Survey on Impulse Noise Suppression Techniques for Digital Images

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Abstract-Noise suppression from images is one of the most important concerns in digital image processing. Impulsive noise reduction is the most important aspect considered while acquiring a digital image. Images are often corrupted by impulse noise during transmission. Various approaches have been used in the past to reduce impulse noise from digital images in such a way that the important information of the images is preserved. This paper presents the review of various such techniques that have been used in the past for reduction of impulse noise from digital images.

Keywords-Impulse noise, Salt and pepper noise, spike noise, Median filter, Noise density.

I. INTRODUCTION

Images are often polluted by various noises during the course in which they are generated or transmitted. The most well known version of such noise is the fat tailed distributed or impulsive noise, also called salt and pepper noise or spike noise. The noise, which when sprinkles like black and white dots, significantly reduces the visual effects of the images. Linear filtering techniques fail when noise is non additive and they not effective in removing the impulse noise. This has led to the use of non linear filter signal processing techniques. Various such techniques which were used for noise reduction in the past have been discussed in section II and conclusion of review has been given in III section, thus summarizing the whole discussion.

II. LITERATURE SURVEY

Salt and Pepper noise is a form of noise seen on images. It presents itself as sparsely occurring white and black pixels. Noise can get added in the system during acquisition by camera sensors and transmission in the channel. Linear filters were the primary tools for many of the signal and image processing application. If images were corrupted by white Gaussian noise, linear filters showed very good performance. But they cannot cope up with the non linearities of image formation model and cannot take into account the non linearities of human vision since human vision is sensitive to high frequency information while the image edges and its details have high frequency content. Low pass filtering tends to blur edges and other details of fine image details. This is the reason which has led researchers to the use of non linear filtering techniques for image processing[1].

Zhou wang et al., in year 1999 proposed a progressive switching median filter to restore images which were corrupted by salt and pepper noise [2]. Progressive switching median filter was applied when there was only an impulse noise. This algorithm had two main points 1) switching scheme. 2) Progressive methods. Simulation results showed that progressive switching median filter was better than traditional median based filters. It was able to remove almost all of the noise pixels while preserving details of the image. In this paper, authors presented a new median based switching filter called progressive switching median filter, where both impulse detector and the noise filter were applied progressively in iterative manners. The noise pixels processed in current iteration progressed the other pixels in subsequent iterations and it gave better restoration results when the images were highly corrupted by salt and pepper noise.

Deng zefeng et al., in year 2007 proposed a novel filter on mathematical morphology for high probability impulse noise removal [3]. An impulse noise detector using mathematical residues was proposed to identify pixels that were contaminated by salt and pepper noise, then the image was restored using specialized open close sequence algorithms that could be applied only to noisy pixels. It fully determined the impulse noise with a low percentage error. Mathematical morphology was non linear image processing methodologythat was based on application of lattice theory to spatial structures. It was based on erosion and dilation operators. Further an open close sequence algorithm and block smart erase method was introduced.

MadhuS.Nair et al ., in year 2008 proposed an improved decision based algorithm for the restoration of gray scale and color scale images that were highly corrupted by salt and pepper noise [4]. This algorithm utilized previously processed neighboring pixel values to get better image quality than the one utilizing only the just previously processed pixel values. Different grey scale and color images were tested by using DBA(Decision Based Algorithm) to produce better PSNR (Peak Signal to Noise Ratio). Computation time was less as it used window of size 3*3. This algorithm detected the impulse noise also. The corrupted and uncorrupted pixels in the image were detected by checking the pixel element value against the maximum and minimum value that the impulse noise took in the dynamic range of 0 to 255. The median of window was calculated and the corrupted pixels were replaced by it. If this calculated median value was also corrupted, then,the mean of previously processed pixels was calculated and corrupted pixels were replaced with it.

Chen cong- ping et al., in year 2011 proposed a new adaptive weight algorithm for removal of salt and pepper noise [5]. The proposed algorithm had two major steps. First was to detect noise pixels according to correlation between pixels and secondly according to the level of noise density. Thus different approaches were taken into consideration. For low noise level, mean method was adopted and for high noise level, adaptive weight algorithm was used. It was proposed for improving de-noising ability and had advantages over other methods in terms of both edge preservation and noise removal.

Sham lal et al., in the year 2012 proposed a super mean filter to remove high density impulse noise from digital images [6]. The proposed filter worked in two stages. In the first stage, the noisy pixels were detected and in second, each noisy pixel was replaced by the mean value of noise free pixel of 2*2 matrix. This algorithm used a simple fixed length window of 2*2 matrix which made its implementation very simple. Extensive simulation and experimental results showed that super mean filter worked well consistently for suppressing impulse noise of different gray scale images. It showed better performance as compared to other de-noising filters as it removed up to 95 percent noise density level.

Vivek Chandra et al., in year 2013 proposed an algorithm based on adaptive and unsymmetric trimmed median filter[7]. This algorithm was proposed for restoration of gray scale as well as color images which were highly corrupted by impulse noise. The proposed algorithm selected a window which had noisy and non noisy pixels. Mean or median of non noisy pixels in the selected window was calculated. These pixels were replaced by previous calculated mean or median in the selected window. The proposed algorithm adaptively controlled the window size that was dependent on the relative amount of noisy pixels compared to non noisy pixels in the selected window. This algorithm was tested against different grey scale and color images which gave better PSNR and image enhancement factor at different noise densities. The performance of algorithm was tested on wide range of noise densities on both grey scale and color image. It found applications in different areas such as medical diagnostics, satellite imaging etc.

V.R. Vijay Kumar et al ., in year 2014 proposed a fast switching based median mean filter for high density salt and pepper noise in images [8]. The extreme minimum value and extreme maximum value of noisy image was used to identify noise pixels. In the filtering stage, the corrupted pixels were replaced either by median or mean value and that were based on number of noise pixels in the filtering window. It used a 3*3 size window for processing noisy image. This filter overcame the problem of streaking effects in DBA and poor noise removal capability of MDBUTF at higher densities. The proposed algorithm preserved edges without compromising on time complexity, thus making its hardware realization feasible.

Different techniques presented by authors to suppress noise includes varying window size , various different filtering algorithms to reduce the level of impulse noise from digital image. Non linear filters gave better results for removing the impulse noises from digital images. More edge preservation and less blurring of the edge details was found when nonlinear filters of same window size were used as compared with linear filters.

Table 1. Comparison of different algorithms for removal of noise.

Sr no	Title	Journal/ Conference	Author & Year	Findings	Weakness
1	PSMF for the removal of impulse noise from highly corrupted images.	IEEE	Zhou Wang et al., 1999	It removed all noise pixels and preserved edge details.	It had very high computati-onal complexity due to its iterative nature.
2	High probability impulse noise removing – Removing algorithm based on mathematical morphology	IEEE	Deng Ze-Feng et al., 2007	It detected impulse noise with a low percent error.	It was unable to remove noise at very low and very high noise density.
3	Removal of salt and pepper noise in images: A New DBA	IMECS	Madhu S. Nair et al., 2008	It helped in removing noisy pixels by median value of previously processed neighboring pixel values.	Streaking occured at higher noise densities due to replacement with neighborhood pixel value.
4	A new adaptive weight algorithm for salt and pepper noise removal.	IEEE	Chen Cong-ping et al., 2011	It was good for both edge preservation and noise removal at low and medium noise density.	At higher noise density, original and replaced median pixel values were less correlated. Hence smearing occurred.
5	Removal of high density salt and pepper through MDBUTAMF	IJEAT	Vivek Chandra et al., 2013	It gave results for a wide range of noise densities on both gray scale and color images.	At higher noise densities if all the pixels were corrupted by either salt or pepper it used mean value of all elements in the filtering window

					to replace the noise pixel which were also noisy.
6	Fast Switching based median mean filter for high density salt and pepper noise removal	Elsvier	V.R. Vijay Kumar, 2014	Alternate replacement preserved edges without compromising time and complexity .	Noise is removed from 10%to 90% .

III. CONCLUSION

In the previous researches, various methods were used for the removal of impulse noise (salt and pepper) from images. Progressive switching was used which had a very high computational complexity due to its iterative nature. An algorithm based on mathematical morphology was introduced which was unable to remove noise at very low and high noise density. To overcome the above stated algorithm's shortcoming, a new decision based algorithm was developed but in this algorithm, streaking occurrence was the problem. To remove it,a new adaptive weight algorithm was proposed. However, here the problem of smearing was found. Super mean filter, for removing salt and pepper noise, used 2*2 simple fixed length window which made its implementation very easy. Fast switching mean median filter, which removed all the problems, had a fixed window size but it does not give results for image enhancement factors.

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