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Filtering Techniques Used to Reduce the Noise in Image Processing

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ABSTRACT

Noise is always presents in digital images during image acquisition, coding, transmission, and processing steps. It is very difficult to remove noise from the digital images without the prior knowledge of filtering techniques. Noise, which is an unwanted signal or variation of brightness, may destroy part of an image. In this paper, we used different Filtering Techniques to reduce the noise in image processing. These filters can be selected by analysis of the noise behavior. In this way, a complete analysis of noise and their best suited filters will be presented over here First, we give the formulation of the different types of noise and then we apply the different filtering techniques to restore the image with high quality parameters.

Keywords: adaptive filter, Gaussian noise, Gaussian filter, median filter, poisson noise, speckle noise and wiener filter

I. INTRODUCTION

Image processing is known to be an important area to bring out the best in an image and it is useful in several areas such as remote sensing, medical field, image shaping and restoration, machine vision, pattern recognition and video processing. Several noise removal techniques are described in this paper in other to remove noise. With the explosion in the number of digital images taken every day, the demand for more accurate and visually pleasing images is increasing. However, the images captured by modern cameras are inevitably degraded by noise, which leads to deteriorated visual image quality. Therefore, work is required to reduce noise without losing image features (edges, corners, and other sharp structures). So far, researchers have already proposed various methods for decreasing noise. 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 [10].Noise means, the pixels in the image show different intensity values instead of true pixel values that are obtained from image. Due to the great development in the field of information technology and its equipment, the images taken by this technology has become a source of interest for many and the search for the best image and more accurate demand of many, so there are several ways to process and improve images in case of noise or any other effects[4]. After researching and reading studies interested in the subject of noise and how to remove them using many types of filters. We found it necessary to conduct an analytical study with practical application to know which performance from filters is the best in noise removal and its ability to preserve images. In this paper, selected four types of noise and added to the images. These types of noise were removed using four types of filters. The main objective of this paper is to understand the type of noise and find out the best suitable filter to remove the noise.

II. NEED OF FILTERING TECHNIQUES IN IMAGE PROCESSING

Filtering is a technique for modifying or enhancing an image. For example, you can filter an image to emphasize certain features or remove other features. Image processing operations implemented with filtering include smoothing, sharpening, and edge enhancement. Filtering is a neighbourhood operation, in which the value of any given pixel in the output image is determined by applying some algorithm to the values of the pixels in the neighbourhood of the corresponding input pixel. A pixel's neighbourhood is some set of pixels, defined by their locations relative to that pixel[5].Linear filtering is filtering in which the value of an output pixel is a linear combination of the values of the pixels in the input pixel's neighbourhood. In image processing filters are mainly used to suppress either the high frequencies in the image, i.e. smoothing the image, or the low frequencies, i.e. enhancing or detecting edges in the image. An image can be filtered either in the frequency or in the spatial domain. The first involves transforming the image into the frequency domain, multiplying it with the frequency filter function and re-transforming the result into the spatial domain. The filter function is shaped so as to attenuate some frequencies and enhance others. For example, a simple low pass function is 1for frequencies smaller than the cut-off frequency and 0 for all others. The corresponding process in the spatial domain is to convolve the input image f(i,j) with the filter function h(i,j). This can be written as

$$g(i,j) = h(i,j)\, \dot{O}\, f(i,j)$$

The mathematical operation is identical to the multiplication in the frequency space, but the results of the digital implementations vary, since we have to approximate the filter function with a discrete and finite kernel[6].The discrete convolution can be defined as a `shift and multiply' operation, where we shift the kernel over the image and multiply its value with the corresponding pixel values of the image. For a square kernel with size M× M, we can calculate the output image with the following formula:

$$g(i,j) = \sum_{m=-\frac{M}{2}}^{\frac{M}{2}} \sum_{n=-\frac{M}{2}}^{\frac{M}{2}} h(m,n) f(i-m, j-n)$$

Image filtering is changing the appearance of an image by altering the colors of the pixels. Increasing the contrast as well as adding a variety of special effects to images are some of the results of applying filters. Image filtering is done to improve the quality of the image. For ex smoothing an image reduces noise, blurred images can be rectified. There are broadly two types of filtering techniques linear [1] and non linear [2].

III.TYPESOFNOISE

Different noises have their own characteristics which make them distinguishable from others. Image noise can also originate in film grain and in the unavoidable shot noise of an ideal photon detector. Image noise is an undesirable by-product of image captured. 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: The imaging sensor maybe affected by environmental conditions during image acquisition, Insufficient Light levels and sensor temperature may introduce the noise in the image, Interference in the transmission channel may also corrupt the image, If dust particles are present on the scanner screen, they can also introduce noise in the image. 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 colorimage[3].

Image Noise is classified as

A. salt and pepper noise

Salt and pepper noise refers to a wide variety of processes that result in the same basic image degradation: only a few pixels are noisy, but they are very noisy. The effect is similar to sprinkling white and black dotssalt and pepperon the image. In other words, the contribution to the MSE from the most significant bit is approximately three times that of all the other bits. The pixels whose most significant bits are changed will likely appear as black or white dots[9].

B. Gaussian noise

Gaussian noise is a statistical noise having a probability density function equal to normal distribution, also known as Gaussian Distribution. Random Gaussian function is added to Image function to generate this noise. It is also called as electronic noise because it arises in amplifiers or detectors.

C. Shot noise or Poisson noise

It is a type of noise which can be modelled by a Poisson process. In electronics shot noise originates from the discrete nature of electric charge. Shot noise also occurs in photon counting in optical devices, where shot noise is associated with the particle nature of light.

D. Speckle noise

Speckle noiseis a multiplicative noise that affects pixels in a gray-scale image, and mainly occurs in low level luminance images such as Synthetic Aperture Radar (SAR) images and Magnetic Resonance Image (MRI) images

Figure1:Saltandpeppernoise

Figure2:Gaussiannoise

Figure3:Poissonnoise

Figure4:Specklenoise

IV.TYPESOFFILTERS

A. Linear filtering

Linear filtering is one of the most powerful image enhancement methods. It is a process in which part of the signal frequency spectrum is modified by the transfer function of the filter. In general, the filters under consideration are linear and shift-invariant, and thus, the output images are characterized by the convolution sum between the input image and the filter impulse response; that is:

$$y(m,n) = \sum_{i=0}^{M}\sum_{j=0}^{N} h(m-i,n-j)x(i,j) = h(m,n)^{**}\, x(m,n)$$

Where the following is true:
he y(m,n) is the output image.
The h(m, n) is the filter impulse response. The x(m, n) is the input image.

B. Non-linear filters

Non-linear filtersmay also be useful when certain "nonlinear" features of the signal are more important than the overall information contents. A linear noise-removal filter will usually blur those features; a non-linear filter may give more satisfactory results (even if the blurry image may be more "correct" in the information-theoretic sense). Many nonlinear noise-removal filters operate in the time domain. They typically examine the input digital signal within a finite window surrounding each sample, and use some statistical inference model (implicitly or explicitly) to estimate the most likely value for the original signal at that point. The design of such filters is known as the filtering problem for a stochastic process in estimation theory and control theory.

C. Wiener filter

Wiener filter is the MSE-optimal stationary linear filter for images degraded by additive noise and blurring. Calculation of the Wiener filter requires the assumption that the signal and noise processes are second-order stationary(in the random process sense). For this description, only noise processes with zero mean will be considered (this is without loss of generality)[7].Wiener filters are usually applied in the frequency domain. Given a degraded image x(n,m),one takes the Discrete Fourier Transform(DFT)to obtain X(u,v). The original image spectrum is estimated by taking the product of X(u,v) with the Wiener filter G(u,v):

$$S(u,v) = G(u,v)X(u,v)^n$$

The inverse DFT is then used to obtain the image estimate from its spectrum. The Wiener filter is defined in terms of these spectra: H(u,v) Fourier transform of the point spread function(PSF) Ps(u,v)Power spectrum of the signal process, obtained by taking the Fourier transform of the signal autocorrelation Pn (u,v) Power spectrum of the noise process, obtained by taking the Fourier transform of the noise autocorrelation

The Wiener filter is:

$$G(u,v) = \frac{H^*(u,v)Ps(u,v)}{|H(u,v)^2|Ps(u,v)+Pn(u,v)}$$

D. Guassian filter

The Gaussian smoothing operator is a 2-D convolution operator that is used to `blur' images and remove detail and noise. In this sense it is similar to the mean filter, but it uses a different kernel that represents the shape of a Gaussian (`bell-shaped') hump[8]. This kernel has some special properties which are detailed below. The Gaussian distribution in 1-D has the form:

$$G(x) = \frac{1}{\sqrt{2\pi\sigma}} e^{\frac{-x^2}{2\sigma^2}}$$

where σ is the standard deviation of the distribution. We have also assumed that the distribution has a mean of zero (i.e. it is centred on the line x=0). The distribution is illustrated in Figure 1.

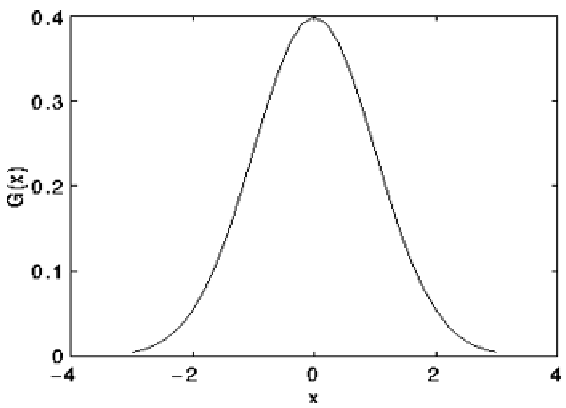

Figure5:1-DGaussian distribution with mean 0and σ=1

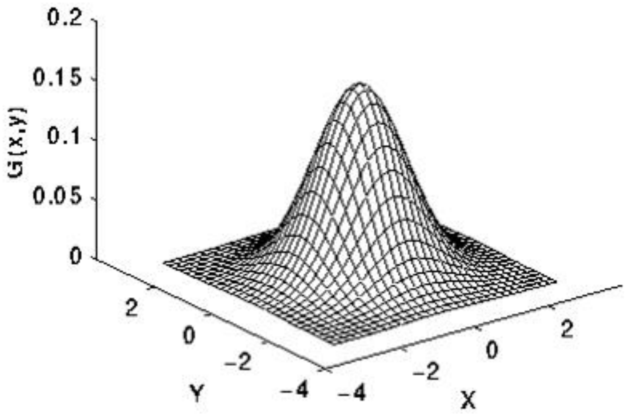

Figure6:2-DGaussian distribution with mean(0,0) and σ=1

In-D,anisotropic(i.e.circularly symmetric) Gaussian has the form: This distribution is shown in Figure2.

$$G(x) = \frac{1}{\sqrt{2\pi\sigma}} e^{\frac{-x^2+y^2}{2\sigma^2}}$$

Figure7:Originalimage

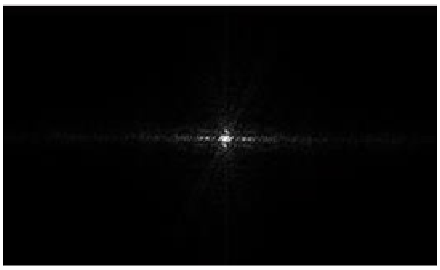

Figure8:FFToforiginal image

Figure9:Lowpassfilteredimage

Figure20:GaussianLPFH(f)

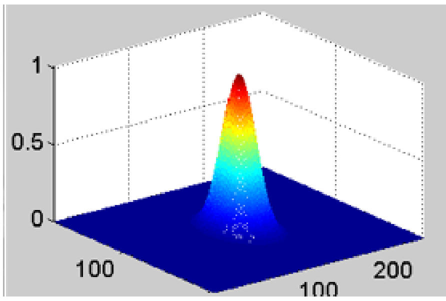

Figure31:GaussianHPFH(f)

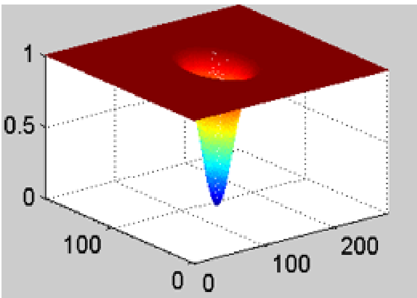

Figure42:Highpassfilteredimage

V. CONCLUSION

In this paper, we discussed different types of noise and filtering techniques for removing noises in colour image. Also we represent that how noise affects the image, we compare the different noise and filtering techniques. The results obtained using Gaussian filter technique ensures noise free and quality of the image as well. The main advantages of this paper is you can remove the noise by identifying its type and also can able chose best suitable filter for respective reduction of noise. Although deep learning is developing rapidly, it is not necessarily an effective way to solve the denoising problem. The main reason for this is that real-world denoising processes lack image pairs for training. This paper aims to offer an overview of the available denoising methods. Since different types of noise require different denoising methods, the analysis of noise can be useful in developing novel denoising schemes. For future work, we must first explore how to deal with other types of noise, especially those existing in real life.

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