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An Adaptive approach to retrieve image affected by impulse noise from documents

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Abstract: *Impulsive noise is sometimes called salt-and-pepper noise or spike noise is most oftenly occuring image detoriation. An image containing salt-and-pepper noise will have dark pixels in bright regions and bright pixels in dark regions at random space. This type of noise can be caused by almost lost value of pixels, analog-to-digital converter deficiencies, bit errors in transmission, fault in communication etc. The traditional filtering techniques such as mean median and average are available to remove the noise from an image one of the most oftenly used is Gaussian filtering technique. But these filtering techniques are not generic, where as such techniques are useful in preparing adaptive algorithm for the general purpose filters.*

I. Introduction

Digital image processing is a tree with many advanced applications like robotics, medical imaging, computer vision, feature detection and remote sensing as fruits.

It has many roots such as image acquisition, image restoration, color image processing, image morphology, image segmentation etc.

In this paper, there are topics associated with the image restoration were discussed such as cause for impulse noises in image, filtering techniques used to restore the images.

Image is a proper organization of the pixels. Each pixel can be represented as two dimensional function. Image processing involves changing the nature of an image in order to either
1) Improve the pictorial information for interpretation by human
2) Apply it more suitable for independent machine acceptance

Image acquisition is the first process in image processing, it involves preprocessing such as scaling.

Image enhancement is among the simplest and most appealing areas of the digital image processing, its purpose is to bring out details that obscured, or highlighting the certain feature of interest. Image restoration concerns the removal or reduction of degradations which have occurred during the image acquisition. Such deterioration of the image may include noise, which are distraction in the pixel values, or optical effect such as out of focus blurring, or blurring due to camera motion. We shall see that some restoration techniques can be performed very successfully using nearby neighborhood operations, while some method requires the use of frequency domain processes.

Image restoration remains one of the most important field of image processing, but in this paper the emphasis will be on the techniques for dealing with restoration, and degradations types, or the properties of electronic equipment which give rise to image degradation.

In addition to this there are other steps in digital image processing such as color image, processing, wavelet,compression,morphological,segmentation,representation and description and object recognition.

In image restoration process the output generally are images, as in object recognition the outputs are the attributes of images.

II. Impulse noise

Image processing has become an ordinary component in modern science and has many important applications. With the expanding use of images in daily-life applications, image quality researches are rapidly growing. Unfortunately, during image acquisition, transmission and storage, many types of distortions contaminate the quality of received images.

Impulsive Noise (IN) occurs mostly due to the transmission medium imperfections, transmission system errors, sensor motion during image exposure, faulty memory-sensor units, electro-optic imperfections, electromagnetic interferences, storage medium and image processing method properties. An impulse noise also called salt and pepper noise or shot noise or binary noise caused by sharp, rapid disturbances in the image signal. Its appearance is randomly scattered white or black (or both) pixels over the image.
The PDF (probability density function) of impulse noise is given by

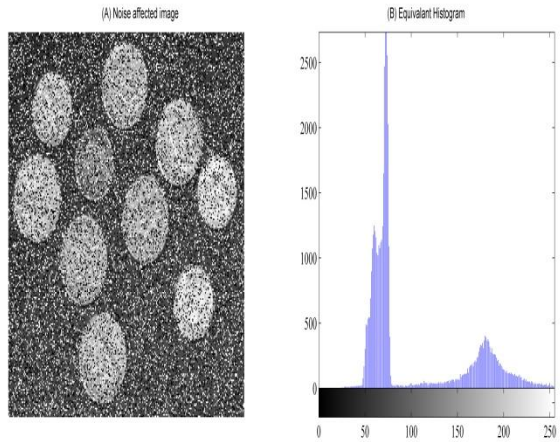
$$p(z) = \begin{cases} P_a & \text{for } z = a \\ P_b & \text{for } z = b \\ 0 & \text{Otherwise} \end{cases}$$

If b > a, gray-level b will appear as a light dot in the image.

Conversely, level a will appear like dark dot. If either Pa or Pb is zero, the impulse noise is called unipolar. If neither probability is zero, and especially if they are approximately equal, impulse noise values will resemble salt-and-pepper granules randomly distributed over the image. For this reason, bipolar impulse noise also is called salt-and-pepper. Shot and spike noise also are terms used to refer to this type of noise. In our discussion we will use the terms impulse or salt-and-pepper noise interchangeably.

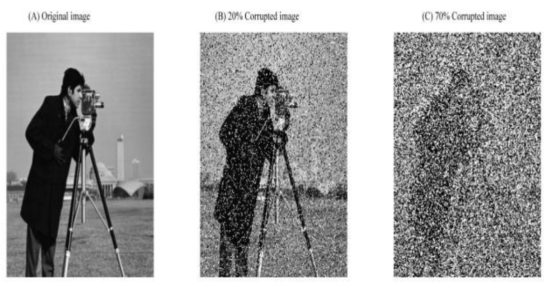
Noise impulses can be negative or positive. Scaling usually is part of the image digitizing process. Because corruption usually is part of the image digitizing process. Because impulse corruption is large compared with the strength of the image signal, impulse noise generally is digitized as extreme (pure black or white) values in an image. Thus, the assumption usually is that a and b are “saturated” values, in the sense that they are equal to the minimum and maximum allowed values in the digitized image. As a result, negative impulses appear as black (pepper) points in an image. For the same reason, positive impulses appear white (salt) noise. For an 8-bit image this means that a = 0 (black) and b = 255 (white).

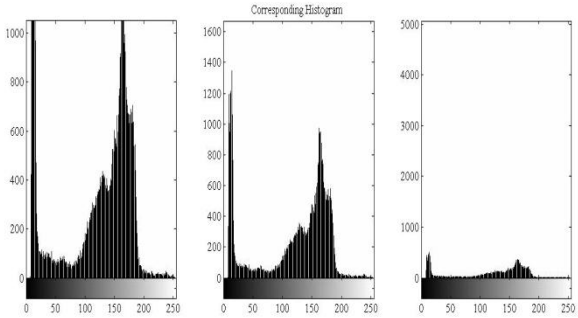
Graphically as shown below.



Adaptive filters are a class of filters which change their characteristics according to the values of the grey scales under the mask in the matrix, they may act more like median filters, or more like average filters. Depending on their position within the image matrix. Such a filter can be used to clean Gaussian noise by using local statistical properties of the values under the matrix mask.

Salt-and-pepper impulse noise is one the often and commonly encountered noise type during image and video communication. So far the state of the art methods can reasonably restore images corrupted by salt-and-pepper noise whose level is up to 70%





III. Filters

A. Mean filtering

To recover the image from its noise there exits many mean filtering techniques which are application oriented method. Some filtering techniques have better effects than the others according to noise category and type. Mean filtering techniques are described below

1) Arithmetic Mean Filtering (AMF) Technique: This is the simplest of the mean filtering techniques. Let Sxy represent the set of coordinates in a rectangular sub image window of size m x n centered at point (x, y).

The AMF technique computes the average value of the corrupted image g(x, y) in the area defined by Sxy. The value of restored image f at any point (x,y) is simply the Arithmetic Mean computed using the pixels in the region defined by Sxy. We can express AMF by the equation [4]

$$f(x,y) = \frac{1}{mn} \sum_{(s,t)\in S_{xy}} g(s,t)$$

2) Geometric Mean Filtering (GMF) Technique:

For GMF technique each restored pixel is given by the product of the pixels in the sub image window, raised to the power (1/mn). A Geometric Mean Filter achieves smooth image comparable to the Arithmetic Mean Filter but it tends to lose less image quality during the process. GMF can be expressed by the expression given below [4]

$$f(x,y) = \left[\prod_{(s,t)\in S_{xy}} g(s,t) \right]^{\frac{1}{mn}}$$

3) Harmonic Mean Filtering (HMF) Technique:

The Harmonic Mean Filter works well for Salt noise but fails for Pepper noise. It does well also with other types of noise like Gaussian noise. The HMF operation is given by the expression below [4]

$$f(x,y) = \frac{mn}{\sum_{(s,t)\in S_{xy}} \frac{1}{g(s,t)}}$$

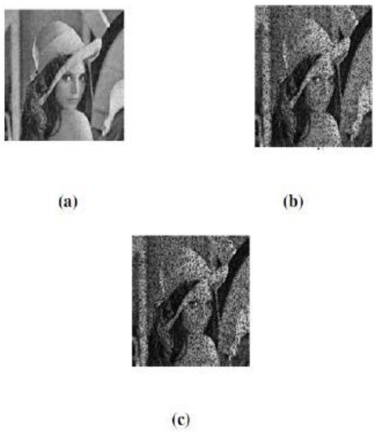


Fig. 3. Arithmetic mean filtering(AMF)(a), Geometric mean filtering(GMF) (b), Harmonic mean filtering (HMF) (c) [4]

B. Median filtering

Median Filter is an image filter that is more effective in situations where white spots and black spots appear on the image. For this technique the middle value of the mn window is considered to replace the black and white pixels.

When white spots and black spots appear on the image, it becomes very difficult to guess which pixel is the affected one. Replacing those disturbing pixels with AMF, GMF and HMF is not sufficient because those pixels are replaced by a value which is not appropriate to the original one. We have seen over the distorted images that Median Filter has better influence than that of AMF, GMF and HMF, where AMF is the best among all the mean filtering techniques and HMF has the worst performance. [4]

Median filtering seems almost tailor-made for removal of salt and pepper noise. Recall that the median of a set is the middle value when they are sorted. If there is an even number of values, the median is the mean of the middle two. A median filter is an example of a non-linear spatial filter. The operation of obtaining the median means those very large or very small values noisy values will end up at the top or bottom of the sorted list. Thus the median will in general replace a noisy value with one closer to its surroundings.

In MATLAB, median filtering is implemented by the medfilt2 function:

Fig. 4. Filtered image with median filters [4]

C. Adaptive filtering

Adaptive filters are a class of filters which change their characteristics according to the values of the grey scales under the mask; they may act more like median filters, or more like average filters, depending on their position within the image. Such a filter can be used to clean Gaussian noise by using local statistical properties of the values under the mask.

One such filter is the minimum mean-square error filter; this is a non-linear spatial filter; and as with all spatial filters, is implemented by applying a function to the grey values under the mask. Since we are dealing with additive noise, our noisy image M’ can be written as

$$M' = M + N$$

Where M is the original correct image and N is the noise; which we assume to be normally distributed with mean 0.

However, within our mask, the mean may not be zero; suppose the mean is m_f , and the variance in the mask is σ_f^2 Suppose also that the variance of the noise over the entire image is known to be σ_g^2. Then the output value can be calculated as

$$m_f + \frac{{\sigma_f}^2}{{\sigma_f}^2 + {\sigma_g}^2}(g - m_f)$$

Where g is the current value of the pixel in the noisy image. Note that if the local variance σ_f^2 is high, then the fraction will be close to 1, and the output close to the original image value g This is appropriate, as high variance implies high detail such as edges, which should be preserved. Conversely, if the local variance is low, such as in a background area of the image, the fraction is close to zero, and the value returned is close to the mean value[4][5].

1) Adaptive median filtering:

Conventional median filtering approaches apply the median operation to each pixel unconditionally, that is, without considering whether it is uncorrupted or corrupted. As a result, even the uncorrupted pixels are filtered, and this causes image quality degradation. An intuitive solution to overcome this problem is to implement an impulse noise detection mechanism prior to filtering; hence, only those pixels identified as corrupted pixel which would undergo the filtering process, while those identified as uncorrupted would remain at same value. By incorporating such noise detection mechanism or intelligence into the median filtering technique, the so called switching median filters had significant performance improvement in output.

The most popular approaches for dealing with such noise have been based on median filtering and/or on the best class of order statistic filters that have emerged from the study of median filters. Recently, variations on the median filtering scheme have been shown predictable amount of good ressult, under various specific signal-noise models, to deliver improved performance relative to other corresponding traditional methods. Examples include the minimum maximum exclusive mean filter (MMEM), Signal dependent rank-order mean (SDROM) filter, Florencios, conditional median filtering (CMF). These filters have all demonstrated excellent performance, but at the price of significant computational complexity also increase. The main hurdle is that characterizes all approaches of this type is that they involve extra computation to determine one or more of the local order statistics.

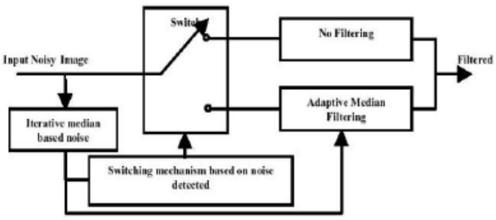


Fig. 5. Block diagram of adaptive median Filter [6]

IV. Conclusion

In this proposed paper the two advanced filtering techniques were discussed namely linear filters such as arithmetic mean filter, geometric mean filter, harmonic mean filters etc, these have output images slightly blurred. In another technique namely non-linear filters such as median filter which has smooth output. The advanced adaptive technique also discussed which work better than the linear and non-linear filter on impulse noise which is known as adaptive median filtering technique. These adaptive filters are very useful in many applications.

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