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Color Image De-noising Based on Mean, Median, and Gaussian filters

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Abstract: Image filtering algorithms are employed to eliminate various types of noise from established images, such as the Lena image. This noise can either be present in the image during the image capture process or as a result of transmission. The present study aims to compare the performance of mean, median, and Gaussian filters in the de-noising of Lena images affected by Gaussian noise, salt and pepper noise, and speckle noise. The evaluation of a performance is carried out using the Peak Signal to Noise Ratio (PSNR) metric.

Keywords: Gaussian noise, Salt & Pepper noise, Speckle noise, Mean filter, Median filter, Gaussian Filter, and PSNR.

I. INTRODUCTION

Noise may be introduced into an image during various stages of image transmission, coding, processing, or acquisition. They not only distort accurate information within the image but also significantly impact its visual appeal. One variety of such noise is known as salt and pepper noise, which is a prevalent form of impulse noise characterized by the sporadic occurrence of pixels with either a minimum or maximum value within an image [1]. The aforementioned phenomenon is typically attributed to inaccuracies in the transmission of data or the malfunctioning of individual pixel components within camera sensors, as well as defective memory locations or timing errors that occur during the digitization process [2]. The aforementioned phenomenon is typically attributed to inaccuracies in the transmission of data or the malfunctioning of individual pixel components within camera sensors, as well as defective memory locations or timing errors that occur during the digitization process [3]. The SPN can only assume two values, namely a and b. In the context of an 8-bit image, it is customary for pepper noise to be represented by a value of 0, while salt noise is typically denoted by a value of 255. Each has a probability that is typically below 0.1. The image's SPN appearance is achieved by alternating the corrupted pixels between the minimum and maximum values. The pixels that are not affected remain unaltered. The second category of noise is known as Gaussian noise, which is statistical noise characterized by a probability density function (PDF) that is equivalent to that of the normal distribution. This noise is a common occurrence that can happen during both image acquisition and transmission. For instance, poor illumination can cause sensor noise, while electronic circuit noise can cause noise during transmission. The third category of noise is known as speckle noise, which can manifest in an image in a manner similar to Gaussian noise. This type of noise is classified as multiplicative noise and is commonly observed in coherent imaging systems, including radar, acoustics, and laser, among others. Moreover, extensive research has been conducted on Poisson noise and various additional types of noise in the field of image processing [3,4,5].

The reduction of noise holds significant importance in the realm of image processing and computer vision analysis. In the case of an image that has been corrupted by noise, various linear or nonlinear filter methods can be employed to effectively reduce the noise. In the realm of frequency analysis, the particulars of an image are represented by high-frequency components that may be erroneously identified as high-frequency noise. However, these methodologies are frequently designed for gray images. In order to enable the application of these methodologies to color images, it is necessary to devise an iterative process capable of processing the individual components (red, green, and blue) of a color image. Numerous techniques have been proposed for removing noise from images; however, their efficacy is limited when applied to color images[6-10].

This paper aims to analyze the known noisy image (Lena image) by decomposing it into its three fundamental color channels (red, green, and blue). Each channel is then subjected to independent processing using Gaussian and median filters. Subsequently, these individual channels are combined to produce the resultant colored image. The mean filter was also utilized to reduce the noise present in the image. The quantitative performance was analyzed using the peak signal-to-noise ratio (PSNR).

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II. DE-NOISING FILTERS

Gaussian Filter

The Gaussian filter is a type of low-pass filter that is commonly employed for the purpose of noise reduction. The initial step in applying the Gaussian filter to the noisy image involves determining the appropriate size of the kernel matrix to be utilized for image reduction. Comprehensive outcomes can be calculated based on the central pixel. Furthermore, it should be noted that the kernels exhibit symmetry, thereby possessing an equal number of rows and columns. Additionally, the kernel exhibits symmetry, resulting in an equal number of rows and columns[11]. The values within the kernel are calculated using the Gaussian function, which is expressed as follows:

$$\ldots\ldots\ldots\ldots\ldots(1)\ G(x,y) = \frac{1}{2\pi\sigma^2}\ e^{-\frac{x^2+y^2}{2\sigma^2}}$$

The standard deviation, denoted by σ, has been utilized in selecting the 3 by 3 Gaussian Kernel Approximation in two dimensions. Specifically, the chosen kernel approximation with σ = 1 is represented in Fig. 1 as follows:

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1	2	1
2	4	2
1	2	1

Figure 1: Gaussian kernel with σ = 1.

Mean Filter :

The mean filter is a rudimentary sliding-window kernel. The process involves replacing the central pixel value within the kernel window with the arithmetic mean of all pixel values contained within the corresponding kernel window, which is expressed as follows [12]:

5	2	8
1	3	4
6	9	7

→

5	2	8
1	5	4
6	9	7

Mean =(5+2+8+1+3+4+6+9+7)/9=45/9=5

Figure 2: The fundamental principle of the mean filter involves the application of a 3x3 window size for processing.

Median Filter :

The median filter is a commonly used sliding-window filter in image processing. Its operation involves replacing the central pixel value within the kernel window with the median value of all the pixel values present in that particular kernel window [13, 14, 15]. It is imperative that the kernel size be a positive, odd integer. In this

particular instance, the size of the kernel is 9, so the median can be determined by calculating the (9+1)/2 = 5th element. Additional details are provided below:

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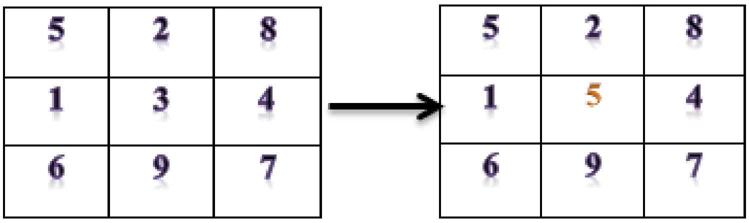

Figure 3: The median filter is based on the fundamental principle of employing a 3x3 window size for processing.

I. Proposed Technique

The de-noising process of the Lena image is carried out by employing the mean filter, median filter, and Gaussian filter. The effectiveness of these de-noising techniques is assessed using the peak signal-to-noise ratio (PSNR). An overview of the proposed technique is presented in Fig. 4.

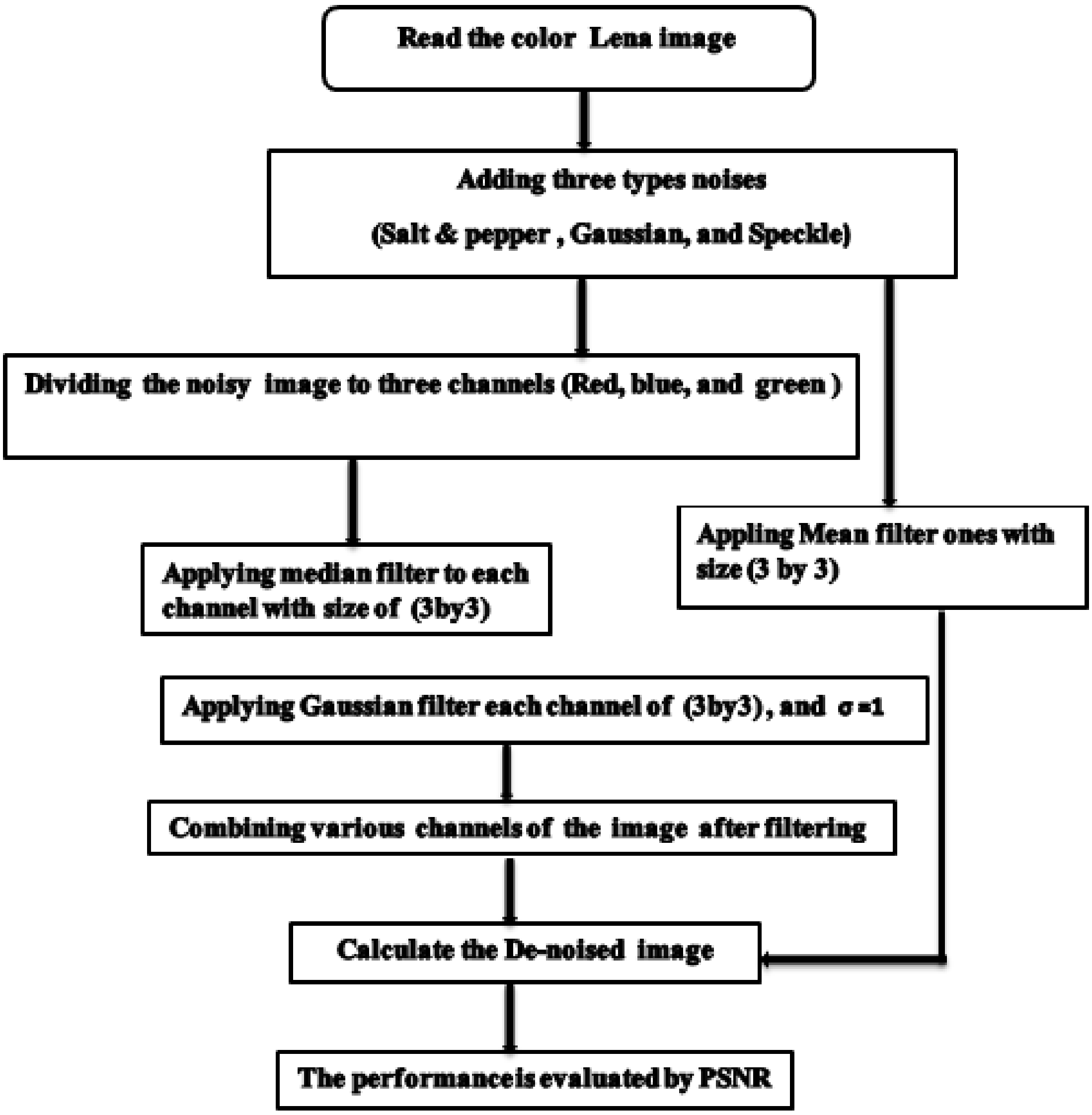

Figure 4: Representation of the Proposed Approach.

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II. SIMULATION RESULTS

The simulation results that have been achieved by the PSNR. This method is frequently employed to assess the efficacy of image quality by comparing distorted images to their original image. It calculates the ratio of the peak signal power to the noise power, providing a precise measurement of the image quality. A high value of PSNR is a reliable indicator of minimal image degradation [a]. The mathematical expressions for PSNR are presented below [2].

$$PSNR = 10\ Log\ 1o\left(\frac{255^2}{MSE(X,Y)}\right) \quad ....(2)$$

The mean squared error (MSE) is a metric that quantifies the cumulative squared error between the original and de-noised images [k4]. It is calculated as the average of the squares of the errors.

$$MSE(X,Y) = \frac{1}{m\,n} \sum_{i=1}^{m} \sum_{j=1}^{n} (x_{ij} - y_{ij})^2 \quad ...(3)$$

Where , $X = x_{ij}$ be the original image, and $Y = y_{ij}$ be the de-noised image.

Figure5 :Original Lena image, noisy image with salt and pepper, Gaussian, Speckle noise, and enhanced images using median filter, respectively.

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Figure 6 :Original Lena image, noisy image with salt and pepper, Gaussian, Speckle noise, and enhanced images using mean filter, respectively.

Figure 7 :Original Lena image, noisy image with salt and pepper, Gaussian, Speckle noise, and enhanced images using Gaussian filter, respectively.

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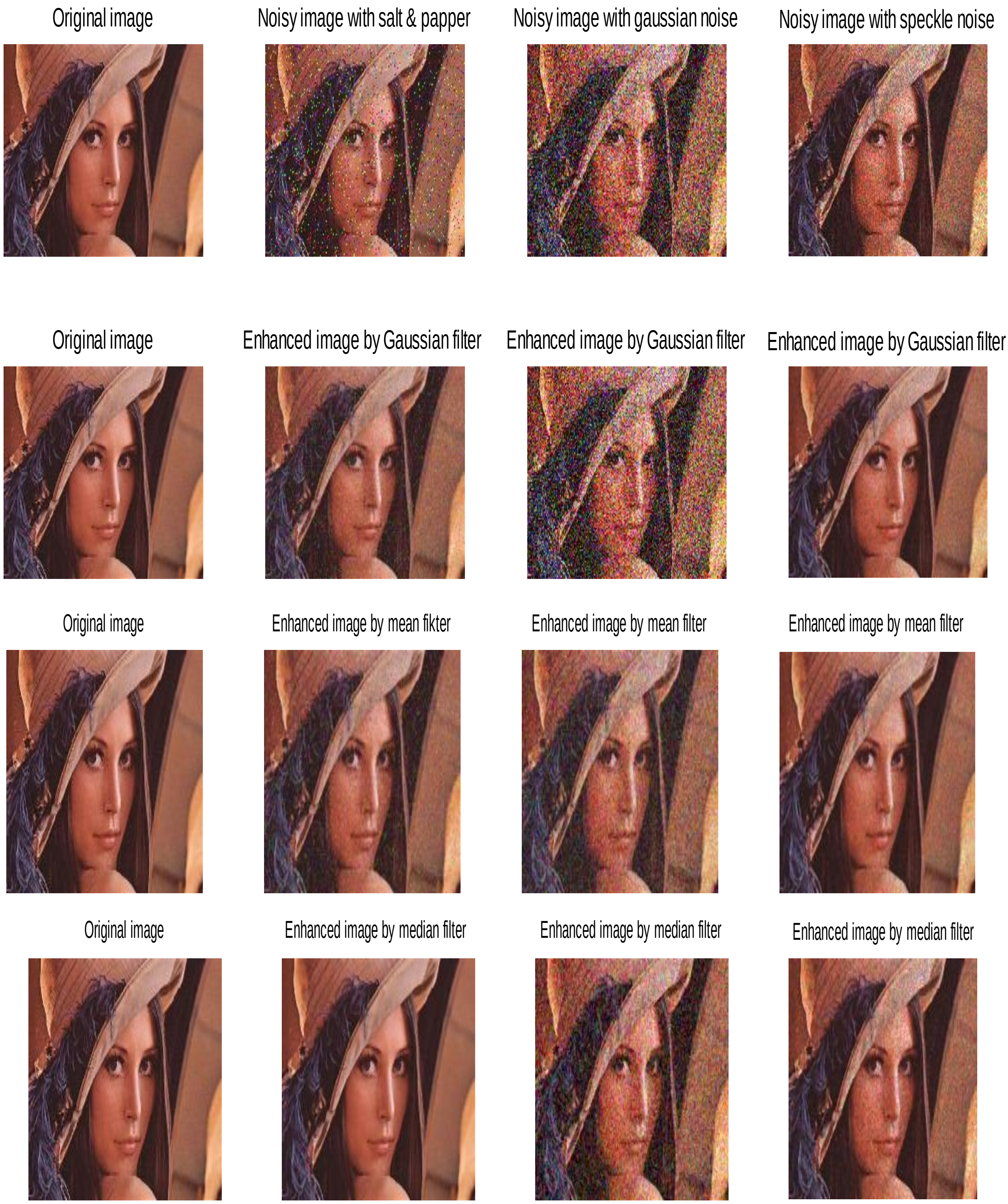

Figure 8: Original Lena image added with salt and pepper, Gaussian, and speckle noise with noise density at 0.05, and de-noising using Gaussian, mean filter, and median filter, respectively.

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Table 1: The determination of the PSNR values for the median, mean, and Gaussian filters at a noise density of 0.05

	Salt & peppers noise	Gaussian noise	Speckle noise
Median filter	33.3203	31.5947	31.597
Mean filter	32.794	28.8801	31.7205
Gaussian filter	33.3693	29.2185	32.41

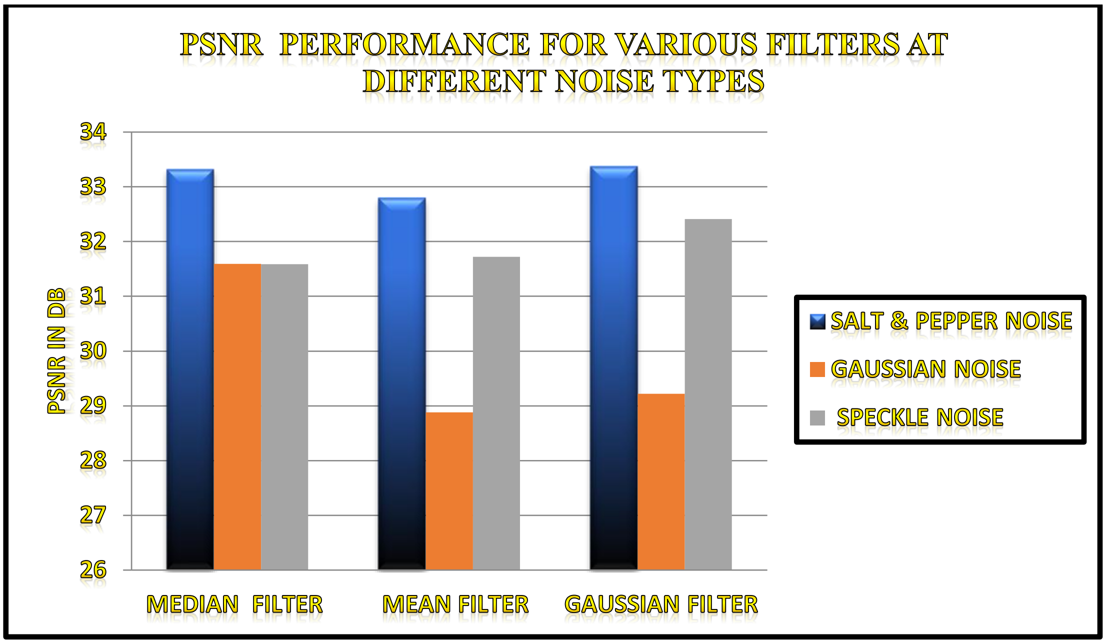

Figure 9: A comparative analysis of de-noising filters in terms of PSNR through various types of noise at a density of 0.05 for the Lena image.

III. CONCLUSION

According to the simulation results obtained from both experimental and mathematical analyses, it can be concluded that the median and Gaussian filters are the most effective option for reducing SPN noise when compared to the mean filter. These filters demonstrate the highest PSNR for the resulting image in comparison to the mean filter. The median filter is also considered an optimal filter for Gaussian noise in terms of PSNR. However, the enhanced image derived from the implementation of the Gaussian filter exhibits a complete absence of speckle noise and closely approximates the high-quality image. The clarity of the image is preserved, in contrast to the effects of other filters.

REFERENCES

[1]. ELAWADY, IMAN and ÖZCAN, "A new effective denoising filter for high density impulse noise reduction" , *Turkish Journal of Electrical Engineering and Computer Sciences*, vol. 30, no.4, 2022.

[2]. V. Kumar, et al, "Comparative Performance Analysis of Image De-noising Techniques", *International Conference on Innovations in Engineering and Technology*,pp.47-52 ,December 2013.

[3]. A.K. Boyat and B.K. Joshi, " A REVIEW PAPER: NOISE MODELS IN DIGITAL IMAGE PROCESSING", *An International Journal (SIPIJ)* ,vol.6, no.2, April 2015.

[4]. P. Shetti, and A. P. Patil. " Performance Comparison of Mean, Median and Wiener Filter in MRI Image De-noising", *International Journal for Research Trends and Innovation*, vol.2, no.6, 2017.

[5]. H. K. Omar, and K. H. Jihad, " A STUDY ON IMAGE NOISE AND VARIOUS IMAGE DENOISING TECHNIQUES", Research JET journal of Analysis and Invention ,vol.2, no.11,November 2021.

[6]. I.R Ansari, " IMAGE DENOISING USING SPATIAL DOMAIN FILTERS", International Journal of Advanced Technology in Engineering and Science", vol.1, no.2, February 2013

DOI: 10.17148/IJARCCE.2023.12816

[7]. N. Kumar, A.K. Dahiya, and K. Kumar, " Modified Median Filter for Image Denoising", International Journal of Advanced Science and Technology, vol. 29, no. 4, 2020

[8]. V.M. Gupta, K. Murthy, and R. S. Shankar, " A Novel Approach for Image Denoising and Performance Analysis using SGO and APSO", *Journal of Physics: Conference Series 2070 012139*, 2021

[9]. S. Rani, and Y.Chabbra, "An Improved Denoising Algorithm for Removing Noise in Color Images", *Engineering, Technology & Applied Science Research*, vol. 12, no. 3, pp.8738-8744, June 2022.

[10]. Anutam and Rajni, "COMPARATIVE ANALYSIS OF FILTERS AND WAVELET BASED THRESHOLDING METHODS FOR IMAGE DENOISING", *Computer Science & Information Technology Conference* , pp. 137–148 , May 2014.

[11]. A.Singh and J. Singh, " Comparative Analysis of Gaussian Filter with Wavelet Denoising for Various Noises Present in Images", *Indian Journal of Science and Technology*,vol.47, no.9, December 2016.

[12]. S. Swamy and P.K. Kulkarni, "A BASIC OVERVIEW ON IMAGE DENOISING TECHNIQUES", *International Research Journal of Engineering and Technology*, vol. 7, no. 5 , May 2020

[13]. M. J, Mane, and M .S.Chavan , "DESIGN AND IMPLEMENTATION OF MEDIAN FILTER FOR IMAGE DENOISING", International Journal Electrical and Electronic Engineering and Telecommunication , *vol. 30, no. 4, April 2013.*

[14]. M. Nagu, and N.V. Shanker, " Image De-Noising By Using Median Filter and Weiner Filter", *International Journal of Innovative Research in Computer and Communication Engineering* , vol. 2 , no. 9, September 2014.

[15]. Y. Zhu, and C. Huang," An Improved Median Filtering Algorithm for Image Noise Reduction", *International Conference on Solid State Devices and Materials*, PP. 609 – 616, 2012.