Indian Journal of Science and Technology, *vol 8(22), DOI: 10.17485/ijst/2015/v8i22/79318, September 2015*
ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645

Image Enhancement Techniques: A Study

P. Janani*, J. Premaladha and K. S. Ravichandran

School of Computing, SASTRA University, Thanjavur – 613401, Tamil Nadu, India;
jananipurushothaman@gmail.com, premaladha@sastra.edu, raviks@it.sastra.edu

Abstract

Image enhancement is considered as one of the most important techniques in image research. The main aim of image enhancement is to enhance the quality and visual appearance of an image, or to provide a better transform representation for future automated image processing. Many images like medical images, satellite, aerial images and also real life photographs suffer from poor and bad contrast and noise. It is necessary to enhance the contrast and remove the noise to increase image quality. One of the most important stages in medical images detection and analysis is Image Enhancement Techniques. It improves the clarity of images for human viewing, removing blurring and noise, increasing contrast, and revealing details. These are examples of enhancement operations. The enhancement technique differs from one field to another depending on its objective. The existing techniques of image enhancement can be classified into two categories: Spatial Domain and Frequency Domain Enhancement. In this paper, we present an overview of Image Enhancement Processing Techniques in Spatial Domain. More specifically, we categorise processing methods based representative techniques of Image enhancement. Thus the contribution of this paper is to classify and review Image Enhancement Processing Techniques as well as various noises has been applied to the image. Also we applied various filters to identify which filter is efficient in removing particular noises. This is identified by comparing the values obtained in PSNR and MSE values. From this we can get an idea about which filters is best for removing which types of noises. It will be useful and easier to detect the filters for future research.

Keywords: Filters, Image Enhancement, MSE Calculation, PSNR, Spatial based Domain Enhancement Methods, Types of Noise

1. Introduction

For improving the quality of the image and to give better input for processing the image, we use image enhancement technique. Based on this, the enhancement techniques are categorized into two types: 1. Spatial domain methods: In this method, the operation takes place directly on the pixels of the image which in turn leads to contrast enhancement. 2. Frequency domain methods: In this method, the operation takes place on the Fourier transform of the respective image. Real time solutions are carried out in spatial domain, because it is very simple, easy to interpret and mainly the complexity range is very low. Robustness and imperceptibility factors are the two major criteria which is lacking in spatial domain. The assessments of functions are performed with respect to frequency in frequency domain method for the purpose of increasing the quality of the image. It works on Fourier transform, discrete cosine and sine transform of the image. By using this method we can improve the quality of the respective image by making changes in the transform coefficient functions. The advantages of frequency domain image enhancement include low complexity of computations, manipulating the frequency coefficient of an image and by the application of improved version of domain properties. The major drawback of this method is it cannot produce clear picture of background. That is basically it cannot enhance all the parts of the image. It can focus only on particular parts. Noise removal from the image plays a vital role and it is also one of the most important tasks in applications such as medical field, in which the noise free images will lead to

**Author for correspondence*

minimum error detection. Filtering is a technique which acts as a tool for removing the noise present in the image. The paper presents the narration of spatial domain techniques, different type of noises and the filters applied to the noises. The comparison is carried out with respect to the performance of filters (Median Filter, Gaussian Filter, Mean Filter, Wiener filter) to de-noise the salt & pepper noise, Gaussian noise, Poisson noise and Speckle noise is presented.

The study of image enhancement is provided as follows:

Section 2 states the introduction of spatial domain filtering and its implementation of image enhancement technique.

Section 3 deals with filters which are tested with different kinds of noises.

Section 4 comprised of results and discussions. Performances of filters with respect to removal of noise are measured by calculating Mean Square Error (MSE) and Peak Signal to Noise Ratio (PSNR) values. The values are compared and results are tabulated. Section 5 gives the conclusion of the study.

2. Spatial Domain Filtering Techniques

Inadequate amount of processing tools are required for spatial domain technique and mainly it requires very less computation time. This process is done by using the mathematical formula, and it is denoted by the Eq. (1).

$$g(x,y) = T\left[f(x,y)\right] \quad (1)$$

Where

f(x,y) corresponds to the image which is taken as input,

g(x,y) corresponds to image which we obtain as output,

T denotes operator which is defined on f applied over a neighbouring point*(x, y.)*

Here by using this technique, we can reduce the noise by applying this operator to the single pixel of an image or to different set of images. The spatial processing includes basic intensity transformation functions. The respected value which is obtained from the function is given in the expression of the form in Eq. (2).

$$S = T(r) \quad (2)$$

The pixel value(*r*) is mapped with pixel value(*s*) by using the transformation *T*. Intensity transformation involves three types of transformations which are used for image enhancement process. They are:

- Linear- negative transformation.
- Logarithmic- log transformation.
- Power law- Intensity transformations.

These transformation functions are very effective and considered to be the simplest and easiest methods to implement[8]. Here the functions *r* and *s* represents the pixel values before and after processing the image. These techniques were used in[5].

2.1 Image Negatives

Negative of the image or inverting the pixel of the image is one of the methods in image enhancement process. Image negatives are calculated by negative transformation with the intensity level is present in the range of *[0, L-1]*. It is represented by the formula (Eq. (3)).

$$S = L\text{-}1\text{-}r \quad (3)$$

Photographic negative of an image is obtained by reversing or inverting the intensity level of the image. In an image, if the darker areas are predominant and larger means we can apply this technique for improving the grey or white information combined with darker parts of the image. Inverting input low lighting video as well as dehaze algorithm techniques are used in image negative by[7]. These algorithms are used in the improvement of LCD displays and low quality videos. Figure 1 represents original image. Figure 2 represents the negative of the original image.

2.2 Log Transformation

Log transformations are mathematically expressed using the Eq.(4).

$$S = c \log (1+r) \quad (4)$$

Figure 1. Original Image.

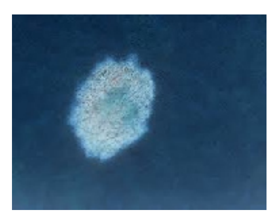

Figure 2. Negative Image.

Where *C* is taken as constant. It is taken that *r*>=0.

This technique was used by[24]. By using this log transformation darker pixel values of the image are expanded by compressing the values in the higher levels. For inverse log transformation function the process is done at the reverse order. Compression of dynamic range values in an image by giving large variation in the pixel value is considered as the main characteristics of log transformation. Log reduction zonal magnitude technique was used in[5]. These techniques are mainly used in security surveillance applications. Figure 3 represents log transformation image.

2.3 Power Law Transformation

Power law transformation is another technique used for image enhancement process. The basic form of power law transformation is given in the Eq.(5).

$$S = c\, r^{\gamma} \tag{5}$$

Where *c* and *γ* are positive constants[6] used this technique. The input value which is thin and of darker range is mapped with output value which is having broader range by using the power law curves with the fractional values of *γ*. If higher level values are given to input, the process is done in the reverse order. Capturing image, respond to display of the image and printing the image are considered as the applications done by using power law technique. In general we state the exponent of power law equation as gamma. Gamma correction is the process or procedure which will rectify or correct the power law response.

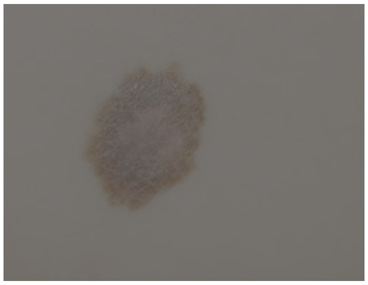

Figure 3. Log transformation image.

Figure 4. Power law transformation image.

It can also be also useful for general purpose contrast manipulation. Bitwise linear transformation technique is uses here by by[38]. This technique is applied in computer vision enhancement. Figure 4 shows power law transformation image.

2.4 Piecewise Linear Transformation

In this transformation each pixel value of the image is manipulated. This transformation technique is used for enhancing the quality of the image by altering the range of values. Content classification and adaptive processing techniques are used here by[11]. Arbitrary complex functions can also be solved by using piecewise linear method. This is considered as the major advantage of this technique. There are three different types for this kind of transformations. The types are

- Contrast stretching method
- Intensity level slicing method
- Bit plane slicing method

Patidar et al.[26] used this technique for image enhancement. Figure 5 shows piece wise linear transformation functions. The main applications are the improvement in the quality of image/video security surveillance. Contrast stretching is treated as easiest and simplest methods of linear transformation functions. Content adaptive algorithm is proposed by[19]. Improper illumination occurrence in low contrast value, in image sensor there will be loss of dynamic value and also in acquisition of image wrong placement of lens aperture may happen during processing the image. According to the display

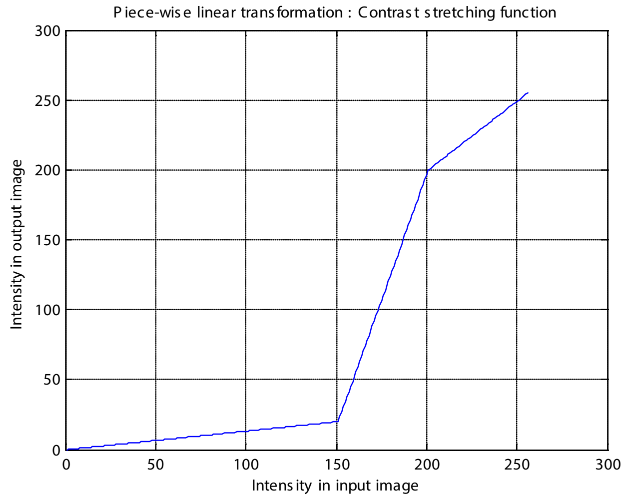

Figure 5. Piecewise linear transformation graph.

device contrast stretching will expand the intensity level range in the respective image such that it covers the full intensity value[3]. Figure 6 represents original image Figure 7 represents contrast stretching.

Another type is intensity level slicing. It is basically used to improve the quality of image[33]. Specific range of intensity of the image is highlighted in intensity level slicing method. It can be implemented in several ways, but most are the variations of two themes. One value is mapped with similar range of interest and other with similar range of intensities. This is one of the approach[15]. Figure 8 reveals images of intensity level slicing.

Next approach is slicing the pixel values bit by bit. In an image pixels are represented as the digital values defined bit by bit. Suppose the intensity of each and every pixel in a grey scale image having 256 bits is composed of 8 bits each, then we can highlight the appearance of the overall image by specific group of bits instead of highlighting the range of intensity level. Genetic algorithms are given in bit plane slicing method proposed by[23]. These techniques are mainly used in CT scan and medical imaging. Relative importance of an image is analysed in the image bit by bit using decomposition of an image into its respective bit planes. Quantisation of image is done determining the adequacy of bits that is produced as a whole. This is the procedure done in bit plane slicing[18]. Image compression can also be done by using this decomposition procedure, in which fewer than all planes are used in reconstructing an image. Figure 9 represents images of bit plane splicing.

Figure 6. Original image.

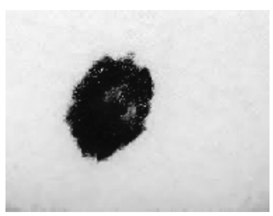

Figure 7. Contrast stretched image.

Numerous spatial domain process consider histogram as the efficient technique for pre-processing. Histogram manipulation is the process in which the values obtained from the values are mapped with the functions to enhance the appearance of the image. Image segmentation, compression, recognitions are those methods which are useful for retrieving and improving the pixel quality. Digital image with respect to histogram processing is a discrete function having the intensity level with the range of [*0, L-1*] (See Eq.(6))

$$h\,(r_k) = n_k \tag{6}$$

Where

r_k is k^{th} intensity value of the image.

n_k is the number of pixels present in the image.

The normalized histogram is obtained by dividing each component by image considering the entire pixel. It is represented with product MN, Where M and N represents row dimension as well as column dimensions of equalized image[16]. Thus as a result histogram which is normalized is given by Eq.(7).

$$P(r_k) = n_k/MN \tag{7}$$

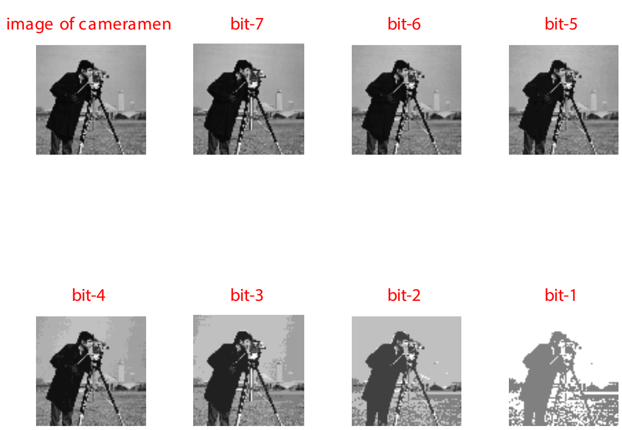

Figure 8. Images of intensity level slicing.

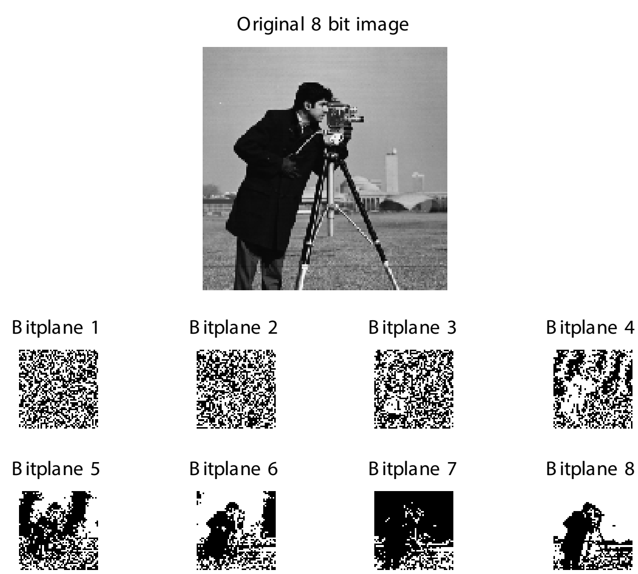

Figure 9. Images of Bit plane slicing.

where $k = 0,1\ldots L\text{-}1$. The total number of sum of all values present in the histogram is normalised to 1. Contrast enhancement techniques is generally divided into two groups

- Histogram Equalization (HE),
- Tone Mapping.

Equalization of histogram is basically used for contrast enhancement. Histogram modification framework technique was given by[13]. It matches with uniform distribution function by altering the spatial histogram. In the input image the cumulative distribution function should obtain uniformly distributed histogram. This is considered as the main target of equalization process. Very small details of the image that are in association with histogram are discarded. This is considered to be the main advantage. Visual quality of the data and intensity scale is obtained as the result of equalization[32]. implemented this technique. The main application includes face recognition. Figure 10 shows histogram processing.

Intensity value of the image which is yet to be processed is taken as r also r is in the range between $[0,L\text{-}1]$. $r = 0$, denotes black. $r = L\text{-}1$, specifies white. Figure 11 represents Histogram of the given input image. Figure 12 represents histogram after histogram equalization.

Transformation function is given in the Eq.(8).

$$S = T(r) \tag{8}$$

- $T(r)$ is the function which is monotonically increasing having the interval $0 \le r \le L\text{-}1$
- $0 \le T(r)\ L\text{-}1$ for $0 \le r \le L\text{-}1$

Probability Density Function (PDF) of transformed variable s can be obtained by Eq. (9).

$$Ps(s) = pr(r)\,|dr / ds| \tag{9}$$

The Cumulative Distribution Function (CDF) is given in Eq. (10).

$$S = T(r) = (L\text{-}1) \int p_r\,(w)\,dw \tag{10}$$

Another approach is tone mapping, which emphasizes contrast enhancement techniques. High dynamic range of the image is given as input in tone mapping technique. Dynamic Histogram Equalization technique is given by[22]. for tone mapping. This technique is used in the enhancement of information present in the medical image. The intensity range of the pixel is mapped and converted as lower range. Important application of tone mapping is in

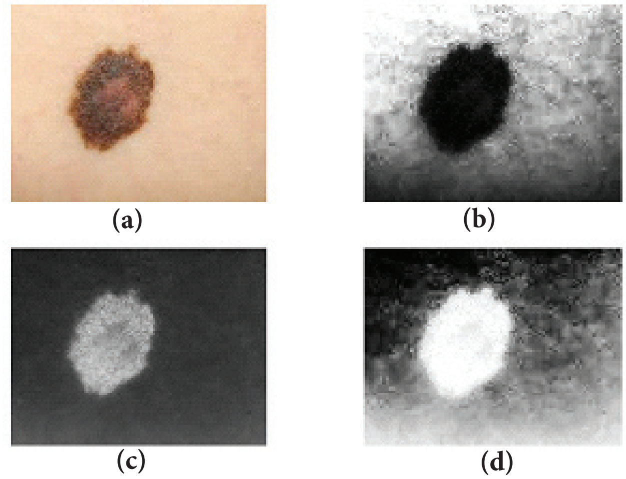

Figure 10. Histogram processing, (a) Original image, (b) After histogram equalization (c) After linear grey level transformation and (d) After histogram LGLT.

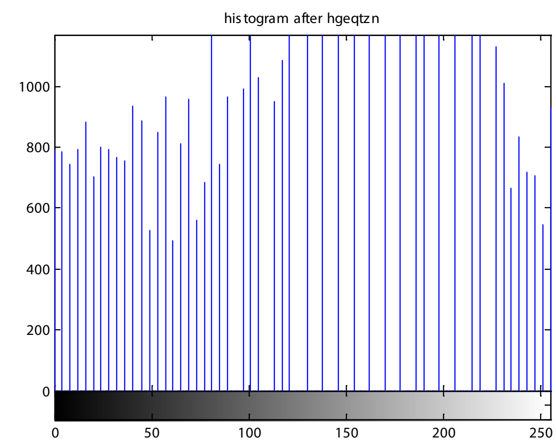

Figure 11. Histogram for the given input image.

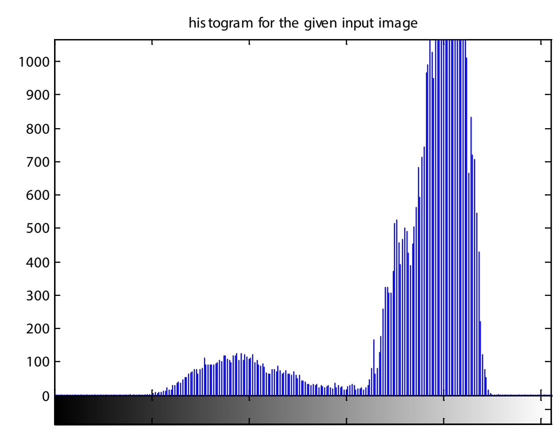

Figure 12. Histogram after Histogram equalization.

image processing and also in computer graphics. It will map the colours and approximate the high dynamic range values. Mapping is generally one at luminance channel, also at logarithmic scale[31]. It will convert radiance map of floating point value into 8-bit representation. They are used in rendering applications. The tone mapping algorithms have two main goals: 1. Preserving the details of the image 2. Absolute brightness information of the tone mapped image is provided in low dynamic range. The transformation function of the image is given based on the image input especially at grey levels. Manual calculation of the histogram is provided with the respective functionality. Based on local minima of the image and the respective grey level intensity values that are assigned to the pixel, the histogram of the image is partitioned. Depending on the local minima and grey level range of an image histogram is partitioned. After this process, histogram equalization is applied to each level of partition. Agaian et al.[1] implemented this technique for image enhancement.

Histogram specification is used for specifying the pixel intensity values by mapping the range to improve the quality information. Depending on the histogram of input image transformation function is performed followed by manual calculation[17]. Broad view of contrast enhancement technique is elaborated as follows. Table 1 describes about various techniques and applications.

3. Noises vs. Filters

Noise is defined as random variations in image intensity. It appears as grains in the image. Noise can inserted into the image through different ways[37]. It mainly depends on how an image is created. Noise is generated in sensor or transmission channel during the acquisition process. In image processing image enhancement and noise

Table 1. List of Techniques and Applications

References	Model	Techniques	Applications
Bedi et al.[5]	HE based Logarithmic transform LTHS	Log reduction and zonal magnitude Technique.	Traffic monitoring, Security Surveillance method.
Wang et al.[38]	Power law	Bitwise linear transformation technique	Computer vision
Garg et al.[7]	Image negative	dehaze algorithm	LCD display device; Low quality video
Hasan et al.[11]	Content based adaptive video processing model	Classifying the content and adaptive Processing function.	Traffic monitoring; Medical imaging
Jain et al.[13]	HE based modification	Histogram modification Framework	Image processing
Chung et al.,2011	Contrast stretching	content adaptive algorithm	Image/ Video Security Surveillance
Mandeep Kaur et al.[22]	Tone mapping	Dynamic form of Histogram Equalization Technique	Medical Image, poor quality Video as well as audio.
Nancy et al.[23]	Bit plane slicing	Genetic algorithms	Compression video, CT scan
Papiya Chakraborty.[24]	Log transformation Model	Inverting the input low lighting Video	Satellite image
Parth Bhatt et al.[25]	Histogram Equalization	Global Histogram Equalization	Face recognition.
Rajlaxmi Chouhan et al.[30]	Improve HS and HE	histogram equalization methods	MRI scans.
Ramkumar et al.[32]	Dynamic range compression	Histogram based image enhancement	Compute high dynamic range image processing
Shenbagavadivu et al.[35]	MHE model	Multi histogram equalization Methods	Computer aided diagnosis.

removal proved to be the major challenge. Noise should be removed from the image in order to recover the original information. Many factors contribute to their role in the introduction of noise in an image. The quantification of noise specifies the number of pixels in the image which is corrupted[37]. Various source of noise in digital images are:

- Environmental condition
- Insufficient light levels.
- Interference in transmission channel.
- Dust particles.

Noise will affect the quality of the image based on the type of disturbance and to which extent it gets embedded in the image. In digital image different types of noises will occur. They are

- Gaussian Noise
- Salt and Pepper Noise
- Speckle Noise
- Poisson Noise
- Quantisation Noise

3.1 Gaussian Noise

Probability density function of statistical distribution which is similar to that of normal distribution is generally termed as Gaussian noise. This distribution can also be stated as Gaussian distribution.

The probability density function of Gaussian random variable z is stated as in Eq. (11):

$$p_G(z) = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-(z-\mu)^2}{2\sigma^2}} \quad (11)$$

Where
z is grey level value,
μ is the mean value function,
σ is standard deviation that is distributed.

In digital image processing occurrence of Gaussian noise is considered to the common problem. Even high resolution photo have some noise in it[26]. In an image even very minute features say texture of the piece of cloth, eyelashes are specified by many numbers of pixels. And for high quality and high resolution of an image small quantity of blur will be more than enough. Additive nature of the image is treated as the standard model for Gaussian noise. Figure 13 represents greyscale image. Gaussian noise of an image is showed in Figure 14.

3.2 Salt and Pepper Noise

Salt and pepper noise is the most widely present in images. In an image the white pixels and black pixels are described as this type of noise which occurs randomly. Median filter is used to remove this kind of noise. Salt- and-pepper noise is the combination of salt and impulsive noise. It is also called as spike noise[27]. If suppose the image is having dark pixel in the light region and vice versa then that image is said to have salt and pepper noise. During transmission, presence of bit errors, error due to conversion of analog to digital values etc. are the major reason for occurrence of this type of errors. Here, the main cause of this noise is due to data transmission error. Maximum values are either applied to the corrupted pixels in the image or it may have only one bit flipped with it (which appears like a snow in image). The image will get the 'salt and pepper' appearance by setting one pixel value either to zero or to the maximum value in some rare cases[21]. The pixels which are not affected by the noise remains the same. The noise is usually calculated by pixel's percentage which gets distorted and affected. Figure 15 represents greyscale image Figure 16 shows the salt & pepper noise.

3.3 Speckle Noise

Speckle noise can also be represented as granular noise. The quality of the aperture synthetic radar images gets degraded due to this kind of noise. An improper fluctua-

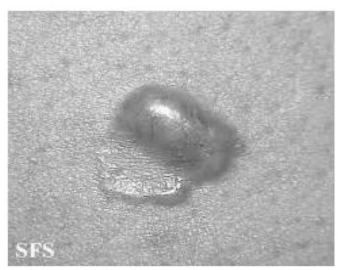

Figure 13. Greyscale image.

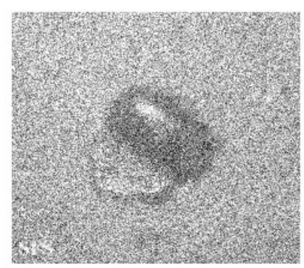

Figure 14. Gaussian noise.

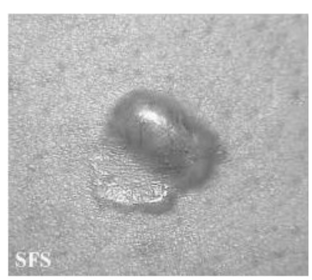

Figure 15. Greyscale image.

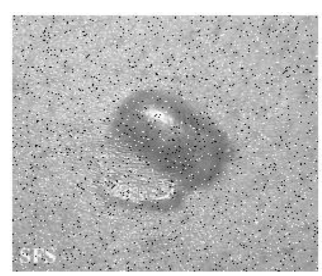

Figure 16. Salt & pepper noise.

tion occurs in the object from the signal due to speckle noise available in older version of radar. One element having image processing is not bigger than the previous one. The grey level of the image is having the mean value[9]. The interpretation of image processing is very tedious process and also it is more effective which is applied to this noise in the field of oceanography. The targets which are scattered in the multiple directions in which signals which gets backscattered because of coherent processing. Elementary scatters of the signal, ripples of image in capillary-gravity range, manifestation of pedestal image below the sea at oceanography are the areas in which speckle noise occurs[36]. This type of noise can be calculated by multiplication of random value with respect to the pixel values present in the image. It can be expressed as in the Eq. (12).

$$J = I + n{*}I \tag{12}$$

In an image distribution of speckle noise is denoted as *J*, *I* is input image, image having noise which have uniform distribution is represented as n having mean defined as *o* and variance represented as *v*. Figure 17 represents greyscale image Figure 18 shows the speckle noise in an image.

3.4 Poisson Noise

When statistical information which is identified by the sensor is not having sufficient amount of photons means Poisson noise will occur. It is also represented as short photon noise[2]. Image having square root intensity value is directly proportional to the poison noise in the image having root mean square value. Noise values which are not dependent will suffer from images having different pixel values. The signal gets affected and corrupted at varied proportions depending upon the types of sensor in the poisson noise[27]. Figure 19 represents greyscale image Figure 20 shows the Poisson noise.

Figure 17. Greyscale image.

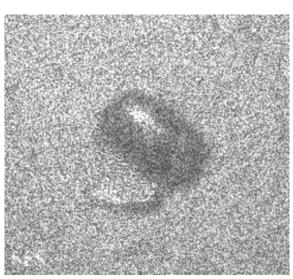

Figure 18. Speckle noise.

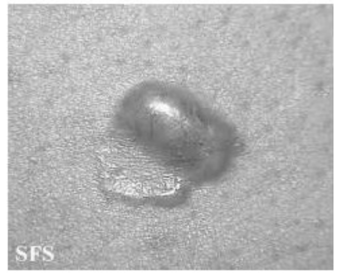

Figure 19. Greyscale image.

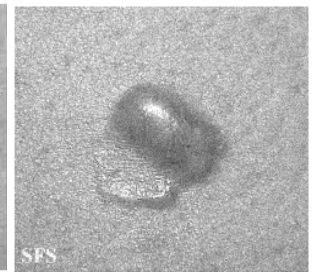

Figure 20. Poisson noise.

3.5 Filters Applied for Different Noises

High frequency that are present in the image, (smoothing the image) or low frequency of an image, (enhancing or detecting edges of an image) can be removed or suppressed by using the filters. Three types of filters, its implementation and performance of filters on different noises are discussed here.

- Mean filter
- Median filter
- Wiener filter

Digital filtering technique which is nonlinear also represented as median filter, is most predominantly used to eradicate the unwanted disturbances which is present in an image. The results that are obtained for later processing will enhance the pre-processing function and is considered for reduction of noise in an image (like edge detection in an image)[28]. Median filtering preserves edges while removing noise[12]. The signal is processed entry by entry with respect to the median occurring in the neighbour of the image by replacing each and every entry is considered to be the main idea of the median filter[30]. The output y at that moment t is evaluated as input values having median, corresponding to the moments of the pixels which is adjacent with respect to t (See Eq.(14)).

$$y(t) = median((x(t\text{-}T/2),x(t\text{-}T1+1),\ldots,x(t),\ldots,x(t+T/2)) \tag{14}$$

t- median filter of the window having noise. Figures 21, 22, 23 and 24 shows implementation of median filter for Poisson noise, salt and pepper noise, speckle noise and Gaussian noise.

Certain kinds of noises are removed by the application of linear filtering technique. This technique include average filter which is also called as Gaussian filter is considered to be more accurate for this purpose[20]. In an image there is an occurrence of noise called as grain noise, that noise is removed by the application of this average filter. Because in an image each pixel is assigned

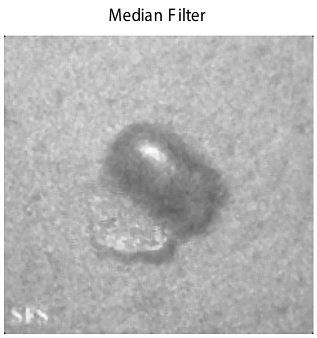

Figure 21. For Poisson Noise.

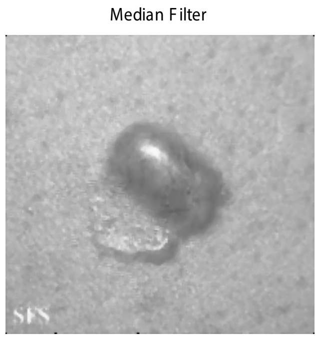

Figure 22. For Salt and Pepper Noise.

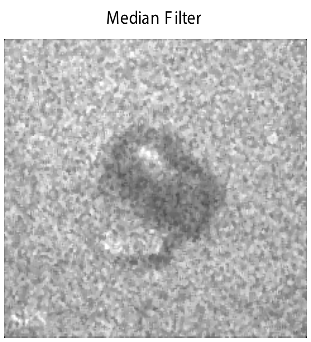

Figure 23. For Speckle Noise.

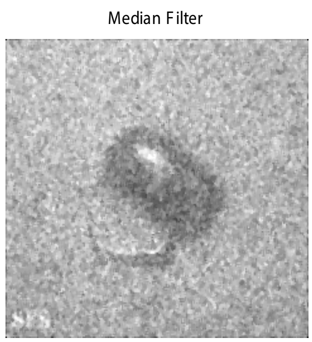

Figure 24. For Gaussian Noise.

to its neighbouring pixels for removing noise[26]. Grain which causes local variation in the values gets decreased. Generally linear filtering. In digital image processing different types of algorithms are applied for eradicating impurities present in the image. Mean Filter is considered to be one of the simplest techniques for image enhancement.

Mask is applied over each and every pixel present in the signal, which is used in mean filter. Mean filter is basically linear filter[4]. In the mask pixels are grouped together which falls under the same category. This filter is otherwise represented as average filter. Figures 25, 26, 27 and 28 shows implementation of average filter for Poisson noise, salt and pepper noise, speckle noise, Gaussian noise.

Wiener filters are considered to be the linear filters which generate optimum value. From other related sequence of signals, wiener filters optimize linear estimation of the desired sequence of values. For the removal of certain unwanted additive noise from the image having desired signal, we have to make use of certain statistical parameters (e.g. mean as well as correlation function)

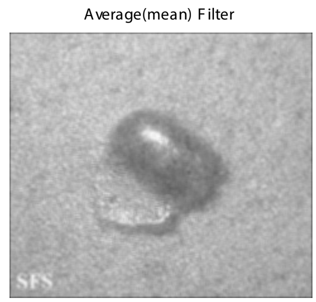

Figure 25. For Poisson Noise.

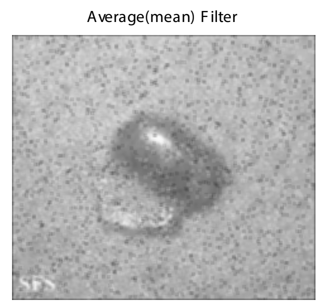

Figure 26. For Salt and Pepper Noise.

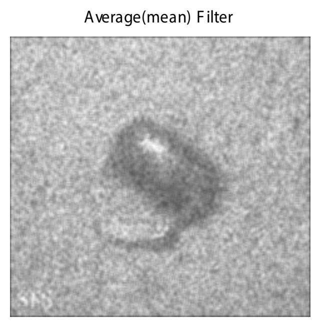

Figure 27. For Speckle Noise.

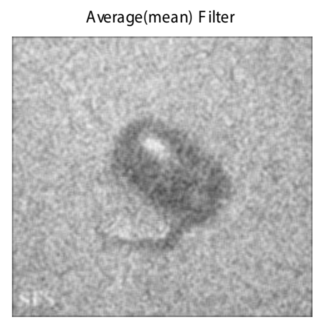

Figure 28. For Gaussian Noise.

for fixing the problem faced by linear filtering technique. This is considered to be the conventional and statistical approach[26]. Suppose if the image which is having noise as well as corrupted or unwanted data is given as input to the system means, the filter should remove the noise and it should produce the output with enhanced quality. This is the task done by this filter. One of the benefits obtained by applying this kind of filter-optimization problem is to reduce the mean-square value present in the signal which is having error values[14]. Original filter output as well the desired response differences are considered, and this value will give the presence of noise in the signal. For stationary inputs, the solution is generally referred as Weiner filter. The main purpose is to reduce the noise present in a signal by comparing estimation of desired noiseless signal. It can mathematically expressed as in Eq.(15) and (16).

$$G\,(u,v) = H^{*}(u,\,v)\;P_s\,(u,\,v) \tag{15}$$

$$|H\,(u,\,v)\,|2p_s\,(u,\,v) + P_n\,(u,\,v) \tag{16}$$

Figures 29, 30, 31 and 32 shows implementation of wiener filter for Poisson noise, salt and pepper noise, speckle noise, Gaussian noise.

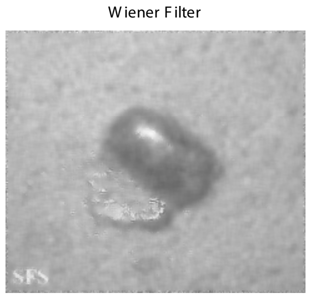

Figure 29. For Poisson Noise.

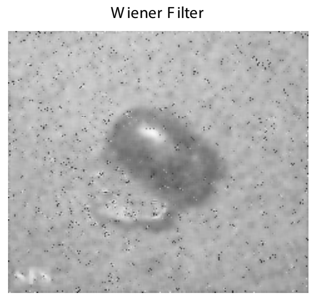

Figure 30. For Salt and Pepper Noise.

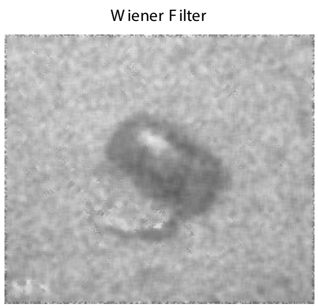

Figure 31. For Speckle Noise.

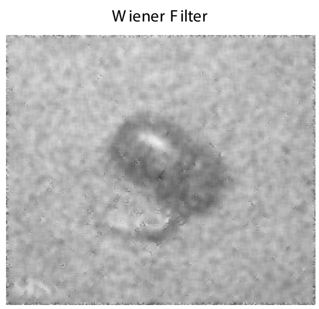

Figure 32. For Gaussian Noise.

4. Statistical Measures

4.1 Peak Signal to Noise Ratio (PSNR) and Mean Square Error (MSE)

PSNR is used to measure the quality of reconstruction due to lossy compression. In this case signal is the original data, and noise is basically the error produced by compression[34]. PSNR is considered as an *approximation* to human perception of the reconstruction quality. Even though a higher PSNR indicates that the reconstruction is of greater quality, in some situations it may not be like that. PSNR is defined via the Mean Squared Error (*MSE*). Consider a noise-free $m \times n$ monochrome image, with I and its noisy approximation K, then *MSE* is defined as in Eq. (17), (18).

$$\mathrm{MSE} = \frac{1}{mn} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} \left[\mathrm{I}(i,j) - \mathrm{K}(i,j) \right]^2 \qquad (17)$$

$$PSNR = 10 \cdot \log_{10}\left(\frac{MAX_I^2}{MSE}\right) \qquad (18)$$

5. Results and Discussion

In this paper various image enhancement techniques were discussed. Different kinds of noises are applied to the image. Then filters are applied to those noisy images. The results were checked using PSNR and MSE calculations. PSNR is the ratio of maximum power of the signal to the power of the noise which is corrupted, which affects the fidelity of representation. MSE is used to find out the occurrence of unwanted noise in the image. In Table 2 PSNR values for different noises re calculated. Table 3 shows MSE calculations. By comparing the results of MSE, the best filters for the noise removal were identified.

It is stated that if the PSNR value is large, then it will remove the noise in efficient manner. From Table 2 when we compared the value, we can frame the idea that, median filter is best for removing salt and pepper noise, Also, wiener filter is considered to be better for removing other kinds of noises. In Table 3 MSE values are calculated. In general the value of MSE should be low. If it is like that means that filter is considered as the best for noise removal. By comparing these MSE values we came to know that wiener filter is having less value. So that is considered to be the better filter for removing noises.

6. Conclusion

Image enhancement is the improvement of digital image quality (wanted e.g. for visual inspection or for machine analysis), without knowledge about the source of degradation. In this paper spatial domain techniques like

Table 2. PSNR Values

	Gaussian Noise	Salt And Pepper Noise	Speckle Noise	Poisson Noise
Median Filter	22.12	27.44	20.80	26.55
Mean Filter	23.15	24.65	22.89	20.00
Wiener Filter	24.37	23.17	24.51	27.02

Table 3. MSE of Different Noise

	Gaussian Noise	Salt And Pepper Noise	Speckle Noise	Poisson Noise
Median Filter	398.94	117.21	539.91	143.62
Mean Filter	262.99	354.95	281.07	431.47
Wiener Filter	237.36	313.23	229.81	129.04

intensity transformation, piecewise linear transformation techniques, histogram equalization were reviewed in detail. Different processing techniques and applications of those spatial domain enhancements were analysed. Also different kinds of noises are assessed and desired filters are applied for the removal of those noises. From the experimental calculations presented, we can come to the conclusion that, Mean filter is best for removing the salt and pepper noise efficiently. Mean filter is worst among all the three filters. Wiener filter is excellent for removing Gaussian, Speckle and Poisson noises. So we can generally conclude that wiener filter is suitable and compatible for removing almost all kinds of noises.

7. References

1. Agaian S, Silver B, Karen A.; Transform coefficient histogram-based image enhancement algorithms using contrast entropy. IEEE Transaction on Image Processing. 2007; 16(3):741–58.
2. Agrawal A, Raskar R. Optimal single image capture for motion deblurring. Proceedings of IEEE Conference on Computer Vision and Pattern Recognition; 2009. p. 2560–7.
3. Arun R, Madhu S, Nair R, Vrinthavani, Tatavarti R. An alpha rooting based hybrid technique for image enhancement. Engineering Letters. 2011; 19(3):159.
4. Bao P, Wu LZ. Canny edge detection enhancement by scale multiplication. IEEE Transactions on Pattern Analysis and Machine Intelligence. 2005; 27(9):1485–90.
5. Bedi SS, Rati K. Various image enhancement techniques: A critical review. International Journal of Advanced Research in Computer and Communication Engineering. 2013; 2(3):1605–9.
6. Duan F, Zhang YJ. A highly effective impulse noise detection algorithm for switching median filters. IEEE Signal Processing Letters. 2010 July; 17(7):647–50.
7. Garg A, Kumar. Comparison of various noise removals using bayesian framework. International Journal of Modern Engineering Research. 2012; 2(1):265–70.
8. Gonzalez R. Image restoration and reconstruction. Digital Image Processing. 3rd Ed. India: Pearson Prentice Hall; 2011. p. 322–30.
9. Hanggi P, Marchesoni, Jung F. Stochastic resonance. Reviews of Modern Physics. 2011; 70(3):223–70.
10. Hasan D, Anbarjafari G. Discrete wavelet transform-based satellite image resolution enhancement. 2011; 49(6): 1997–2004.
11. Hassan NY, Aakamatsu N. Contrast enhancement technique of dark blurred image. International Journal of Computer Science and Network Security (IJCSNS). 2006; 6(2):223–6.
12. Church JC, Chen Y, Stephen V. Chen Y, Stephen V, Rice. A Spatial Median Filter for Noise Removal in Digital Images. Rice Department of Computer and Information Science, University of Mississippi; 2009. p. 618–23.
13. Jain P, Kaur G. Analysis the impact of filters in spatial domain on grayscale image. International Journal of Computer Application. 2011; 36(7):47–51.
14. Jayaraj V, Ebenezer D. A new adaptive decision based robust statistics estimation filter for high density impulse noise in images and videos. International Conference on Control, Automation, Communication and Energy Conversion; 2009. p. 1–6.
15. Jinno M, Okuda, Adami N. Acquisition and encoding of high dynamic range images using inverse tone mapping. Proceedings of IEEE International Conference on Image Processing. 2010; 4(3):81–184.
16. Kim S, Chung M. Recursively separate and weighted histogram equalization for brightness preservation and contrast enhancement. IEEE Transaction on Communication, Networking and Broadcasting; 2008. p. 1389–97.
17. Komal V, Singh Y. Comparison between different techniques of image enhancement. International Journal of VLSI and Signal Processing Applications. 2011; 1(2):2231–3133.
18. Kong NSP, Ibrahim H. Color image enhancement using brightness preserving dynamic histogram equalization. IEEE Transaction on Communication, Networking and Broadcasting; 2008. p. 1962–8.
19. Kuo C, Lai Y, Chen C, Yang W, Lin G. Local brightness preservation for dynamic histogram equalization; 2011. p. 1–4.
20. Lin TC, Yu PT. Adaptive two - pass median filter based on support vector machine for image restoration. Neural Computation. 2004; 16(3):333–54.
21. Madhu SN, Revathy K, Tatavarti R. An improved decision based algorithm for impulse noise removal. Proceedings of International Congress on Image and Signal Processing;

2008 May; Sanya, Hainan, China: IEEE Computer Society Press. 1(4):426–31.

22. MandeepKaur K, Jain I, Virender. Study of image enhancement techniques: A review. Lather International Journal of Advanced Research in Computer Science and Software Engineering. 2013; 3(4):846–8.
23. Nancy E, Kaur S. Image enhancement techniques: A selected review. IOSR Journal of Computer Engineering (IOSR-JCE). 2013; 9(6):84–8, e-ISSN: 2278-0661, p- ISSN: 2278-8727.
24. Papiya C. Histogram equalization by cumulative frequency distribution. International Journal of Scientific and Research Publications. 2012; 2(7):1–4.
25. Parth B, Patel S. Image enhancement using various interpolation methods. International Journal of Computer Science and Information Technology and Security (IJCSITS). 2012; 2(4):799–803. ISSN: 2249-9555.
26. Patidar P. Image de-noising by various filters for different noise. International Journal of Computer Applications 2010; 9(4):506–10.
27. Prabhdeep S, Arora A. Analytical analysis of image filtering techniques. International Journal of Engineering and Innovative Technology (IJEIT). 2013; 3(4):234–7.
28. Pushpavalli V, Srinivasan. Decision based switching median filtering technique for image denoising. CiiT International Journal of Digital Image Processing. 2010 Oct; 2(10):405–10.
29. Pushpavalli R, Srinivasan E, Himavathi S. A new nonlinear filtering technique. International Conference on Advances in Recent Technologies in Communication and Computing; ACEEE; 2010. p. 2981–5.
30. Rajlaxmi C, Pradeep KC, Kumar R et al. Contrast enhancement of dark images using stochastic resonance in wavelet domain. International Journal of Machine Learning and Computing. 2012; 2(5): 671–6.
31. Rajesh G, Mittal B, Garg M. Histogram equalization techniques for image enhancement. IJECT. 2011; 2(1): 2230–9543.
32. Ramkumar M, Karthikeyan B. A survey on image enhancement methods. International Journal of Engineering and Technology (IJET). 2013; 5(2): 960–1012.
33. Raman M, Aggarwal H. A comprehensive review of image enhancement techniques. Journal of Computing. 2010; 2(3):2151–9617.
34. Shakair K, Mahmud J. Salt and pepper noise detection and removal by tolerance based selective arithmetic mean filtering technique for image restoration. 2008 Jun; 8(6):1234–9.
35. Shenbagavadivu S, Devi R. An investigation of noise removing techniques used in spatial domain image processing. International Journal of Computer Science and Information Technology. 2013; 2(7):198–203.
36. Sedef K, Ocan ON, Ensari T. Speckle reduction of synthetic aperture radar images using wavelet filtering. EUSAR 2004 Proceedings of 5th European Conference on Synthetic Aperture Radar; Astrium. 2004. p. 176–81.
37. Verma R, Jahid A. A comparative study on various types of image noise and efficient noise removal techniques. International Journal of Advanced Research in Computer Science and Software Engineering. 2013; 3(10):10–4.
38. Wang C, Ye Z. Brightness preserving histogram equalization with maximum entropy: A variational perspective. IEEE Transactions on Consumer Electronics. 2005; 51(4):25–30.