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Image Denoising Using Median Filter with Edge Detection Using Canny Operator

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Abstract: ***Image denoising is one of the fundamental problem in image processing.In this paper, a novel approach to suppress noise from the image is conducted by applying the median filter, which is order-statistics filter and simpler. The noise level have not been reduced by using median filter.Interquartile range (IQR) which is one of the statistical methods used to detect outlier effect from a dataset. The essential advantage of applying IQR filter is to preserve edge sharpness better of the original image. PSNR was calculated and compared with median filter. The purpose of edge detection is to significantly reduce the amount of data. This paper compares and analyzes several kinds of image edge detection, including prewitt, sobel and canny with matlab tool. The experimental results on standard test images demonstrate this filter is simpler and better performing than median filter.***

Keywords: Noise removal, edge detection, image filter, canny operator, median filter, IQR filter**.**

1. Introduction

Image quality improvement has been a concern throughout the field of image processing. Images are affected by various type of noise [1]. One of the most important areas of image restoration is that cleaning an image occurring by noise. The goal of reducing noise is to eliminate noisy pixels. Noise filtering can be used as replacing every noisy pixel in the image with a new value depending on the neighbouring region. The filtering algorithm varies from one to another by the approximation accuracy for the noisy pixel from its surrounding pixels [8]. Image de-noising is an vital image processing task i.e. as a process itself as well as a component in other processes. There are many ways to de-noise an image or a set of data and methods exists.

The proposed algorithm in this paper focuses on how to effectively detect the noise and efficiently restore the image. Once pixel is detected as noise in previous phase, their new value will be estimated and set in noise reduction phase. The filters are used in the process of identifying the image by locating the sharp edges which are discontinuous. These discontinuities bring changes in pixels intensities which define the boundaries of the object. Edge detection is a problem of fundamental importance in image analysis. The purpose of edge detection is to identify areas of an image where a large change in intensity occurs. Edges are basically discontinuities in the image intensity due to changes in the image structure. These discontinuities originate from different features in an image. In typical image, edge characterise object boundaries and are useful for segmentation, registration and identification of objects in a scène. Edges are classified into step, line, ramp and roof edge.

2. Image Denoising

Image denoising is the process of finding unusual values in digital image, which may be the result of errors made by external effects in image capturing process. Identifying these noisy values is an essential part of image enhancement [10] [12] [19]. In the past three decades, a variety of deposing methods have been proposed in the image processing. In spite of these methods are very different, but they tried to remove the noisy pixels without affecting the edges, as much as possible. One of the most common filters is the median filter. Median filter is very effective in removing salt and pepper and impulse noise while preserving image details. In particular, the median filter performs well at filtering outlier points while leaving edges unharmed. One of the undesirable properties of the median filter is that it does not provide sufficient smoothing of non impulsive noise.

3. Median Filter

The Median filter is a nonlinear digital filtering technique, often used to remove noise. Such noise reduction is a typical pre-processing step to improve the results of later processing (for example, edge detection on an image).Median filtering is very widely used in digital image processing because under certain conditions, it preserves edges whilst removing noise. The main idea of the median filter is to run through the signal entry by entry, replacing each entry with the median of neighboring entries. Note that if the window has an odd number of entries, then the median is simple to define: it is just the middle value after all the entries in the window are sorted numerically. For an even number of entries, there is more than one possible median. The median filter is a robust filter. Median filters are widely used as smoothers for image processing, as well as in signal process and time series processing [21].

A major advantage of the median filter over linear filters is that the median filter can eliminate the effect of input noise values with extremely large magnitudes. (In contrast, linear filters are sensitive to this type of noise - that is, the output may be degraded severely by even by a small fraction of anomalous noise values). The output y of the median filter at the moment t is calculated as the median of the input values corresponding to the moments adjacent to t:

$$y(t) = median\left(\left(X\left(t-\frac{T}{2}\right), X(t-T1+1), \ldots, X(t), \ldots, x\left(t+\frac{T}{2}\right)\right)\right) \quad (1)$$

where t is the size of the window of the median filter. Besides the one-dimensional median filter described above, there are two-dimensional filters used in image processing .Normally images are represented in discrete form as two dimensional arrays of image elements, or pixels - i.e. sets of non-negative values Bij ordered by two indexes i =1,…, Ny (rows) and j = 1,…,Ny (column). where the elements Bij are scalar values, there are methods for processing color images, where each pixel is represented by several values, e.g. by its "red", "green", "blue" values determining the color of the pixel.

4. Interquartile Range(IQR)

The Five Number Summary is a method for summarizing a distribution of data [20]. The five numbers are the minimum, the first quartile Q_1, the median, the third quartile Q_3, and the maximum [4].The IQR is the range of the middle 50% of a distribution. It is calculated as the difference between the upper quartile and lower quartile of a distribution. Since an outlier is an observation which deviates so much from the other observations. Therefore, any outliers in the distribution must be on the ends of the distribution, the range as a measure of dispersion can be strongly influenced by outliers. One solution to this problem is to eliminate the ends of the distribution and measure the range of scores in the middle. Thus, the IQR will eliminate the bottom 25% and top 25% of the distribution, and then measure the distance between the extremes of the middle 50% of the distribution that remains. IQR is a robust measure of variability [4].The general formulas for calculating both Q_1 and Q_3 are given as

Q1= (n+1)/4th ordered observation (2)
Q3=3(n+1)/4th ordered observation (3)

4.1 Proposed IQR filter

In this article, a novel filter based on the concept of the Interquartile range which is one of the measures of dispersion used in statistics that calculates variation between elements of a data set. In order to apply IQR filter, a window of size k×k was used to implement the proposed method. First, the pixels in the k×k window are sorted in ascending order in order to calculate the first and third quartiles, Q_1 and Q_3 respectively [20]. Second, the IQR is calculated by subtracting Q_1 from Q_3. Third, all the pixels that lie outside the IQR are treated as suspected pixels (SP). Those suspected pixels may be passing through a permission procedure to check whether they are noisy or not.

4.2 Permission Procedure

Actually, not all the pixels outside the IQR are noisy image. A threshold may be established to permit the external pixels (the pixels outside the IQR) to be in or out. The permission procedure is implemented in two sides which are left and right, i.e. Q_1 *and* Q_3. According to left side, the difference between Q1 and the suspected pixel is calculated. If $|Q_1\text{-SP}|<T_1$, then the pixel is not noisy, otherwise it is. On the other hand, the same procedure is repeated for the right hand with Q3. Therefore, two thresholds (T_1 and T_2) may be found to determine the truly noisy pixels. As an example, an arbitrary 8×8 window size from a random image was chosen to apply the previously mentioned procedure, Table (1).

Table 1: Arbitrary 8×8 Window Size From A Random Image

103	103	102	100	99	99	103	0
103	255	103	102	101	101	103	105
102	103	105	105	103	102	255	104
101	104	106	107	106	104	103	103
100	103	107	108	106	104	103	102
100	103	106	107	105	103	102	102
100	102	105	0	103	102	102	102
100	102	104	103	102	101	101	102

The first quartile was found to be (Q_1=102) and the third quartile was (Q_3=104). Hence, IQR=104-102=2. Now, after transform the 8×8 block into a vector of size 64 and sorting it, the suspected pixels corresponding to the left side are 0, 0, 99, 99, 100, 100, 100, 100, 100, 101, 101, 101, 101, and 101 because they are less than Q_1 and hence outside IQR from left. Obviously, 99, 100 and 101 are not highly differing from Q_1; therefore, they are not noisy pixels and must be inside. Mathematically speaking, |102-99|=3, |100-102|=2, and |102-101|=1 which are all have small difference with Q_1. So, if a threshold T1 was determined such that the difference of the suspected pixels is less than T1. Also, all pixels higher than T1, i.e. the two 0's, since |102-0|=102>T1. As a result, the noisy pixels from the left side are (0, 0). The same procedure could be applied to the right side and getting (255,255) as right noisy pixels, Figure (1).

4.3 Estimating Noisy Pixels

After the determination of the noisy pixels, the estimation method used to donate a value for each noisy image is the local averaging [16]. First, the noisy image could be classified into three types. According to Figure(2), the three noise types are: corner noise (A, C, G, and I), border noise (B, D, F, and H) and interior noise(E).For the corner noise pixels, the estimation could be obtained by summing all the surrounding values (which are always three) and dividing them by 3. While for the border noise, the surrounding pixels are 5.Hence, the average for each surrounding pixels could be found. Finally, the interior noise pixels are surrounded by nine points. As an example, the estimation of the corner noise pixel (0), upper right, in Fig.1,is computed as summing all the surrounding three pixels (103+103+105)/3=103.67=104 which is a very sophisticated value. The Peak Signal to Noise Ratio (PSNR) was used to measure the dissimilarities between the noisy image and the original image, table (4). The IQR filter was found to perform quite well on images corrupted with large window size, figure (4).

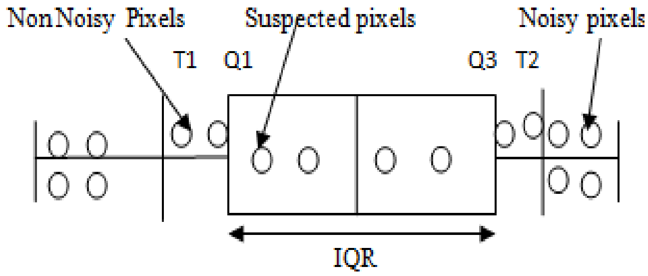

Figure 1: IQR with T1 and T2

4.4 Noisy Neighbours Problem

Since the noise imposed randomly, the noise pixels may be neighbours in the image array.Therefore, the procedure of local averaging could be risky because of including another noisy pixel in the summation which is wrong. Hence, some procedure to get rid of the noisy neighbour just during the local averaging is very important. According to Figure (3), both A and B are noisy pixels. As mentioned previously, the local averaging is used to estimate the value of the noisy pixel A by finding the local averaging of the surrounding pixels to A which are 84, B, 85, 87, and 86. But B is also a noisy image and this will affect the average directly. As an example, if the value of A is 0, then (84+0+85+87+86)/5 =52 which is very far from the nearest neighbours.So, by neglecting B and calculating the summation for all the surrounding pixels without B as (84+85+87+86)/4 =86 and that is seems to be rational approximation.

Table 2: Noisy Neighbours

84	A	86
B	85	87
84	84	86

4.5 IQR Algorithm

For each window of size k×k do the following:

1. Compute *Q1*, *Q3*, and IQR distance
2. Find all suspected noisy pixels outside IQR distance
3. Compute the permission distance by two thresholds T1 and T2
4. Return all pixels within T1 and T2 to the no noisy pixels

5. Estimate all noisy pixels greater than T1 and T2 by local averaging

A	0	0	0	B	0	0	0	C
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
D	0	0	0	E	0	0	0	F
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
G	0	0	0	H	0	0	0	I

Figure 2: Three Noise Types

6. Types of Noise

6.2 Amplifier noise (Gaussian noise)

The standard model of amplifier noise is additive, Gaussian, independent at each pixel and independent of the signal intensity. In color cameras where more amplification is used in the blue color channel than in the green or red channel, there can be more noise in the blue channel. Amplifier noise is a major part of the "read noise" of an image sensor, that is, of the constant noise level in dark areas of the image [22].

6.2 Salt-and-pepper noise

An image containing salt-and-pepper noise will have dark pixels in bright regions and bright pixels in dark regions [22].This type of noise can be caused by dead pixels, analog-to-digital converter errors, bit errors in transmission, etc.This can be eliminated in large part by using dark frame subtraction and by interpolating around dark/bright pixels.

6.3 Poisson noise

Poisson noise or shot noise is a type of electronic noise that occurs when the finite number of particles that carry energy, such as electrons in an electronic circuit or photons in an optical device, is small enough to give rise to detectable statistical fluctuations in a measurement [22].

6.4 Speckle noise

Speckle noise is a granular noise that inherently exists in and degrades the quality of the active radar and synthetic aperture radar (SAR) images [22].

6.5 Edge-Detection

Gradient-based edge detection is the most common approach for detecting meaningful discontinuities in gray level. This leads to formalism in which "meaningful" transitions in gray levels can be measured. An ideal edge is a set of connected pixels, each of which is located at a step transition in gray level. The gradient of an image *f(x, y)* at location *(x, y)* is defined as vector. The gradient vector points in the direction of maximum rate of change of f at coordinates *(x, y)*. An important quantity in the edge detection is magnitude of this vector, denoted as f, Where $f=\sqrt{Gx^2+Gy^2}$ where Gx = Horizontal gradient, Gy = Vertical gradient

Table 3: Robert-cross operator

Gx		Gy	
1	0	0	-1
0	-1	1	0

6.6 Canny's Edge Detection

The Canny Edge Detection Algorithm has the following Steps:

Step 1: Smooth the image with a Gaussian filter.
Step 2: Compute the gradient magnitude and orientation using finite-difference approximations for the partial derivatives. Step 3: Apply non maxima suppression to the

gradient magnitude, Use the double thresholding algorithm to detect and link edges. Canny edge detector approximates the operator that optimizes the product of signal-to-noise ratio and localization. It is generally the first derivative of a Gaussian [23].

6.7 Classical (Sobel, Prewitt)

The primary advantages of the classical operator are simplicity. The Roberts cross operator provides a simple approximation to the gradient magnitude. The second advantages of the classical operator are detecting edges and their orientations. In this cross operator, the detection of edges and their orientations is said to be simple due to the approximation of the gradient magnitude. The disadvantages of these cross operator are sensitivity to the noise, in the detection of the edges and their orientations. The increase in the noise to the image will eventually degrade the magnitude of the edges. The major disadvantage is the inaccuracy, as the radiant magnitude of the edges decreases. Most probably the accuracy also decreases [23].

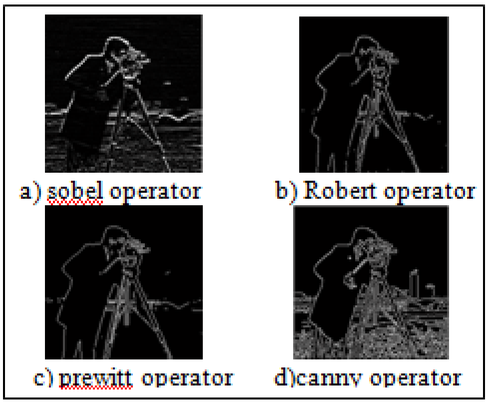

Figure 3: Comparison of different edge detection

Table 4: PSNR Values for 512×512 Test Images

S. No	Image	*3×3Window size*		*5×5window size*		*7×7window size*	
		median filter	*IQR Filter*	*median filter*	*IQR Filter*	*median filter*	*IQR Filter*
1	Lena	35.0945	38.9235	30.9786	36.7854	28.6724	37.3126
2	Peppers	35.8371	37.6059	32.3491	32.9871	30.0969	32.4500
3	Boys	29.2751	31.1613	27.5362	30.9018	26.3659	30.6026
4	Bird	31.2095	33.2074	27.7528	32.8480	25.7590	32.5171
5	Baboon	22.8738	30.2606	20.6409	31.5668	19.9158	30.8693

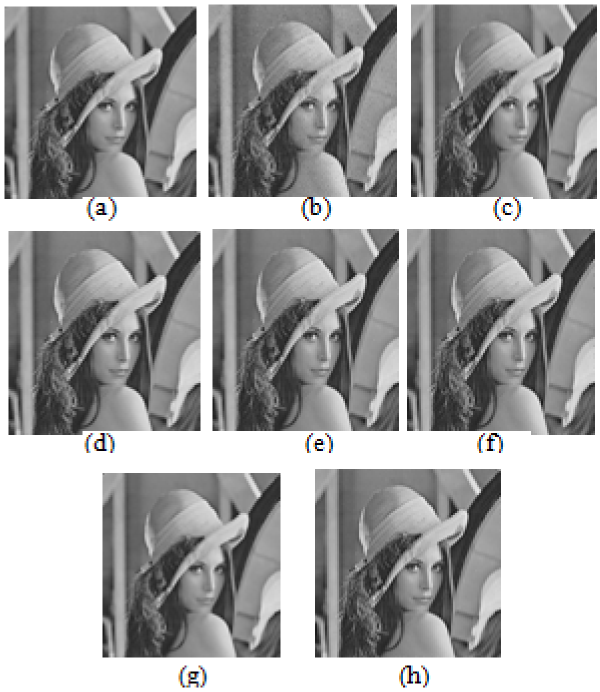

Figure 4: (a) Original Image (b) Noisy Image (c) 3×3 Median Filter (d) 3×3 IQR Filter (e) 5×5 Median Filter (f) 5×5 IQR Filter (g) 7×7 Median Filter (h) 7×7 IQR Filter

7. Conclusion

In this paper, a new and simple approach for removing salt and pepper noise from corrupted images has been presented. The proposed filter use statistic in a way that removes outlier from a window of size k×k. It can be seen that IQR filter preserves edge sharpness better of the original image than median filter. As a main conclusion from this article is that whenever the window size is increased the preserving of the edges is not affected highly which is on the contrary of the median filter? Results show this filter can effectively reduce salt and pepper noise. Various edge detection algorithms and design methods have been described and discussed in this paper. The major research directions that can be followed and improvements to be made in the future edge detection techniques are categorized in the following categories:

1) Image noise reduction.
2) Precise edge detections with a minimum error detection possibility.
3) Accurate edge localization that can detect edges within a single pixel.

8. Future Work

Different-filtering techniques can be introduced to reduce the noise. The integration of multiple algorithms for image segmentation in addition to Sobel-edge detection and binary image segmentation can be considered.

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References

[1] A. A. Gulhane and A. S. Alvi, "Noise Reduction of an Image by using Function Approximation Techniques", International Journal of Soft Computing and Engineering (IJSCE) Volume-2, Issue-1, March 2012.

[2] C. Liu, R.Szeliski, S.B.Kang, C. L. Zitnick, and W. T. Freeman, "Automatic Estimation and Removal of Noise from a Single Image Noise from a Single Image", IEEE Transactions on Pattern Analysis And Machine Intelligence, Vol. 30, No. 2, February 2008.

[3] D. Shekar and R. Srikanth,"Removal of High Density Salt & Pepper Noise in Noisy Images Using Decision Based UnSymmetric Trimmed Median Filter (DBUTM)", International Journal of Computer Trends and Technology, vol. 2, Issue 1, 2011.

[4] F. M. Dekking, C. Kraaikamp, H.P. Lopuhaa, L.E. Meester, A Modern Introduction to Probability and Statistics: Understanding Why and How, Springer-Verlag, London Limited, 2005, pp: 236.

[5] G. Hanji and M. V. Latte, "A New Impulse Noise Detection and Filtering Algorithm", International Journal of Scientific Research and Publications, Vol. 2, Issue 1, 2012.

[6] H. Hosseini, F. Marvasti, "Fast Impulse Noise Removal from Highly Corrupted Images".

[7] H. Hwang and R. A. Haddad, "Adaptive Median Filters: New Algorithms and Results", IEEE Transactions on Image Processing, Vol. 4, No. 4, 1995 http://arxiv. Org/ftp/arxiv/papers/1105/11052899.pdf.

[8] J.M.C.Geoffrine and N.Kumarasabapathy, "Study And Analysis Of Impulse Noise Reduction Filters", Signal & Image Processing: An International Journal (SIPIJ), Vol.2, No.1, March 2011.

[9] J.S. Marcel, A. Jayachandran, G. K .Sundararaj, "An Efficient Algorithm for Removal of Impulse Noise Using Adaptive Fuzzy Switching Weighted Median Filter", International Journal of Computer Technology and Electronics Engineering (IJCTEE), Vol 2, Issue 2, 2012.

[10] K. R. Castleman, Digital Image Processing, Prentice Hall, 1996, pp: 414.

[11] M. S. Nair, K. Revathy, and R. Tatavarti, "Removal of Salt-and Pepper Noise in Images: A New Decision-Based Algorithm", Proceedings of the International MultiConference of Engineers and Computer Scientists IMECS, 19-21 March, Hong Kong, Vol I, 2008.

[12] R. C. Gonzalez and R. E. Woods. Digital Image Processing, Prentice Hall, New Jersey 07458, second edition, 2001, pp: 222.

[13] R. H. Chan, C.-W. Ho, and M. Nikolova, "Salt-and-Pepper Noise Removal by Median-Type Noise Detectors and Detail-Preserving Regularization", IEEE Transactions on Image Processing, Vol. 14, No. 10, October 2005.

[14] S.S.Al-Amri, N.V.Kalyankar, and Khamitkar S.D,"A Comparative Study of Removal Noise from Remote Sensing Image", International Journal of Computer Science Issues, Vol. 7, Issue. 1, No. 1, January 2010.

[15] S.-S. Ieng, J.-P. Tarel and P. Charbonnier, "Modeling Non-Gaussian Noise For Robust Image Analysis", In proceeding of: VISAPP 2007: Proceedings of the Second International Conference on Computer Vision Theory and Applications, Barcelona, Spain, March 8-11, 2007 - Volume 1.

[16] T.Gebreyohannes, and K.Dong-Yoon,"Adaptive Noise Reduction Scheme for Salt and Pepper", Signal & Image Processing: An International Journal, Vol. 2 Issue 4, Dec2011 p47.

[17] V. Jayaraj, D. Ebenezer, and K. Aiswarya, "High Density Salt and Pepper Noise Removal in Images using Improved Adaptive Statistics Estimation Filter", International Journal of Computer Science and Network Security, Vol.9 No.11, November 2009.

[18] V.R.Vijay Kumar, S. Manikandan, P. T. Vanathi, P. Kanagasabapathy, and D. Ebenezer, "Adaptive Window Length Recursive Weighted Median Filter for Removing Impulse Noise in Images with Details Preservation", ECTI Transactions on Electrical Eng., Electronics, and Communications, Vol.6, No.1 February 2008.

[19] W. K. Pratt, Digital Image Processing, Fourth Edition, John Wiley & Sons, Inc., Publication, 2007, pp: 267.

[20] W. W. Daniel, Biostatistics: A Foundation for Analysis in the Health Sciences, eighth edition, John Wiley & Sons Inc., 2005, pp: 44-47.

[21] Raman Maini & Dr. Himanshu Aggarwal "Study and Comparison of Various Image Edge Detection Techniques" International Journal of Image Processing (IJIP), Volume (3): Issue (1).

[22] Pawan Patidar Manoj Gupta "Image De-noising by Various Filters for Different Noise" Volume 9– No.4, November 2010.

[23] Charles Boncelet (2005)."Image Noise Models". in Alan C.Bovik. Handbook of Image and Video Processing.

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