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Image Noise Reduction and Filtering Techniques

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Abstract: ***Images are often degraded by noises. Noise can occur and obtained during image capture, transmission, etc. Noise removal is an important task in image processing. In general the results of the noise removal have a strong influence on the quality of the image processing techniques. Several techniques for noise removal are well established in color image processing. The nature of the noise removal problem depends on the type of the noise corrupting the image. In the field of image noise reduction several linear and nonlinear filtering methods have been proposed. Linear filters are not able to effectively eliminate impulse noise as they have a tendency to blur the edges of an image. On the other hand nonlinear filters are suited for dealing with impulse noise. Several nonlinear filters based on Classical and fuzzy techniques have emerged in the past few years. For example most classical filters that remove simultaneously blur the edges, while fuzzy filters have the ability to combine edge preservation and smoothing. Compared to other nonlinear techniques, fuzzy filters are able to represent knowledge in a comprehensible way. In this paper we present results for different filtering techniques and we compare the results for these techniques.***

Keywords: Linear smoothing filter, median filter, wiener filter, adaptive filter and Gaussian filter

1. Introduction

Noise is a random variation of image Intensity and visible as a part of grains in the image. It may cause to arise in the image as effects of basic physics-like photon nature of light or thermal energy of heat inside the image sensors [16]. It may produce at the time of capturing or image transmission. Noise means, the pixels in the image show different intensity values instead of true pixel values that are obtained from image. Noise removal algorithm is the process of removing or reducing the noise from the image. The noise removal algorithms reduce or remove the visibility of noise by smoothing the entire image leaving areas near contrast boundaries. But these methods can obscure fine, low contrast details [1]. The common types of noise that arises in the image are: a) Impulse noise, b) Additive noise [9] c) Multiplicative noise. Different noises have their own characteristics which make them distinguishable from others. Image noise can also originated in film grain and in the unavoidable shot noise of an ideal photon detector. Image noise is an undesirable by-product of image captured.

2. Various Sources of Noise in Images

Noise is introduced in the image at the time of image acquisition or transmission. Different factors may be responsible for introduction of noise in the image. The number of pixels corrupted in the image will decide the quantification of the noise. The principal sources of noise in the digital image are: a) The imaging sensor may be affected by environmental conditions during image acquisition. b)Insufficient Light levels and sensor temperature may introduce the noise in the image. c) Interference in the transmission channel may also corrupt the image. d) If dust particles are present on the scanner screen, they can also introduce noise in the image.

3. Types of Noise

Noise to be any degradation in the image signal caused by external disturbance .If an image is being sent electronically from one place to another via satellite or wireless transmission or through networked cables, we may expect errors to occur in the image signal. These errors will appear on the image output in different ways depending on the type of disturbance in the signal. Usually we know what type of errors to expect and the type of noise on the image; hence we investigate some of the standard noise for eliminating or reducing noise in color image. Image Noise is classified as Amplifier noise (Gaussian noise), Salt-and-pepper noise (Impulse noise), Shot noise, Quantization noise (uniform noise), Film grain, on-isotropic noise, Speckle noise (Multiplicative noise) and Periodic noise.

3.1 Amplifier Noise (Gaussian noise)

The standard model of amplifier noise is additive, Gaussian, dependent at each pixel and dependent of the signal intensity, caused primarily by Johnson–Nyquist noise (thermal noise), including that which comes from the reset noise of capacitors ("kTC noise"). It is an idealized form of white noise, which is caused by random fluctuations in the signal [12]. In color cameras where more amplification is used in the blue color channel than in the green or red channel, there can be more noise in the blue channel. Amplifier noise is a major part of the noise of an image sensor, that is, of the constant noise level in dark areas of the image. In Gaussian noise, each pixel in the image will be changed from its original value by a (usually) small amount [4]. A histogram, a plot of the amount of distortion of a pixel value against the frequency with which it occurs, shows a normal distribution of noise. While other distributions are possible, the Gaussian (normal) distribution is usually a good model, due to the central limit theorem that says that the sum of different noises tends to approach a Gaussian distribution. Not only that but also Gaussian noise represents statistical noise having probability density function (PDF) equal to that of the normal distribution, which is also known as the Gaussian distribution. In other words, the values that the noise can take on are Gaussian distributed. The probability density function of a Gaussian random variable Z is given by:

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

Where represents the grey level, μ the mean value and the standard deviation. A special case is white Gaussian noise, in which the values at any pair of times are identically distributed and statistically independently (and hence uncorrelated).In communication channel testing and modelling, Gaussian noise is used as additive white noise to generate additive white Gaussian noise [3]. In signal processing, white noise is a random signal with a constant power spectral density. [4]The term is used, with this or similar meanings, in many scientific and technical disciplines, including physics, acoustic engineering, telecommunications, statistical forecasting, and many more .Example of gaussian noise

Figure 1: Before Gaussian noise

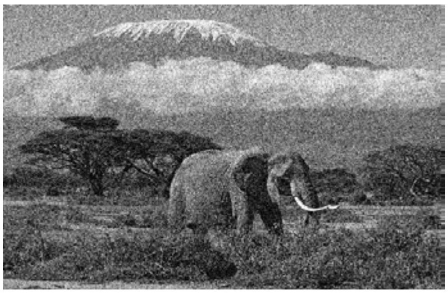

Figure 2: After Gaussian noise

In matlab code if we want to add some Gaussian noise then we will write in matlab editor:
J = imnoise(I,'gaussian',m,v) adds Gaussian white noise of mean m and variance v to the image I. The default is zero mean noise with 0.01 variance. J = imnoise(I,'localvar',V) adds zero-mean, Gaussian white noise of local variance V to the image I. V is an array of the same size as I. J = imnoise(I,'localvar',image_intensity,var) adds zero-mean, Gaussian noise to an image I, where the local variance of the noise, var, is a function of the image intensity values in I. The image_intensity and var arguments are vectors of the same size, and plot (image_intensity,var) plots the functional relationship between noise variance and image intensity. The image_intensity vector must contain normalized intensity values ranging from 0 to 1. In shortly

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```
A=imread('tanzania-mount-kilimanjaro.jpg');saved here
imshow(I);figure(1)
I= rgb2gray(A);
J=imnoise(I,'gaussian',0,0.025);
figure(2);imshow(J);
```

3.2 Salt-and-Pepper Noise (Impulse Noise)

Salt and pepper noise is sometimes called impulse noise or spike noise or random noise or independent noise. In salt and pepper noise (sparse light and dark disturbances), pixels in the image are very different in color or intensity unlike their surrounding pixels. Salt and pepper degradation can be caused by sharp and sudden disturbance in the image signal. Generally this type of noise will only affect a small number of image pixels. When viewed, the image contains dark and white dots, hence the term salt and pepper noise [13]. Typical sources include flecks of dust inside the camera and overheated or faulty (Charge-coupled device) CCD elements. An image containing salt-and-pepper noise will have dark pixels in bright regions and vice versa. This type of noise can be caused by dead pixels,It known as impulsive noise. It appearances is randomly scattered white or black pixel over the image. It sometimes happen for memory cell failure,for synchronization errors in image digitizing or transmission. This type of noise can be caused by analog to digital converter errors,bit error in transmission. Example of salt-and-pepper noise:

Original image before and after noise.

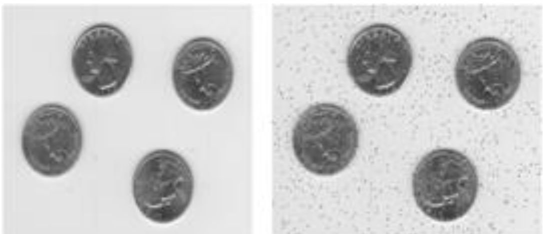

Figure 3

3.3 Shot Noise

The dominant noise in the lighter parts of an image from an image sensor is typically that caused by statistical quantum fluctuations, that is, variation in the number of photons sensed at a given exposure level; this noise is known as photon shot noise. Shot noise has a root mean-square value proportional to the square root of the image intensity, and the noises at different pixels are independent of one another. Shot noise follows a Poisson distribution, which is usually not very different from Gaussian. In addition to photon shot noise, there can be additional shot noise from the dark leakage current in the image sensor; this noise is otherwise known as "dark shot noise" or "dark-current shot noise".

3.4 Quantization Noise (Uniform Noise)

The noise caused by quantizing the pixels of a sensed image to a number of discrete levels is known as quantization noise; it has an approximately uniform distribution, and can be signal may dependent, though it will be signal independent if other noise sources are plenty that cause dithering, or if dithering is explicitly applied.

3.5 Film Grain

The grain of photographic film is a signal-dependent noise, related to shot noise. That is, if film grains are uniformly distributed (equal number per area), and if each grain has an equal and independent probability of developing to a dark silver grain after absorbing photons, then the number of such dark grains in an area will be random with a binomial distribution; in areas where the probability is low, this distribution will be close to the classic Poisson distribution of shot noise; nevertheless a simple Gaussian distribution is often used as an accurate model.

3.6 Speckle Noise (Multiplicative Noise)

Speckle is a granular 'noise' that inherently exists in and degrades the quality of the active radar and synthetic aperture radar (SAR) images.[6] Speckle noise in conventional radar results from random fluctuations in the return signal from an object that is no bigger than a single image-processing element. It increases the mean grey level of a local area. Speckle noise in SAR is generally more serious, causing difficulties for image interpretation.[10]It is caused by coherent processing of backscattered signals from multiple distributed targets. In SAR oceanography, for example, speckle noise is caused by signals from elementary scatters, the gravity-capillary ripples, and manifests as a pedestal image, beneath the image of the sea waves. Synthetic Apertures Radar (SAR) technique is popular because of its usability under various weather conditions, its ability to penetrate through clouds and soil. A SAR image is a mean intensity estimate of the radar reflectivity of the region which is being imaged. Speckle noise in such system is to be referred as the difference between a measurement and the true mean value. Degraded image with speckle noise in ultrasound imaging is given by the equation. G(n,m)= f(n,m)*u(n,m)+ξ(n,m) Where g(n,m) is the observed image. u(n,m) is the multiplicative component and ξ(n,m) is the ξ(n,m) is the additive component of the speckle noise. Here and denotes the axial and lateral indices of the image samples. While Gaussian noise can be modeled by random values added to an image, speckle noise can be modeled by random values multiplied by pixel values hence it is also called multiplicative noise. Speckle noise is a major problem in some radar applications.

Examples: An original image

Figure 4: After adding Speckle Noise

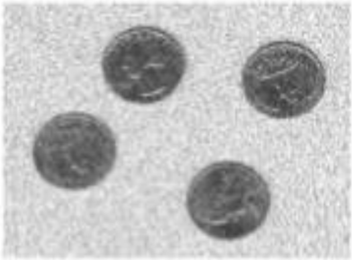

Figure 5

4. Removing Noise from Images by Filtering

Image noise is an unavoidable side-effect occurring as a result of image capture, more simply understood as inaudible, yet inevitable fluctuations. In a digital camera, if the light which enters the lens misaligns with the sensors, it will create image noise. Even if noise is not so obviously visible in a picture, some kind of image noise is bound to exist. Every type of electronic device receives and transmits some noise and sends it on to what it is creating. When the images are transmitted over channels, they are corrupted with impulse noise due to noisy channels. This impulse noise consists of large positive and negative spikes [4]. The positive spikes have values much larger than the background and thus they appear as bright spots, while the negative spikes have values smaller than the background and they appear as darker spots. Both the spots for the positive and negative spikes are visible to the human eye. Also, Gaussian type of noise affects the image. Thus, filters are required for removing noises before processing. There are lots of filters in the paper to remove noise. They are of many kinds as linear smoothing filter, median filter, wiener filter and Fuzzy filter. In this filtering technique, the three primaries(R, G and B) are done separately. It is followed by some gain to compensate for attenuation resulting from the filter. The filtered primaries are then combined to form the colored image [3]. This process is very simple. This approach shown in figure below as.

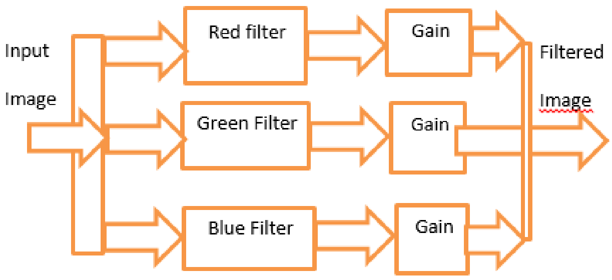

Figure 6

4.1 Linear Filters

Linear filter used to remove certain types of noise. Averaging or Gaussian filters are appropriate for this purpose. Linear filters also tend to blur sharp edges, destroy lines and other fine image details, and perform poorly in the presence of signal-dependent noise. Example, the Gaussian mask comprises elements determined by a Gaussian function.This convolution brings the value of each pixel into closer harmony with the values of its neighbors.In general, a smoothing filter sets each pixel to the average value, or a weighted average, of itself and its nearby neighbors; the Gaussian filter is just one possible set of weights.Smoothing filters tendto blur an image, because pixel intensity values that are significantly higher or lower than the surrounding neighborhood would "smear" across the area.[9] Because of this blurring, linear filters are seldomused in practice for noise reduction; they are, however, often used as the basis for nonlinear noise reduction filters.

4.1.1 Adaptive Filter

The wiener function applies a Wiener filter (a type of linear filter) to an image adaptively, tailoring itself to the local image variance.[11] If the variance is large, wiener performs little smoothing. If it is is small, wiener performs more smoothing. This approach often produces better results than linear filtering. The adaptive filter is more selective than a comparable linear filter, preserving edges and other high-frequency parts of an image.[14] In addition, there are no design tasks; the wiener2 function handles all preliminary computations and implements the filter for an input image. wiener2, however, does require more computation time than linear filtering.[6] Wiener works best when the noise is constant-power ("white") additive noise, such as Gaussian noise. Another method for removing noise is to evolve the image under a smoothing partial differential equation similar to the heat equation which is called anisotropic diffusion. Another method for removing noise is to evolve the image under a smoothing partial differential equation similar to the heat equation which is called anisotropic diffusion.

The Fourier domain of the Wiener filter is: G(u,v)=H*(u,v)/[|H(u,v)|2 Ps(u,v) + Pn(u,v)] Where H*(u,v)=Complex conjugate of degradation function Pn(u,v)=Power spectral density of noise Ps(u,v)=Power spectral density of non-degraded image H(u,v)=Degradation function.

Example of adaptive filtration using wiener filter:

Gaussian added noise

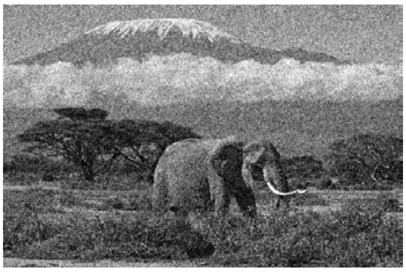

Figure 7: Filtered image

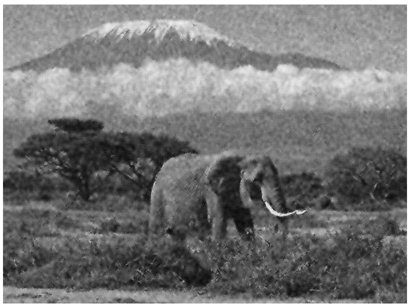

Figure 8

In Matlabeditor : I=imread('tanzania-mount-kilimanjaro.jpg'); \\ read file imshow(I);figure(1) I= rgb2gray(A); \\ convert to grayscale J=imnoise(I,'gaussian',0,0.025); \\addgausian noise figure(2);imshow(J); K=wiener2(J,[5 5]); \\ remove noise using wiener filter figure(3);imshow(K);

4.1.2 Non -linear filter

In recent years, a variety of nonlinear median type filters such as weighted median, rank conditioned rank selection, and relaxed median have been developed to overcome this is shortcoming. To run a median filter: 1.Consider each pixel in the image 2. Sort the neighboring pixels into order based upon their intensities

To replace the original value of the pixel with the median value from the list

A median filter is a rank selection (RS) filter, a particularly harsh member of the family of rank-conditioned rank-selection (RCRS) filters;[4]a much milder member of that family, for example one that selects the closest of the neighboring values when a pixel's value is external in its neighborhood, and leaves it unchanged otherwise, is sometimes preferred, especially in photographic applications. Median and other RCRS filters are good at removing salt and pepper noise from an image, and also cause relatively little blurring of edges, and hence are often used in computer vision applications. Median filtering is similar to using an averaging filter, in that each output pixel is set to an average of the pixel values in the neighborhood of the corresponding input pixel.However, with medianfiltering, the value of an output pixel is determined by the median of the neighborhood pixels, rather than the mean.The median is much less sensitive than the mean to extreme values (called outliers).Median filtering is therefore better able to remove these outliers without reducing the sharpness of the image.Median Filter is a simple and powerful non-linear filter which is based order statistics.It is easy to to implement method of smoothing images.Median filter is used for reducing the amount of intensity variation between one pixel and the other pixel. In this filter, 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 by first sorting all the pixel values into ascending order and then replace the pixel being calculated with the middle pixel value. If the neighboring pixel of image which is to be consider contain an even numbers of pixels, than the average of the two middle pixel values is used to replace.The median filter gives best result when the impulse noise percentage is less than 0.1 %.When the quantity of impulse noise is increased the median filter not gives best result.

4.2.Algorithms of Median filter

The algorithm for the median filter is as follows: Step 1. Select a two dimensional window W of size 3*3. Assume that the pixel being processed is Cx,y. Step 2. Compute Wmed the median of the pixel values in window W. Step 3. Replace Cx,y by Wmed. Step 4. Repeat steps 1 to 3 until all the pixels in the entire image are processed.

	10	5	20						
	14	80	11						
	8	3	22						

(3,5,8,10,11,14,20,22,80)

Median (Central value 80 is replaced by 11).

4.2.1 Advantage

a) It is easy to implement.
b) Used for de-noising different types of noises.

4.2.2 Disadvantage

a) Median Filter tends to remove image details while reducing noise such as thin lines and corners.
b) Median filtering performance is not satisfactory in case of signal dependent noise. To remove these difficulties different variations of median filters have been developed for the better results.

5. Result for Project

If we can add salt and pepper noise to the image. This type of noise consists of random pixels being set to black or white (the extremes of the data range). Notice that medfilt2 does a better job of removing noise, with less blurring of edges of the coins.

```
Kmedian = medfilt2(J);
imshowpair(Kaverage,Kmedian,'montage'
```

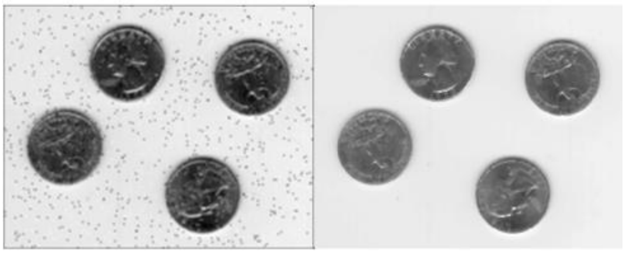

Figure 9

6. Conclusion

In this paper, we discussed different filtering techniques for removing noises in color image. Furthermore, we presented and compared results for these filtering techniques. The results obtained using median filter technique ensures noise free and quality of the image as well. The main advantages of this medium filter are the denoising capability of the destroyed color component differences. Hence the method can be suitable for other filters available at present. But this technique increases the computational complexity. Our future research will be focused on the construction of other Median filtering methods for color images to suppress other types of noises.

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