iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 7 **Issue:** XII **Month of publication:** December 2019

DOI: http://doi.org/10.22214/ijraset.2019.12113

Elimination of Noise using Linear and Non Linear Filters from the Images of a Smart Waste Segregation System

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Abstract: Due to the emerging smart city development across the cities in India, Smart Garbage Management system is the need of the hour. Globally, the annual solid waste is expected to reach 2.2 billion tonnes by 2025, which would cost 375.5 billion dollars in waste management . Improper waste management will have enormous adverse impacts on the economy, the public health, aw well as the environment. Waste may be generated during the extraction or processing of raw materials, consumption of final products and human activities. Improper disposal of garbage has many hazards affecting all forms of life leading to contamination of air, water and soil and also causes dangerous diseases to human beings. There are a number of important reasons for why we should encourage waste segregation; legal obligations, cost savings and protection of human health and the environment. The proposed work is an automated waste classification system to classify objects into biodegradable and non-biodegradable. Image de-noising is very important task in image processing for the analysis of images in the proposed system. Numerous image de-noising algorithms are available, but the best one should remove the noise completely from the image, while preserving the details. De-noising methods can be of two types namely linear as well as non-linear. Linear methods are fast, but they do not preserve the details of the images. Non- linear methods are able to preserve the details of the images. The proposed work, discusses about different types of noises present in the image, different sources which are responsible for producing these noises and different types of filters which are used to remove these noises.
Keywords: Segregation, biodegradable, non-biodegradable, noises, denoising

I. INTRODUCTION

Urban waste management is one of the burning issues as we fail to manage our waste whichis being generated due to a mismatch in the requirement and lack of services to deal with the same. According to the present scenario, we are not only limited to managing waste due our day-to-day activities, but also waste from the various industries located in the peripheral areas of our urban settlements. Waste can be either hazardous or non-hazardous. According to the Waste Regulations 2011,we should segregate paper, cardboard, plastic, metal and glass at source unless it is technically or economically not feasible. Also, you should implement the waste hierarchy; reduce, reuse, recycle, other recovery and disposal.Waste segregation helps with recycling in particular. Effective segregation of wastes means that less waste goes to landfill which makes it better for public health and the environment.Wastes that are hazardous can cause long term health problems, so it is very important that they are disposed of correctly and safely and without the environment getting affected. The main goal of digital image processing is to improve the potential information of an image for easier human interpretation and to process the image for easy storage, transmission and representation . Digital images are often corrupted by various factors like impulse noise during transmission, malfunctioning of pixel elements in the camera, sensor's faulty memory locations etc..Different types of noise are generated during the process of acquisition, transmission, and reception, and storage and retrieval and they affect the image and can degrade the quality of the image.Many researches have been done on the restoration of images corrupted . Image deploring and image de noising are the two sub areas of image restoration . Image denoising is the most common method used for the restoration of the image. For example, median filter was once the most popular non- linear filtering technique for removing noise, because of its good de noising power and computational efficiency . However the noise level over 60% some details and edges of the original image are smeared by the filter .The median filter is a nonlinear operator which first arranges the pixels in a local window according to the size of their intensity values and then replaces the value of the pixel in the resulting image by the middle value in this order. In general, noise arise in a digital image during the time of image acquisition or transmission. During that time the performance of imaging sensors may affected by a variety of factors, such as environmental conditions during image acquisition and the quality of the sensing elements themselves. At the time of image acquisition with a charge coupled device [CCD], noise generated mainly depends on the light level and sensor temperature . Then the noise in an image is the result of errors in the image acquisition process.This results in an image whose pixel value does not reflect the true intensities of real picture. The image may appear grainy, rough, molted or snowy. The magnitude of image noise can vary from almost one image to the other depending on how complex the noise generated is. Noise can also be generated in an image due to interference in the channel used for transmission. For example an image transmitted using a wireless network might be corrupted as a result of lightning or other atmosphere disturbance.

II. RELATED WORKS

Image de-noising is an important image processing task i.e. as a process itself as well as a sub process in other processes. There are numerous methods to de-noise an image or a set of data .A good image de-noising model should completely remove noise well as preserve edges to a great extent. there are two types of denoising models i.e. linear model and non-liner model. Generally, linear models are used. The advantage of linear noise removing models is the speed and the disadvantage is that they are not able to preserve edges of the images in a efficient manner. The edges, which are recognized as discontinuities in the image, are removed. On the other hand, Non-linear models can handle edges better than linear models.

In [1] Mr. Mandar D. Sontakke discusses different types of noises present in the image, the different sources of these noises and also different types of filters which can be used to remove them. In [2] Pawan Patidar proposed a comparison of using Mean filter, Median filter for denoising four types of noises which are Gaussian noise , Salt & Pepper noise, Speckle noise and Poisson noise and results are compared for these noises. In [3] Ankitha proposed that image enhancement through de-noising is one of the most important applications of digital image processing and is still a challenging problem and also gives the detail of effects of various noise on the images and also describe the methods to remove the noise by using various filters. Images may be defective due to usage of poor image sensors, poor image acquisition device or transmission errors etc., which will create problems for the subsequent process to interpret the images. Obtaining an efficient method of removing noise from the images, before processing them for further analysis is one of the major challenges for the researchers. Noise can affect the image at the time of capturing or transmission of the image. Noise removal from the images is done to every image prior to applying image processing tools , Ample algorithms are available, but they have their own assumptions, merits and demerits. The choice of the noise removal algorithms depends on the type of noise present in the image. If testing image model follows the assumptions best results are obtained.

In [4] Mr. Rohit Verma presents the results of applying different noise types to an image and evaluated the results of applying various noise reduction techniques for removal of each kind of noise. In [5] Mr.Ranu Gorai also presented a description of various noises present in an image. Digital images have a major role in our day to day life since it is being used in different user applications such as satellite television, magnetic resonance imaging, and computer tomography and also in areas of research and technology such as geographical information systems and astronomy. But the major challenge is that reference images may get corrupted with noise during acquisition, transmission, or retrieval from storage media. In some cases each and every pixel of image is important and if by any means some of the portion of the image is lost or noised then it becomes totally value less. Some images may also contain complex type of noise, originating from two distinct sources and noise arising from the application of different types of quantization, reconstruction and enhancement algorithms.

In [6] Sukhjinder Kaur proposed that to send visual digital images are a major issue in the modern data communication network. The images sent from sender end may not be the same at the receiving end. The images are often corrupted with noise after transmission . The transmission medium may be affected by noise due to various factors like a noisy channel, errors during the measurement process and during quantization of the data for digital storage. The image obtained at the receiver side needs further processing before it can be used for various applications. The most challenging task for the researchers is to restore the original image at the receiver end .

In [7] Govindaraj.V presented a work wherein Gaussian noise, Salt and Pepper noise, Speckle noise and Poisson noise are being considered and it can be reduced using Gaussian filter, Wiener filter, Mean filter and Median filter. The result shows the comparison evaluation of the performance of different types of filters to denoise the noised images from different types of noises using PSNR values. Noise can be defined as a random variation of image Intensity and visually seen as grains in the image. It is introduced in the image due to the effects of photon nature of light or thermal energy of heat inside the image sensors. Noise may be produced at the time of capturing or image transmission. Noise can be simply defined , as the pixels in the image showing different intensity values instead of true pixel values. Therefore noise removal algorithm is the process of removing or reducing the noise from the image. The task of a noise removal algorithm is to reduce or remove the visibility of noise by smoothing the entire image leaving areas near contrast boundaries. Different noises have their own characteristics which make them distinguishable from others.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue XII, Dec 2019- Available at www.ijraset.com

III. TYPES OF NOISE

A Guassian Noise

Gaussian noise is a type of statistical noise. It is evenly distributed over the signal. The Gaussian noise is also called the normal noise and it is a major part of read noise of an image sensor, that is of the constant noise level, in dark area of the image. The probability density function (PDF) of Gaussian noise is equal to that of the normal distribution and also known as Gaussian distribution. It is commonly used as additive white noise which results in additive white Gaussian noise (AWGN)

ORIGINAL IMAGE

GUASSIAN NOISE

B Local Variance

It is defined as a gaussian-distributed additive noise, with a specified local variance at each point of image. Variance is normally used to find how much each pixel varies from the neighbouring pixel (or centre pixel). A variance image is defined an image of the variances, which is in turn the squares of the standard deviations, in the values of the input or output images. The user can provide both a variance image of the input as well as receive a variance image of the smoothed output.

ORIGINAL IMAGE

LOCAL VARIANCE

C Salt and Pepper Noise

Salt-and-pepper noise, also known as impulse noise can be caused by sharp and sudden disturbances in the image signal. It is visually seen as sparsely occurring white and black pixels. For denoising these kind of noise an effective noise reduction method is a median filter or a morphological filter. For denoising either salt noise or pepper noise, but not both, a contraharmonic mean filter can be effective. Practically, when an analog image signal is transmitted in a linear dispersive channel the image edges (step like or pulse like signal) get blurred and the image signal gets contaminated with additive white Gaussian noise. If the channel is so poor that the noise variance is high enough to make the signal excurse to very high negative or positive value when the thresholding operation at the frontend of the receiver will contribute saturated min and max value. As a result, the image contains some black and white spot. Such kind of noise is called salt and pepper noise. At the same time the image contain the dark is called pepper and the image contain the bright pixel is known as salt.

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue XII, Dec 2019- Available at www.ijraset.com

ORIGINAL IMAGE

SALT NOISE

ORIGINAL IMAGE

PEPPER NOISE

ORIGINAL IMAGE

SALT AND PEPPER NOISE

D Speckle Noise

Speckle noise is is found commonly in the active radar and Synthetic Aperture Radar (SAR) images and degrades its quality It is a granular noise. In some Biomedical applications like Ultrasonic Imaging and a few emergency applications like Synthetic Aperture Radar (SAR) imaging such noise is encountered. In the speckle noise, if the image pixel magnitude is high then the noise is also high. So speckle noise is dependant to the signal. The noise is multiplicative because initially a transmitting system transmits a signal to the object and the reflected signal is recorded. When the signal is transmitted, the signal may get contaminated with additive noise in the channel. Due to varying reflectance of the surface of the object, the reflected signal magnitude varies. So also the noise varies since the noise is also reflected by surface of the object. Noise magnitude is therefore higher when the signal magnitude is higher so we say that the speckle noise is multiplicative in nature.

ORIGINAL IMAGE

SPECKLE NOISE

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E Poisson Noise

Poisson noise is the kind of noise that is caused when number of photons sensed by the sensor is not sufficient to provide detectable statistical information. This noise exists because a phenomenon such as light and electric current consists of the movement of discrete packets. Poisson noise could be dominated when the finite number of particles that carry energy is sufficiently small so that uncertainties due to the Poisson distribution are of significance. Such uncertainities describe the occurrence of independent random events, . Magnitude of Poisson noise increases with the average magnitude of the current or intensity of the light.

ORIGINAL IMAGE

POISSON NOISE

IV. DENOISING OF IMAGES

Image denoising refers to the recovery of a digital image that has been contaminated by noise. The presence of noise in images is unavoidable. Noise may be introduced during image formation, recording or transmission phase. Further processing of the image often requires that the noise must be removed or at least reduced. Although the amount of noise is small its effect can be large in cases when high accuracy is required. The noise can be of different types. The most popular ones are additive white Gaussian noise (AWGN), speckle noise, impulse noise, Poisson noise etc. Mathematically the degradation process can be denoted as G=F&V. Here F is the clean image, G the noisy image and V, the noise. '&' is a mathematical operation which can be additive or multiplicative depending upon the type of noise. An image denoising algorithm attempts to obtain the best estimate of F from G. Images captured both digital cameras and conventional film cameras will pick up noise from a variety of sources. The types of noise possibly corrupting images are too numerous to list here. The Gaussian noise and the salt and pepper noise are the two most common noises in this category. In both cases, the noise at different pixels can be either correlated or uncorrelated. In some cases, noise values at different pixels are modelled as being independent and identically distributed, and thus they are uncorrelated. Gaussian noise is a statistical noise that has a probability density function (pdf) of the normal distribution (also known as Gaussian distribution). For each pixel, a random value drawn from a normal distribution is added to the clean pixel value. The distribution is the same for every pixel (i.e. the mean and variance are the same) and the noise samples are drawn independently of each other. In case of Gaussian noise, an amount of noise is added to every part of the picture i.e., each pixel in the image will be changed from its original value by a small amount. Gaussian noise is the most common noise and can be produced by the thermal agitation of charged carriers (usually the electrons) inside an electrical conductor. It is properly defined as the noise with a Gaussian amplitude distribution with a bell-shaped probability density function, known as the Gaussian function or informally as the bell curve. The following are some of the filters used for denoising:

A. Mean filter

Mean filter is an averaging linear filter. Here the filter computes the average value of the corrupted image in a specific area. Then the intensity value of center pixel is replaced by that average value. It is a simple spatial filter. It is a kind of sliding-window filter which replaces the center value in the window with the average mean of all the pixel values in the kernel or window. The shape of the window is usually square but it can be of any shape.

B. Median filter

Median filter is a non- linear filter, whose response is based on the ranking of pixel values contained in the filter region. Median filter is frequently used for reducing certain types of noise. Here the value of the center pixel is replaced by the median of the pixel values under the filter region .Median Filter is a simple and powerful non-linear filter. It is easier method to implement for smoothing images. Median filter is primarily used for reducing the amount of variation in intensity between two pixels. Here, we do not replace the pixel value of image with the mean of all neighboring pixel values, we replaces it with the median value. Then the median is calculated first by sorting all the pixel values into ascending order and then replace the pixel being calculated with the middle pixel value. The result of median filter is the best when the impulse noise percentage is less than 0.1 %. Greater the quantity of impulse noise lesser the accuracy of the result. It is more suitable for removing for salt and pepper noise. These filters are widely used as smoothers for image processing, as well as in signal processing. The merit of the median filter over linear filters is that the median filter can eliminate the effect of input noise values with extremely large magnitudes.

C. Bilateral filter

A bilateral filter is a non-linear filter used for smoothing images. It is a kind of edge-preserving filter for denoising images. It replaces the value of intensity of each pixel with a weighted average of intensity values of nearby pixels. This weight can be based on a Gaussian distribution The weights depend on various factors like Euclidean distance of pixels, and radiometric differences like., range differences, such as color intensity, depth distance,etc.. This preserves sharp edges. Similar to the Gaussian convolution, the bilateral filter is also defined as a weighted average of pixels. But the difference between the two is that the bilateral filter takes into account the variation of intensities to preserve edges. The key idea of bilateral filtering is that two pixels are close to each other not only if they occupy nearby spatial locations but also if they have some similarity in the photometric range.

D. Guassian filter

The Gaussian filter is used to `blur' images and remove noise from the image. It is same as mean filter, but it uses a different kernel that represents the shape of a Gaussian (`bell-shaped') hump. It basically uses a 2 D convolutional operator. The Gaussian filtering scheme is based on the peak detection. It is a smoothing filter and the peak detection is based on the fact that peaks are to be impulses. The key point it that this filter corrects not only the spectral coefficient of interest, but all the amplitude spectrum coefficients within the filter window.

V. RESULT ANALYSIS

TABLE I
Denoising Various Noises Using Bilateral Filter And Guassian Filter

TYPES OF NOISE	FILTERS USED	
	BILATERAL FILTER	GUASSIAN FILTER
GUASSIAN NOISE		
LOCAL VARIANCE		
SALT		

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
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PEPPER		
SALT AND PEPPER		
POISSON		
SPECKLE		

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
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Table II. Denoising Various Noises Using Median Filter And Mean Filter

Types Of Noise	FILTERS USED	
	MEDIAN FILTER	MEAN FILTER
GUASSIAN NOISE		
LOCAL VARIANCE		
SALT		
PEPPER		
SALT AND PEPPER		
POISSON		
SPECKLE		

Table III. Denoising Using Combination Of Filters

TYPE OF NOISE	COMBINATION OF FILTERS		
	Bilateral+ Guassian	Bilateral+Median	Bilateral+Mean
GUASSIAN			
LOCAL VARIANCE			
SALT			
PEPPER			
SALT AND PEPPER			
POISSON			
SPECKLE			

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Volume 7 Issue XII, Dec 2019- Available at www.ijraset.com

Table IV. Denoising Using Combination Of Filters

TYPE OF NOISE	COMBINATION OF FILTERS USED		
	Guassian+Bilateral	Guassian+Median	Guassian+Mean
GUASSIAN			
LOCAL VARIANCE			
SALT			
PEPPER			
SALT AND PEPPER			
POISSON			
SPECKLE			

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue XII, Dec 2019- Available at www.ijraset.com

Table V. Denoising Using Combination Of Filters

TYPE OF NOISE	COMBINATION OF FILTERS USED		
	Median+Bilateral	Median+Guassian	Median+Mean
GUASSIAN			
LOCAL VARIANCE			
SALT			
PEPPER			
SALT AND PEPPER			
POISSON			
SPECKLE			

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Table VI. Denoising Using Combination Of Filters

TYPE OF NOISE	COMBINATION OF FILTERS USED		
	Mean+Bilateral	Mean+Guassian	Mean+Median
GUASSIAN			
LOCAL VARIANCE			
SALT			
PEPPER			
SALT AND PEPPER			
POISSON			
SPECKLE			

Table VII. PSNR Values When Using Combination Of Filters

COMBINATION OF FILTERS	TYPES OF NOISE						
	GUASSIAN	LOCALVAR	SALT	PEPPER	SALT AND PEPPER	POISSON	SPECKLE
B+G	29.573	29.530	29.447	29.050	29.148	33.778	30.298
B+MD	29.623	29.942	29.520	29.095	29.209	34.472	30.299
B+M	29.625	29.625	29.355	29.044	29.101	33.616	30.198
G+B	29.647	29.679	29.382	29.016	29.075	29.053	29.069
G+MD	29.615	29.705	29.405	29.146	33.679	30.282	29.169
G+M	29.586	29.556	29.330	29.106	34.378	33.670	30.259
MD+B	29.647	29.903	29.473	29.052	20.320	33.678	30.222
MD+G	29.605	29.752	29.436	29.065	29.113	33.580	30.182
MD+M	29.562	29.704	29.354	29.056	29.081	33.497	30.170
M+B	29.592	29.588	29.312	28.989	29.013	33.585	30.174
M+G	29.619	29.564	29.310	29.053	29.036	33.626	30.237
M+MD	29.615	29.6112	29.311	29.047	29.057	34.294	30.209

TABLE VIII
PSNR values when using a single filter

TYPES OF NOISE	TYPES OF FILTERS			
	BILATERAL	GUASSIAN	MEDIAN	MEAN
GUASSIAN	29.671	29.683	29.619	29.632
LOCALVAR	30.082	29.777	29.922	29.606
SALT	29.846	29.508	29.538	29.393
PEPPER	29.195	29.115	29.148	29.070
SALT AND PEPPER	29.287	29.173	29.202	29.027
POISSON	33.906	33.910	33.828	33.623
SPECKLE	30.507	30.402	30.288	30.216

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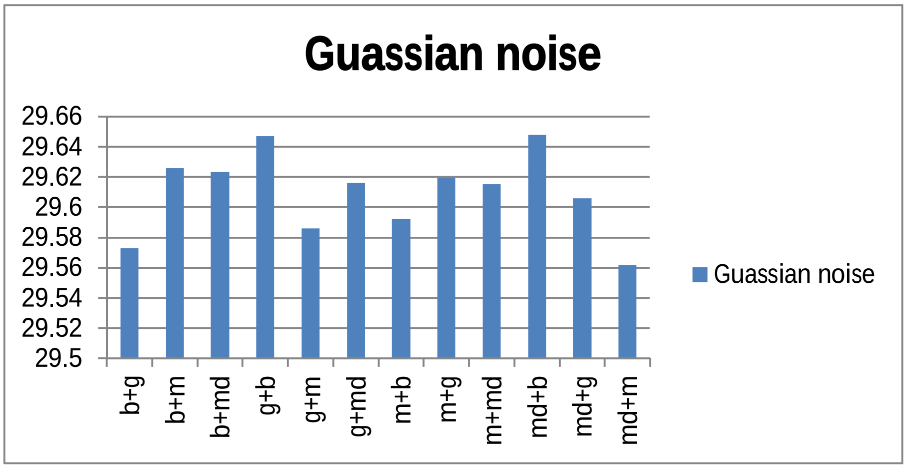

Fig 1 : Graphical representation of PSNR values for the removal of guassian noise using combination of filters

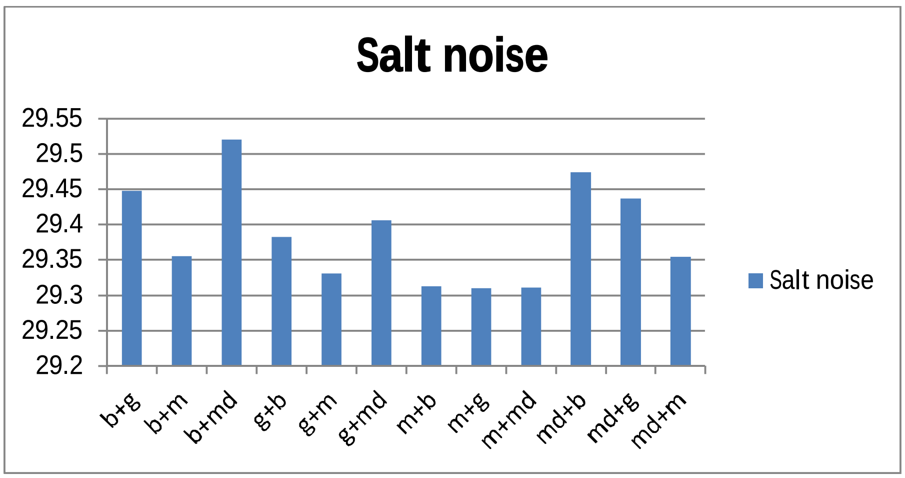

Fig 2 : Graphical representation of PSNR values for the removal of salt noise using combination of filters

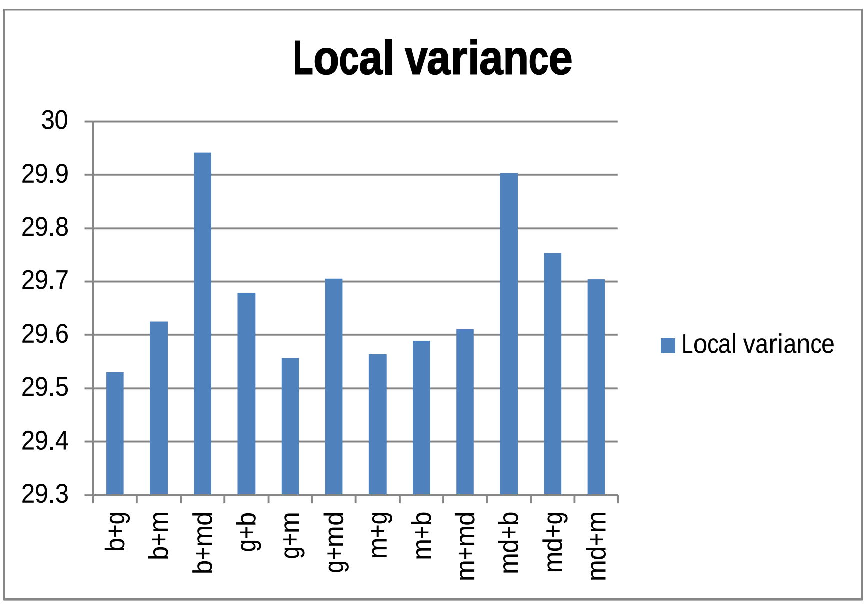

Fig 3 : Graphical representation of PSNR values for the removal of local variance noise using combination of filters

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue XII, Dec 2019- Available at www.ijraset.com

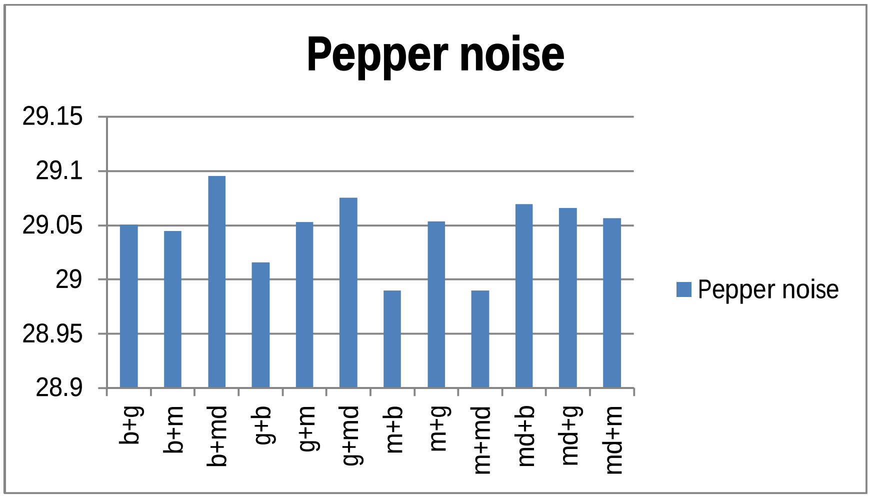

Fig 4 : Graphical representation of PSNR values for the removal of pepper noise using combination of filters

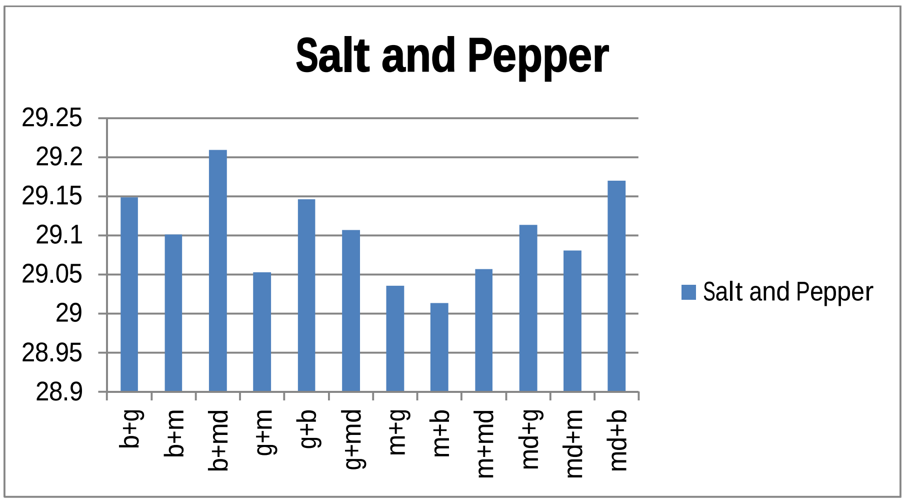

Fig 5 : Graphical representation of PSNR values for the removal of salt and pepper noise using combination of filters

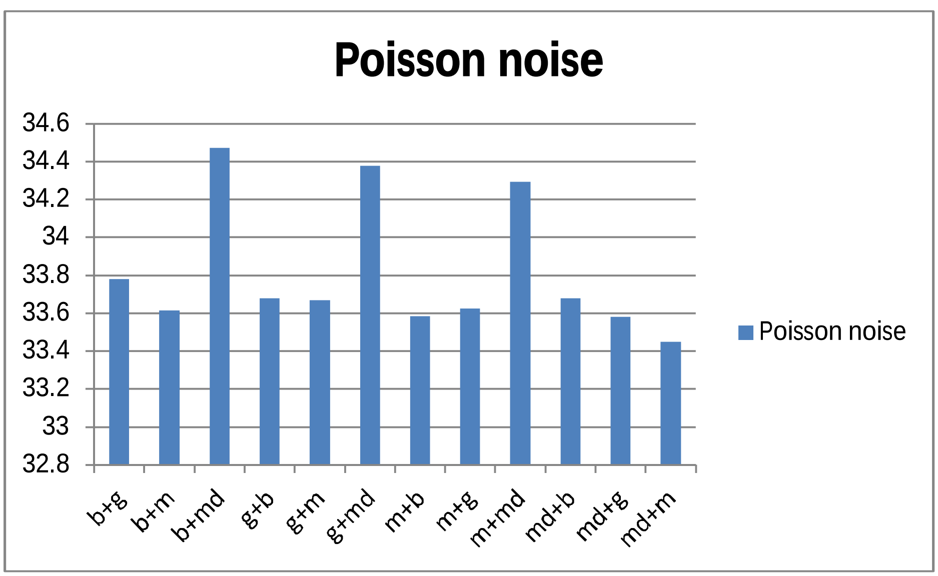

Fig 6 : Graphical representation of PSNR values for the removal of poisson noise using combination of filters

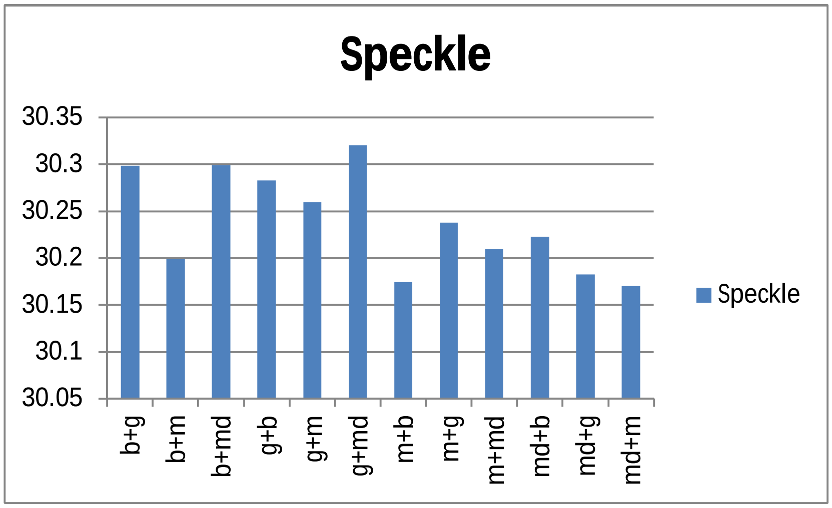

Fig 7 : Graphical representation of PSNR values for the removal of speckle noise using combination of filters

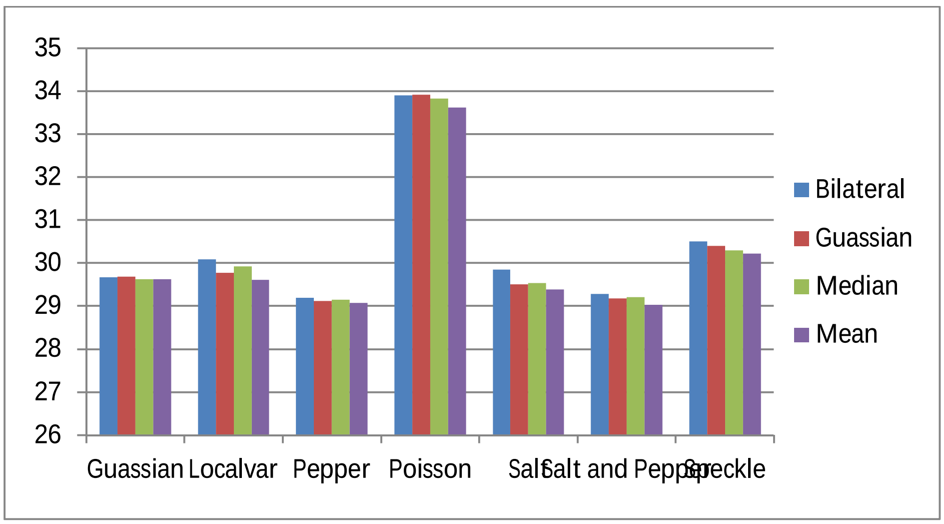

Fig 8 : Graphical representation of PSNR values for the removal of noise using single filter

VI. CONCLUSION

Image de-noising is vital task in image processing for the analysis of images. There are several image de-noising algorithms, but the best one should remove the noise completely from the image, while preserving the details. According to our result analysis using PSNR values, for the removal of guassian and poisson noise guassian filter provides the best result. And for the removal of local variance, salt, pepper , salt and pepper, speckle noise bilateral filter gives the best result. Preprocessing is used to define operations with images for the purpose of improving the image data that suppress unwanted distortions or enhances some image features important for further processing. The main goal of preprocessing is to enrich the visual look of the images. Preprocessing mainly aims to remove the clamour, stabilizing the intensity of the images and clear the artefacts. Image preprocessing is the technique of enhancing the image data prior to computational processing. Most of preprocessing techniques are application-specific and techniques have to be applied to all applications. Depending on factors that affected quality of images each application may require different preprocessing techniques such as those introduced during the image acquisition stage. De-noising methods are broadly classified as linear and non-linear. Even though linear methods are fast enough, they do not preserve the details of the images, whereas the non- linear methods preserve the details of the .images

VII. ACKNOWLEDGMENT

The authors would like to thank Gary Thung, Mindy Yang for providing the ‘TrashNet’ dataset. And also sincere thanks to Head of the Department , project guide and project coordinator for their valuable feedback.

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