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An Efficient Approach for the Removal of Bipolar Impulse Noise using Median Filter

Kalyan Sagar Kadali[1*] and L. Rajaji[2]

[1]Department of Electrical and Electronics Engineering, AMET University, Chennai - 603112, Tamil Nadu, India; Kalyansagar.k@gmail.com
[2]Department of Electrical and Electronics Engineering, ARM College of Engineering and Technology, Chennai - 603209, Tamil Nadu, India

Abstract

Background/Objectives: A new decision based algorithm for the removal of salt and pepper noise, also known as bipolar impulse noise. **Methods/Statistical Analysis**: Comparison of matrices such as 3x3, 5x5, 7x7, 9x9 is performed using median filtering techniques. **Results/Findings**: The result obtained, it is found that 5x5 is better to produce the clear noise free image with high degree of salt and pepper noise elimination compared to previously proposed method. **Conclusion/ Application**: It can be concluded that by comparing 3x3, 5x5, 7x7, 9x9 corrupted matrixes of an image using standard median filtering techniques proves that 5x5 is better than all other matrix combinations. This helps to eliminate the salt and pepper noise of corrupted pixel and provides better noise elimination capability. The amount of noise eliminated can be estimated by considering the PSNR values.

Keywords: Median Filter, Processing Element, Systolic Algorithm

1. Introduction

Digital image processing finds its application in many important fields such as satellite communication, business applications etc. Processing an image is a complex task. Any signal processing system, even though it is digital, it is not perfect due to the constraints of noise. Therefore, main problem in image processing is to reduce the effect of noise and present it with perceptible details. Median filter is a non-linear filter which highly eliminates the salt and pepper noise from the corrupted image. Here we have used standard median filter which effectively removes the noise from the corrupted image. The 3x3 window for an image is not that much efficient because when you consider the whole image and perform sorting for the corrupted pixel by using median filtering technique it results in blurred image. 3x3 windowing technique remove the noise effectively even at noise level as high as 90% and preserve the edges without any loss up to 80% of noise level.

2. Introduction to Existing Method

In 3x3 windowing technique, a particular set of pixels of corrupted image is taken and based on the median value sorting is performed. If the median value lies between (0,255) then sorting process is not necessary. If the median value is 255, then adjacent pixel value of the corrupted image is taken to eliminate noise. If the noise density is high, there is a possibility that the median value is also a noise value.

** Author for correspondence*

3. Proposed Method

In this method, to eliminate the corrupted pixel from the image of a 5x5 matrix the following sorting is performed. This is illustrated with the help of following matrix.

Corrupted matrix

123	0	156	255	234
255	0	214	98	0
0	234	255	133	190
199	255	234	255	0
255	167	210	198	178

Row sorting

0	123	156	234	255
0	0	98	214	255
0	133	190	234	255
0	199	234	255	255
167	178	198	210	255

Column sorting

0	0	98	210	255
0	123	156	214	255
0	133	190	234	255
0	178	198	234	255
167	199	234	255	255

Diagonal sorting

0	0	98	210	167
0	123	156	178	255
0	133	190	234	255
0	214	198	234	255
255	199	234	255	255

In the above 5x5 matrix, the center pixel is corrupted. So, it is called as corrupted matrix. This must be replaced by the value in the range of (0,255). Then row sorting is performed. But, the Pmax value along the adjacent diagonal is 255 which is maximum value. In order to minimize that value we are going for column sorting. After performing column sorting also we get the diagonal value as 255. So we are going for the diagonal sorting where the adjacent diagonal value is in the required range [Pmin, (0,255), Pmax]. Let us consider an image with a corrupted pixel. By using the PSNR value you can find out the noise level. If PSNR value increases noise level decreases and as a result the image is noise free. By using this we can prove that 5x5 is better than 3x3. This is done with the help of following formula.

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

Where

MSE mean square error,

$$MSE = \frac{\sum_{ij}(r_{ij} - x_{ij})^2}{MN}$$

n corrupted image;

R original image;

M x N size of image;

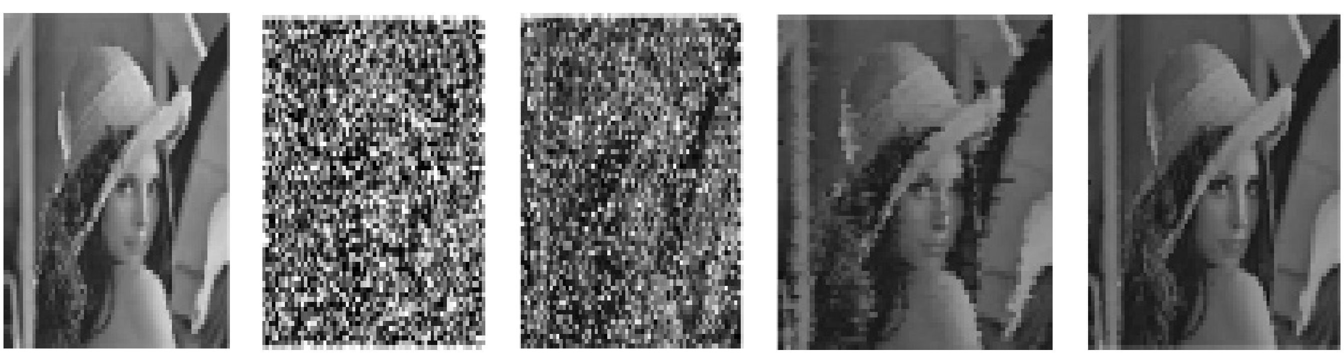
x restored image.

Different cases are considered for the 3x3 matrix of corrupted image. They are as follows.

Case 1. The P(X,Y) is an uncorrupted pixel if Pmin< P(X,Y)< Pmax, Pmin > 0, and Pmax <255; the pixel being processed is left unchanged .Otherwise, P(X,Y) is a corrupted pixel.

Case 2. If P(X,Y) is corrupted pixel, it is replaced by its median value if Pmin < Pmed < Pmax and 0 < Pmed < 255.

Case 3. If Pmin < Pmed < Pmax is not satisfied or 255 < Pmed = 0, then Pmed is a noisy pixel. In this case, the P(X,Y) is replaced by the value of neighborhood pixel value.



(a) **(b)** **(c)** **(d)** **(e)**

Figure 1. **(a)** Original image, **(b)** Corrupted image, **(c)** Output of SMF, **(d)** Simulation output for the 3x3 matrix of the corrupted image and **(e)** Simulation output for the 5x5 matrix of the corrupted image.

Table 1.

Selected Window	MSE	PSNR
3x3	24.6301	34.2161
5x5	24.2619	34.2816
7x7	28.0790	33.6470
9x9	32.2656	33.0434

4. Results

Finally it has been concluded that by comparing 3x3, 5x5, 7x7, 9x9 corrupted matrixes of an image using standard median filtering techniques proves that 5x5 is better than all other matrix combinations. This helps to eliminate the salt and pepper noise of corrupted pixel and provides better noise elimination capability. The amount of noise eliminated can be estimated by considering the PSNR values. The PSNR value is inversely proportional to the noise and if noise level decreases then the PSNR value increases. To analyze it better we can refer back to the Table 1. All the results were obtained by using MATLAB coding and the better noise removal of the images is shown in the above figure. Effective noise removal is seen up to 90% and bipolar noise free image is obtained.

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