Efficient Technique for Color Image Noise Reduction

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Abstract
Images are often degraded by noises. Noise can occur 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 technique. 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 non linear 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 non linear filters are suited for dealing with impulse noise. Several non linear 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 non linear 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 PSNR value

1. INTRODUCTION
Noise is the result of errors in the image acquisition process that results in pixel values that do not reflect the true intensities of the real scene. Noise reduction is the process of removing noise from a signal. Noise reduction techniques are conceptually very similar regardless of the signal being processed, however a priori knowledge of the characteristics of an expected signal can mean the implementations of these techniques vary greatly depending on the type of signal. The image captured by the sensor undergoes filtering by different smoothing filters and the resultant images. All recording devices, both analogue and digital, have traits which make them susceptible to noise. The fundamental problem of image processing is to reduce noise from a digital color image. The two most commonly occurring types of noise are i) Impulse noise, ii) Additive noise (e.g. Gaussian noise) [2] and iii) Multiplicative noise (e.g. Speckle noise).

ISSN: 2078-7952 (print); 2078-7960 (online)

Impulse noise is usually characterized by some portion of image pixels that are corrupted, leaving the remaining pixels unchanged [1]. Examples of impulse noise are fixed-valued impulse noise and randomly valued impulse noise. We talk about additive noise when value from a certain distribution is added to each image pixel, for example, a Gaussian distribution. Multiplicative noise is generally more difficult to remove from images than additive noise because the intensity of the noise varies from the signal intensity (e.g., speckle noise)[4][12].

[1] Represents a survey of 48 filters for impulsive noise removal from color images and also analyzed different distance measures such as Minkowski, Angular and directional-distance.

2. SOURCES OF NOISE IN DIGITAL IMAGES
Noise usually quantified by the percentage of pixels which are corrupted. Corrupted pixels are either set to the maximum value or have single bits. There are several ways that noise can be introduced into an image, depending on how the image has been created. For instance:

- If the image is scanned from a photograph made on film, the film grain is a source of noise. Noise may also be the result of damage to the film, or be introduced by the scanner itself.
- If the image is acquired directly in a digital format, the mechanism for gathering the data (such as a CCD detector) can introduce noise.
- Electronic transmission of image data can make noise.

4. TYPES OF NOISES
Noise to be any degradation in the image signal caused by external disturbance [8]. 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 [11].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 [8]. 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. 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.

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, analog-to-digital converter errors and bit errors in transmission.

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 Non-Isotropic Noise

Some noise sources show up with a significant orientation in images. For example, image sensors are sometimes subjected to row noise or column noise. In film, scratches are an example of non-isotropic noise. While we cannot completely do away with image noise, it can certainly reduce some of it. Corrective filters are yet another device that helps in reducing image noise.

3.7 Speckle Noise (Multiplicative Noise)

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.

3.8 Periodic Noise

If the image signal is subjected to a periodic rather than a random disturbance, we obtain an image corrupted by periodic noise. The effect is of bars over the image.

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 [7]. 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 [9]. This process is very simple. This approach is shown in figure 1.

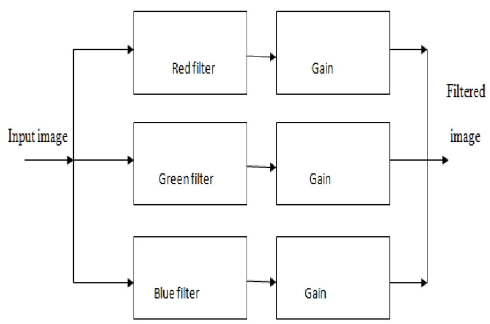

Figure1. Filtering the three primaries separately

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[10].

4.11 Linear smoothing filters

One method to remove noise is by convolving the original image with a mask that represents a low-pass filter or smoothing operation. For 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 tend to blur an image, because pixel intensity values that are significantly higher or lower than the surrounding neighborhood would "smear" across the area. Because of this blurring, linear filters are seldom used in practice for noise reduction; they are, however, often used as the basis for nonlinear noise reduction filters.

4.12 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. 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. 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. 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.

4.2 Non-Linear Filters

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 shortcoming.

4.2.1 Median Filter

A median filter is an example of a non-linear filter and, if properly designed, is very good at preserving image detail. To run a median filter:

1. consider each pixel in the image
2. sort the neighboring pixels into order based upon their intensities
3. 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 median filtering, 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.

4.2.2 Fuzzy Filter

Fuzzy filters provide promising result in image-processing tasks that cope with some drawbacks of classical filters. Fuzzy filter is capable of dealing with vague and uncertain information [5]. Sometimes, it is required to recover a heavily noise corrupted image where a lot of uncertainties are present and in this case fuzzy set theory is very useful. Each pixel in the image is represented by a membership function and different types of fuzzy rules that considers the neighborhood information or other information to eliminate filter removes the noise with blurry edges but fuzzy filters perform both the edge preservation and smoothing .Image and fuzzy set can be modeled in a similar way [6]. Fuzzy set in a universe of X is associated with a membership degree. Similarly, in the normalized image where the image pixels ranging from {0, 1, 2... 255} are normalized by 255, the values obtained are in the interval [0, 1].

A fuzzy set is a class of points possessing a continuum of membership grades, where there is no sharp boundary among elements that belong to this class and those that do not. We can express this membership grade by a mathematical function called membership function or characteristic function $\mu_A(x_i)$. This function assigns to each element in the set a membership grade in the interval [0,1].
If X is a collection of objects denoted generically by x, then a fuzzy set A in X is defined as a set of ordered pairs:

$$A = \{(x, \mu_A(x)) / x \in X\} \quad (1)$$

Where $\mu_A(x)$ is called the membership function for the fuzzy set A. The membership maps each element of X to a membership grade between 0 and 1. In this way, the image is considered as a fuzzy set and thus filters are designed [3]. The results of proposed filtering techniques are shown in figure 2.

5. PERFORMANCE MEASURE

The Peak Signal to Noise Ratio (PSNR) is the value of the noisy image with respect to that of the original image. The value of PSNR and MSE(Mean square Error)for the proposed method is found out experimentally. The PSNR and the Mean Square Error of the retrieved image can be calculated by using the equation number 2 and 3.

$$PSNR(Img, Org) = 10\log_{10} \frac{S^2}{MSE(Img,Org)}$$

$$MSE(Img,Org) = \frac{\left(\sum_{c=1}\sum_{i=1}\sum_{j=1}[Org(i,j,c) - Img(i,j,c)]^2\right.}{3NM}$$

Where Org is the original image, Img is the filtered color image of size M. M, S is the maximum possible intensity value (with m-bit integer values, S will be 2^m-1). The results of the calculations for the proposed method are given in Table I.

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 Fuzzy filter technique ensures noise free and quality of the image as well. The main advantages of this fuzzy 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 fuzzy filtering methods for color images to suppress other types of noises.

Table 1. Performance Measure

Filter	MSE(Mean Square Error)	PSNR(Peak Signal to Noise Ratio)in dB
Linear smoothing filter	265.1121	55.0237
Median filter	131.3515	62.0465
Wiener filter	39.2500	74.1258
Fuzzy filter	3.3282	98.8009

(a)original image **(b) using linear filter** **(c) using median filter** **(d) using wiener filter** **(e) using fuzzy filter**

Figure II. Results of the Proposed Filtering Techniques

7. REFERENCES

[1] M. Emre Celebi, Hassan A. Kingravi, Y. Alp Aslandogan.2007. Nonlinear vector filtering for impulsive noise removal from color images. Journal of Electronic Imaging. 2007, 1-21.

[2] Parminder Kaur and Jagroop Singh. 2011.A Study on the Effect of Gaussian Noise on PSNR Value for Digital Images. International Journal of Computer and Electrical Engineering.Vol. 3, No. 2, 1793-8163.

[3] Stefan Schulte, Valérie De Witte, and Etienne E. Kerre.2007. A Fuzzy Noise Reduction Method for Color Images. IEEE Transactions On Image Processing, Vol. 16, No. 5, 1425-1436.

[4] V.R.Vijay Kumar, S.Manikandan, D.Ebenezer, P.T.Vanathi and P.Kanagasabapathy.2007.High Density Impulse noise Removal in Color Images Using Median Controlled Adaptive Recursive Weighted Median Filter. IAENG International Journal of Computer Science. 1-10.

[5] P.Murugeswari, Dr. D.Manimegalai.2011.Noise Reduction in Color image using Interval Type-2 Fuzzy Filter (IT2FF). International Journal of Engineering Science and Technology (IJEST), 1334-1338.

[6] Om Prakash Verma1, Madasu Hanmandlu2, Anil Singh Parihar3 and Vamsi Krishna Madasu4.2009.Fuzzy Filters for Noise Reduction in Color Images. ICGST-GVIP Journal, Volume 9, Issue 5, 29-42.

[7] J.Harikiran, B.Saichandana, B.Divakar.2010 Impulse Noise Removal in Digital Images. International journal of computer science. Volume 10– No.8, 39-42.

[8] Alasdair Mcandrew.2004. Introduction to digital image processing with MATLAB, Course Technology a part of cengage learing.

[9]S.Jayaraman, S.Esakkirajan and T. Veerakumar.2009.Digital Image Processing, Tata McGraw Hill Education Private Limited.

[10] Nachtegael, M, Schulte, S, Van der Weken. D, De Witte. V, Kerre, E.E.2005.Fuzzy Filters for Noise Reduction: The Case of Gaussian Noise. IEEE Xplore, 201-206.

[11]Tom M´elange, Mike Nachtegael, Etienne E. Kerre.2009.A Fuzzy Filter for the Removal of Gaussian Noise in Colour Image Sequences. 1474-1479.

[12]Dimitri Van De Ville, *Member, IEEE*, Mike Nachtegael, Dietrich Van der Weken, Etienne E. Kerre.2003. Noise Reduction by Fuzzy Image Filtering. IEEE Transactions on Fuzzy systems, Vol. 11, No. 4, 429-436.

[13] Rafael.C.Gonzalez, Richard E.Woods.2008. Digital image processing, 3rd edition, Pearson education.

[14] Orlando.J, Tobias.2004. Image segmentation by histogram thresholding using fuzzy sets. IEE transaction on image processing, Vol.11, No.12.

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