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Competent Impulse Noise Removal Algorithm for Medical Images Using Non-Local Means Filter and LOG Filter

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ABSTRACT

Impulse noise is a complication in all medical images. In this, the paper best method is proposed to suppress high-density impulse noise[IN]. Removal of noise is major work while working with various image. In order to restore the corrupted pixels, an impulse detector is applied first. The detecting device will verify the noisy pixels in impulse noise. Then the Non-local means filter and LoG filter is applied. Non- local means filtering and LoG filtering method is the most suitable denoising technique for medical images. The experimental results show the image quality and change in PSNR by using the algorithm. With this denoising of a medical image is performed.

KEYWORDS

Non-local Means Filtering, Image Denoising, Impulse Detector, Impulse Noise, LoGFilter.

Introduction

Image quality has an significant parameter as noise. Alwaystheimageiscorruptedwithimpulse noiseduringthe image acquisition and transmission process. For the reduction of this impulse noise, many algorithms are developed.

In [1] the switching filter and median filter are used to correct and identify the noisy pixels. PNSR and structural similarity index measures are measured. Compared to other methods this provides better performances. Up to 100% of the noise is removed from high-density noisy images.

A Non-local mean based noise suppression algorithm is proposed by [2]. In this paper, a two-stage detection process is performed. First, a robust outlyingness ratio (ROR) is given to measure the corrupted pixels. Then, the cluster-based pixel division is done. This method speaks about high PSNR and improved image quality.

Improvedweightedaveragedfiltering[3]usedforimpulse noise removal algorithm. The original image is interpolated by the nearest neighborhood algorithm. The pure and noisy pixels are computed to give weights. Improved PSNRandgoodimagequalityaretheresultsobtainedbythis method.

A switching based weighted mean filter is done [4] for pepper and salt noise removal. The neighbor's pixels and current pixels are computed to having an already known threshold to bring noisy pixels. The uncorrupted neighbor pixels replace the corrupted pixels with weightedmean. In this method, the computational efficiency is increased.

Unsymmetrical trimmed median filter is given infor corrupted color images. Replacing of noisy is either by trimmed median filter or mean value. Based on the presence of lowest gray value and highest gray value in the particular window.

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Anedge-preservingfilter[6]isproposedfortheremoving salt and pepper noise from the noisy image. A review of modern techniques insists on the recent technology applied for removing the impulse noise.

Impulse Noise Representation

There are various kinds of noise corrupting image. Impulse noise of type fixed value can be called salt and pepper noise and they are represented as in Eq. (1),

$$f(a,b) = \begin{Bmatrix} L_{min} \ with\ Probability\ P/2 \\ L_{max} \ with\ Probability\ P/2 \\ f(a,b)1-P \end{Bmatrix} \quad (1)$$

f (a,b), J (a,b), and P are the actual, noisy images and noise density ~~r~~espectively. (a,b) is the corresponding image coordinate. The values of Lmin and Lmax represent that the image self pixels have the probability of corrupting with few extreme values which are having the same probability. The impulse value of the pixel should be identified. It is then located exactly and with the help of good pixels to recover noisy image. The original value of the noisy pixels is calculated.

Proposed Method

Detecting the impulse and restoring the image are the two steps involved in the removal of noise. The two stages of noise removal procedure are as follows.

1) Detecting the Impulse

Assuming all the pixels with extreme gray levels are corrupted pixels will end in false detection. So, identifying corrupted pixels should be efficient. Specific value of impulse in the original image is useful in determining and estimating the noisy pixels.

Two extreme gray level values can have two equal impulse noise. So, the difference between the original and noisy pixels can be determined by evaluating the orientation and coordination of the corrupted pixels with the adjacent pixels.

2) Selection of Window Size

Choosing the size of the optimum windows will estimate the accuracy of the proven algorithm. The binomial distribution says about the chosen window that it will contain noisy pixels equal to the value of (W2 – 1) (1- Ƥ) if the window size is W and the noise probability isƤ.

As per equation, the number of corrupted pixels is kept as 5 or 8. If we take the value as 8, then, the window size is represented as in Eq. (2) and (3),

$$(W^2-1)(1-p)=8 \quad (2)$$

$$W=\sqrt{1+8/(1-p)} \quad (3)$$

Decreasing the value will increase the detection error and increasing the value will decrease the detection accuracy. Therefore, the selection of noisy pixel values and the design of window size should be precise to maintain the accuracy and to improve the image quality. so, it is necessary tochoosethe windowsizegreaterthan

$$\sqrt{1+8/(1-p)}$$

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The steps to know the noisy pixels are as follows:

(i) The set of noisy(corrupted) pixels VNisconstructedwith Lminand Lmaxvalues

$$V_N = (f(a,b) = L_{min})||(f(a,b) = L_{\max}) \qquad (4)$$

|| indicates the logical OR.

(ii) The noise probability Ƥ and the window size are calculated as per the equation definedalready.

$$W = \sqrt{1 + 8/(1-p)} \qquad (5)$$

(iii) The new sets Smin(a,b) and Smax(a,b) are formed with the neighboring pixel inclined at the coordinate (a,b), having the two extreme gray level values Lmin andLmax.

(iv) To calculate the set of noisypixels,

$$V = V_N \cap [V_{N1} \cup V_{N2}] \qquad (6)$$

$$V_{N1} = \{S_{min}(a,b) + S_{max}(a,b) = W^2\} \qquad (7)$$

$$V_{N2} = (f(a,b) = L_{min}\&\&S_{max}(a,b)||f(a,b) = L_{max}\&\&S_{min}(a,b)\} \qquad (8)$$

The two sets are calculated with a comparison of Smin(a,b) and Smax(a,b). But this may result in the wrong identification of original pixels as corrupted pixels and may reduce the accuracy.

(v) V = VN ∩ [VN1 U VN2] is computed with the selected noisy pixels. Thus the noisy pixel identification procedure is done successfully leaving out the original pixels with the values of impulse values.

Then the mask is defined as

$$Mask(a,b) = \begin{Bmatrix} 0, if\ (a,b) \in V \\ 1, if\ (a,b)\, Otherwise \end{Bmatrix} \qquad (9)$$

3) Retrieval of Image

We propose a Non-local Mean filter. Development of the first stage image will replacing the noisy pixel with the adjacent pixel available in the all four corners. the Same method is used to replace the noisy pixel by choosing the best impulse value[8]. Here, the Non -local mean filtering technique is used to give the bestresults.

4) Reconstruction of the Original Image

Non- Local Means Filter(NLM)

Non - Local Means filter is more powerful noise removal method[9]. All NLM pixels in the image was established by the fundamental process of averaging all the NLM pixels in the image. The geometrical composition is compared with the specific pixel in the gray level. A gray level of specific pixel is compared with the geometrical composition.

Considering distinct image(i) such that

$$i = \{i(a)\,|a \in 1\} \qquad (10)$$

the approximate NL(i(a)) NLM value, forpixel (a) is calculated

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$$NL(i(a)) = \sum_{b \in i} w(a,b)\, i(b) \tag{11}$$

Weights {w(a,b)}b is dependent onnumber of similarity that comes in pixels a and b, fulfilling the given work

$$0 \leq w(a,b) \leq 1 \; and \; \sum_b w(a,b) = 1 \tag{12}$$

NL(i(a)) denotes the image pixels by weighted average.Thesimilaritybetweentwo typepixelsaand b are found by intensity gray level vectors $i(N_a)$ and $i(N_b)$, where N_k correspond to pixel nearby have a square configuration and centering at a pixel k, having a fixed size. The Euclidean distance d, which is weighted in nature, is used for knowing the similarities between pixels and it's givenby

$$d = ||i(N_a) - i(N_b)||_{2,p}^2 \tag{13}$$

Where (p > 0) depict the standard deviation of Gaussian kernel(G kernel). If the gray level neighbor of pixel is similar to $i(N_a)$, then it possess larger weight in equating the average as compared to another pixels in the image. The weights are shown as

$$w(a,b) = \frac{a}{Z(a)} e^{\left(\frac{||i(N_a) - i(N_b)||_{2,p}^2}{h^2}\right)} \tag{14}$$

Z(a) is normalizing constant

$$Z(a) = \sum_b e^{\left(\frac{||i(N_a) - i(N_b)||_{2,p}^2}{h^2}\right)} \tag{15}$$

and h denotes degree of filtering parameter and it controls the decompose of exponential function. The Norm function is represented by ||.

Laplacian of Gaussian Filter(LOG)

Laplace operator can detect edges and also the noise, first it can smooth the images by convolution ofG kernel withwidth σ

$$G_\sigma(a,b) = \frac{1}{\sqrt{2\pi\sigma^2}} exp\left(-\frac{a^2+b^2}{2\sigma^2}\right) \tag{16}$$

toreducenoisebeforeedgedetection usingLaplace:

$$\Delta[G_\sigma(a,b) * f(a,b)] = [\Delta G_\sigma(a,b) * f(a,b) = LoG * f(a,b) \tag{17}$$

First equal sign is because

$$\frac{d}{dt}[h(t) * f(t)] = \frac{d}{dt}\int f(T)h(t-T)dT = \int f(T)\frac{d}{dt}h(t-T)dT = f(t) * \frac{d}{dt}h(t) \tag{18}$$

So, first Laplacian of Gaussian$\Delta g_\sigma(a,b)$ is obtained and then the input image is convolve. Consider

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$$\frac{\partial}{\partial a}G_\sigma(a,b) = \frac{\partial}{\partial a}e^{-(a^2+b^2)/2\sigma^2} = -\frac{a}{\sigma^2}e^{-(a^2+b^2)/2\sigma^2} \tag{19}$$

and

$$\frac{\partial^2}{\partial^2 a}G_\sigma(a,b) = \frac{x^2}{\partial^4}e^{-(a^2+b^2)/2\sigma^2} - \frac{1}{\partial^2}e^{-(a^2+b^2)/2\sigma^2} = \frac{a^2-\sigma^2}{\sigma^4}e^{-(a^2+b^2)/2\sigma^2} \tag{20}$$

Note that to be more easierwe remove the normalizing coefficient $1/\sqrt{2}\prod\sigma^2$ Similarly, we get

$$\frac{\partial^2}{\partial^2 b}G_\sigma(a,b) = \frac{b^2-\sigma^2}{\sigma^4}e^{-(a^2+b^2)/2\sigma^2} \tag{21}$$

Finally LoG operator is defined as,

$$LoG \stackrel{\Delta}{=} \Delta G_\sigma(a,b) = \frac{\partial^2}{\partial a^2}G_\sigma(a,b) + \frac{\partial^2}{\partial b^2}G_\sigma(a,b) = \frac{a^2+b^2-2\sigma^2}{\sigma^4}e^{-(a^2+b^2)/2\sigma^2} \tag{22}$$

Result of Non Local Mean Filter & Laplacian of Gaussian Filter

Fig. 1,2,3,4 & 5 represent the output of Non Local Mean Filter.

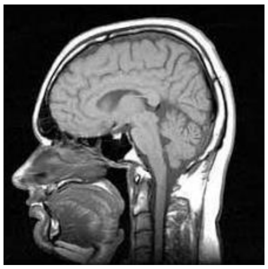

Fig. 1. Original image

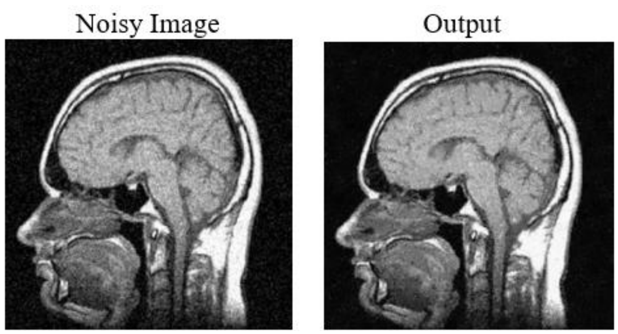

Fig.2. When Noise is 20%

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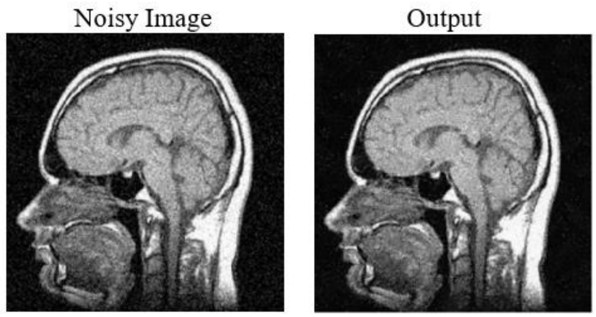

Fig.3. When Noise is 40%

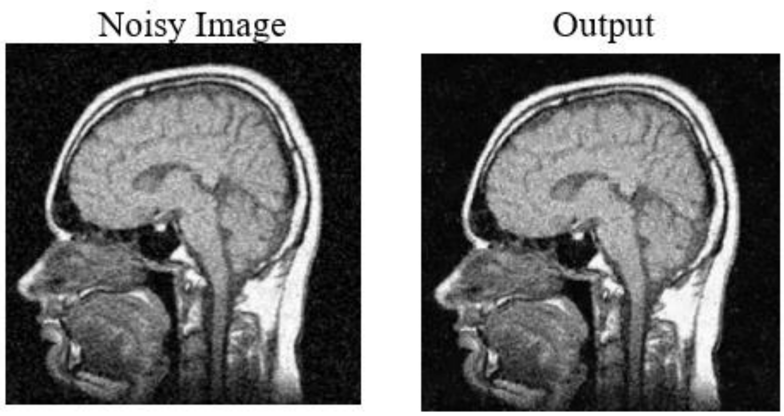

Fig.4. When Noise is 60%

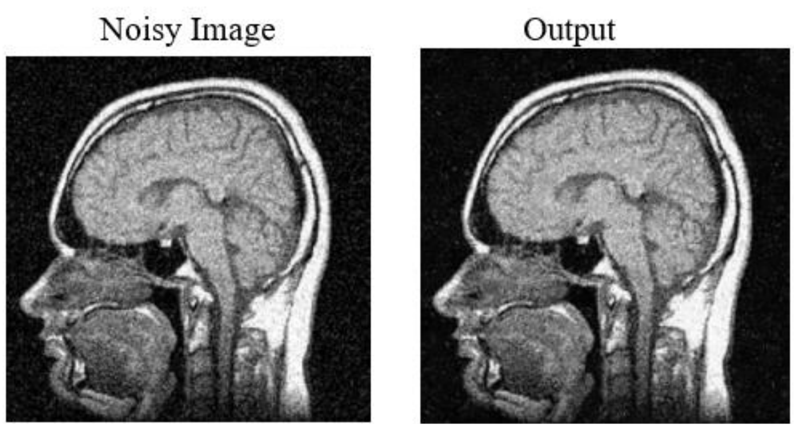

Fig.5. When Noise is 80%

Fig. 1,2,3,4 & 5 represent the output of Laplacian of Gaussian.

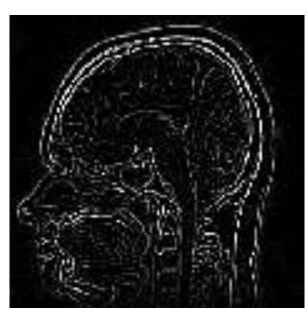

Fig.6. Gray Level **Fig.7.**Laplacian of Gaussian

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Table 1. Comparison between Noise and PSNR(db)

NOISE	PSNR(db)
20%	30.52
40%	27.46
60%	26.21
80%	25.09

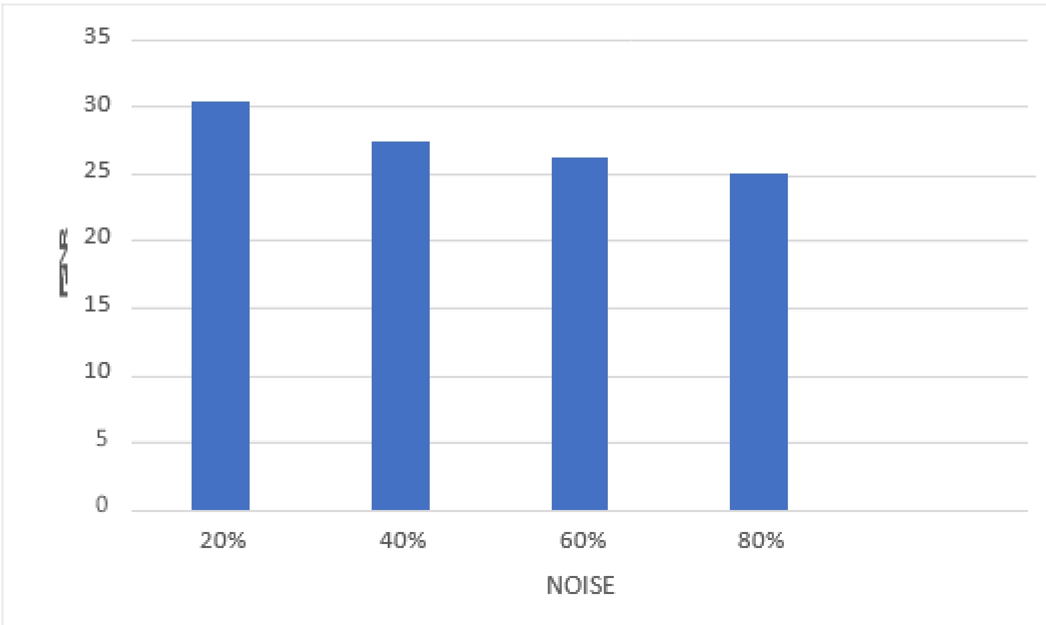

Fig. 8. Noise vs PSNR

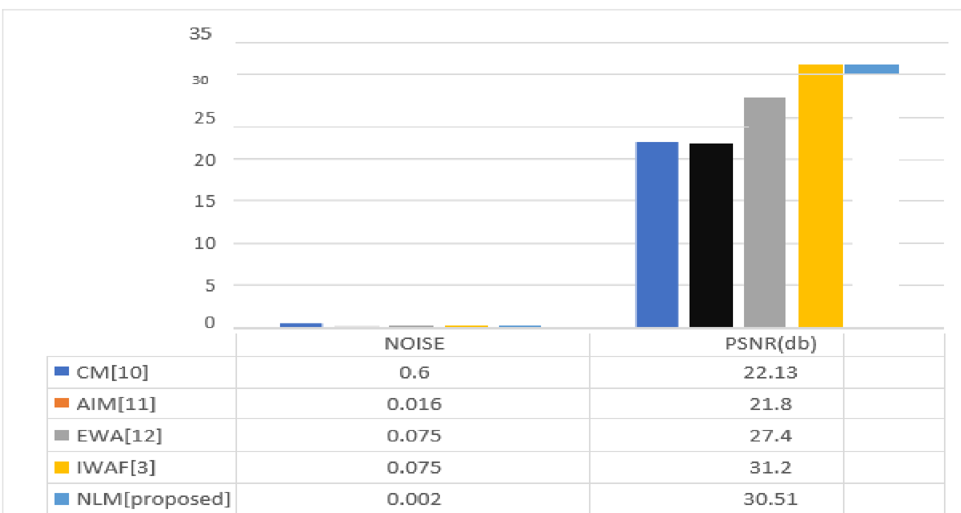

Fig. 9. Comparison charts of various methods of impulse denoising:

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Discussion

For better performance study, 256 x 256 image with varying values of noise densities is taken into account and the values of PSNR is compared with the best available methods for removing the Impulse Noise[IN]. Various IN patterns are added for testing purposes. NLMperforms better compared to all other existingmethods.

Conclusion

Our paper proposed a novel method to suppress the impulse noise using Non-Local Means Filter and LOG Filter using the nearest neighboring interpolation for constructing the initial image. Next, filtering technique is applied to remove the noise. Experimental results indicate that our method gives best PSNR value and also compatible with the existing method for run time. As the visual quality is enhanced better, this method suits many real-time applications.

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