International Journal for Modern Trends in Science and Technology
Volume: 03, Issue No: 06, June 2017
ISSN: 2455-3778
http://www.ijmtst.com

An Efficient Support Vector Machines based Random Valued Impulse noise suppression Technique

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To Cite this Article
Bibekananda Jena and Punyaban Patel, "An Efficient Support Vector Machines based Random Valued Impulse noise suppression Techniques", *International Journal for Modern Trends in Science and Technology*, Vol. 03, Issue 06, June2017, pp. 200-206

ABSTRACT

This paper proposes an efficient technique to reduce the effect of random valued impulse noise from the contaminated image under consideration. The proposed method only targets the corrupted pixels, while the original pixels retain their value the process of noise filtering. To allow the unhealthy pixels only in filtering stage, an impulse noise detection process is first applied to the test image. The proposed scheme uses Support vector Machine with parameters of the noisy image as input to classify healthy and unhealthy pixels. The filtering process is performed recursively, so that the restored identified noisy pixel elements of the current filtering window can take part in the detection phase of the next window. Exhaustive simulations show that the scheme proposed here consistently outperforms its counterparts in suppressing impulsive noise and retaining image details.

KEYWORDS: *Salt and Pepper Noise (SPN),Random Valued Impulse Noise (RVIN),Peak Signal to Noise Ratio (PSNR), Mean Square Error(MSE), Image Quality Index(IQI)*

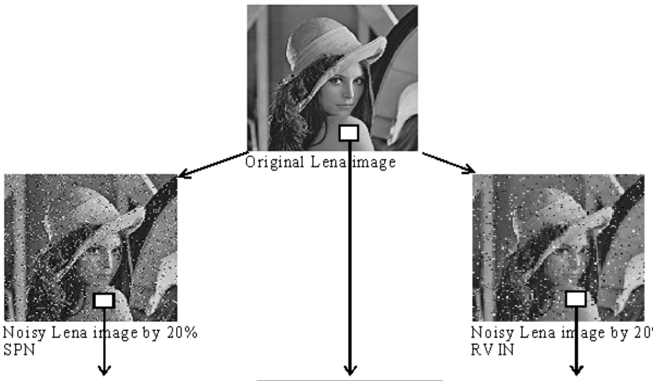
I. INTRODUCTION

Images may be affected by noise due to the fault of image sensor used for acquisition, atmospheric turbulence or in the process of transmission. The two variations of impulse noise are, Salt and pepper noise and Random valued impulse noise. Figure:1 shows two noisy images, one is contaminated by Salt and pepper noise and another one is by Random Valued impulse noise. It can be seen from the figure that, in salt and pepper noise, the noise element of the original image is switched to 0 or 255, whereas in RVIN the noisy pixels can attain any intensity level in the available dynamic range, i.e. in between 0 and 255 for 8-bit images. Hence a single threshold value will not be enough to mitigate the effect of such noise. Salt & pepper noises can be detected and filtered by most of the reported method efficiently. But their performances are not satisfactory when dealing with random valued impulse noise (RVIN). Therefore, an effective denoising technique is required to reduce the effect of noise in the image before use of any applications. The main objective of an efficient denoising method is not only to reduce the noise effect, but also preserves the edge as well as image details. The classical method of filtering proposed earlier introduced blurring effect in the output image of the filter due to its averaging properties. However the use of non-linear filters [1, 2] performs better in denoising by producing satisfactory response to a noisy image. One of the most popular non-linear filters is the Standard Median filter [3], which simply arranges the pixels in the filtering windows in ascending order and replaces the test pixels with its median value. Even though the filter is simple to implement and well enough to reducing the impulse noise effect, it has some limitations. But the scheme fails to remove high density of noise, because use of large window size for high noise severely affects the fine details of the image. To overcome such problems, some modified median filtering technique known as Weighted Median Filter (WM) [4]and Center weighted Median(CWM)[5] Filter introduced which assign different weight to different pixels in the filtering window. The CWM filter gives more emphasis to the center pixel to remove high density impulse noise. The well-known median filter and its variants filter all the pixel elements of the image irrespective of its originality. Thereby the value of non-noisy pixels is also changing which affect the detail information of the image badly in the presence of high density of noise.

The said problem is overcome by introducing a noise detection stage prior to filtering, where the identification of noisy pixel operation is performed. The efficiency of these techniques is highly dependent on the effectiveness of the noise detection stage. The well-known Tri-state median (TSM) [6] filter works on this principle. In this case, an impulse noise detector is used, which receives the outputs from the two different filters: SM filter and CWM filter, and compares them with the test pixel value to give a tri-state decision. Based on a threshold, the test pixel under consideration is replaced by the output of either SM filter or CWM filter or identity filter. In last few year some better noise removal algorithm with different kinds of noise detectors have been proposed, such as signal-dependent rank order mean (SD-ROM) filter [7], multistate median (MSM) filter [8], adaptive center-weighted median (ACWM) filter [9] and the pixel-wise MAD (PWMAD) filter [10] ,adaptive mad-based threshold (ADMAD)[11], the Alpha Trimmed Median Based filter(ATMBF)[12], Modified switching Weighted median filter(MSWMF) [13] a directional weighted median (DWM) filter [14] and so on. DaeGeun Lee proposed a powerful adaptive switching median filter based on support vector machine (SVM-ASM)[15] for effectively reduce impulse noise effect in images without affecting the image details and features. But the detection method fails to identify noisy pixels for high density noise.

Some more advanced filters have been also been proposed for suppressing for mixed noise. One of such filter is the trilateral filter [16], which is the modification of the well-known bilateral filter [17] with incorporated rank-order absolute difference (ROAD) statistics for impulse noise detection. Rank-Ordered Absolute Difference (ROAD) [18] is a feature that measures the closeness of a test pixel with its neighbors. It has been especially designed for uniform impulse and Gaussian noise removal. The newly introduced robust Outlyingness ratio (ROR) based noise detector (ROR-NLM) [19] works efficiently for impulse, Gaussian and Mixed noise. The use of non-local means (NLM) method in noise removal with this detector enhances the filtering capability and has attracted a lot of attention of researchers, works in the area of signal and image processing. The Optimal direction based impulse noise suppression proposed by Ali S.Awad in [20] uses the optimal direction of a filtering window known as normalized distance in the optimal direction (NDOD) as a measure with proper threshold value to classify between noise-free and noisy pixel. Unlike above method this method works effectively in detecting edge pixels in presence of impulse noise. GuangyuXualso proposed a universal noise filter in which is the Extension of NLM (ENLM)[21] filtering method by combining the robust local image statistics called the extreme compression rank order absolute difference with the nonlocal means. The filter is capable of suppressing any type of impulse noise efficiently by varying some parameters discussed in the method. Muhammad. Habib proposed another fuzzy based method called adaptive fuzzy inference system based directional median filter (AFIDM) [22] method for impulse noise removal. The algorithm uses fuzzy logic to construct a membership function adaptively for robust fuzzy inference based impulse noise detector which can efficiently distinguish between original pixels and noisy pixel element without affecting the edges and detail information present in the image.

In this paper, a Support vector Machine based filter is introduced to suppress the Random Valued Impulse Noise effect in images. The proposed scheme aims at efficient classification of pixels as noisy or noise free. The input parameters, to the classifier are derived from two different statistical parameters, namely, the robust Outlyingness ratio (ROR) [19] and Rank-Ordered Absolute Difference (ROAD) a similarity measure discussed in [18]. Subsequently, the identified noisy pixels are filtered with an adaptive median filter. The overall paper is organized as follows. Section-I deals with introduction. Section:II describes the proposed denoising work. Section-III discusses the simulation and results. Finally, Section-IV provides the concluding remarks.



84	86	84	**0**	85
86	**255**	85	84	**0**
85	86	85	**0**	85
87	87	**255**	84	84
255	84	86	86	87

84	86	84	86	85
86	87	85	84	86
85	86	85	85	85
87	87	85	84	84
86	84	86	86	87

84	86	84	**0**	85
86	**44**	85	84	86
85	86	85	**50**	85
87	87	85	84	**167**
255	84	86	**128**	87

Figure 1:Original and noisy Lena image with SPN and RVIN

II. PROPOSED METHOD

SVM based impulse noise suppression technique is proposed in this work. Support vector Machine introduced by Vapnik [23], targets at differentiating two given classes. The training set of SVM contains N tuples. Each input data is a vector with some features belongs to a class The SVM first maps the input vector space to some high dimensional feature space, and then creates a maximum margin hyper plane to separate the two given classes. Given an unbalanced sample, the SVM can predict its class by mapping it into the feature space and then computing its position with respect to the constructed hyper plane. The proposed method composed of two state, i.e impulse detection and Noise Filtering as shown in Figure-2.

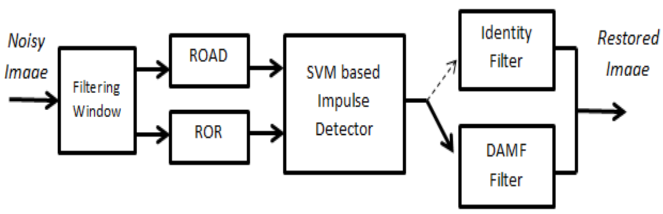


Figure-2: Block Diagram of the proposed Technique

A. SVM Impulse Detection:

The test pixels are first identified by the SVM impulse detector whether it is corrupted or not. The SVM impulse detector uses two important features derived from a filtering window to classify the signals into two classes: non-noisy and noisy signals. This structure of the noise detection consists of two stages: feature extraction and Training SVM network

1)Feature Extraction:

The most important in the machine learning algorithm is the selection of feature set. The ROR add NDOD derived above are taken as two feature vector to train the SVM. The features are described as follows:

a) Robust Outlyingness Ratio (ROR) [19].

This is a newly proposed parameter for detection of RVIN noise in images. ROR measures how much each pixel gets affected by impulse. The computation of ROR involves the following steps.

Step 1: Consider a 5 x 5 window, W with center pixel as the test pixel y

Step 2: Compute Med(y) as the median of the window

Step 3: Compute the median of absolute deviation, MAD as,

MAD(y)=Med {|x-Med(y)|,x ∈W}

Step 4: Compute MADN(y) empirically as,

MADN(y)= (MAD(y))/0.6457

Step 5: Compute ROR(y)=|((y-Med(y)))/MADN(y)|

b) *Rank-orderedabsolutedifference(ROAD):[18]*

ROAD statistic is introduced in [18] which is a very valuable parameter to distinguish between noisy and non-noisy pixels. ROAD value is high for noisy elements, and low for non-noisy image element. The ROAD factor is calculated as follows:

1.The absolute difference between the center pixel and the surrounding neighbor pixel of the filter window is calculated and denoted by 'diff' (for a c window).

diff=|cp-wn|

Where cp indicates the center pixel and wn indicates its neighbor pixels

2. Sort diff values in the increasing order and let the sorted values as rn

rn=sort(diff)

3. The ROAD factor is calculated by summing up the first 'n' values of 'rn'

For each pixel ROAD value is calculated using its v window and is used as the second input to the SVM classifier.

2.Training the SVM impulse detector:

Before the SVM used for classification of noisy and non-noisy pixels it need to be trained with the suitable inputs. To get the optimal hyperplane for separating noisy and non-noisy element present in the test image, the algorithm calculates the ROR and ROAD features using a 5×5 window for each pixel of an image corrupted with 30% Random Valued Impulse noise . We have used the Lena image of size 256 × 256 as shown in Figure 1. If we trained the SVM network with high noise ratio to get a satisfactory result for highly corrupted image, the number support vector will increase. Similarly a high an image having large size produces a finer intensity scale, but increases the network training time as well as execution time. For generating the training pattern, a total of 1000 noisy pixels and 1000 non-noisy pixels are collected randomly in the image. For every training pixel both ROR and ROAD are computed. The noisy class is represented by '1' and that of a healthy pixel is '0'. Once the SVM is trained, it can be used for impulse detection in image by applying the ROR and ROAD value for each pixel at its input. The output of the SVM is a binary map, where '1' represents the presence of noise in the corresponding location in the image.

B. Noise Filtering:

The identified noisy pixel from the detection stage with the help of Binary map is now going through the filtering process. The filtering process used here is the dynamic adaptive median filtering technique as discussed below.

Step 1. Choose a 3 × 3 filtering window 'w' from the Image 'I' and corresponding 3 × 3 window from generated binary map B.

Step 2. Find out the number of uncorrupted pixels in the current filtering window from the corresponding binary map window.

Step 3. If the presence of uncorrupted pixels is less than three in the filtering window, the size of the filtering window is increased outwards by one pixel and go to step-2 otherwise proceed to step-4

Step 4. Replace the noisy element by the median of the uncorrupted pixels in the current filtering window.

III. SIMULATION AND DISCUSSION OF RESULT

To assess the filtering performance of the proposed method, extensive simulations are carried out on standard gray scale images of size 512×512, likes Lena, Peppers, Bridge, Boat and Airplane. The performance of the proposed method is evaluated in terms of the peak signal-to-noise ratio (PSNR)[2] and Image Quality Index (IQI)[24, 25] to analyze the denoising performances of the proposed method quantitatively and qualitatively respectively.as defined below.

$$PSNR(dB) = 10\, log_{10}\left(\frac{255^2}{MSE}\right) \qquad (1)$$

$$MSE = \frac{1}{M \times N}\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}(X_{i,j} - \hat{X}_{i,j})^2 \qquad (2)$$

Where X and $\hat{X}$ represents the original and the restored image respectively, 255 is the peak gray-level of the 8-bit image. PSNR has been employed to measure the restoration performance

The distortion in the image may be due to loss of correlation, changes in luminance or distortion in contrast level. IQI combines the above parameters to represent the degradation level and defined as:

$$IQI = (1/M)\sum_{j} IQI_j \qquad (3)$$

Where, j=1, 2, 3..........M and

$$IQI_j = Corr(X_w, \hat{X}_w) * Lum(X_w, \hat{X}_w) * Cont(X_w, \hat{X}_w)$$

for each 8× 8 local region. M is the total number of such region in the image.

where, $Corr(X_w, \hat{X}_w) = \sigma_{X\hat{X}}/\sigma_X\sigma_{\hat{X}}$

$$Lum(X_w, \hat{X}_w) = 2\mu_X\mu_{\hat{X}}/(\mu_{\hat{X}}^2 + \mu_{\hat{X}}^2)$$

$$Cont(X_w, \hat{X}_w) = 2\sigma_X\sigma_{\hat{X}}/(\sigma_{\hat{X}}^2 + \sigma_{\hat{X}}^2)$$

The maximum value that the IQI attends is 1, which represent the restored and original image are almost equal

In this paper the results obtained from the standard Boat and Bridge images are discussed. The input images are corrupted with RVIN from 10% to 50%. The proposed scheme along with the well performing algorithms like MSM, ADMAD, ATBMF, SVM-ASM, NDOD, DWM, ROR-NLM, ENLM, AFIDM are applied to the noisy images.

Table-1 represents the comparative analysis of Peak Signal to Noise Ratio for different standard images at various RVIN noise levels respectively. It can be seen that the proposed method provides significant improvement over existing techniques. It is clear from the graphs that the performance of the proposed method is better than others. Along with the numerical value, the restored Peppers images of different method are given in Figure:3. Each filter process the same Peppers image corrupted with 50% RVIN. Compared with the original image, the proposed scheme shows a superior restoration performance. To observe the similarity between Original image and the restored images of the proposed method image Quality Index (IQI) along with Image Quality maps[25] has also been generated and shown in Figure-4. More the brightness of the quality map (IQI closer to 1) specifies that the filtered image is closer to the original test image, and low intensity image quality map specifies that the filtered image is more distant from the original test image.

Table1: Comparative Analysis of PSNR for Various restoration techniques

Noise/ Methods	PSNR								
	% of Noise								
	30%	40%	50%	30%	40%	50%	30%	40%	50%
	Peppers			Boat			Bridge		
MSM	27.06	23.71	20.53	26.07	23.25	20.46	26.31	23.28	20.33
ADMAD	27.35	23.67	20.34	26.65	23.35	20.24	26.47	22.93	19.96
ATBMF	31.64	28.92	25.21	29.29	27.16	24.45	29.03	26.83	23.95
SVM-ASM	30.99	27.16	25.02	28.86	27.03	24.33	30.01	24.53	23.78
NDOD	29.95	27.64	24.38	27.41	25.78	23.52	27.36	25.31	23.02
DWM	30.90	28.84	26.80	28.90	27.47	25.79	29.23	27.25	25.45
ROR-NLM	32.54	31.21	28.42	29.17	27.13	25.95	30.01	28.55	26.18
ENLM	30.34	28.38	26.50	30.01	27.78	26.91	30.34	28.98	26.96
AFIDM	31.25	30.58	28.21	31.13	28.02	27.12	30.57	29.02	27.33
PROPOSED	31.75	30.91	28.55	32.04	28.75	28.12	31.18	29.95	27.49

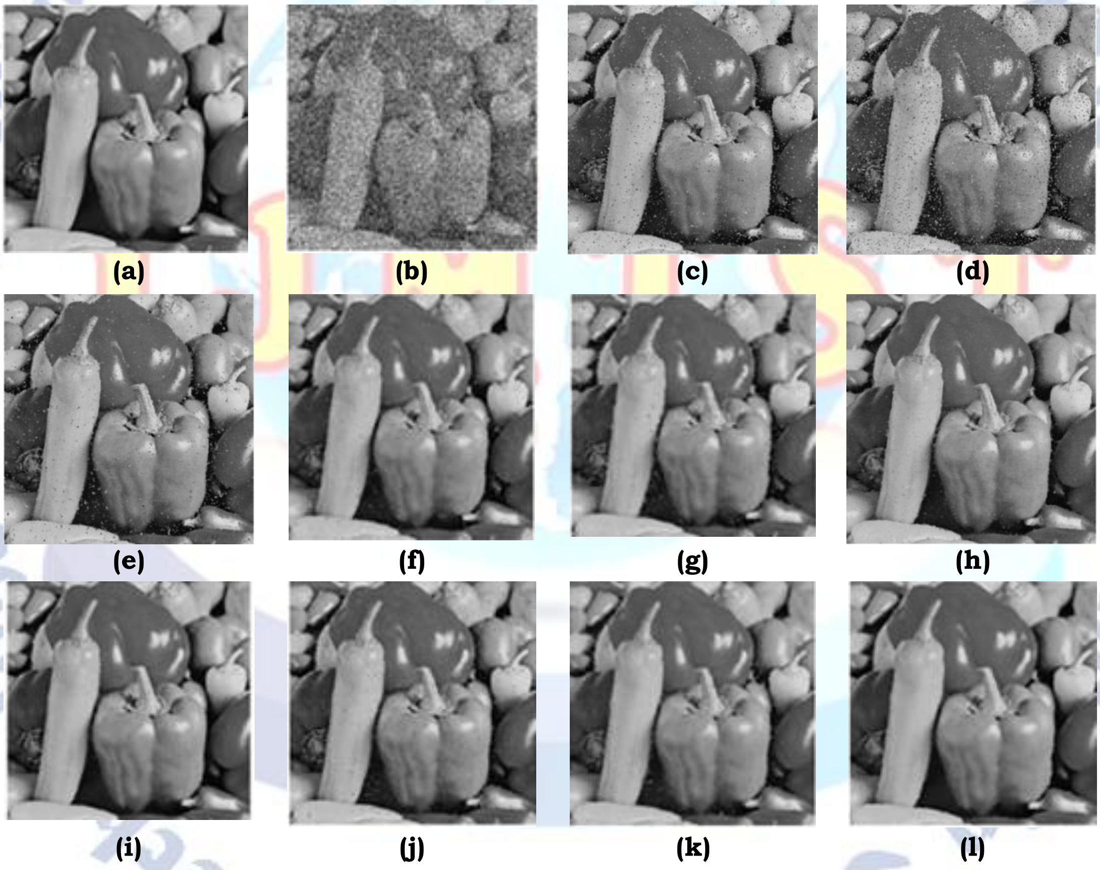


Figure 3: Restored Pepper images of various filters for image corrupted with 50% Random valued impulse noise (a) Original pepper image (b) noisy image (c) MSM (d) ADMAD (e) ATBMF (f) SVM-ASM (g) NDOD (h) DWM (i) ROR-NLM (j) ENLM (k) AFIDM (i) Proposed Method.

IV.CONCLUSION

The proposed algorithm recovers images corrupted with RVIN effectively. The filter initially detects the location of corrupted pixels by proposing SVM based impulse detector model followed by the dynamic adaptive median filtering operation. The two features discussed above used as the input to the SVM impulse detector make the accuracy of detection, high enough and generalized for which the structure not required to be trained differently for different noise ratio or different images. Filtering is applied to the identified noisy pixels only keeping the uncorrupted pixels as it is. Bothqualitatively and quantitatively measures are used for evaluation of the proposed technique. The comparative results show that the proposed technique gives superior results than other existing technique not only suppression of impulse noise but also preservation of image details.

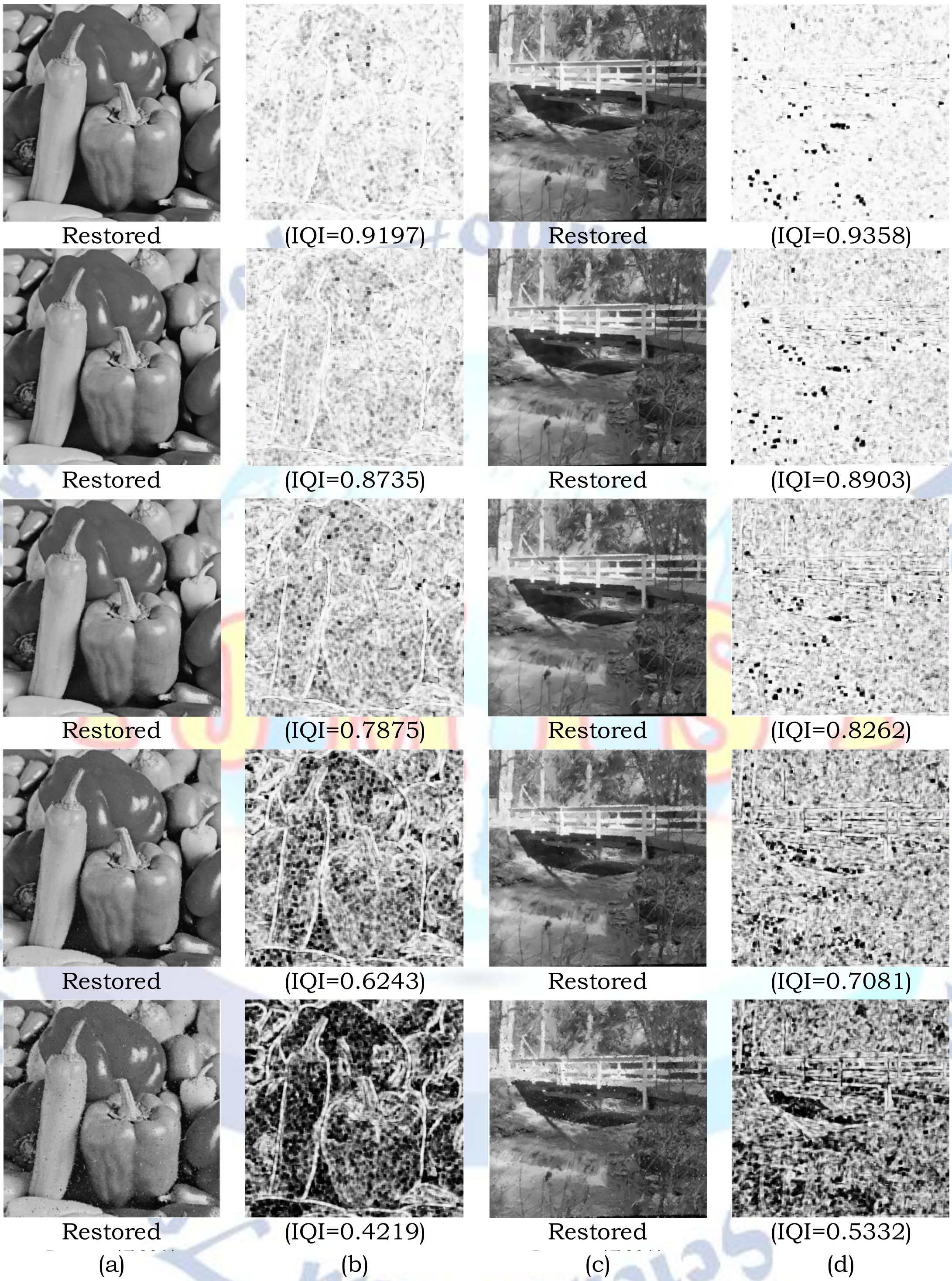


Figure-4: Column (a) represents Restored Peppers Image Column(b) represents corresponding Image Quality Map. Column(c) represents Restored Bridge Image, Column (d) represents corresponding Image Quality Map

REFERENCES

[1] R. C. Gonzalez and R. E. Woods, Digital Image Processing. Pearson Education, Upper Saddle River, New Jersey, 2007.

[2] B. Chanda and D. DuttaMajumder," Digital Image Processing and Analysis", Prentice-Hall of India, 1st edition, 2002.

[3] W. K. Pratt, Digital Image Processing. New York: Wiley-Interscience, 1991.

[4] D. R. K. Brownrigg, "The Weighted Median Filter," Communications ACM, vol. 27, pp. 807 - 818, August 1984.

[5] Sung-JeaKo and Yong Hoon Lee, "Center Weighted Median Filters and Their Applications to Image

Enhancement" IEEE Transactions On Circuits And Systems, pp.984-993 ,Vol. 38, No.9, September 1991
[6] Tao Chen, Kai-Kuang Ma, and Li-Hui Chen," Tri-State Median Filter for Image Denoising", IEEE Transactions On Image Processing, pp.1834-1838, Vol. 8, No. 12, December 1999.
[7] E. Abreu, M. Lightstone, S. Mitra, and K. Arakawa, "A new efficient approach for the removal of impulse noise from highly corrupted images," IEEE Trans. Image Process., vol. 5, no. 6, pp. 1012–1025, Jun. 1996.
[8] Tao Chen and Hong Ren Wu, "Space Variant Median Filters for the Restoration of Impulse Noise Corrupted Images", IEEE Transactions on Circuits and Systems—II: Analog and Digital Signal Processing, Vol. 48, No. 8, pp.784-789, August 2001.
[9] Tao Chen and Hong Ren Wu," Adaptive Impulse Detection Using Center-Weighted Median Filters", IEEE Signal Processing Letters, pp: 1-3,Vol. 8, No. 1, January 2001.
[10] Vladimir Crnogavic, VojinSenk, and ZeljenTrpovski, "Advanced impulse detection based on pixel-wise MAD", IEEE Signal Processing Letters, 11(7):589-592, July 2004.
[11]WenbinLuo," An Efficient Detail-Preserving Approach for Removing Impulse Noise in Images", IEEE Signal Processing Letters, Vol. 13, No. 7, pp.413-416, July 2006.
[12] J. B. Bednar and T. L. Watt, "Alpha-trimmed Means and their Relationship to Median Filters," IEEE Trans. Acoust., Speech, Signal Process., vol. ASSP-32, no. 1, pp. 145–153, Feb. 1984.
[13] Chung-Chia Kanga,Wen-JuneWang, "Modified switching median filter with one more noise detector for impulse noise removal" International Journal Electron.Commun.(AEÜ) 63(2009) 998–1004
[14] Y. Q. Dong and S. F. Xu, "A new directional weighted median filter for removal of random-valued impulse noise," IEEE Signal Process. Lett.,vol. 14, no. 3, pp. 193–196, Mar. 2007.
[15] DaeGeunLeea, Min Jae Parkb, Jeong Ok Kimb, Do Yoon Kimb, Dong WookKimc,DongHoon Lim1, "Adaptive Switching Median Filter for Impulse Noise Removal Based on Support Vector Machines", Communications of the Korean Statistical Society 2011, Vol. 18, No. 6, pp. 871–886
[16] Roman Garnett, Timothy Huegerich, Charles Chui, Wenjie He, "A Universal Noise Removal Algorithm with an Impulse Detector", IEEE transactions on image processing, vol. 14, no. 11, November 2005
[17] C. Tomasi and R. Manduchi, "Bilateral filtering for gray and color images," in Proc. IEEE Int. Conf. Computer Vision, 1998, pp. 839–846
[18] R. Garnett, T. Huegerich, C. Chui, and W. He, "A Universal Noise Removal Algorithm With an Impulse Detector," IEEE Transactions on Image Processing, vol. 14, no. 11, pp. 1747 - 1754, November 2005.
[19] Bo Xiong and Zhouping Yin, "A Universal Denoising Framework With a New Impulse Detector and Nonlocal Means', IEEE Transactions on Image Processing", VOL. 21, NO. 4, pp.1663-1675, April 2012
[20] Ali S.Awad, "Standard Deviation for Obtaining the Optimal Direction in the Removal of Impulse Noise", IEEE Signal Processing Letters, Vol. 18, No. 7, pp.407-410, July 2011.
[21] Xu, Guangyu.,& Tan, Jieqing.(2013). A Universal Impulse Noise Filter with an Impulse Detector and Nonlocal Means. Circuits Syst Signal Process, DOI:10.1007/s00034-013-9640-1, Springer Science Business Media New York.
[22] Habib, Muhammad.,Ayyazhussain, Rashsed, Saqib., & Ali, Mubashir. (2016). Adaptive fuzzy inference system based directional median filter for impulse noise removal. Int. J. Electron Commun, (AEU) 70 (2016), pp.689-697.
[23] Vapnik, V. (1998). The Nature of Statistical Learning Theory, Springer-Verlag, New York.
[24] Zhou Wang, Alan C. Bovik, "A Universal Image Quality Index", IEEE Signal Processing Lett, vol. XX, no. Y, 2002
[25] Madhu S. Nair and G. Raju, "A new fuzzy-based decision algorithm for high-density impulse noise removal", Journal of Signal, Image and Video Processing, Springer in press, DOI10.1007/s11760-010-0186-4,2010.