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An Efficient Impulse Noise Removal Image Denoising Technique for MRI Brain Images

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Abstract

Image enhancement is an important challenge in medical field. There are various techniques for image enhancement during last two decades. The objective of this paper is to remove impulse noise for MRI brain image. This paper proposed an efficient filter for removing impulse noise. The shape of the filter is changed to diamond. Experiments are conducted for various noise levels. The proposed method is compared with the existing Denoising techniques. The experimental results proved that the proposed filter performed well than the other methods.

Index Terms: Denoising, Impulse noise, MRI Image, PSNR, SSIM, filters.

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1. Introduction

During last two decades, digital and communication technology have major development. Digital images are captured through various electronic devices. Image transmission is common even to the layman. During these image acquisition and transmission, the image is corrupted with noise. Salt & Pepper Noise in the images is caused by malfunctioning pixels in camera sensors, faulty memory locations in hardware, or transmission in a noisy channel [1]. For images corrupted by salt-and-pepper noise, noisy pixels can take only the maximum or the minimum values. There are many works on the restoration of images corrupted by salt & pepper noise. The median filter was once the most popular nonlinear filter for removing salt & pepper noise because of its good denoising power and computational efficiency [2]. However, when the noise level is over 50%, some details and edges of the original image are smeared by the filter.

Different remedies of the median filter have been proposed, e.g., the adaptive median filter [3], the switching median filter [4], Decision Based Algorithm (DBA) [5], Modified Decision Based Unsymmetric

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Trimmed Median Filter (MDBUTMF) [6]. These filters first identify possible noisy pixels and then replace them by using the median filter, while leaving all other pixels unchanged. These filters are good at detecting and removing noise even at a high noise level.

Their main drawback is that the noisy pixels are replaced by some median value in their vicinity without taking into account local features such as the possible presence of edges. Hence, details and edges are not recovered satisfactorily, especially when the noise level is high [7]. Salt and pepper noise is a form of noise usually seen on images. It uniquely represents itself as randomly occurring white and black pixels. An effective noise reduction approach for this type of noise involves the usage of a median filter or a contrast harmonic mean filter. Salt and pepper noise affects into images in situations where the image is transferred quickly. The aim of these methods is to detect edges and details by means of local statistics and smooth them less than the rest of the image to better preserve their sharpness. However, these methods commonly identify Impulses as details or edges to be preserved, and, therefore, they are not able to reduce that this present system evaluate the performance of the image denoising techniques namely MBUTAMF [8]. Fuzzy Peer Group Filter (FPGF) [9] Switching Bilateral Filter (SBF) [10] and BDND filter [11]. The BDND filter removes high density noises only. It gives the best result for comparing with existing filters [12].

The proposed work changes the filter size from conventional square shape to diamond shape. The filter is made adaptive by making the changes transparent to the next process.

Section 2 depicts the system architecture. Section 3 explains the working function of the proposed filter. Section 4 describes the noise detection process and filtering process with diamond shaped filter. Section 5 demonstrates the Experimental Results followed by conclusion in Section 6.

2. System Architecture

The conventional image enhancement technique has the system architecture depicted in Fig. 1. The original image is corrupted with impulse noise to obtain a noisy image. A filter is designed to remove noise from the image. The efficiency of the filter is measured using Peak Signal to Noise Ratio (PSNR). Various levels of noise are added to calculate the performance of the proposed filter. The proposed filter is discussed in Section 3.

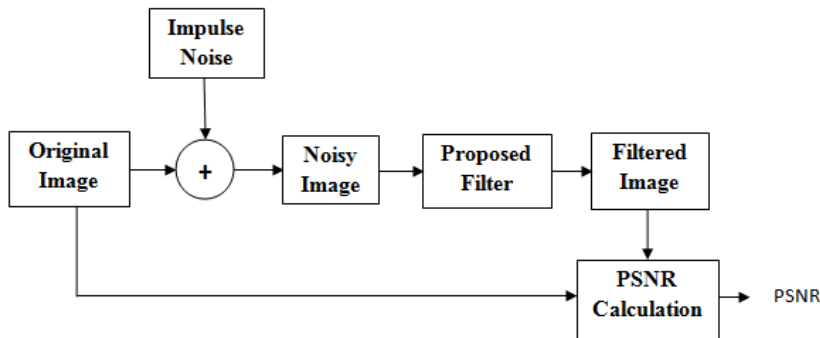


Fig. 1.1. System Architecture

3. Proposed Work

The proposed technique is based on replacing only noisy pixels. Each pixel in the image is checked whether noise is present or not. If noise is present, neighboring pixels are grouped to form a block. The noisy pixel is replaced with the median of the block. If there is no noise detected, the pixel is not replaced. It is illustrated in Fig. 1.2.

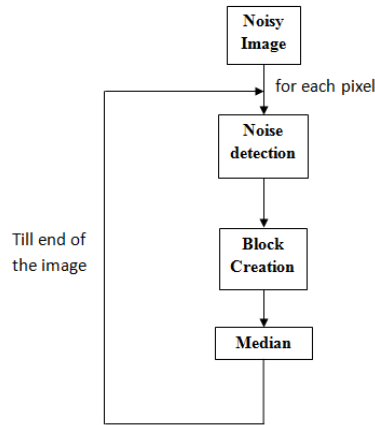


Fig. 1.2. Working function of the Proposed Filter

Steps involved in the proposed work are as follows:

Step: 1 each pixel in the image is detected for noise.

Step: 2 if there is noise, block is created using neighbouring pixels. Median is calculated and the noisy Pixel is replaced

Step: 4 if there is no noise, it is not replaced

4. Noise Detection and Block Creation

The impulse noise consists of either 0 or 255. Each pixel is checked for 0 or 255. If either is present, it is assumed to be noisy. Otherwise, it is noise-free. If noise is present, block is created using neighbouring pixels. In the conventional method, the window size is square shape. The square shape is formed around ± 1 distance of the center pixel. The size of the square may be varied to find an efficient size. And, window size 3×3 is proved to be an efficient filter size. This window contains 8 neighboring pixels around the center pixel. The coordinates of square shaped filter is given by

$$(i \pm 1, j), (i \pm 1, j - 1), (i \pm 1, j + 1) \tag{1}$$

The square shaped filter size and its coordinates are shown in Fig. 1.3.

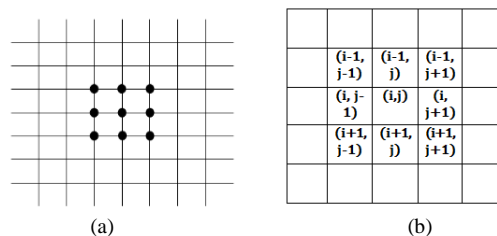


Fig. 1.3. Conventional Square shape filter (a)pixel location (b)Coordinate values

In the proposed work, the diamond shape is created around ± 2 distance of the center pixel. It is shown in Fig. 1.4. If the noisy pixel is at (i, j) , then the neighbourhood pixels in diamond shape are given by

$$(i \pm 2, j), (i - 1, j \pm 1), (i, j \pm 2), (i + 1, j \pm 1) \tag{2}$$

The coordinate pixels are shown in Fig. 1.4. The filter near corner and edges are shown in Fig. 1.5. and Fig. 1.6.

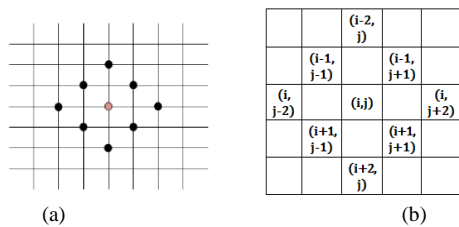


Fig. 1.4. Diamond shaped filter (a) pixel location (b) coordinate values

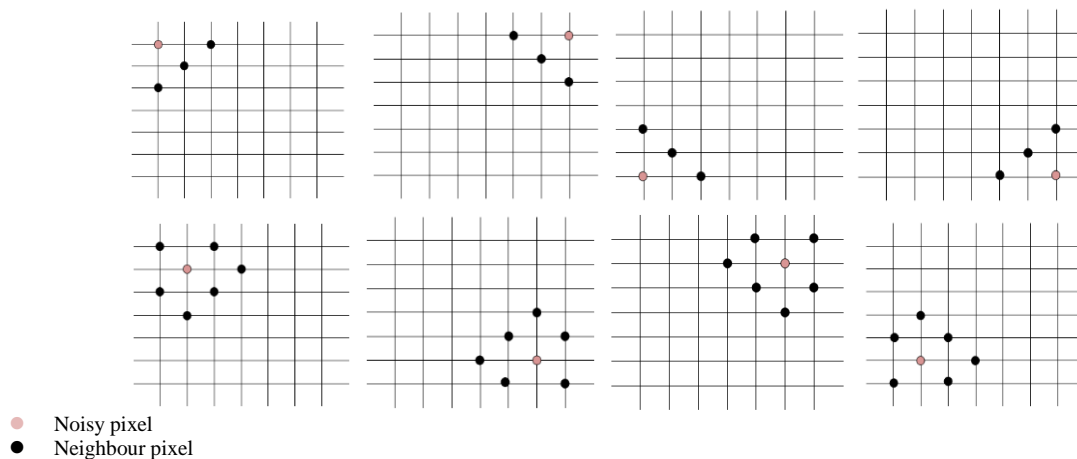


Fig. 1.5. Pixel locations at corners

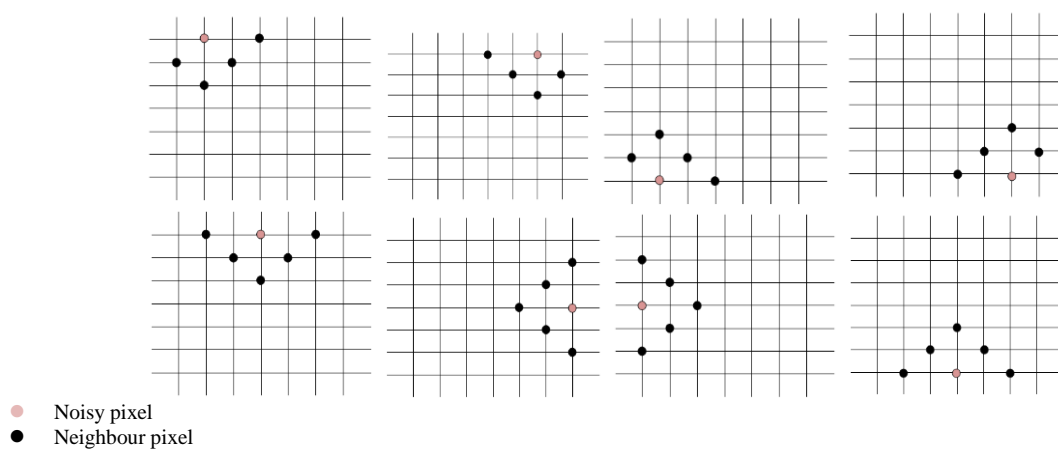


Fig. 1.6. Pixel locations near edges

After the block creation, median of the block is calculated. It is given by

$$\text{Median} ((i \pm 2, j), (i-1, j \pm 1), (i, j \pm 2), (i+1, j \pm 1)) \quad (3)$$

The proposed work is adaptive. The noise free coordinates are used for the next process. Hence the proposed work is more efficient.

5. Experimental Result

The performance of the proposed filter is analyzed by fifty different MRI brain images with varying noise level ranging from 10% to 90%. The capability and potential of the proposed filter is compared with various filters with respect to two performance metrics. Comparison is done between proposed filter, NLM filter [13], DNLM filter [13], EFPGF filter [14], MDBUTMF filter [6], MBUTAMF filter [8], for performance evaluation, this paper uses the following metrics. The efficiency of the filter is measured using Peak signal to Noise Ratio (PSNR), and Structure Similarity Index Measure (SSIM).

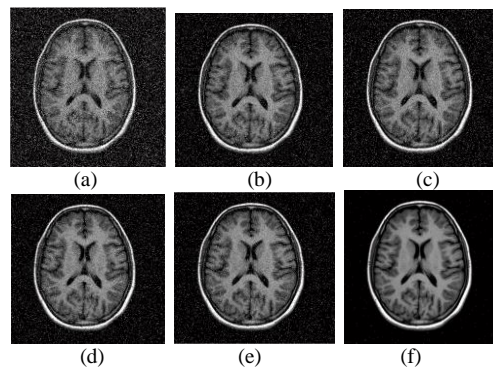


Fig. 1.7. The various Filter are (a) NLM Filter, (b) DNLM Filter, (c) EFPGF Filter, (d) MDBUTMF Filter, (e) MBUTAMF Filter, (f) Proposed Filter

Table 1.1. PSNR value for proposed impulse noise removal filtering technique

Noise Ratio in %	NLM	DNLM	EFPGF	MDBUTMF	MBUTAMF	Proposed Filter
0.01	24.93	25.97	36.32	37.34	37.12	40.37
0.02	22.17	24.44	35.15	34.12	36.48	41.17
0.03	19.82	23.23	35.00	32.67	35.02	39.14
0.04	18.08	22.27	34.19	30.98	33.67	35.85
0.05	16.84	21.62	33.43	28.32	32.39	36.12
0.06	15.89	20.85	33.26	26.81	31.51	33.39
0.07	15.08	20.49	32.89	24.32	30.27	32.73
0.08	14.46	19.84	32.18	21.28	29.04	31.26
0.09	13.95	19.54	31.73	18.45	28.49	31.93
0.1	13.44	19.08	31.03	17.76	26.32	30.14

Table 1.2. SSIM value for proposed impulse noise removal filtering technique

Noise Ratio in %	NLM	DNLM	EFPGF	MDBUTMF	MBUTAMF	Proposed Filter
0.01	0.4587	0.4740	0.9189	0.9109	0.9299	0.9993
0.02	0.3452	0.4449	0.9187	0.8119	0.9287	0.9312
0.03	0.2785	0.4202	0.9071	0.8064	0.9171	0.9943
0.04	0.2306	0.4046	0.9027	0.8051	0.9127	0.9991
0.05	0.2007	0.3927	0.9012	0.8021	0.9112	0.9969
0.06	0.1759	0.3793	0.8990	0.7873	0.8992	0.9961
0.07	0.1607	0.3665	0.8993	0.6939	0.8995	0.9989
0.08	0.1460	0.3541	0.8988	0.6981	0.8991	0.9987
0.09	0.1386	0.3504	0.8984	0.6943	0.8979	0.9987
0.1	0.1266	0.3317	0.8819	0.6811	0.8871	0.9987

6. Conclusions

Image enhancement is a compulsory task in many fields. This paper proposed an efficient filter for removing impulse noise. The size of the filter is changed from square to diamond. The filter is designed to be adaptive. Experiments were conducted for MRI brain image with noise ratio ranges from 0.01 to 0.1. The efficiency is measured by PSNR, and SSIM. The experimental results proved that the proposed filter works better than the existing methods.

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