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Study of Various Noise Removal Techniques

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Abstract: Noise is an important factor that influences image quality which is mainly produced in the processes of image acquirement and transmission. In image processing, noise reduction and restoration of image is expected to improve the qualitative inspection of an image and the performance criteria of quantitative image analysis techniques. Digital image is inclined to a variety of noise which affects the quality of image. The main purpose of de-noising the image is to restore the detail of original image as much as possible. The criteria of the noise removal problem depends on the noise type by which the image is corrupting .In the field of reducing the image noise several type of linear and non linear filtering techniques have been proposed . Different approaches for reduction of noise and image enhancement have been considered, each of which has their own limitation and advantages.In this paper, light is thrown on some important type of noise and a comparative analysis of noise removal techniques is done.

Keywords: noise, linear, correlation, filtering, signal.

I. INTRODUCTION

Noise[1,5] is unwanted fluctuation in the pixel values of an image. And hence noise suppression or noise removal is an important task in image processing. There are many ways to de-noise an image or a set of data and methods exists. The important property of a good image de- noising model is that it should completely remove noise as far as possible as well as preserve edges. We may define 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 cable, 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. Cleaning an image corrupted by noise is thus an important area of image restoration.

II. SOURCES OF NOISE

Digital images[2,5] are prone to a variety of types of noise. Noise is the result of errors in the image acquisition process that result in pixel values that do not reflect the true intensities of the real scene. There are several ways that noise can be introduced into an image, depending on how the image is created. For example:

a. If the image is scanned from a photograph made on film, the film grain is a source of noise. Noise can also be the result of damage to the film, or be introduced by the scanner itself.
b. The imaging sensor[3, 5] may be affected by environmental conditions during image acquisition.
c. Insufficient Light levels and sensor temperature may introduce the noise in the image.
d. Interference in the transmission channel may also corrupt the image.
e. If dust particles are present on the scanner screen, they can also introduce noise in the image.
f. If the image is acquired directly in a digital format, the mechanism for gathering the data (such as a CCD detector) can introduce noise.
g. Electronic transmission of image data can introduce noise.

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[5]. The principal sources of noise in the digital image are:

To simulate the effects of some of the problems listed above, the toolbox provides the imnoise function, which you can use to *add* various types of noise to an image. The examples in this section use this function.

A. Gaussian Noise:

The Random noise that enters the imaging system from external sources typically has a Gaussian, or normal distribution. Gaussian noise is an idealized form of white noise, which is caused by random fluctuations in the signal. We can observe white noise[2, 5] by watching a television which is slightly mistuned to a particular channel. Gaussian noise is white noise which is normally distributed.

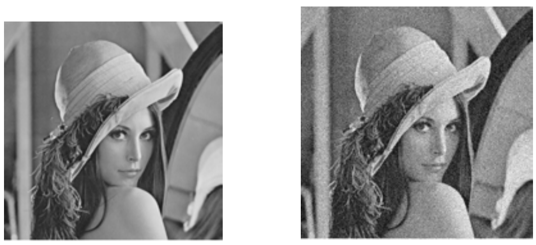

Figure 1. a) Original image Leena b)image with Gaussian noise

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B. Speckle:

Speckle noise[1,5] (or more simply just speckle) can be modelled by random values multiplied by pixel values; hence it is also called multiplicative noise. Speckle noise is a major problem in some radar applications. Speckle is the dominant form of noise in medical ultrasound imaging because many microscopic tissue components, smaller than the spatial resolution of the technique, act to reflect sound waves incoherently. Speckle is not an *entirely* bad thing in ultrasound.

Figure 2. a) Original image b) image with speckle noise

C. Salt and Pepper:

Most image noise causes relatively small random deviations from the expected ‘true’ image intensity. Extreme intensity deviations may also occur resulting in image pixels being incorrectly assigned the maximum or minimum possible values.

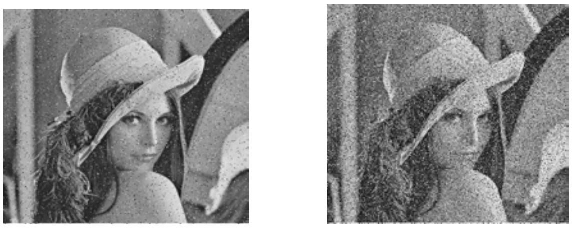

Figure 3 a)10% salt and peppper Noise b) 20% salt and peppper Noise

This ‘Salt and Pepper’, or *Impulse*, noise appears as randomly distributed white and black pixels in a digital image[2, 6]. It is also called impulse noise, shot noise, or binary noise. This degradation can be caused by sharp, sudden disturbances in the image signal; its appearance is randomly scattered white or black (or both) pixels over the image. It can arise from defects in single elements of a semiconductor sensor, sometimes called ‘stuck pixels’, defects in a semiconductor memory or storage device, noise affecting data transmission, or even image reconstruction and processing errors.

III. REMOVING NOISE BY LINEAR FILTERING

After 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 *neighborhood 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 neighborhood of the corresponding input pixel. A pixel’s neighborhood is some set of pixels, defined by their locations relative to that pixel. *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 neighborhood. Linear filtering can be use to remove certain types of noise. Certain filters, such as averaging or Gaussian filters[1, 2, 7], are appropriate for this purpose. For example, an averaging filter is useful for removing grain noise from a photograph. Because each pixel gets set to the average of the pixels in its neighborhood, local variations caused by grain are reduced.

A. Convolution:

Linear filtering of an image is accomplished through an operation called *convolution*. Convolution is a neighborhood operation in which each output pixel is the weighted sum of neighboring input pixels. The matrix of weights is called the *convolution kernel*, also known as the *filter*. A convolution kernel is a correlation kernel that has been rotated 180 degrees.

B. Correlation:

The operation called *correlation* is closely related to convolution. In correlation, the value of an output pixel is also computed as a weighted sum of neighboring pixels. The difference is that the matrix of weights, in this case called the *correlation kernel,* is not rotated during the computation.

C. Linear Filtering of Images Using imfilter:

Filtering of images, either by correlation or convolution, can be performed using the toolbox function imfilter. This example filters an image with a 5-by-5 filter containing equal weights. Such a filter is often called an *averaging filter*.

```
I = imread('coins.png');
h = ones(5,5) / 25;
I2 = imfilter(I,h);
imshow(I), title('Original Image');
figure, imshow(I2), title('Filtered Image')
```

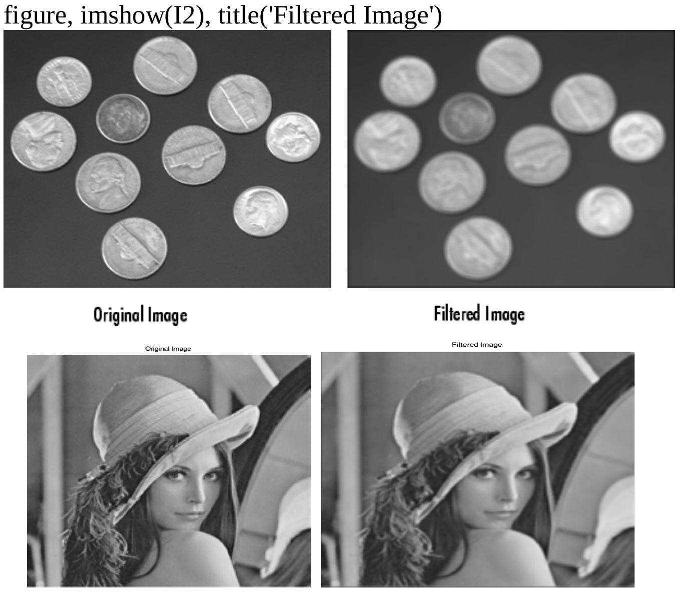

Figure 4: Coin and leena image with 5x5 linear filtered image

IV. REMOVING NOISE BY MEDIAN FILTERING

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

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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[1, 8] is therefore better able to remove these outliers without reducing the sharpness of the image. The medfilt2 function implements median filtering. The following example compares using an averaging filter and medfilt2 to remove *salt and pepper* noise. This type of noise consists of random pixels' being set to black or white (the extremes of the data range). In both cases the size of the neighborhood used for filtering is 3-by-3.

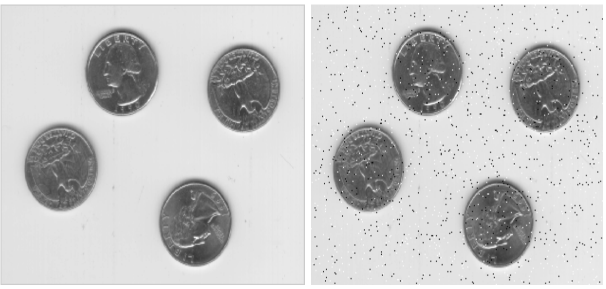

Figure. 5 a) Original image b) salt paper noise added

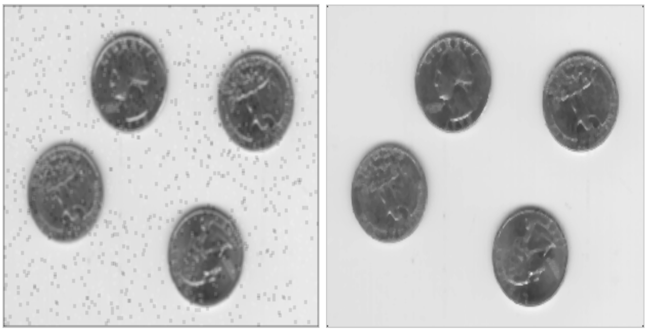

Figure. 6 a) 3x3 avg filter b) 3x3 median filter

V. REMOVING NOISE BY WIENER FILTER

The goal of the Wiener filter is to filter out noise that has corrupted a signal. It is based on a statistical approach.

Typical filters are designed for a desired frequency response. The Wiener filter approaches filtering from a different angle. One is assumed to have knowledge of the spectral properties of the original signal and the noise, and one seeks the LTI filter whose output would come as close to the original signal as possible.

The wiener2 function applies a Wiener filter (a type of linear filter) to an image *adaptively,* tailoring itself to the local image variance. Where the variance is large, wiener2 performs little smoothing. Where the variance is small, wiener2 performs more smoothing. This approach often produces better results than linear filtering. The adaptive filter[2, 9] 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[1].

wiener2 works best when the noise is constant-power ("white") additive noise, such as Gaussian noise. The example below applies wiener2 to an image of Saturn that has had Gaussian noise added.

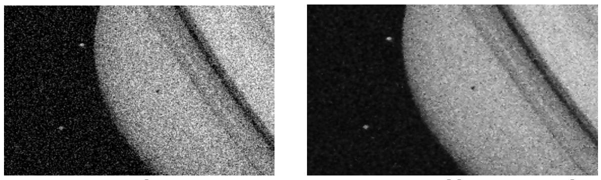

Fig 7 :Image with Gaussian Noise Noise Removed by Wiener Filter

VI. CONCLUSION

Linear filtering can be use to remove certain types of noise. Certain filters, such as averaging or Gaussian filters, are appropriate for this purpose. For example, an averaging filter is useful for removing grain noise from a photograph. Because each pixel gets set to the average of the pixels in its neighborhood, local variations caused by grain are reduced. 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. Where the variance is large, wiener2 performs little smoothing. Where the variance is small, wiener2 performs more smoothing. This approach often produces better results than linear filtering. wiener2 works best when the noise is constant-power ("white") additive noise, such as Gaussian noise. Salt and pepper noise, Gaussian noise and speckle noise can all be cleaned by using spatial filtering techniques

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