stage MRI denoising is used based on the 3D version of Non-Local Mean and multidimensional PCA(MPCA) [5].

Gaussian Noise Representation

Gaussian filtering techniques are used to remove the white Gaussian noise in the images and also blur the image detail. In 1D (dimension), the Gaussian filter is Eq.(1),

$$G(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{x^2}{2\sigma^2}}$$

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Therefore, σ is the standard deviation for thediffusion. The mean spread is presumed to have zero. Gaussian filter techniques are utilized in numerous researchzones:

- Gaussian filter defines probability for the distribution of the noise.
- It represents the smoothingoperator.
- It is preferred inmathematics.

The Gaussianfunctions havea main property which is verified by reference to integral,

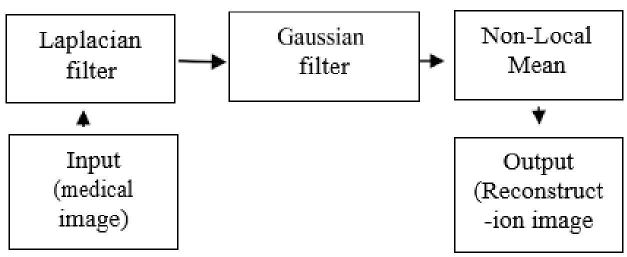
$$I = \int_{-\infty}^{\infty} \exp(-x^2)\,dx = \sqrt{\pi}$$

In possible terms, it describes 100% of the probabilistic values for any given space when varying from negative to positive values. The Gaussian function isn't adequate to zero.

TheGaussianfiltersworksasapoint-spreadprocess by using 2D distribution. It is often got by convolving the 2D Gaussian distribution with the images. We also like to provide a discrete assumption to Gaussian function.

Proposed Method

IdentifyingtheGaussiannoiseandrestoringtheimagearethe two steps involved here to remove the noise. Stages of noise removal procedure are asfollows.



Flow chart for the proposed model

Smoothing the Image by LaplacianFilter

SmoothingtheimagebyLaplacianfilter. Itisanedgedetector andit'saLowpassfilterwhybecauseitsmoothedtheImage.Laplacian*L(m,n)*ofaimage bypixelintensity*I(m, n)* is shownby:

$$L(m,n) = \frac{\partial^2 I}{\partial x^2} + \frac{\partial^2 I}{\partial y^2}$$

The following check box is a Matrix representation of the Laplacian filter.

0	-1	0
-1	4	-1
0	-1	0

Fig: Matrix representation of Laplacian filter

The Laplacian filter matrix has negative values in a cross pattern. Corner of the matrix to be either zero or positive values in the matrix, array in the center array, value at the centercanbeeitherpositiveornegative.Byusingthismatrix we can easily program in Matlab (programming). The following array is an example of a 3x3 (Matrix)kernel for a Laplacian filter.

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Removing White Gaussian Noise

Gaussian filter is specifically removing the white Gaussian noise. Gaussian function eq

$$G(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{x^2}{2\sigma^2}}$$

Gaussian filter is preferred for removal of noise and also blurring the image in one dimensional. We want to remove the gaussian from the image so we are using the gaussian filter, Gaussian filter is very important for removing the noisy component.

LoG- Laplacian of Gaussian Filter

For LoG, Operator which normally took a gray level image for input, from LoG is the combination of both the previous steps that are Laplacian and Gaussian filter. Laplacian for smoothingtheinputimageandthentheimageisprocessedto Gaussian filter for removing thewhiteGaussian noise. Laplacian filter which also reduces its sensitivity of corruption in the image.

Laplace operator detect the edges and also the noise, first, it can smooth images with a convolution of aGaussian kernel σ of width,

$$G_\sigma(\mathrm{m, n}) = \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left(-\frac{m^2+n^2}{2\sigma^2}\right)$$

noise is reduced before using Laplace for detecting edges:

$$\triangle\,[G_\sigma(m,n) * f(m,n)] = LoG * f(m,n)$$

First equal sign is because

$$\frac{d}{dt}[h(t) * f(t)] = \frac{d}{dt}\int f(T)h(t-T)dT$$

$$\Rightarrow\ f(T)\frac{d}{dt}h(t-T)dT = f(t) * \frac{d}{dt}h(t)$$

So, the first Laplacian of Gaussian Δg_σ(m, n) is obtained and then the input image is convolved. Consider

$$\frac{\partial}{\partial m} G_\sigma(m,n) = \frac{\partial}{\partial m} e^{-(m^2+n^2)/2\sigma^2} = -\frac{m}{\sigma^2} e^{-(m^2+n^2)/2\sigma^2}$$

And

$$\frac{\partial^2}{\partial^2 x} G_\sigma(m,n) = \frac{x^2}{\sigma^4} e^{-(m^2+n^2)/2\sigma^2} - \frac{1}{\sigma^2} e^{-(m^2+n^2)/2\sigma^2} = \frac{m^2-\sigma^2}{\sigma^4} e^{-(m^2+n^2)/2\sigma^2}$$

Note that to be easier we remove the normalizing coefficient 1/√2∏σ2 similarly, we get

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$$\frac{\partial^2}{\partial^2 x} G_\sigma(m,n) = \frac{n^2 - \sigma^2}{\sigma^2} e^{-\ (m^2+n^2)/_{2\sigma^2}}$$

Finally, the LoG operator is defined as,

$$LoG \triangleq \triangle G_\sigma(m,n) = \frac{\partial^2}{\sigma m^2} G_\sigma(m,n) + \frac{\partial^2}{\sigma n^2} G_\sigma(m,n) = \frac{m^2 + n^2 - 2\sigma^2}{\sigma^4} e^{-\ (m^2+n^2)/_{2\sigma^2}}$$

Reconstruction of the Original Image Non-Local MeanFilter

Itis determined as thebasicmethodof averaging entire non local mean pixels in the image. A strong noise removaltechniqueissaidasNon -LocalMeansalgorithm [9].The specific gray level pixels is compared by the geometrical composition in all the surroundings.

$$i=\{i(m)|m \in 1\}$$

the non-local means NL(i(u)) is approximated, for each pixelis calculated as

$$NL(i(m)) = \sum_{n\in 1} w(m,n) i(n)$$

Where, group of weights $\{w(m, n)\}_m$ is depending on thesimilarities between the pixels (m) and (n) and fulfilling the given statements

$$0 \le w(m,n) \le 1 \text{ and} \sum_n \mathrm{w(m,n)} = 1$$

NL(i(m)) denotes the weighted mean of the image's pixel value.Theclosenessthatcomes in-betweentwopixelsaand bareevaluatedwithintensitygray-levelvectorsi(N_m)and i(N_n), where N_k correspond to the nearby pixel having a square arrangement and centering atpixel k and with fixed size. The Euclideandistance d (a decaying function), which is weighted in nature and its used for measuring the comparison between the pixels, it’s shown as

$$d= \|i(N_m) - i(N_n)\|_2^2 \quad p$$

If gray-level neighboring pixel is same as that of i(N_m), it possesses more weightsforcomputingtheaveragetocomparedwithotherpixels which are in the image. The weight is describedas,

$$w(m,n) = \frac{m}{Z(m)} e^{\left(\frac{\|i(N_m) - i(N_n)\|_2^2 \quad p}{h^2}\right)}$$

Where, normalizing constant is Z(m)

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$$Z(m) = \sum_{n} e^{\left(\frac{\|i(N_m) - i(N_n)\|_2^2 \quad p}{h^2}\right)}$$

and value h represents the degree for filtering and it manages the delay ofexponential parameter.

Result of NonLocal Mean Filter & Laplacian of Gaussian Filter

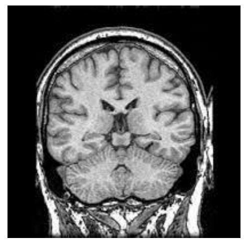

Fig.1. Original image

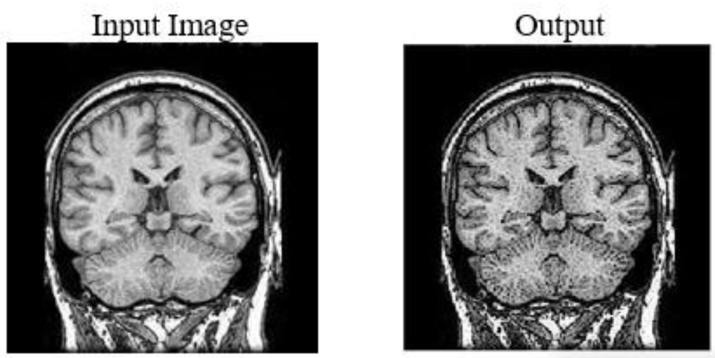

Fig.2. Laplacian Filter

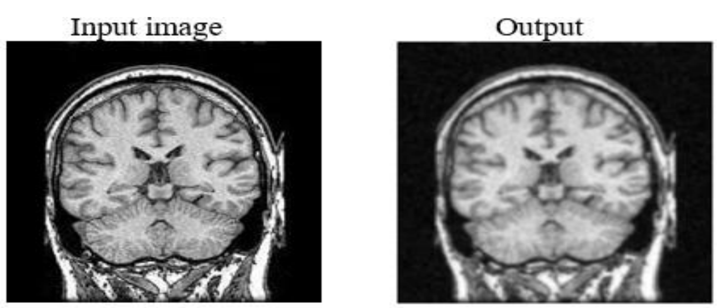

Fig.3. Gaussian filter

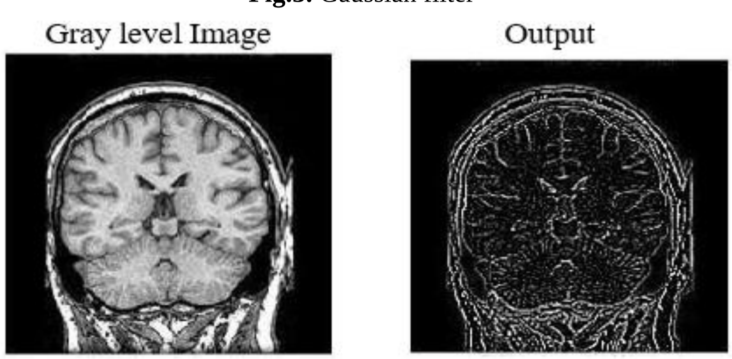

Fig.4. Laplacian of Gaussian filter

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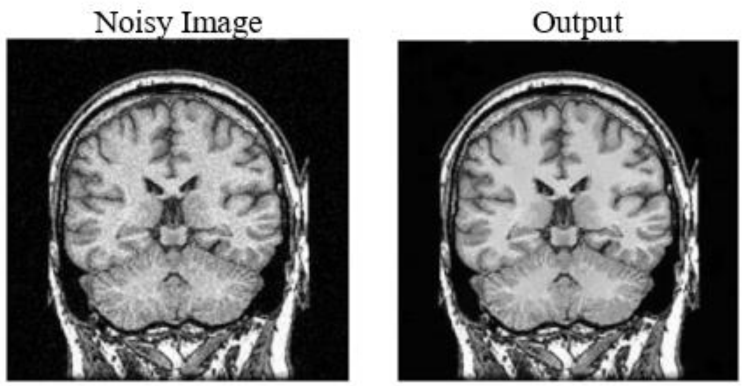

Fig.5. Non-Local Means

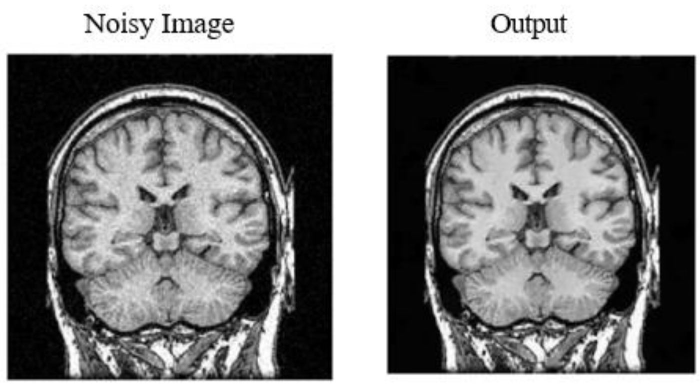

Fig.6. When noise 20%

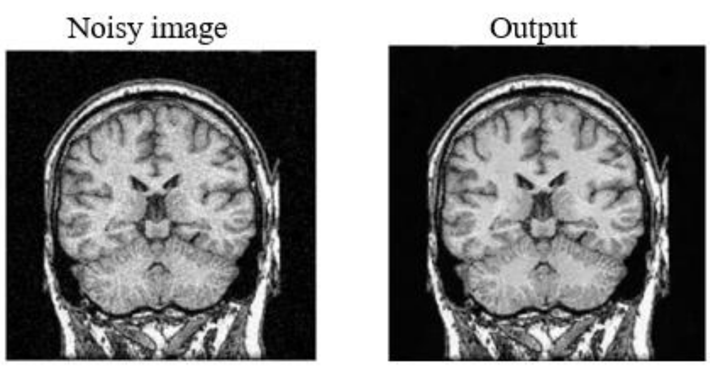

Fig.7. When noise 40%

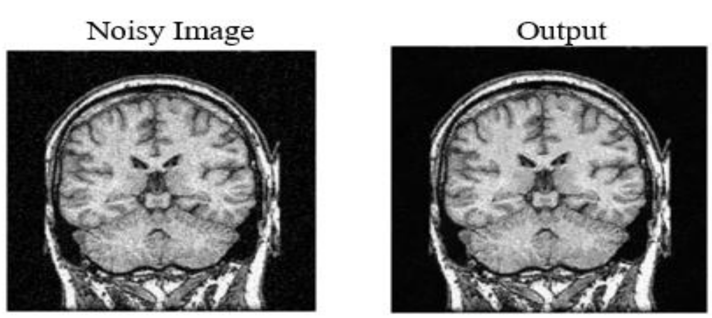

Fig.8. When noise 60%

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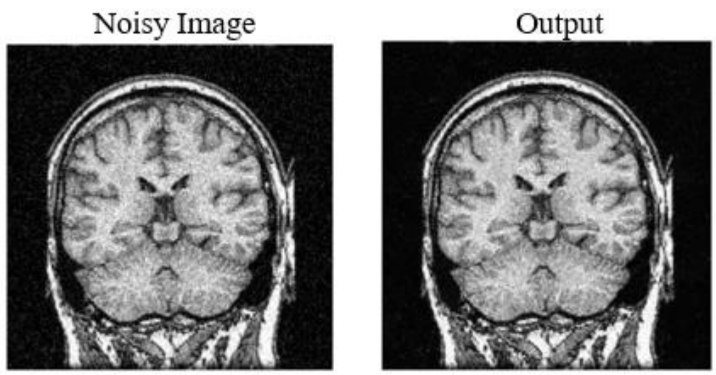

Fig.9. When noise 80%

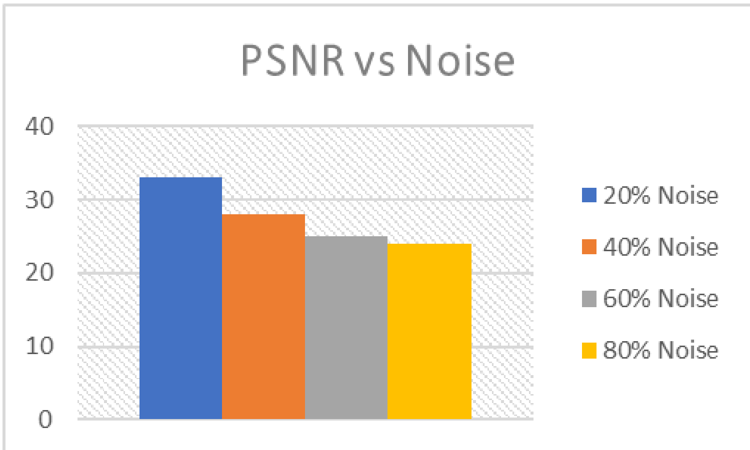

Fig. 10. Noise vs PSNR

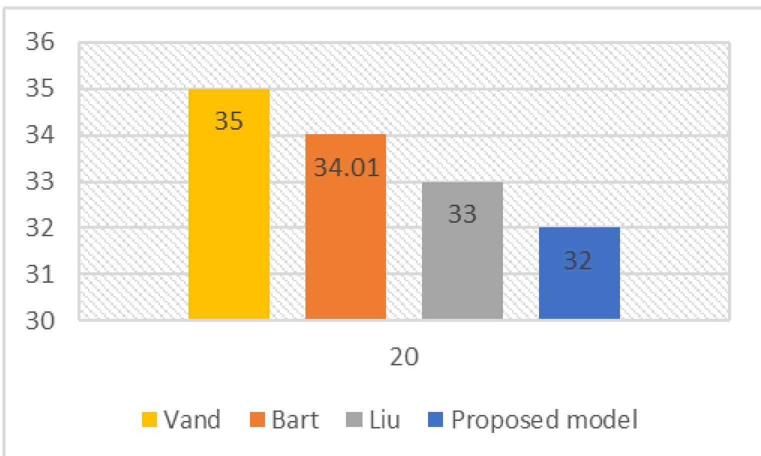

Fig.11. Comparison charts of various methods of NLM PSNR

Discussion

For better performance study, 256 x 256 imagewith varying values of noise densities is taken into account. Various gaussian noise patterns are added for testing purposes. NLM performs better compared to all other existingmethods.

Conclusion

Our paper proposed a novel method to suppress the GaussiannoiseusingNon-LocalMeansFilterandLOGFilter using the nearest neighboring interpolation for constructing the initial image. Next, the filtering techniqueisused for removal of noise. The above experimental results indicate our method produces the best PSNR value and compatible with the existing methods for run time. As the visualqualityisenhancedbetter,thismethodsuitsmanyreal-timeapplications.

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