A Comparative Study of Various Noise Removal Techniques Using Filters

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ABSTRACT

Increasing the coefficient of performance of conventional air conditioning system by adopting the method of sub cooling. Due to sub cooling the saturated liquid at the outlet of condenser is sub cooled which will results in increase in the refrigerating effect. The sub cooling is done by extracting the heat from condenser by employing the tubing (Heat exchanger) between the fan and the condenser. The tubing is placed parallel to the condenser and the fan blows the cool air from the tubing. Tubing consists of combination of partial refrigerant taken from the evaporator outlet and the coolant which is circulated using a pump. This will result in extraction of extra amount of heat from the refrigerant owing through the condenser. Hence the sub cooling is achieved. This will also ensure the constant supply of refrigerant in saturated vapour phase in the compressor and hence the compressor life will increase providing higher overall efficiency of the system. The use of coolant for condenser cooling shows positive response. By implementing this kind to reforms in the conventional air conditioning system we can increase the coefficient of performance and also increase the power saving of the conventional air conditioning system. The average cop improved obtained to be 50 percent so that Power consumption is reduced by 20-25 percent.

INTRODUCTION

Digital images are playing very important role in research and technology Digital image processing involves the modification of digital data for improving the image qualities with the aid of computer. The processing helps in maximize the clarity, sharpness of image and details of features of interest towards extraction of information and further analysis. Image noise is random variation of brightness or color information in images, which are used in face recognition, automatic license plate recognition, finger print recognition, signature recognition, satellite television, magnetic resonance imaging, computed tomography etc. Images are used in various fields like medical and education but images often degraded by noise. Noise can occur during image acquisition, transmission, reproduction etc. If the images are corrupted by noise then the quality of images will be reduced [1]. To retain the original image from the noise corrupted image noise removal techniques are used. Denoising means removal of unwanted information from an image. Different noise removal techniques are used to filter various types of noises.

NOISE TYPES

The main source of noise in digital images arises during image acquisition (digitization) or during image transmission. The performance of image sensor is affected by variety of reasons such as environmental condition during image acquisition or by the quality of the sensing element themselves. Imaging sensors can be affected by ambient conditions [2]. Interference can be added to an image during transmission. We can consider a noisy image to be modeled as follows:

$$g(x, y)= f (x, y) +\eta (x, y) \quad (1)$$

Where f(x, y) is the original image pixel, η(x, y) is the noise term and g(x, y) is the resulting noisy pixel. If we can estimate the type of the noise in an image, that appropriate filtering techniques are employed to restore the original image.

TYPES OF NOISE

Depending on the kind of disturbance, the noise will have an effect on the image to completely different extent. Typically our focus is to take away bound quite noise. Thus we tend to establish bound quite noise and apply completely different filtering techniques to get rid of the noise [3]. The various forms of noises square measure mathematician Noise, Poisson Noise, Salt and Pepper Noise and Speckle Noise. These are not all noises that are encountered in an image but these are the common noises that are encountered.

GAUSSIAN NOISE

Also called as additive noise it is called so as each and every pixel is modified such that a certain distribution is added to each pixel [4]. The most common distribution observed is the Gaussian distribution or a bell curve **(Figure 1)**. It is caused due to poor illumination during capture or due to high temperatures **(Figure 2)**. It can also be caused due to noise present in electronic circuits. The probability density function P of a Gaussian random variable z is given by:

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

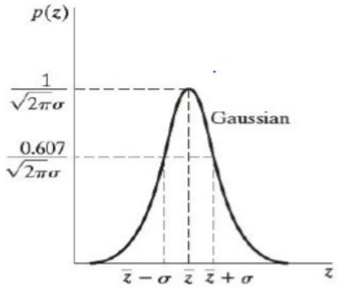

Figure 1. PDF of Gaussian noise.

Figure 2. Image with Gaussian noise.

POISSON NOISE

Also called shot noise or photon noise. Dominant noise inside the lighter elements of an associated image .It is caused as a result of variation in the photons detected at a given exposure level. This follows a statistical poisson distribution. This noise has root mean square worth proportional to root intensity of the image. Completely different pixels are suffered by different noise values [5]. The photon noise and numerous different sensor based device noise corrupts the signal at completely different proportions. The PDF of Poisson Noise is shown in following equation and in **Figures 3 and 4**.

$$P(x) = \frac{e^{-\lambda} \lambda^{x}}{x!} \quad (3)$$

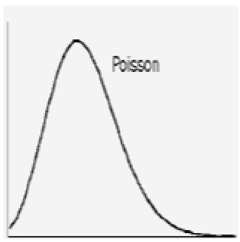

Figure 3. PDF of Poisson noise.

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Figure 4. Image with poisson noise.

SALT AND PEPPER NOISE

An interesting type of noise also referred to as impulse noise. It can be characterized as sparse disturbances in the image leading to discoloration of few pixels in the image as you can see a few pixels have become black and rest of the image has been left untouched [6]. It is caused due to sudden disturbances like dust faulty charge coupled device during the capturing of the image. The noise effects only on small no. of pixels leaving the rest of the picture untouched. In salt and pepper type of noise, the noisy pixels takes either salt value (gray level -225) or pepper value (grey level -0) and it appears as black and white spots on the images **(Figure 5).** In case of random valued impulse noise, noise can take any gray level value from zero to 225.

Figure 5. Image with salt and pepper noise.

SPECKLE NOISE

Is a type of multiplicative noise. It causes any distribution to be multiplied by each pixel in the picture. It corrupts images like ultrasounds, laser, and sonar. This noise usually degrades synthetic Aperture radar (SAR) images to massive extent [7]. This noise is mostly caused owing to random ups and downs in the signal coming from an object that is smaller than a single image processing component. This is conjointly caused by consistent processing of back scattered signals from a number of distributed targets **(Figure 6)**. This noise additionally will increase the mean gray level of the image. This noise creates a heap of problem in deciphering the image.

Figure 6. Image with speckle noise.

NOISE REMOVAL FILTERS

Here filtering is used for image noise removal. Filtering is a technique in image processing which is used for different tasks like noise reduction, interpolation, and re-sampling. It is mostly used in all image processing systems. The choice of filter depends upon the type and amount of noise present in an image because different filters can remove different types of noise efficiently. Spatial Domain has following types of filters [8].

LINEAR FILTER

Is used for reducing random noise, sharpening the edges and correcting unequal illuminations. These filters blur the edges and destroy the fine details of an image. They have poor performance in removing signal dependent noise. Linear filtering is a filtering in which the value of an output pixel is a linear combination of the values of the pixels in the input pixels neighborhood, procedure is carried out by filtering the image with correlation of an appropriate filter kernel [9]. The value of output pixel is calculated as a weighted sum of neighboring pixels called Convolution. The linear filter can be represented by the following equation.

Convolution: $r(j,k) = \sum_{s}^{k} = -k \sum_{t}^{k} = -k f(-s,-t) I(j+s, k+t)$ (3)

MIN FILTER

Min filter is also known as 0th percentile filter. It replaces the value of pixel by the minimum intensity level of the neighborhood of that pixel. This filter is used to find is used to find the darkest points in an image. It finds the minimum value in the area encompassed by the filter and enhances the dark areas of the image. Min filter reduces the salt noise as a result of the min operation [10]. The min filter can be represented by the following equation:

Min Filter: $f\hat{}(x,y) = min\{g(s,t)\}\ where\ (s,t) \in Sxy$ (4)

MAX FILTER

Max filter is also known as 100th percentile filter. It replaces the value of pixel by the maximum intensity level of the neighborhood of that pixel. This filter finds brightest points in an image. Finds the maximum value in the area encompassed by the filter and enhances bright areas of image [11]. It removes pepper noise from an image containing salt and pepper noise due to its very low intensity values as a result of the max operation.

Max Filter: $f\hat{}(x,y) = max\{g(s,t)\}\ where\ (s,t) \in Sxy$ (5)

If min and max filters are used together the pepper noise can be eliminated as a whole.

MEDIAN FILTER

It is conjointly known as order statistics filter. It is most well-known and usually used nonlinear filter. It removes noise by smoothing the images. This filter additionally lowers the intensity variation between one and rest of all the pixels of an image. In this filter, pixel value of the image is replaced with the average value the median value is calculated by initially arranging all the picture element values in ascending order later replace the middle picture element with the value calculated. If the neighboring component of image which is to be take into account, contains an even no of pixels, then it replaces the component with average of two middle component values. The median filter provides best result once the impulse noise share is a smaller amount than 0.1 It doesn't perform well in removing high density salt and pepper noise [12].

The mean filter can be represented by the following equation:

$f\hat{}(x,y) = median\{g(s,t)\}\ where\ (s,t) \in Sxy$ (6)

WIENER FILTER

In signal process, the Wiener filter is a kind of adaptive filter used to provide an estimate of a desired or target random process by linear time-invariant (LTI) filtering of an observed noisy process, assuming familiar stationary signal and noise spectra, and additive noise [13]. If the variance is smaller, wiener performs better smoothing and if variance performs little smoothing. The adaptive filter is more selective than linear filter as it preserves edges and other high frequency parts of an image. Wiener filter provides a statistical estimate of an unknown signal by using a relative signal as an input and using that known signal to produce an estimate as the output.

GAUSSIAN FILTER

A Gaussian kernel gives less weight to pixels further from the centre of the window. The kernel is an approximation of a Gaussian function, is used to blur the image. It effectively reduces the noise and the image details.

$H[u,v] = \frac{1}{2\pi\sigma^2} \exp\left(\frac{u^2 - v^2}{2\sigma^2}\right)$ (7)

A Gaussian filter is a linear filter. It's usually used to blur the image or to reduce noise. If you use two of them and subtract, you can use them for "unsharp masking" (edge detection). The Gaussian filter alone will blur edges and reduce contrast. The standard deviation of the Gaussian function plays an important role in its behavior. This is very important when designing a Gaussian kernel of fixed length.

GUIDED FILTER

The guided filter performs edge preserving, smoothing of an image, using the content of the second image called guidance image, to influence the filtering. The guidance image can be the image itself, a different version of the image or a completely different image. It takes into account the statistics of a region in the corresponding spatial neighborhood in the guidance image when calculating the value of the output pixel. If the guidance is the same as the image to be filtered the structures are the same. If the guidance image is different, structures in the guidance image will impact the filtered image [14].

Guided filter is a fastest linear-time algorithm, whose computational complexity is independent of the filtering kernel size. The guided filter is both effective and efficient in a great variety of computer vision and computer graphics applications including noise reduction, detail smoothing/enhancement, HDR compression, image feathering, haze removal, and joint up sampling **(Figure 7)**.

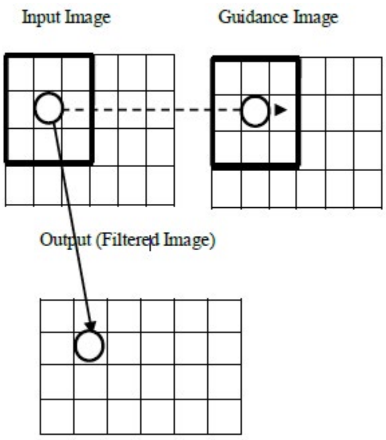

Figure 7. Guided filter.

BM3D (BLOCK MATCHING AND 3D FILTERING)

This is the most complex and advanced method of image filtering. It groups similar 2D image fragments into 3Ddata arrays called as "groups". We undertake the block-matching plan for a loud image tends to method image blocks in an exceedingly slippery manner; we tend to tend to look for blocks that exhibit similarity to the currently-processed one. The matched blocks square measure stacked on to form a 3D array. In this fashion, we tend to tend to induce high correlation of the array among that the blocks square measure stacked. Collaborative filtering reveals: The finest details are shared by grouped blocks and Preserves the essential unique features of each individual block.

ADAPTIVE FUZZY SWITCHING MEDIAN FILTER

This filter is a noise adaptive fuzzy switching median filter. Initially, the detection stage will utilize the histogram of the corrupted image to identify noise pixel. These detected "noise pixels" will then be subjected to the second stage of the filtering action, while "noise-free pixels" are returned and left unprocessed. Then, the filter employs fuzzy logic to handle uncertainty present in the extracted local information as introduced by noise. Fuzzy set theory and fuzzy logic offer powerful tools to represent and process human knowledge in the form of fuzzy if-then rules. On the other side, many difficulties in image processing arise because the data/tasks/results are uncertain. This uncertainty, however, is not always due to the randomness but to the ambiguity and vagueness. Fuzzy filters eliminate impulse noise satisfactorily. Even though, these are commonly found to be non-adaptive to noise density variations and prone to misclassifying pixel characteristics.

IMPLEMENTATION AND RESULTS

Experiments were carried out on various standard grayscale images of size 256 x 256.Simulation is performed using mat lab R2013a software. The input images are corrupted by a simulated Gaussian white noise (mean=0, variance=0.01), Salt and Pepper noise (noise density= 0.05), Speckle noise (mean=0, variance=0.04), Poisson noise. For denoising process, various filters like linear filter (3x3) median filter (3x3), min filter (3x3), max filter (3x3), wiener filter (3x3), Gaussian smoothening filter, BM3D filter (3x3),Adaptive Fuzzy switching The Quantitative performance of the filters is evaluated through **(Table 1)**.

$$MSE = \frac{\sum\sum(rij-xij)}{MXN}(rij - xij) \quad (8)$$

Peak signal to noise ratio

PSNR = 20 * log10 (255 / sqrt(MSE)) (9)

Where, r refers to Original image; x denotes the restored image; M × N is the size of processed image.

Table 1. Performance comparison of various filters of different types of noise using cameraman image.

TYPES OF NOISE	Noise measuring metrics	TYPES OF FILTERS								
		Linear Filter	Min Filter	Max Filter	Median Filter	Wiener Filter	Gaussian Filter	Guided Filter	BM3D Filter	Adaptive Fuzzy
GAUSSIAN NOISE	PSNR	13.97	14.767	14.681	25.497	23.217	23.725	20.04	29.81	31.246
	MSE	1600.8	1177.45	1086.6	407.65	309.97	643.83	1029.4	104.45	48.76
POISSON NOISE	PSNR	14.45	18.853	18.493	29.212	25.93	30.085	16.991	30.21	28.706
	MSE	1330.41	1075.52	1156.6	237.58	165.968	482.95	1099.9	95.14	8.887
SPECKLE NOISE	PSNR	13.34	18.853	18.493	23.375	19.913	22.571	24.16	27.74	29.948
	MSE	2011.45	1535.2	1353.2	825.36	663.29	8-25.4	249.39	168.02	65.81
SALT AND PEPPER NOISE	PSNR	14.08	13.676	13.654	30.508	24.273	22.179	19.08	26.14	33.483
	MSE	1539.9	1788.65	1804.5	532.04	243.06	735.16	803.59	242.59	391.15

CONCLUSION

It was difficult to say which filter is the best among all the filters but depending upon the type of noise, the filters can be used, after simulation a comparative analysis of noise removal techniques is done. Investigating the results by applying different noise types to an image model the following conclusions are made: The Block Matching filter(BM3D) was found to be stable and comprehensive. We also observe that Median filter worked very well for Salt and Pepper noise and Gaussian noise. Linear filter worked very well for Poisson noise. Wiener filter has done well for Poisson noise, Similarly Salt and Pepper Gaussian, Poisson, and Speckle noises were moderately worked for Min and Max filters. Guided filter done a very good job with Poisson noise. The Adaptive Fuzzy Median filter has proved to be best for Salt and Pepper noise. Finally drawn a conclusion that BM3D filter is powerful filter which has worked very well with all kinds of noises.

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