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IMPROVED TWO-PHASE TECHNIQUE FOR REMOVAL OF VERY HIGH DENSITY SALT AND PEPPER NOISE IN GREY SCALE IMAGES

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ABSTRACT: In this digital era, huge amount of digital data is transferred from place to another due to vast digital technology. The transfer of data and images from one point to another plays a vital role in this digital world. One of the common examples of digital data is image. During transferring of image, it may lose its quality and it is also sensitive to noise which degrades the quality of the image or destroy its edges. To overcome all these problems image processing is used. It is nothing but the processing of image using mathematical operators in which input is an image and output is desired characteristics of the image. In image processing, non-linear filters plays a vital role in removal of salt and pepper noise or impulse noise as linear filter fails to do so. In literature several non-linear filters were proposed to get better denoised image along edge preservation. But at very high noise density the existing non-linear filter either fails to preserve edges or fails to get better denoised image at noise density as high as 99%. In this thesis, a modified two-stage algorithm is proposed which is the fusion of best existing non-linear filtering techniques, retain the denoised image as much as possible. The proposed algorithm is tested for different grayscale images. The qualitative and quantitative results are examined by performance metrics Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE), Image Enhancement Factor (IEF) and Structural Similarity Index Measure (SSIM). The worth full results of the proposed algorithm are compared with several existing non-linear filtering techniques and it has found that the proposed algorithm gives best results in terms of different performance parameters as compared to different non-linear existing filtering techniques.

Key Words: Salt and Pepper Noise (SPN), Image Processing, Image Denoising, Peak Signal to Noise Ratio (PSNR), Structural Similarity Index Measure (SSIM), Image Enhancement Factor (IEF)

1. INTRODUCTION

A new technique to remove the salt and pepper noise is proposed in the digital image utilizing approaches such as: alpha trimmed mean median (ATMM) and singular value decomposition (SVD). SVD is used in the process of detection by considering the pixel values distribution in the processed digital image. Further, ATMM is used to detect the noisy pixels and replace them with a new obtained value [1]. The technique of removing the salt and pepper noise and conserving the surface and boundary details is suggested in the Synthetic Aperture Radar (SAR) images utilizing a technique of Decision Based Adaptive Double Median Filter (DBADMF). The proposed method is compared with several existing techniques such as Median Filter, Mean Filter, Adaptive Median Filter and Decision Based Median Filter etc. [2]. A robust novel algorithm is presented to remove the salt and pepper noise (SPN) which is based on a statistical golden ratio method. The proposed process utilizes a two phase filtering technique for enhancing the quality of an image by removing the SPN. In Phase-I, statistical golden ratio based filtering method is used to detect the noisy pixels in an image. In Phase-II, an alpha trimmed filter is applied for further enhancing the image quality using the local features [3]. The process of image restoration is proposed which involves the dealing with the corrupted images. Also, the degradation model can be utilized to train the filtering techniques for detecting and eliminating the noise phase. Primary noise removing techniques perform superior in case of simple noise but these techniques are insufficient to detect or remove more complex noises. Present work focuses on different techniques of soft computing, approaches of non-classic algorithms and use of artificial neural networks (ANN) [4]. A novel two-phase method is used for removing Gaussian based Impulse noise mixed with blind noise densities in the digital images. In first phase, the preprocessing of noisy image is done using a Pseudo–Convolutional Neural Network (P-CNN). In second phase, an improved Convolutional Neural Network is applied on the preprocessed image of phase-1 for obtaining a hidden clean image [5]. The novel image restoration method is proposed for removing the High Density Impulse Noise by Two-Phase Method (RHDINTPM). In phase-1, a two-step noise detector is used to diagnose the corrupted pixels. In phase-2, the remaining uncorrupted pixels of phase-1 are investigated using cellular automata (CA) to increase the accuracy of noise detection [6]. A review of substantial work done in the different image de-noising techniques is presented. These techniques are spatial domain, wavelet domain, or combination of both methods. Also, a comparison of numerous image de-noising techniques is performed. Further, standard measuring parameters have been utilized for computing the results and evaluating the performance of different de-noising techniques [7]. The image restoration problems in image processing field are suggested as input image quality is greatly improved using this technique. A two-stage filter is suggested for SPN removal with high density. The suggested de-noising algorithm works well for removing the noise from images corrupted with low to high density. The proposed technique is compared with other conventional de-noising techniques to prove its effectiveness [8]. A new technique to recover an image corrupted by SPN utilizing a hybrid genetic algorithm (HGA) is suggested with varying densities. The suggested algorithm helped in combining the image de-noising techniques with hybrid genetic algorithm. Experimental and simulation results on diverse images using performance metrics like peak signal-to-noise ratio, image enhancement factor, universal quality index, and structural similarity index metric indicated that the suggested algorithm clearly outperforms other techniques for SPN removal at moderate to high densities [9]. A novel approach is proposed for SPN removing from a given corrupted image. The suggested algorithm worked on the basis of statistical quantities like standard and mean deviation. This technique facilitates iteratively and can remove the impulse peaks reinstating the edges with minute details. This technique's performance is calculated by comparing with other accessible techniques with noise density images and is established to perform better [10]. An Iterative Mean Filter (IMF) is utilized for SPN elimination. IMF calculates the average value of gray images with noiseless pixels for a window with fixed-size. This feature finds helpful for IMF for evaluating a gray value for central pixel. Various performance matrices like PSNR, Structural Similarity, Image Enhancement Factor, Visual Information Fidelity, and Multi-scale Structure Similarity were analyzed for assessing the image quality [11].

In this paper, **Section 1** describes the comprehensive literature review of various papers published by different authors on SPN removal in image processing. Whereas, the proposed algorithm is provided in **Section 2**. Results and discussions are described in **Section 3**. Also, conclusions drawn from present research work are provided in **Section 4.**

2. PROPOSED ALGORITHM

Our proposed algorithm processes the noisy image in modified two-stages. A Decision Based Partial Trimmed Global Mean Filter works in first phase in all probable cases. Whereas second stage executes a decision based un-symmetric trimmed Winsorized mean filter for preserving the edges in an image. Different steps in the proposed algorithm are provided as below:

Phase I

Step 1: Suppose the corrupted image is symbolized as I_{ij}. Take a two-dimensional window having size of 3×3. The processing pixels of this processing window are assumed as W_{ij}.

Step 2: If $0 < W_{ij} < 255$ then W_{ij} represents weight of non-noisy pixel. This is shown in case 1).

Step 3: If $W_{ij} = 0$ or $W_{ij} = 255$, then W_{ij} is noisy pixel. For this, different likely stages are:

Stage 1: This stage is consisting of three likely cases such as:

Case i) If the processing window contains all pixels as 0's and 255's. The then W_{ij} remains unaltered.

Case ii) If processing window bears all pixels as 0's exclusively, then W_{ij} remains unaltered.

Case iii) If processing window bears all pixels as 255's exclusively, then W_{ij} remains unaltered.

Stage 2: If pixels other than 0's and 255's are contained by processing window, then trimmed mean is calculated.

Phase II

It is measured at higher noise (up to 99%) densities when there is still noisy pixel contained by phase I output. The steps are given below.

i) Consider all the pixels in processing window except the processing pixels.

ii) Fetch the non-noisy neighborhood pixels.

iii) When all pixels of processing window are corrupted, substitute the processing pixels with Winsorized mean of the neighborhood pixels.

FLOW-CHART

The filtering process in this proposed algorithm is consisting of two phases. In proposed algorithms all the pixels with gray values ('0' or '255') are considered as corrupted pixels. When a corrupted pixel is detected, a window of fixed size is taken by considering the corrupted pixel as center pixel of this window. In the phase-I, if processing window is bearing only non-corrupted pixel having value (0 and 255) and phase-II is used to process it. If processing window is bearing noisy pixels along with other non-noisy pixels, then the processing pixel is substituted by Winsorized mean value of the processing window. Also, if processing window bears all pixel 0's exclusively and 255's exclusively, then the processing pixel is substituted by the global mean value of the image, excluding 0's and global mean value of image, excluding the 255's respectively. The phase-II is executed if the image recovered from phase-I is still consisting of noisy pixel, then the processing pixel is substituted with the Winsorized mean value of weighed diagonal pixels. Flow-chart of the proposed algorithm is illustrated in Figure 1.

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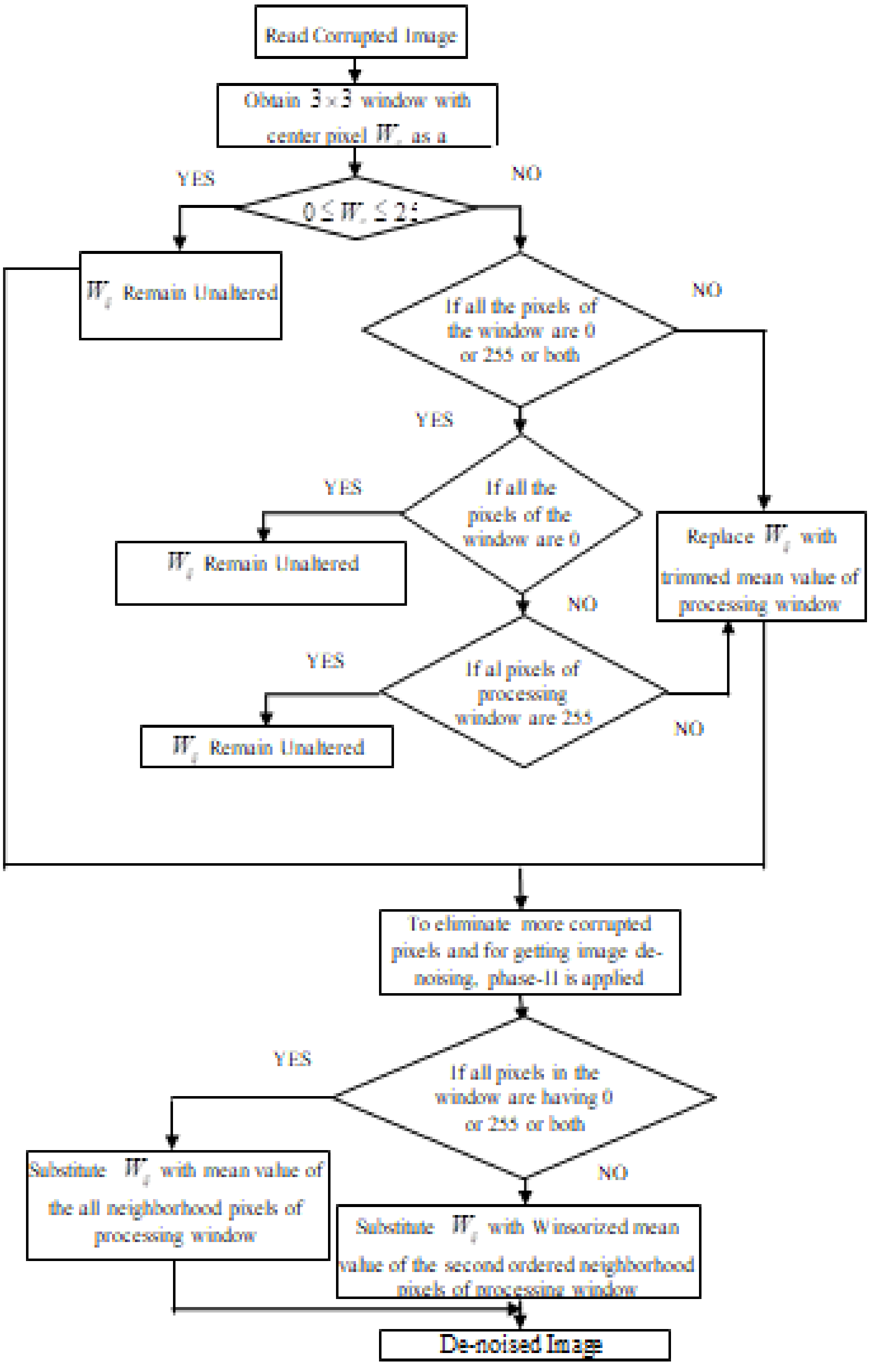


Figure 1: Flowchart for Proposed Algorithm

3. RESULTS AND DISCUSSIONS

The proposed algorithm is evaluated for testing its performance using various grayscale images. The intensity of noise is varied from 60% to 97%. The proposed algorithm's performance is quantitatively evaluated using performance matrices like PSNR, IEF and SSIM as defined using equations 1 to 3 respectively.

$$PSNR = 10\log_{10}\left(\frac{255^2}{MSE}\right) \quad (1)$$

$$IEF = \frac{\sum_i \sum_j \left(n_{ij} - o_{ij}\right)^2}{\sum_i \sum_j \left(r_{ij} - o_{ij}\right)^2} \quad (2)$$

$$SSIM\left(p,q\right) = \frac{\left(2\mu_p\mu_q + c_1\right)\left(2\sigma pq + c_2\right)}{\left(\mu_p^2\mu_q^2 + c_1\right)\left(\sigma p^2 + \sigma q^2 + c_2\right)} \quad (3)$$

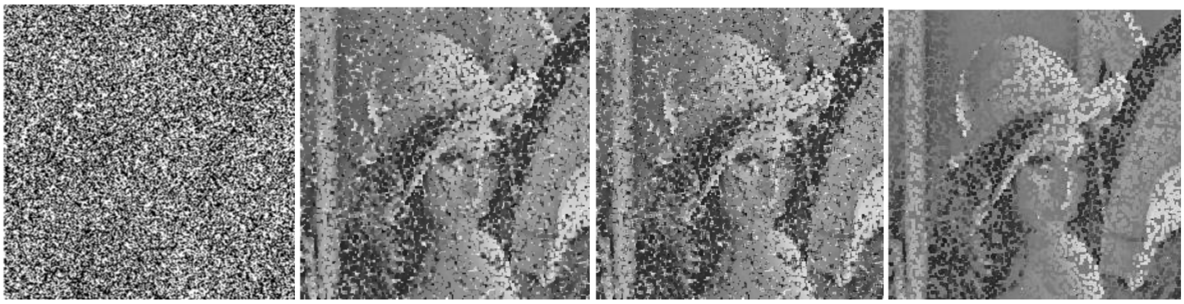
Here 'o' represents original image, noisy image is represented by 'n', and 'r' denotes the restored image. 'M' represents width of image and 'N' represents the height of image. μ_p Denotes the original image mean intensity and μ_q denotes the restored image mean intensity. σ_p Represents the original image standard deviation and σ_q denotes the restored image standard deviation. σ_{pq} is covariance between original and recovered images. c_1 and c_2 are variables such as $c_1 = \left(0.01L\right)^2$ and $c_2 = \left(0.03L\right)^2$ where L is the dynamic range and for gray scale images, L = 255.

For the purpose of comparing proposed algorithm with other conventional algorithms, Lena image is used as reference. This image is as shown in Fig. 2.

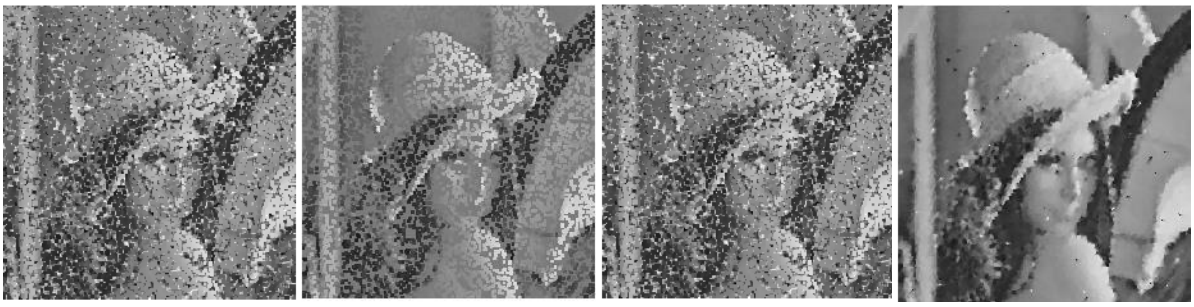
Figure 2: Grayscale image of Lena for comparing different algorithms

In this Lena image, 90% noise density is added and then it is termed as noisy image as shown in Fig. 3 (a). Then different algorithms such as DATMWMF (Fig. 3b) DBANMF (Fig. 3c), DBPTGMF (Fig. 3d), DBUTWMF (Fig. 3e), MDBUT_GM (Fig. 3f), MDBUTMF (Fig. 3g), and Proposed algorithm (Fig. 3h) are applied to remove noise from the noisy image.

As can be seen from Figure 3h, the proposed algorithm provides the best results as compared to other conventional algorithms for removing the salt and pepper noise (SPN) from the noisy image.



(a) (b) (c) (d)



(e) (f) (g) (h)

Figure 3: Qualitative results of Lena Image at noise density 90% for different algorithm (a) Noisy image (b) DATMWMF (c) DBANMF (d) DBPTGMF (e) DBUTWMF (f) MDBUT_GM (g) MDBUTMF (h) Proposed algorithm.

The simulation is done on Intel i3 processor-4005 with operating frequency 1.70 GHz and 4 GB RAM capability. Table 1 represents the comparative analysis of the proposed algorithm tested on different images with that of literature for PSNR, IEF and SSIM performance metrics. It is clear from the represented table that the proposed algorithm gives best results for very high noise density.

Table 1: PSNR, IEF &SSIM values for different algorithms at various noise densities for Lena image

Noise in %	Performance Metrics	MDBUTMF [8]	MDBUTMF_GM [12]	DBPTGMF [13]	DBUTWMF [15]	DBANMF [16]	DATMWMF [14]	PA
60	PSNR	36.3769	36.3750	36.3784	36.5238	35.2658	36.3333	**36.7977**
	IEF	86.4293	103.5041	103.4572	93.0270	59.2561	85.9107	**144.6044**
	SSIM	0.8475	0.8650	0.8650	0.8541	0.8033	0.8467	**0.9138**
70	PSNR	34.9399	34.8080	34.8072	35.0372	34.2917	34.9267	**35.7104**
	IEF	47.8988	65.9726	65.5834	49.0672	39.6099	47.7846	**115.4392**
	SSIM	0.6852	0.7458	0.7449	0.6883	0.6509	0.6849	**0.8779**
80	PSNR	33.0977	32.9209	32.9248	33.1274	32.7905	33.0942	**34.6965**
	IEF	21.3878	34.1227	33.8324	21.5234	19.6510	21.3773	**85.2473**

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	SSIM	0.4440	0.5690	0.5666	0.4455	0.4163	0.4439	**0.8307**
90	PSNR	30.5779	30.3324	30.3319	30.5847	30.5138	30.5766	**33.3673**
	IEF	9.9122	16.5189	16.2843	9.9176	9.3662	9.9103	**59.3302**
	SSIM	0.2149	0.3813	0.3754	0.2149	0.1995	0.2149	**0.7529**
95	PSNR	29.2475	28.8630	28.8642	29.2486	29.2369	29.2476	**31.9603**
	IEF	6.5102	11.3477	11.0770	6.5107	6.2186	6.5100	**37.7634**
	SSIM	0.1162	0.3150	0.3024	0.1162	0.1062	0.1162	**0.6570**
97	PSNR	28.6585	28.3897	28.3853	28.6587	28.6767	28.6583	**31.0180**
	IEF	5.6229	9.9378	9.6733	5.6231	5.3570	5.6230	**24.4656**
	SSIM	0.0797	0.3137	0.2968	0.0797	0.0720	0.0797	**0.5863**
99	PSNR	28.1047	28.1713	28.1687	28.1047	28.1237	28.1047	**29.9459**
	IEF	4.8763	8.6032	8.3363	4.8763	4.6375	4.8763	**13.1484**
	SSIM	0.0550	0.3625	0.3399	0.0550	0.0485	0.0550	**0.4601**

Figure 4 shows the graphical representation of proposed algorithm in contrast to other existing noise removal techniques. From the representation of images at variable noise density it has been proved that the proposed algorithm gives its best performance at very high noise density.

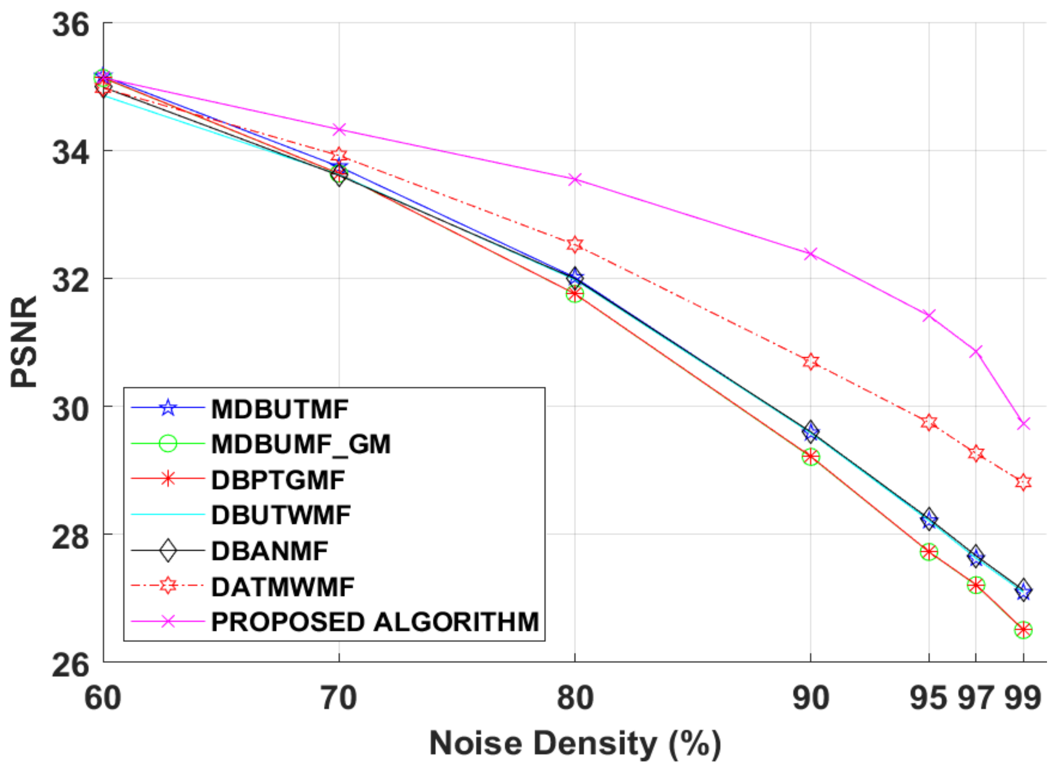

Figure 4: PSNR versus Noise Density variation for Lena Image

4. CONCLUSIONS

In this research work a modified two-stage approach for minimizing very high density salt and pepper noise (noise levels up to 99 %) is analyzed and discussed. Proposed algorithm provided superior performance as compared to numerous conventional non-linear filters in terms of quantitative as well as qualitative analysis. The proposed algorithm provided best results using different images preserved fine details of these images. This was obtained by fusion of DBPTGMF, DBUTWMF, and DBDNA and represents excellent two-phase scheme. It represents better PSNR, IEF and SSIM. Hence the proposed algorithm is worthy for removing salt and pepper noise with high density. From the simulation results, it can be concluded that implemented scheme has high imperceptibility and enhanced performance when compared to the other non-linear filtering techniques.

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