

Survey on Salt and Pepper Noise Removal Techniques

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ABSTRACT: In the challenging area of Digital image processing, the image is degraded by noise. A large number of image de-noising techniques are proposed to remove noise from the images. These techniques depend on the type of noise present in the images. This paper focuses on the techniques proposed to remove the salt and pepper noise. Some of the de-noising techniques are Mean Filter, Median Filter, Mean-Median filter, Weighted Median Filter (WMF), Standard Median Filter (SMF), Super Mean Filter (SUMF), Decision Based Median Filter (DBMF). Among the existing de-noising techniques Weighted median Filter provides satisfactory results in de-noising the image by preserving the edges for the high level noise.

KEYWORDS: De-noising, Salt and pepper noise, WMF, SMF, SUMF, DBMF.

I. INTRODUCTION

Digital image processing improves the pictorial information for human interpretation, processing of image data for storage, transmission and representation for autonomous machine perception. It allows a much wider range of algorithms to be applied to the input data and can avoid problems such as the build-up of noise and signal distortion during processing. Images often contain noise, which may arise during capturing and transmission of images, due to sensor imperfection, poor illumination, or communication errors. The main aim of an image de-noising algorithm is to achieve both noise reduction and feature preservation. It is the most important pre-processing step for image analysis. The nature of noise removal depends on the type of noise. There are various types of noise that affects the original image. Poisson noise is an electronic noise shaped by Poisson process, which occurs in counting optical devices, where Poisson noise is associated with particle of light. Film grain noise is the random optical structure of photographic film due to the presence of small particles of metals which receives proton. It is an optical effect, the magnitude of which depends on both the film stock. Gaussian noise is a sensor noise that is caused by high temperature in digital image during acquisition. Quantization noise is a type of impression, which occurs when analog waveform is encoded into a digital signal and then decoded back into an analog signal. Salt-and pepper noise which is an impulse noise is caused by sudden disturbances in the image signal. It is in the form of white and black pixels. Various types of filtering techniques for removing salt and pepper noise are Mean Filter, Median Filter, Mean-Median filter, Weighted Median Filter(WMF), Standard Median Filtering(SMF), Super Mean Filter(SUMF), Decision Based Median Filter(DBMF).

II. TECHNIQUES FOR REMOVING SALT AND PEPPER NOISE

2.1 Mean Filter

Mean filter smooth the image by reducing the intensity variation between adjacent pixels. In mean filter the center value of the window is replaced with the mean value of all the pixel values in the window. Spatial filtering is implemented on every pixel in the image using the gray level values in the rectangular window. The average filter calculates the sum of all pixels in the filter window and then divides this sum by the number of pixels in the window. The Average (mean) filter smooth the image. This filter performs spatial filtering on each individual pixel in an image

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using the gray level values in a square or rectangular window surrounding each pixel. The average filter calculates the sum of all pixels in the filter window and then divides the sum by the number of pixels in the filter window. The mean filter is a simple sliding-window spatial filter that replaces the center value in the window with the average (mean) of all the pixel values in the window.

2.2 Median Filter

The main reason for introducing median filter [10] is to run through the signal entry by entry by replacing each entry with the median of neighboring entries. Median filter is an image enhancement technique and is less sensitive than linear techniques to extreme changes in pixel values; it can remove the salt and pepper noise without reducing the sharpness of an image. Median filter is a nonlinear operation used in image processing to reduce salt and pepper noise. The median filter do not replace the pixel value with the mean of another pixel value as in Mean Filter, but it replaces with the median of those values. The median is calculated by first sorting all the pixel values from the surrounding neighborhood into numerical order and then replacing the pixel being considered with the median pixel value.

2.3 Mean-Median Filter

Mean - Median Filter [10] is a combination of sample mean and sample median. Figure 1 shows the performance of Mean - Median tested against Mean Filter and the Median filter on a standard onion.png for analysis. The images are corrupted with various levels of impulse noise ratio. The significant difference in mean square error (MSE) and Peak signal to noise ratio (PSNR) with other mean and median filters quantifies the superiority of the Mean - Median filter. From the analysis it is very clear that Mean – Median Filter performs well on low level impulse noise levels to very high level impulse noise levels. . Median filters are known for their capability to remove impulse noise as well as preserve the edges. The main drawback of a Standard Median Filter (SMF) is that it is effective only for low noise densities. At high noise densities, SMFs often exhibit blurring for large window sizes and insufficient noise suppression for small window sizes [8] [9].



Figure 1: Image filtered using the Mean, Median and Mean-Median filter.

2.4 Standard Median Filter (SMF)

The Standard Median Filter [13] is a simple basic rank selection filter, used to remove impulse noise by changing the brightness of the central pixel of the filtering window with the median of the brightness of the pixels contained within the window. To overcome the Mean and Median filters the SMF filter is introduced. It is effective for removal of salt and pepper noise from images. SMF can considerably reduce corruption by impulse noise. The uncorrupted pixel intensity values are also altered by the SMF. It uses sorting algorithm such as quick-sort or bubble-sort to organize the samples in decreasing or increasing order

2.5 Super Mean Filter (SUMF)

SUPER Mean filter (SUMF) [7] removes high density salt and pepper noise from digital images. The SUMF filter works in two stages, first stage identifies noisy pixels and second stage removes noisy pixels. To identify the noisy pixel and noise free pixels, identification is based on the two intensities that present the impulse noise are the maximum and the minimum values of the image dynamic range.

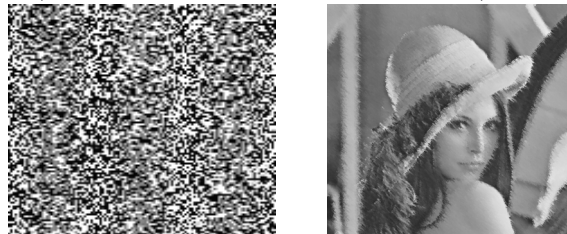
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Then impulse noise is filtered by replacing noisy pixel with calculated mean value of noise free pixels in selected window. The noise free pixel in the selected window is identified. Replace the noisy pixel by the calculated mean value. Repeat steps, to process the entire image for removal of impulse noise.

The performance of SUMF is compared with various previous existing techniques such as SMF, Center Weighted Median Filter (CWMF). Figure 2 shows the output of SUMF by removing the high density noise of 95%. SUMF gives better result as compared to SMF, CWMF. The performance of SUMF filter is evaluated in terms of PSNR and MSE. PSNR on SMF =5.98, SUMF=18.52, CWMF=7.64. MSE on SMF= 16412.70, SUMF=914.28, CWMF=11196.45 [6].



High density noise with 95% Output of SUMF
Figure 2: Noisy images with noise high density 95%

2.6 Weighted Median Filter (WMF):

Weighted median filter is a median filter introduced by Justusson in 1981, has been employed in a wide range of computer vision solutions for its beneficial properties in sparsity representation. But it is hard to be accelerated due to the spatially varying weight and the median property[15]. Weighted Median Filter is the efficient filter to remove noise in gray and color images which gives best performance in comparison with SMF, Adaptive Mean Filter (AMF) in terms of PSNR and MSE. WMF removes salt and pepper noise in image and preserve the shape. WMF filter is the extension of SMF. Pixels are specified within a native neighborhood which gives repeated number of calculation of the median value[1]. The process of weighted median is taking the pixel noise and comparing the block uniformity of 3x3 window with one entire image and then adjusting the size for filtering accordingly through number of points in windows.

Salt-and-pepper noise is a special case of impulse noise where a certain percentage of individual pixels of a digital image are randomly digitized into one of the two extreme (255 or 0) intensities in the dynamic range [4]. WMF smooth the image and allows us to removes sequence of outlying. The detection of noise free pixel and noisy pixel lies between minimum and maximum with in selected window. Dynamic range for salt and pepper noise is (0, 255). If the value lies between (0, 255) then it is uncorrupted image. The value between (0, 255) is a noisy pixel[5]. To determine the noise point of image the important basis are the weights in the weighted algorithm. Figure 3 shows the experimental results of various de-noising filters. With the extension of WMF an Optimal Weighted Filter is developed for finding optimal weighted median [14] which minimize noise subject to a predetermined set of structural constraints on the filter's behavior. Based on the derivation of the output moments of weighted medians, it is shown that optimal weighted medians with structural constraints found by solving a group of linear inequalities. And it is proposed on one-dimensional applications.

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SMF	PSNR =35.6792	MSE =17.6396
AMF	PSNR =40.3887	MSE = 5.96434
MDBUTMF	PSNR=40.6099	MSE = 3.01575
WMF	PSNR =42.3618	MSE =3.01575

Figure 3: De-noising by various filters

The value of PSNR and MSE proved that WMF removes high density noise when compared to SMF, AMF, MDBUTMF, and WMF. A new weighted mean filter is introduced with a two-phase noise detector for image de-noising. In the first phase, a Rank-Ordered Difference of ROAD (ROD-ROAD) scheme is introduced for detecting noise candidates. In the second phase, a local image statistic Minimum Edge Pixels Difference (MEPD) is introduced to identify edge pixels from noise. This preserves edges from being wrongly detected as noise. Finally, an iterative de-noising algorithm is presented by combining the proposed two-phase noise detector and the new WMF. This method is accessible and easy to implement. Result shows that the new weighted filter method is best for removing impulse noise.

2.7 New Decision Based Filter:

Decision Based Median Filter [7] removes impulse noise effectively from highly corrupted image. Since it failed to restore the image, a New Decision Based Filter is introduced. A New Decision Based Filter [11] is for restoration of images that are highly corrupted by impulse noise. The new decision based filter shows significantly better image quality than a SMF, AMF, Threshold Decomposition Filter (TDF), cascade, and recursive nonlinear filters. DBMF detects the noisy and noise-free pixels in the image by checking the pixel values against the maximum and minimum values which will be in the dynamic range (0, 255). If the pixel is being currently processed has a value within the minimum and maximum values in the currently processed window, then it is a noise free pixel and no modification is made to that pixel. If the value doesn't lie within the range, then it is a noisy pixel and will be replaced by either the median pixel value or by the mean of the neighboring processed pixels [2]. To overcome the decision based problem Modified Decision Based Un-symmetric Trimmed Median Filter (MDBUTMF) is used.

Super mean filter also helps to reduce [12] the high density noise but only on grayscale images, and fail to restore the image whereas new decision based filter solves this restoration problem. Non Linear Filters is use to remove high and low density of noise, low density up to 30%, noise high density 80% [3]. By comparing the other filter it performs low because WMF remove high density above 95%

III. CONCLUSION

Various techniques to remove salt and pepper noise are discussed. Mean filter was introduced to remove the salt and pepper noise in an image. After Mean filter the modified Mean-Median is introduced as a new filter which is used to remove the efficient noise from the image. To overcome the Mean-Median filter the SMF is used for remove impulse noise. SUMF is used to remove high density salt & pepper noise from digital images. WMF removes the discontinuity in underlying regression function whereas the Decision Based Filter is efficient to de-noise the low level, it fails in medium and high density because the restored pixel which is the median value of the selected window is also a

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corrupted pixel value. To overcome this problem the new weighted median filter was introduced which gives satisfactory result in reducing high level salt and pepper noise.

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