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Exploring the techniques of denoising highly saturated-impulse noisy images: A Review

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Abstract: Image Denoising is a method of improving the degraded quality of the image to review original information. High density saturated impulse noise is the highly degraded pixels present delve and deeper in the image which hide the original content of the image and make it noisy. Among much degradation like blurring and jittering the salt and pepper noise occurs as impulse in any image that is difficult to remove and find. There are only two intensity values for salt and pepper noise i.e. 0and 255 in 8-bit image. This paper Reviews new techniques and methods to improve the image quality by eliminating the salt and pepper intensity values. In this paper the quantitative and qualitative measures are studied for the image and attributes like Peak Signal Noise Ratio (PSNR), Image Quality Index (IQI), and Image Enhancement Factor (IEF) are likely to improve efficiently. The comparison is studied depending upon the factors like Mean Square Error (MSE), PSNR, and IQI.

Keywords: MSE(Mean Squared Error), PSNR(Peak Signal to Noise Ratio), Image Quality Index (IQI), Image Enhancement Factor (IEF) Impulse noise.

I. INTRODUCTION

Noise pollution has seriously affected the image of the follow-up processing, so image denoising in image processing is a key step [1]. Image denoising has many restoration techniques such as filtering and De-blurring. Filtering is the techniques of restoring an image from a degraded image by processing the windows and filtering the noisy pixels whereas De-blurring is the process of eliminating the blur and corrupted pixels from the image. The most efficient method to remove the high-density saturated impulse noise i.e. salt and pepper noise which has intensities of 0 and 255 is filtering. There are many filters proposed to denoise the image and refine the original image however state of art filters vary the results in different indexes.

The state of art filters were ineffective to remove the impulse and high density noise from the image. The values for the parameters like PSNR, IQI, IEF were inefficient to be recorded as a good index for image denoising. In [2], the progressive switching median (PSM) filter has been developed for removing impulse noise from highly corrupted images. It works by using an impulse detection algorithm and then iteratively detecting and filtering impulse noise, and hence, it performs heavy computation. In [3], a decision-based median filter, which consists of two functions decision making and noise filtering, has been used for noise removal. In [4], an adaptive median based filter has been used for noise removal from images corrupted with various kinds of noises.

The major problem regarding the present restoration techniques is that they cannot be used in images where high density impulse noise is present as they do not find the intensity values for corrupted pixels beyond the limited window size, which results in jitter in the image due to noisy and corrupted pixels.

For a noisy image I with two intense values (i,j) the median filtering operation can be written as:

$$K(i,j) = \text{median} \{ I(i,j), (i,j) \in W \}$$

In decision-based coupled window median filter the problems related to efficiency of attribute values i.e. PSNR, IQI,IEF are calculated with better indexes. In this the increased window size and variable dimensions lead to high probability of finding noise free pixels and initializing them for processing.

1.2 IMAGE RESTORATION TECHNIQUES

To restore the image and refining it from noisy pixels to denoised image there are many image denoising techniques. This section explains, following image restoration techniques:

- Inverse Filter: This filter works to deblurr the blurred image, it measures the sensitivity of noise in image and tends to this sensitivity by removing the noise from the blurred image . It is a good know technique used for restoring the image from blurred image.
- Weiner Filtering: This filter is used to remove the blur from images and is widely used for deblurring the images which are blur due to linear motion or unfocused optics. Poor sampling can lead to linear motion blur and can destruct the original image by degrading it with particles of noise.
- Blind Deconvolution: This Technique allows the reconstruction of original images from degraded images even when we have very little or no knowledge about PSF. Blind Image Deconvolution (BID) is an algorithm of this type.
- Non Linearing Filtering: The distortion in images due to non additive noise can be removed with this non linear filter. The high frequency and impulse noise cannot be improved using this filter so in such cases the linear filter overcomes the problem. It has vast applications in removal of spike noise.

1.3 ATTRIBUTES OF IMAGE

To evaluate the quality of the image there are different parameters, commonly used are Peak Signal to Noise Ratio, Mean Squared Error, Image Quality Index and capacity. Different parameters are discussed below as follows

Mean Square Error (MSE)

MSE is used to weigh up the variation between original images with a restored image. If O is the original image of size $M \times N$ and D is the restructured image, then the MSE (Db) is defined as:

$$MSE(dB) = \frac{1}{M \times N} \sum_{i=0}^{M-1} \sum_{j=0}^{N-1} (O - \mathrm{D})^2$$

Peak Signal-to-Noise Ratio (PSNR)

Peak Signal to Noise Ratio estimates the superiority of the recreated image in respect to the original image. Greater the PSNR better will be the reconstructed images. The PSNR (Db) is defined as:

$$PSNR(dB) = 10log_{10}\left(\frac{255^2}{\frac{1}{M\times N}\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}(O-\mathrm{D})^2}\right)$$

Image Enhancement Factor (IEF)

Image Enhancement Factor [8] is the most widely used quality metric. It indicates the performance of filter at different noise densities. Mathematically, it is given as:

$$IEF = \frac{\mathrm{E}[N(i,j) - O(i,j)]^2}{\mathrm{E}[D(i,j) - N(i,j)]^2}$$

II. REVIEW OF EXISTING MEDIAN FILTERS

Earlier the standard median filter (SMF) was effectively working on low density noise. It blur the image when it is used on large window sizes. However when we measured the metrics and worked on small window sizes then degradation in the image due to noisy pixels is not corrected , so the noise is not removed from the image properly. In the study it is found that the blurring is difficult to improve and it is hard to find the noisy pixels for degraded image.

To overcome the problems with SMF the Adaptive median filter (AMF) was introduced however the results were not as expected for the work. When the noise is very high and it is highly dense in the image then it is rarely improved because it is very difficult to remove. In return of the improvement the image turns blur and causes the degradation due to blurred pixels in the image. Although, this filter was proposed to improve the quality of image and for this noisy pixels are replaced by median and variants of medians however results proved inaccurate.

Image enhancement was becoming a major problem for the staid researchers because the images which are degraded were deprived of the original information and cause the barriers between the

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visualization of original image . After Hanging up with AMF the research further proposed the new filter named Modified Decision Based Unsymmetric Trimmed Median Filter (MDBUTMF). In this median filter the window size for degraded image was fixed to 3*3. The impartations of fixed size of window made the filter to work well at higher densities of noise .Where there is dense and highly saturated noise present in the image the MDBUTMF works well. In this filter the affected and noisy pixels are replaced by the mean of that processing window which is selected from the degraded image and the size of that window is 3*3. Furthermore the research for this filter ends with the conclusion that it works well to remove highly saturated and dense noise however it leaves the dark spots and patches behind in the restored image. So, we need to focus on resolution for restoring the image without contaminating it with other types of degradations.

Study of these existing state of art of filters ends up with the outcome of new proposed algorithm Decision Based Coupled Window Median Filter (DBCWMF). In this the above problem of dark patches in the restored image has been overcome by increasing the window size. The main idea of selecting the coupled window of increasing size is to increase the ways of finding the noise-free pixels in the image. In the small window of size 3*3 the probability of noisy-pixels in image entirely is high. However the probability for same noise pixels reduces when the window size is increased to 5*5. Thus the algorithm initializes that if the pixels in the 3*3 window are noisy then by increasing the window size the noise free pixels can be calculated easily. As an outcome the coupled windows worked in an effective way towards the restoration of noisy image. This DBCWMF has reduced the blurring of image when it is restored by working on noise free as well as on noisy pixels of image and results in original and good informative image.

III. EXPERIMENTAL RESULTS

The different image attributes were measured for different images using DBCWMF algorithm. The three different images were taken under observation and the parameters are recorded for penguin, camera-man and baby images respectively. These images are suspected to noise first and then the quality is improved by denoising the image without any blurring effect and any other disturbances the restored image is similar to the original image.

The experimental results for DBCWMF algorithm are recorded in tabular form and are as follows:

TABLE 3.1 The attributes measured for the image penguins.

%	MSE	BER	PSNR	IQI	IEF
10	9.9392	0.0262	38.1573	0.8862	4.6963
20	16.8006	0.0279	35.8776	0.8538	49.997
50	39.5216	0.0311	32.1625	0.7282	89.9821
80	72.3748	0.0339	29.5349	0.5110	113.4675

TABLE 3.2 The attributes measured for the image camera men.

%	MSE	BER	PSNR	IQI	IEF
10	8.5596	0.0258	38.8663	0.9619	1.0384
20	18.6169	0.0282	35.4317	0.9573	945.4448
50	66.2243	0.0334	29.9206	0.9556	563.5606
80	146.2349	0.0378	26.4803	0.9221	386.9154

TABLE 3.3 The attributes measured for the image baby.

%	MSE	BER	PSNR	IQI	IEF
10	2.7191	0.0228	43.7866	0.9522	1.1843
20	5.3885	0.0245	40.8161	0.9445	1.779
50	18.2177	0.0281	35.5259	0.9038	780.4758
80	43.3608	0.0315	31.7598	0.8062	477.8843

The measurements for the attributes experimentally using DBCWMF algorithm is represented in the form of images fig 1.1, fig1.2 and fig1.3 respectively.

Fig 1.1 Simulation results of DBCWMF algorithm for penguin image at 10%, 20%, 50%, 80% noise density. Noise-corrupted image; Output for parameters

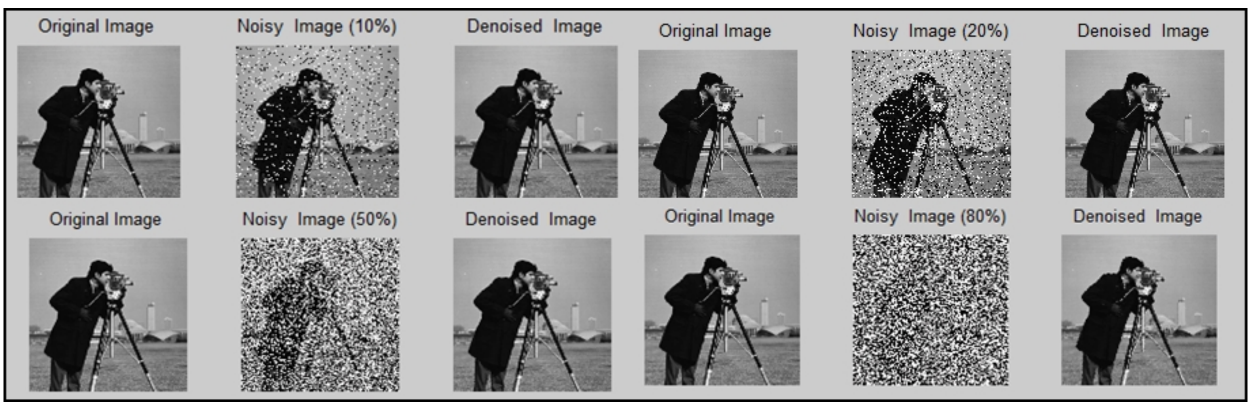

Fig 1.2 Simulation results of DBCWMF algorithm for camera-man image at 10%, 20%, 50%, 80% noise density. Noise-corrupted image; Output for parameters

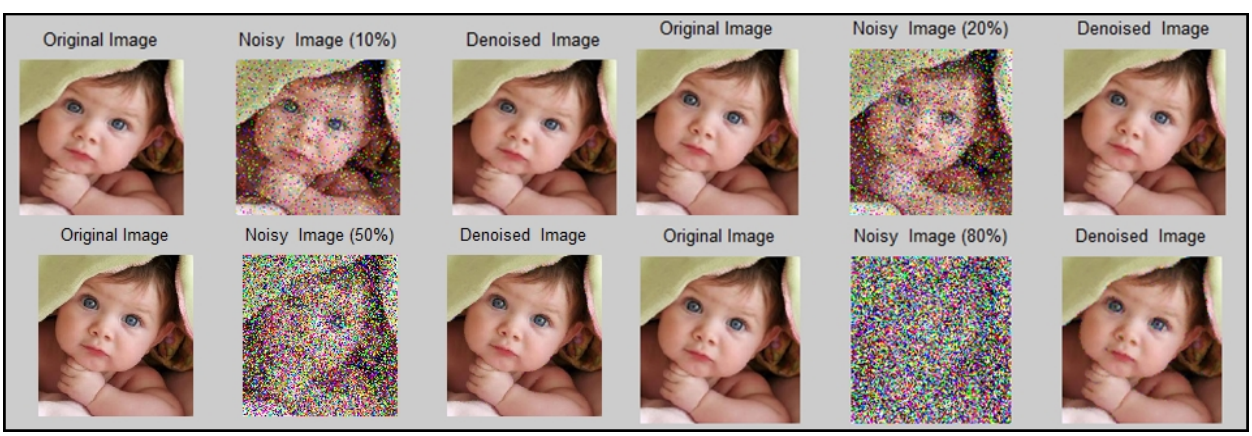

Fig1.3 Simulation results of DBCWMF algorithm for baby image at 10%, 20%, 50%, 80% noise density. Noise-corrupted image; Output for parameters

IV. CONCLUSION

In yester years, the staid researchers have studied the techniques for restoring degraded image to original image however; there is no method which could recover the image with perfection in its quality. In addition to this, the more the image is processed the more its quality gets low. Many state of art filters have been introduced since last researches but decision based coupled window median filter proved to be a better and effective method for restoring the high-density saturated impulse noise from the image moreover it opens the gateway to improve the quality of image by working out on the several parameters of image like; PSNR, IQI, IEF etc. Further research is under-done to measure the metrics for the window size that would be variable according to the noisy pixels in the degraded image.

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