ABSTRACT

Image denoising is used to improve the accuracy and quality of an image. Removing noise from the original image is still challenging for researchers. In this research, an efficient algorithm capable of removing noise from “unprocessed” or raw images is proposed. The algorithm supplants the noise by the median of averages found from a special combination of the pixels. After that, to evaluate the performance of the algorithm, authors have calculated the Signal to Noise Ratio (SNR), the Mean Square Error (MSE), Root Mean Square Error (RMSE), the Root Mean Square Signal to Noise Ratio (RMS\_SNR), Image Fidelity (IFY). Finally, the proposed filtering technique gives a better result with comparison to other existing filtering techniques (Median, Average, Mean, etc).

General Terms

Denoising, Linear Filtering, Raw Images et. al.

Keywords

Image Processing, Image Denoising, Raw Image, Filters, SNR, MSE, RMSE, Performance Evaluation etc.

1. INTRODUCTION

Images are authoritative and the exercise of using digital images has changed. As the imaging devices are not good enough, they produce different impairments. Noise is the most common impairment. It is very crucial to denoise the images. There are piles of algorithms works with different types of noise models [9]. Ultrasound Imaging is used to alleviate quick diagnosis and the images contain dozens of noise. Existing denoising techniques have some limitations [21]. Ultrasound images are damaged by speckle noise [15]. Most of the imaging system of the liver and kidney because of the small structure of organs. Sometimes the edge of an image needs to be detected. Especially in a medical image, edges are very important to define the shape of an object and edge detection is somehow dependent on the noise level. In real-time communication multispectral image plays a critical role which normally contains noises of a different model. This phenomenon disturbs the processing of MSIs [12]. That’s why denoise the images that are needed. Images can be corrupted by impulsive noise and furthermore, the noisy image can’t be used for the diagnostic purpose which is a very large area of image processing.

There exists a bunch of techniques to denoise images. As digital image processing deals with the pixel values, it is not so easy to find out the differences between the noise and the actual properties of the image. Maximum denoising techniques [14] remove the tiny details from the image. Though some proficiency move out the noise smoothly, it is still a matter of thinking about the noise reduction process.

Research is running to upgrade the performance of the denoising algorithm [16], [17], [25], [26]. As mentioned before, researchers tried to get the best proficiency among the filtering techniques with various classes of images. Aerial images are likely to suffer from Gaussian, salt and pepper noise, etc. Peak Signal to Noise Ratio
SNR, RMS, and Image Fidelity were calculated. These edge detection
Because of analyzing an image for edge detection SNR, PSNR,
detection was obtained through the use of different types of filters.
Authors removed the noise using edge detection methodology. Edge
proved performance than the existing methodology. In [22] the au-
maintained a methodology called Bin-
tual solutions especially for physicians to diagnosis properly. Again, in-
cellular properties were generated through this proposed system.
To track Speckle noise of an image, the authors of paper [5] worked
with ultrasound images. The authors had used Fuzzy Logic-based
(FLT) for speckle noise detection. The key idea of us-
ing the method was to replace upper pixel value into lower pixel
value through the help of neighboring pixels. In order to get a bet-
er result, the authors had maintained a methodology called Binn-
ing Method which effectively reduces the noise of an image. This
method result was calculated through SNR, MSE, EMF, and RSME. This proposed proce-
parameters namely MSE, PSNR, EMF, and RSME. This proposed procedure
quality of the images. The aim of paper [24] was to eliminate Gaussian noise
from an image. The key purpose of this work was to build an ef-
solution to remove noise from an image with two dispute parameters namely edge preservation and computational complex-
ity. The contribution of this proposed algorithm had been compared with several types of filtering techniques such as bilateral filter, K-
means filter, wiener filter, alpha trimmed mean filter, and trilateral
filter and found remarkably improved results on basic objective and
subjective evolvement.
The authors of paper [11] had proposed a momentous non-linear
image filtering technique to denoise an image. The working crite-
rion of this proposed methodology were to change a corrupted pixel
the images. The aim of paper [24] was to eliminate Gaussian noise
denosing performance of the algorithm. The authors also assured experimented data analysis using the Convolu-
tional Neural Network (CNN) and find the lower error rates of 14-38
percent. The author of the paper [24] provides a short review of im-
age denoising techniques. Advantages, as well as disadvantages of
image denoising techniques, were also tried to figure out. The au-
authors also tracked out different types of denoting techniques and
compared them with several types of existing solutions. Finally,
this paper inferred a which denoising method is very effective for
the image denoising process. The authors of the paper [24] worked
on a 3D image. The key idea of these works were to despeckle
an ultrasound image. To meet these, the authors had used a linear
regression model to eliminate speckle noise. The authors claimed
that the proposed methodology far more efficient than existing so-
lutions especially for physicians to diagnosis properly. Again, in-
cell properties were generated through this proposed system.
To track Speckle noise of an image, the authors of paper [5] worked
with ultrasound images. The authors had used Fuzzy Logic-based
Techniques (FLT) for speckle noise detection. The key idea of us-
ing the method was to replace upper pixel value into lower pixel
value through the help of neighboring pixels. In order to get a bet-
ner result, the authors had maintained a methodology called Binn-
ing Method which effectively reduces the noise of an image. This
method result was calculated through SNR, MSE, PSNR and Edge
Preservative Factor (EPF). Experimented data analysis showed im-
proved performance than the existing methodology. In [22] the au-
authors removed the noise using edge detection methodology. Edge
detection was obtained through the use of different types of filters.
Because of analyzing an image for edge detection SNR, PSNR,
RMS, and Image Fidelity were calculated. These edge detection
operators provided a much better result than existing edge detect-
tion operators.
The authors of paper [6] proposed an unprecedented mechanism
to process an image using different types of filtering techniques
through image restoration. The authors aimed at the digital image
to rebuild an image in its regular form from the noisy image. The
significance of this work was an overview based image restora-
tion process. To summarize, Histogram Adaptive Fuzzy (HAF) was
used and compared the tested data with several types of filtering
processes such as Adaptive Fuzzy Mean Filter (AFMF), Weighted
Fuzzy Mean (WFM) and Min-Max Exclusive Mean (MMEEM) [19].
The authors also interpreted the capabilities of corresponding
methods and notified the results accordingly. In the paper, [8] the
authors had used two efficient algorithms called Centered- Boundary
(CB) and Bound-to-Boundary (BB). These methodologies had
designed for \( n \times n \) mask, though \( 3 \times 3 \) mask was used for re-
pective implementation certainly required for image convolution
process. BB and CB algorithms were utilized and compared with
traditional average filtering techniques [10] along with four param-
eters namely MSE, PSNR, EMF, and RSME. This proposed procedure
was successfully tested in 1000 images and found a superior
result. The proposed algorithms identically enhanced the quality of
the images. The aim of paper [24] was to eliminate Gaussian noise
from an image. The key purpose of this work was to build an ef-
solution to remove noise from an image with two dispute parameters namely edge preservation and computational complex-
ity. The contribution of this proposed algorithm had been compared with several types of filtering techniques such as bilateral filter, K-
means filter, wiener filter, alpha trimmed mean filter, and trilateral
filter and found remarkably improved results on basic objective and
subjective evolvement.
The authors of paper [11] had proposed a momentous non-linear
image filtering technique to denoise an image. The working crite-
rion of this proposed methodology were to change a corrupted pixel

3. BACKGROUND
Image denoising is a crucial phenomena when it is for the real time
and raw medical images especially [13]. There are many noise fil-
tering processes like mean filter, median filter [24], etc. Most of
the process results in blurred and distorted features. From the above
premises, an efficient denoising technique that will efficiently kick
out the impulse noise from the raw image that have been proposed.

3.1 Noise Detection Technique
In this section, authors sense the image and construct a \( 3 \times 3 \) test
window containing noisy pixels. Several combinations of pixels are
considered from this test window to compute the average values.
Average values are used to filter the image.
3.2 Noise Removing Techniques

Three (3) average values have been calculated from different patterns of previously selected pixels with corruption. The vertical, horizontal, diagonal or any other complexion that has been taken. For example:

\[ X_{1,1} + X_{1,2} + X_{1,3} \]
\[ X_{2,1} + X_{2,2} + X_{2,3} \]
\[ X_{3,1} + X_{3,2} + X_{3,3} \]

Then the averages have been calculated and sort them. The filtering has been finished by replacing the current pixel by the mid average value. Thus it works with the mean and median simultaneously.

\[ \text{Avg} = \left[ X_{ij} + X_{i,j+1} + X_{i,j-1} \right]/3 \]  

(2)

\[ \text{Avg} = \text{Sort}(\text{Avg}) \]  

(3)

\[ \text{Midvalue} = \text{Avg}[2] \]  

(4)

3.3 Evaluation Criteria

The performance is conveyed by means of some statistical models. The SNR, MSE, RMSE, RMS_SNR, and IFY have been used. SNR is the signal to noise ratio defined by the equation which shown in below:

\[ \text{SNR} = \left[ \frac{\sum_{x=1}^{M} \sum_{y=1}^{N} (f_1(x,y) - f_2(x,y))^2}{\sum_{x=1}^{M} \sum_{y=1}^{N} f_2(x,y)^2} \right]^{-1/2} \]  

(5)

Where \( f_1(x,y) \) is the input image and \( f_2(x,y) \) is the processed image. Each image contains \( M \) rows and \( N \) columns. Higher SNR causes better image.

MSE is used to compute RMSE which is another parameter to take decision whether an image is good enough or not.

\[ \text{MSE} = \left[ \frac{\sum_{x=1}^{M} \sum_{y=1}^{N} (f_1(x,y) - f_2(x,y))^2}{M \cdot N} \right] \]  

(6)

\[ \text{RMSE} = \sqrt{\text{MSE}} \]  

(7)

RMS_SNR is calculated from the formula. It is the root mean square of signal to noise ratio.

\[ \text{RMS}_\text{SNR} = \left[ \frac{\sum_{x=1}^{M} \sum_{y=1}^{N} f_2(x,y)^2}{\sum_{x=1}^{M} \sum_{y=1}^{N} (f_2(x,y) - f_1(x,y))^2} \right]^{-1/2} \]  

(8)

IFY is the Image fidelity that defines the image quality of faithful.

\[ IFY = 1 - \frac{1}{SNR} \]  

(9)

4. PROPOSED DENOISING TECHNIQUE

4.1 Proposed Algorithm

The proposed algorithm takes a raw image and some statistical measurements to compare with the result of the proficiency. Comparing the numerical values, the algorithm returns the best measurements with the combination of the pixels used to compute the averages and the median of the averages which is used to replace the image pixel for processing. In the first place, it reads a raw image and starts to process the whole image over and over. In each iteration, a \( 3 \times 3 \) window is defined as the filtering window and a data structure to store and sort the averages. One iteration goes through the pixels of an image and calculates 3 averages with a different combination of pixels.

For example, the pixels horizontally, vertically, or diagonally are chosen. One may choose any other combinations. Substituting the image pixels, a new processed image and then the numerical values are calculated (SNR, MSE, etc.). Finally, the measurements have been compared with the previously provided values and when the parameters are good enough, the algorithm returns the parameters and saves the combinations of pixels for later use. In algorithm, the best parameters have been gotten for the combinations given in Fig. [I]

4.2 Proposed Flowchart

A flowchart has been constructed so that understanding the workflow of the algorithm and the entire process. The flowchart defines the process clearly with the directions of the arrows. The flowchart shows that it needs to choose a combination and assign some structure initially to control and perform the process.

The image is scanned until there remains any pixels. For every pixels in the image, averages are calculated and replaced the current pixel with the median of the averages. After finishing the scan, the statistical terms are measured and compared with the previous one. If the parameters satisfies the condition then the work flow is terminated and the values are returned as documentation. The proposed flowchart is given below in Fig. [II]
Algorithm 1: Proposed Denoising Algorithm

Input: A Raw Image, prevSNR, prevMSE, prevRMS\_SNR, prevRMSE, prevIFY

Output: SNR, MSE, RMS\_SNR, RMSE, IFY

1. \( im \leftarrow \text{raw image} \)
2. while (1) do
3. \( a \leftarrow \text{zeros}(1, 9) \)
4. \( \text{avg} \leftarrow [0, 0, 0] \)
5. for \( x \leftarrow 2 \text{ to } n \) do
6. for \( y \leftarrow 2 \text{ to } n \) do
7. \( a \leftarrow \text{pixel values for } m \times m \text{ window} \)
8. \( \text{avg}[1] \leftarrow \frac{\sum \text{m values from } a}{m} \)
9. \( \text{avg}[2] \leftarrow \frac{\sum \text{m values from } a}{m} \)
10. \( \text{avg}[3] \leftarrow \frac{\sum \text{m values from } a}{m} \)
11. \( \text{avg} \leftarrow \text{Sort(avg)} \)
12. \( \text{im}[x, y] \leftarrow \text{avg}[2] \)
13. end
14. end
15. Calculate SNR, MSE, RMS\_SNR, RMSE, IFY
16. if (parameters == Good()) then
17. \( \text{return SNR, MSE, RMS\_SNR, RMSE, IFY} \)
18. else
19. \( \text{Go to step 3} \)
20. end
21. if (testMore == True) then
22. \( \text{Go to Step 3} \)
23. else
24. \( \text{Break} \)
25. end
26. end

5. EXPERIMENT AND RESULTS ANALYSIS

5.1 Visual Compare

The algorithm on a raw image and visualized the subjective performance have been applied in Fig. 3. Here, the traditional noise removing filter is applied too. The figure shows the original raw image before filtering (a), the result of the traditional filtering technique (b), and the result from proposed method (c). Another example is shown in the Fig. 4. Fig. 4(a) shows the original raw image of carotid artery. After processing the image with existing filtering technique, the result shown in Fig. 4(b). The result from proposed method, Fig. 4(c) seems more brighter than the previous one which is easy to visualise. Comparing the images from the figure and subjectively the result of this method is better. Moreover, the statistical comparison are considered for better understanding.

5.2 Statistical/Numerical Compare

To evaluate the efficiency of the Proposed Method, the simulation study has been approved using MATLAB [8]. One excellent brain noisy image (Raw Image) is selected for simulation learning [2]. The Propose method applies to the 2D raw image which provides a good result compared with the traditional filtering method. This proposed method is compared with the existing method which is shown in Table 1.

From the Table, the proposed filtering technique provides better results than the existing filtering techniques. Because for given image (noisy brain raw image) measurement criteria proposed filter provides better results than existing filters.

Table 1. Comparison of Existing Methods and Proposed Method for Brain Noisy Images

| Values  | Median       | Average      | Mean         | Proposed Method |
|---------|--------------|--------------|--------------|-----------------|
| SNR     | 20.0903      | 19.2371      | 19.4068      | 21.1010         |
| MSE     | 1.8120 × 10^5 | 1.9048 × 10^5 | 1.9032 × 10^5 | 1.7493 × 10^5  |
| RMS\_SNR| 4.4822       | 4.3860       | 4.4053       | 4.5936          |
| RMSE    | 425.6759     | 436.4410     | 436.2544     | 418.2428        |
| IFY     | 0.9502       | 0.9480       | 0.9485       | 0.9526          |

Fig. 5 is provided to visualize the changes in numerical measurements that indicate whether an image is better or not. Fig. 5(a) compares the SNR of this proposed method with the existing methods. Greater the SNR better the image. It is nicely seen that method provides greater SNR than the existing methods. Fig. 5(b) shows the MSE. It is better to have a smaller MSE and the chart bar showed it. This proposed method results in a smaller MSE according to the chart and the table also. In Fig. 5(c) shows that the filtering method gets a greater RMS\_SNR and fortunately it is a piece of good news. Fig. 5(d) is the RMSE chart. RMSE needs to be smaller for the good quality of an image. Here, a little bit lower RMSE which is alright for the image. Finally Fig. 5(e) contains the IFY. The values of IFY from the filters are almost the same but very little difference is still there. A better IFY than the existing methods is gotten.
6. CONCLUSION
This research has been focused on effective algorithms which are used for Image denoising by using different filtering techniques. The proposed algorithm aims to detect the noise as well as remove the unwanted signal from the raw image which gives a better performance than the existing filtering technique based on SNR, MSE, RMSE, IFY, etc. In the interim, the proposed filtering technique has been proposed for denoising an image is evaluated both subjectively and objectively. Furthermore, the result in different parameters has been evaluated by using the proposed filtering technique which provides a better experimental result compare with the existing filtering techniques. In the future, developing a technique to recover images with a high percentage of noise and defects by using machine learning as well as deep learning. Then the proposed method needs to be included more parameters and evaluate the performances of the proposed technique.

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Fig. 3. (a) Original Noisy Image, (b) Filtered Image using Existing Filter, (c) Filtered Image using Proposed Technique

Fig. 4. (a) Raw Carotid Artery Image, (b) Filtered Image using Existing Filter, (c) Filtered Image using Proposed Technique

Fig. 5. Comparison of Existing Methods and Proposed Method for Brain Noisy Images (a) SNR, (b) MSE, (c) RMS_SNR, (d) RMSE, (e) IFY.