EXTRACTION OF INFORMATION FROM NOISY BACKGROUND USING SIGNAL PROCESSING

Mohd Arshad, Prajwal Shukla, Rishabh Saluja, Sohail Khan, Dr Prasanna Singh

Student, Student, Student, Student, Assistant Professor,

Electronics and Communication Engineering,

Noida Institute of Engineering and Technology, Gr Noida, Uttar Pradesh, India.

Abstract: In the current situation, we deal with various forms of noise in image processing, which not only degrade image quality but also hinders useful information stored in an image. Noises degrade images often. During image capture, transmission, and other processes, noise may occur and be acquired. In image processing, noise reduction is a crucial step. Imaging sensing element output is influenced by a range of factors, including the environment throughout image capture and therefore the competence of the sensing parts. In colour image processing, many noise reduction techniques are well-established. The type of noise that is corrupting the picture determines the essence of the noise removal dilemma. Several linear and nonlinear filtering approaches have been proposed in the field of image noise reduction. We present a brief summary of various removal noise models in this paper. The source of these noise removal models can be used to pick them. The results of various filtering techniques are presented in this paper, and the results of these techniques are compared.

Keywords: image enhancement, image processing, non-linear filter.

1. Introduction

Noise may be a spontaneous modification in image intensity that seems as a results of the image's grains. it is going to cause pictures to seem within the image as a result of basic physics, like the photon existence of sunshine. Common varieties of noise that arises within the pictures are Gaussian noise, Salt and pepper noise and Speckle noise. These noises might return from a noise sources within the locality of image capturing devices, faulty memory location or is also introduced because of fault/miscalculation within the image capturing devices like cameras, misaligned lenses, weak distance etc.

Image enhancement should include adjustments to the image's grey level and brightness, as well as noise reduction, sharpening, filtering, interpolation, pseudocolor, magnification, and other techniques. To render the image clearer or darker we are able to manipulate the image's brightness. Brightness may be improved by adding (or subtracting) a constant to every picture element within the image. A low-contrast image may be improvised with a distinct stretching operation.

Digital Image Processing algorithms typically comprises Image enhancement, Image segmentation, Image feature extraction and classification etc. In past few years, several digital image processing toolkits and platform are being developed, such as MATLAB. MATLAB is a high-level technical programming language and cooperative surroundings for designing algorithms, visualising information, analysing information, and performing numeric computations. Students can solve technical computing problems faster with the MATLAB image processing toolbox than they can with conventional programming languages like C and C++.

2. Types of Common Noises in Images

Any degradation in the image signal caused by external interference is referred to as noise. When a picture is transmitted electronically from one location to a different through satellite, space transmission, or fibre cables, we tend to expect image signal errors. Depending on the sort of signal interference, these errors can seem in varied ways that on the image output. we tend to generally recognize what kind of errors to expect and what kind of noise to expect in a picture, thus we look at a number of the standard noises for removing or reducing noise in coloured/grey pictures.

Image Noises can be categorised as following:

2.1 Gaussian Noise (Amplifier Noise):

The standard model of amplifier noise is Additive, Gaussian, dependent at every picture element and dependent of the signal intensity, caused primarily by Johnson–Nyquist noise [Thermal Noise], comprising that which comes from the reset noise of capacitors (KTC noise). It is condensed version of white noise, that is induced from spontaneous signal variations. Gaussian (also known as amplifier) noise models are commonly used in practise due to their mathematical tractability in both the spatial and frequency domains. If an extra amplification is employed within the blue colour channel than within the green or red colour channels, the blue channel will have a lot more noise.

Amplifier noise accounts for a large portion of image sensor noise, i.e., persistent noise level in dark areas of the picture. In Amplifier noise, every pixel in picture is shifted by a small amount from its original value.

A histogram represents a standard distribution of noise by plotting the number of distortions of a picture element value against the frequency during which it happens. While other distributions are possible, according to the central limit theorem, which states that the sum of different noises appears to approach a Gaussian distribution, the Gaussian (normal) distribution is typically a good model. The Probability Density Function (PDF) of Gaussian noise is equal to that of regular distribution, that is also called the Gaussian distribution.

The PDF of a Gaussian random variable is given by:

$$p(z) = \frac{1}{\sqrt{2\pi\sigma}} e^{-(z-\bar{z})^2/2\sigma^2}$$

where z represents intensity, $\bar{z}$ is the mean (average) value of z, and σ is its standard deviation. The standard deviation squared, σ2 is called the Variance of z. Gaussian noise is employed as additive white noise to supply additive white Gaussian noise in communication testing and modelling. White noise may be a random signal with a constant power spectral density in signal processing.

Example of Gaussian noise:

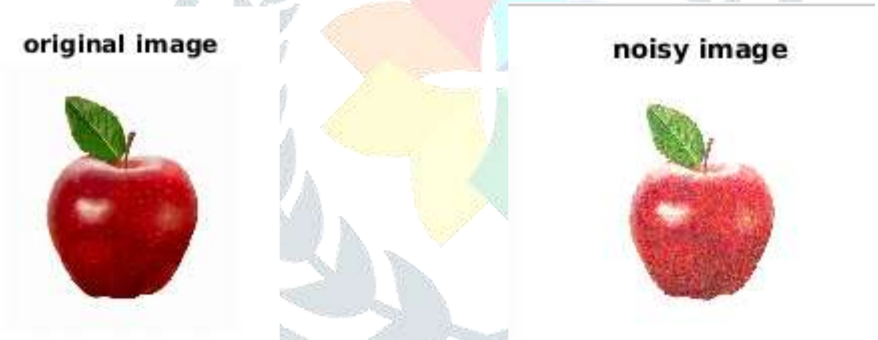

Figure - I

2.2 Salt and Pepper Noise:

Salt and Pepper noise is known by terms like impulse noise, spike noise, random noise. Salt and pepper noise is created by scattering both random bright i.e. [255 pixel] value and random dark i.e. [0 pixel value] pixels in an image. Since it statistically drops the original data values, this model is also known as data drop noise. Salt and pepper noise (sparse light and dark disturbances) occurs when pixels in an image are drastically different in colour or intensity from the pixels around them.

Sharp and abrupt disturbances in the picture can cause salt and pepper degradation. In most cases, this form of noise would only affect a few image pixels. The picture includes chalky(milky) and black spots when viewed, therefore the name salt and pepper noise.

A picture having this noise will have dark pixels in bright parts of the image and other way around. This type of noise can be caused by dead pixels. It appears through scattering of white or black pixels across the picture. It may occur due to memory cell failure, synchronisation errors in picture digitization, or transmission errors. Analog to digital conversion faults, as well as transmission bit error bit errors, may cause this form of noise

The PDF of (bipolar) 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, b will appear in the picture as a light dot. Level a, on other hand, would appear as a dark circle. The impulse noise is considered unipolar if either Pa or Pb is zero. Consequently, bipolar impulse noise is also known as salt and pepper noise.

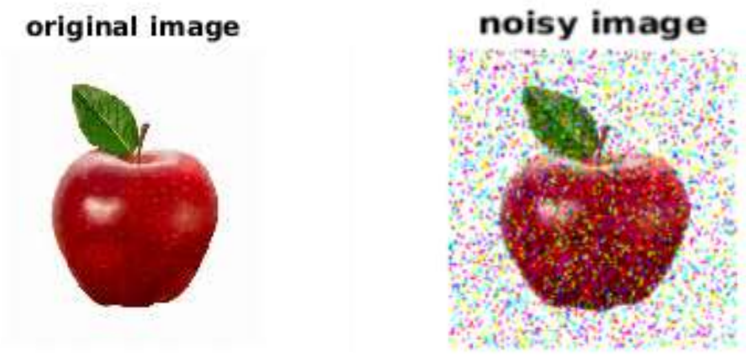

Figure - II

2.3 Speckle Noise (Multiplicative Noise):

Speckle is a granular 'noise' which occurs naturally in active radar or synthetic aperture radar (SAR) images and degrades their quality. In traditional radar, speckle noise is caused by random variations in the bounce back signal from an obstruction not larger than a one image-processing component. It boosts local area's mean grey level. In SAR, speckle noise is more extreme, making image interpretation more difficult. Unlike Gaussian noise, speckle noise (or simply speckle) can be modelled by multiplying random values by pixel values, therefore the name multiplicative noise.

While Gaussian noise and speckle noise appear to be very similar on the surface, they are produced by two very different methods and, as we will see, need two very different approaches to remove.

The PDF Speckle noise is given by

$$F(g) = \frac{g^{\alpha-1} e^{\frac{-g}{a}}}{\alpha-1! a^{\alpha}}$$

Example of speckle noise:

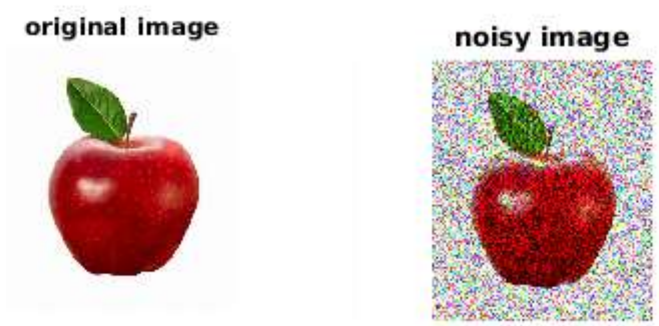

Figure – III

3. Eliminating Noise from Images by Filtering:

Image noise is an unpreventable side effect of image capture, which is best described as inaudible yet unavoidable fluctuations. Images are corrupted with impulse noise when broadcast over networks due to noisy channels. Significant positive and negative spikes create this impulse noise. Positive spikes have values that are much higher than the average, resulting in bright spots, whereas negative spikes have values that are lower than the background, resulting in darker spots. The image is also influenced by Gaussian noise. As a result, filters are needed to remove noises prior to processing.

Since filters respond most strongly to pattern elements that look like the filter, they provide a natural mechanism for finding simple patterns. Smoothed derivative filters, for example, are designed to provide a strong response when the derivative is high. At these points, the filter's kernel resembles the effect it's supposed to detect. Smoothing filters are used to blur images and minimise noise. Pre-handling undertaking, for example, eliminating little data from a picture before (huge) object extraction and connecting little holes in line or bend use obscuring. The three primaries (R, G, and B) are performed separately in the filtering technique. It's then accompanied by some gain to compensate for the filter's attenuation. The coloured image is generated by combining the filtered primaries.

Filters are primarily divided into two categories:

3.1 Linear filter (Smoothing filter):

Certain forms of noise are removed using a linear filter. For this, averaging or Gaussian filters are suitable. Sharp edges are obscured, lines and other fine picture data are lost, and straight channels work ineffectively within the sight of sign ward commotion. A linear spatial filter's response is simply average of the pixels in filter mask's neighbourhood. Linear filters are also known as averaging filters. Smoothing channels work from supplanting estimation of every picture element of the picture with the normal of power levels of the area determined from channel cover, bringing about a picture with less "sharp" force changes. The most evident application of smoothing is noise reduction, since random noise usually comprise of sharp changes in intensity levels.

Smoothing channels cause a picture to obscure since pixel power esteems that are altogether higher or lower than the encompassing area "smear" across the region.

3.2 Non-linear filter (Order Static filter):

Order-statistic filters are nonlinear spatial filters that respond by ordering (ranking) the pixels in the image area covered by filter and then changing the value of the centre pixel with the ranking result**.** The middle channel or median filter replaces the estimation of a pixel with the middle of the power esteems in its area, is the most well-known filter in this group. In the presence of impulse noise median filters are especially powerful.

3.3 Using Adaptive filter to Remove Noise:

Adaptive filters are a type of filter that changes its characteristics depending on the values of the greyscales under the mask; depending on their location within the image, they may act more like median filters or like average filters.

By utilizing the nearby measurable properties of the qualities under the mask, such a filter can be used to clean Gaussian noise. Assume we take the noisy picture shown in figure and use adaptive filtering to clean it up. We will use the wiener2 feature, which accepts an optional parameter specifying the mask size to use. 7 x 7 is the default dimension. Adaptive filtering tends to blur edges and high frequency components of the image since it is a low pass filter. However, it performs much better than a low pass blurring filter. When the variance is not as high as it is in our current picture, we can get really good results for noise. Figure shows the image and its appearance after adaptive filtering.

Figure - IV

3.4 Using Median filter to remove salt and pepper noise:

A median filter is a type of non-linear filter that, when properly designed, can retain a lot of image detail. The elimination of salt and pepper noise appears to be almost tailor-made for median filtering.

The median filter is used to reduce the amount of difference in intensity between two pixels. We do not replace the pixel value of an image with the mean of all neighbouring pixel values in this filter; instead, we replace it with median value. The median is determined by ordering all pixel values in up-trending order, then replacing the pixel being calculated with centre pixel value. If adjacent pixels in the image to be considered have an even number of pixels, sum of two centre pixel values is used to substitute them. When impulse noise percentage is less than 0.1 percent, the median filter shows the best output. The median filter does not produce the best results when the amount of impulse noise is increased.

Median Filter Algorithm: The median filter algorithm is described below:

Phase 1: Build a 3-D window(w) with a scale of 3*3. Suppose that the pixel under consideration is Px,y

Phase 2: Find the median of the pixel values in window(w) with Wmed.

Phase 3: Substitute Wmed for Px,y.

Phase 4: Follow steps 1–3 unless you have processed all of the pixels in the image.

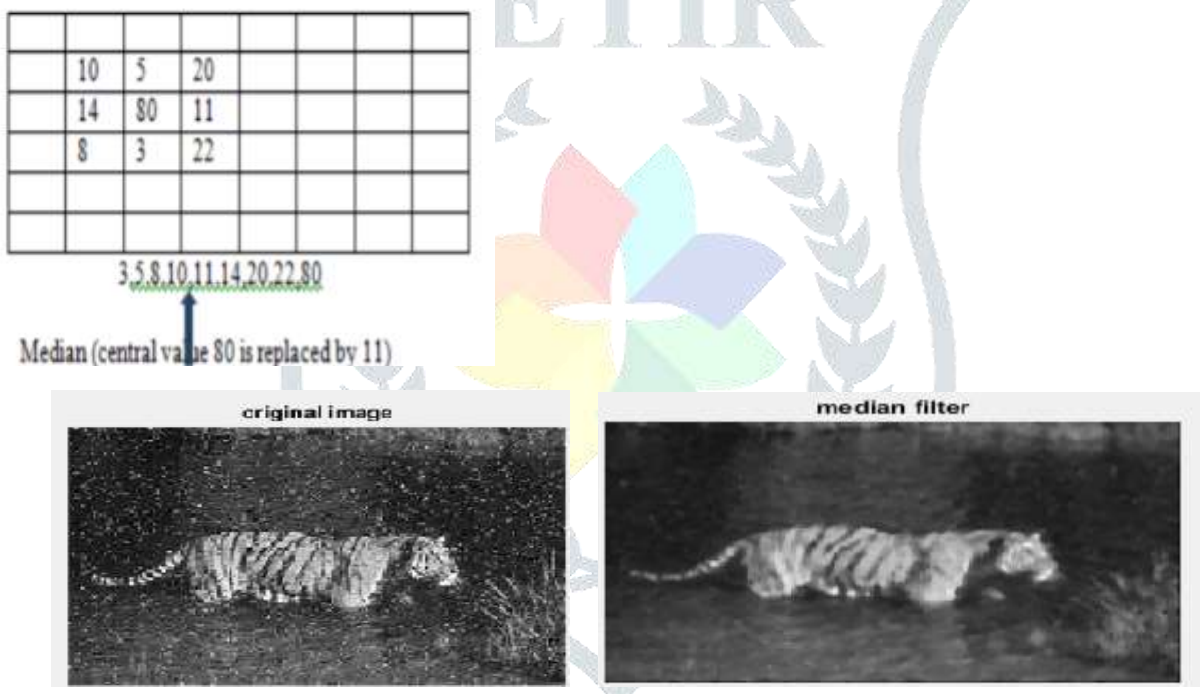

Figure - V

3.5 Wiener Filter:

The Wiener filter is a signal processing filter that filter an observed noisy process using linear time-invariant (LTI) filtering to produce an approximation of a desired or target random process. Between the calculated random process and the desired process, the Wiener filter minimises the mean square error. Wiener filter's aim is to calculate an arithmetical approximation of an unrevealed signal by taking a related signal as input and filtering it to get the approximates as output. The known signal, for instance, may be an unrevealed signal of interest that has been tainted by additive noise. Wiener filter can be used to remove noise from a distorted signal, allowing an approximation of the underlying signal of interest to be obtained. The Wiener filter is based on arithmetical approach, and the minimum mean square error (MMSE) estimator article offers a more statistical account of the theory.

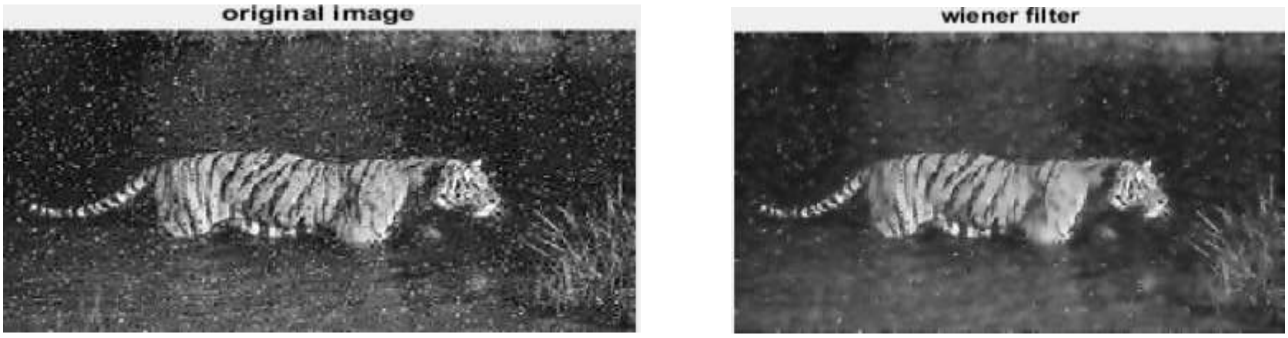

Figure - VI

4. Conclusion

Image noise is visible during image processing and transmission. The noise model characterises this. As a result, studying noise models is an essential aspect of image processing. Picture denoising, on the other hand, is a critical step in the image processing process. We cannot elaborate and perform denoising behaviour without prior knowledge of the noise model.

As a consequence, we have checked and presented various noise models in this article. Different filtering strategies for eliminating noises in grey level and colour images were addressed in this paper. We also discussed and compared the effects of these filtering methods. The results obtained using the median filter technique ensure that the image is noise-free and of high quality. The ability to denoise the destroyed colour component differences is one of this median filter's key advantages. As a consequence, the approach could be applicable to other filters currently usable. However, this approach adds to the computational complexity.

5. References

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