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Image Denoising Using Non Linear Filtering

Miss.Arti V.Gautam*
Student of M.E: Dept. Of Computer Science & Engg.
Sipna's College Of Engg.Technology
Amravati, India
arti.gautam@rediffmail.com

Prof .Mr..D.M.Dakhane
Asst.Prof: Dept. Of Information Technology
Sipna's College Of Engg.Technology
Amravati, India
ddakhane@gmail.com

Abstract: Noise in an image is a serious problem. In this paper, the various noise conditions are studied which are Gaussian noise (GN), Bipolar fixed-valued impulse noise, also called salt and pepper noise (SPN), Random-valued impulse noise (RVIN). Digital images are often corrupted by impulse noise during the acquisition or transmission through communication channels the developed filters are meant for online and real-time applications. In this paper, the following activities are taken up to draw the results: Study of various impulse noise types and their effect on digital images; Study and implementation of various efficient nonlinear digital image filters available in the literature and their relative performance comparison with the proposed filter.

Keywords: Noise, GN,SPN, RVIN, Fixed Valued Impulse Noise

I. INTRODUCTION

Today digital imaging is required in many applications e.g., object recognition, satellite imaginary, biomedical instrumentation, digital entertainment media, internet etc. The quality of image degrades due to contamination of various types of noise. Noise corrupts the image during the process of acquisition, transmission, storage etc[1]. For a meaningful and useful processing such as image segmentation and object recognition, and to have very good visual display in applications like television, photo-phone, etc., the acquired image signal must be noise free and made deblurred. The noise suppression (filtering) and deblurring come under a common class of image processing tasks known as image restoration.

In common use the word noise means unwanted signal. In electronics noise can refer to the electronic signal corresponding to acoustic noise (in an audio system) or the electronic signal corresponding to the (visual) noise commonly seen as 'snow' on a degraded television or video image. In signal processing or computing it can be considered data without meaning; that is, data that is not being used to transmit a signal, but is simply produced as an unwanted by-product of other activities. In Information Theory, however, noise is still considered to be information. In a broader sense, film grain or even advertisements in web pages can be considered noise. In early days, linear filters were the primary tools in signal and image processing However, linear filters have poor performance in the presence of noise that is not additive as well as in systems where system nonlinearities or non-Gaussian statistics are encountered. Linear filters tend to blur edges, do not remove impulsive noise effectively, and do not perform well in the presence of signal dependent noise. To overcome these shortcomings, various types of nonlinear filters have been proposed in the literature.

II. PERFORMANCE MEASURES

The metric used for performance comparison of different filters are defined below:

A. Mean Squared Error (MSE)

The mean squared error (MSE) which for two m×n monochrome images I and K where one of the images is considered a noisy approximation of the other is defined as:

$$MSE = 1/mn \, \Sigma\Sigma[I(i,j)-K(i,j)]^2$$

B. Peak Signal to Noise Ratio(PSNR)

PSNR is usually expressed in terms of the logarithmic decibel scale.The PSNR is most commonly used as a measure of quality of reconstruction of lossy compression codecs (e.g., for image compression). The signal in this case is the original data, and the noise is the error introduced by compression. When comparing compression codecs it is used as an approximation to human perception of reconstruction quality, therefore in some cases one reconstruction may appear to be closer to the original than another, even though it has a lower PSNR (a higher PSNR would normally indicate that the reconstruction is of higher quality). One has to be extremely careful with the range of validity of this metric; it is only conclusively valid when it is used to compare results from the same codec (or codec type) and same content. It is most easily defined via the mean squared error (MSE) as:

$$PSNR = 10 \log_{10} (MAX_I{}^2)/MSE$$

Here, MAX_I is the maximum possible pixel value of the image. When the pixels are represented using 8 bits per sample, this is 255. More generally, when samples are represented using linear PCM with B bits per sample, MAX_I is 2^B-1.

III. LITERATURE REVIEW

In this section an attempt has been made for a literature review for the filtering of random-valued impulsive noise.Removal of the random-valued impulse noise is done by two stages: detection of noisy pixel and replacement of that pixel. Median filter is used as a backbone for removal of impulse noise. Many filters with an impulse detector are proposed to remove impulse noise.

A. Tri State Median Filter [2]

A novel and effective median filter, called *tri-state median* (TSM) filter, is proposed and discussed in this section. Noise detection is realized by an impulse detector, which takes the outputs from the SM and CWM filters and compares them with the origin or center pixel value in order to make a tri-state decision. The switching logic as shown in Figure 1 is controlled by a threshold T ([0; 255] for gray-scale images).

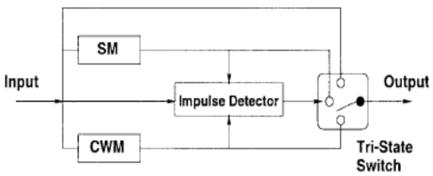


Figure 1. Tri-State Median Filter

B. Adaptive Center-Weighted Median Filter (ACWM) [3]

It devises a novel adaptive operator, which forms estimates based on the differences between the current pixel and the outputs of center-weighted median (CWM) filters with varied center weights. It employs the switching scheme based on the impulse detection mechanisms. It utilizes the center-weighted median filter that have varied center weights to define a more general Equations operator, which realizes the impulse detection by using the differences defined between the outputs of CWM filters and the current pixel of concern. The ultimate output is switched between the median and the current pixel itself.

C. Directional Weighted Median Filter (DWMF) [4]

Another method for removal of random-valued impulse noise is directional weighted median filter (DWM). This filter uses a new impulse detector, which is based on the differences between the current pixel and its neighbours aligned with four main directions. After impulse detection, it does not simply replace noisy pixels identified by outputs of median filter but continue to use the information of the four directions to weight the pixels in the window in order to preserve the details as removing noise. First it considers a 5X5 window. Now it considers the four directions: horizontal, vertical and two diagonal. Each direction there is 5 pixel points. It then calculates the weighted difference in each direction and takes the minimum of them. The minimum value is compared with a threshold value and if it is greater than the threshold value then it is a noisy pixel otherwise not. In filtering phase, it calculates the standard deviation in four directions. Because the standard deviation describes how tightly all the values are clustered around the mean in the set of pixels shows that the four pixels aligned with this direction are the closest to each other. Therefore, the center value should also be close to them. Now it calculates the weighted median, giving extra weight on that direction in which direction standard deviation is small and replaces the noisy pixel with this median value. It is an iterative method. This method repeats 8 to 10 times. It gives the good performance when noise level is high too.

D. Alpha Trimmed Mean Filter [5]

Alpha-trimmed mean filters are widely used for the restorationof signals and images corrupted by additive non-Gaussian noise. They are especially preferred if the underlying noise deviates from Gaussian with the impulsive noise components.

It is based on order statistics and varies between a median and a mean filter. It is used when an image contains both short andlong tailed types of noise (e.g. both Gaussian and salt and pepper noise). To define the alpha-trimmed mean filter, all pixels surrounding the pixel at the coordinate (x,y) in the image A which are specified by an input N x N size square mask A(i) are ordered from minimum to maximum value.The basic idea behind filter is for any element of the signal (image) look at its neighborhood, discard the most atypical alements and calculate mean value using the rest of them.

IV. PROPOSED WORK

The proposed algorithm is as follows:

Step 1: A 2-D window " S_{xy}" of size 3×3 is selected with the pixel to be processed "P(x,y)" as center.

Step 2: Determine the median (P_{med}) of the 9 pixels inside this window.

Step 3: P(x,y) is an uncorrupted pixel if 0<P(x,y)<255 and is left unchanged.

Step 4: If P(x,y) is a corrupted pixel then it is processed as follows.

Step 4(a): If P_{med} is an uncorrupted pixel, then P(x,y) is replaced with P_{med}.

Step 4(b): If P_{med} is a corrupted pixel then another window of size 5×5 is selected with P(x,y) as center and the median(Pmed5) of these 25 pixels are determined.

Step 4(c): If Pmed5 is an uncorrupted pixel then P(x,y) is replaced with Pmed5.

Step 4(d): If Pmed is a corrupted pixel then window Sxy is again considered and the number of uncorrupted pixels (Ns) in window Sxy is counted.

Step 4(e): If Ns is even then P(x,y) is replaced with mean of the uncorrupted pixels in the window Sxy.

Step 4(f): Else P(x,y) is replaced with median of the uncorrupted pixels in the window Sxy.

Step 5: Repeat steps 1 to 4 for all the pixels in the image.

V. SIMULATION RESULTS

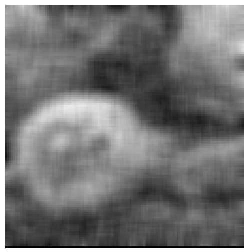
Table I: Comparison of PSNR (dB) for eight Image

Noise Density	*Output PSNR*					
	Before filtering	*TSM*	*ACWMF*	*DWM*	*ATM*	*proposed*
0.1	-	34	34.47	35.86	32.44	35.97
0.2	-	30	31.22	33.54	30.54	34.44
0.3	-	24	29.56	30.24	28.65	31.21
0.4	-	20	22.76	25.65	26.43	27.21

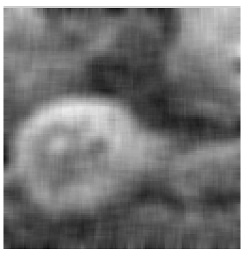
(a)

(b)

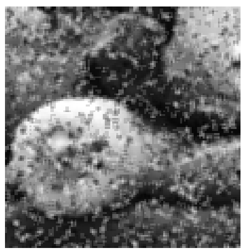
(c)



(d)



(e)



(f)

(g)

Restored results of Eight image corrupted with 30% of RVIN(a) True image, (b) Noisy image, (c)TSM, (d) ACWMF, (e) DWMF, (f)ATM, (h) Proposed.

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